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ADULT AND PEDIATRIC

RECONSTRUCTIVE *and* PLASTIC SURGERY *of the* External Genitalia

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ADULT AND PEDIATRIC

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This book is dedicated to my wife, Irit,
who is my soul mate and constant inspiration,
and Dr. Joseph J. Kaufman, who gave me my chance,
for which I will always be grateful.

Richard M. Ehrlich

I dedicate this book to my mother, Ruth, and late father, Bernard.
Their love, encouragement, and support
have been a source of great comfort and strength.

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Foreword

I am honored to be asked to write about this book and the authors, two good and highly respected friends, each well known in the genital reconstruction field.

Undoubtedly, combining the talents of plastic surgery with urology has increased the speed of acceptance of new and innovative procedures in this area. There is no question that many of these complex techniques can now be done routinely by a well-trained urologist or plastic surgeon. However, this is an area in which both fields contribute to the whole by either technical care in more familiar procedures of his or her specialty or, more important, by exchanging stimulating ideas at the operating table and by extending the status quo to produce more efficient, new, and better methods of care.

It is appropriate that a new screening of the rapid advances of reconstruction be presented. Not only will it be useful for medical-surgical information to physicians, but the public is becoming more inquisitive and desires enlightenment about such problems. Old news and old operations become obsolete quickly. It is also important to hold on to time-tested successes, and a reevaluation of older but respected and honored workable techniques is always worthwhile.

I participated with great pride in the training of one of these editors. The other I have enjoyed as a friend and as a caring, respected physician for many years. I look forward with great pride to the culmination of their tedious and exacting work for us, the readers and purveyors of their advice.

CHARLES E. HORTON, M.D., F.A.C.S., F.R.C.S. (G) (Hon.)

Preface

"We shall not cease from exploration, and the end of all our exploring will be to arrive where we started, and know the place for the first time."

T. S. ELIOT

"To dream is not enough. One must know how."

BAUDELAIRE

Acknowledging the fact that genital surgery has become a true subspecialty, this unique book attempts to highlight and modernize current philosophy and techniques in reconstructive and plastic surgery of the external genitalia. As such, we have been fortunate to gain the expertise of world-class researchers in the field whose efforts are recognized internationally. No other such up-to-date book exists. The text has been patterned after *Horton's Plastic and Reconstructive Surgery of the Genital Area,* from 1973, whose collaboration with Dr. Charles Devine has been an inspiration to strive for excellence in this field.

The natural meld of pediatric urology and plastic surgery provides a seamless approach to inspire creativity, build on each other's strengths, and as a result, offer the very latest in innovative techniques. Caring for children and adults affected with serious congenital defects is a privilege; as such, we owe it to them to provide the utmost in proficient surgical reconstruction. It is our hope that we have accomplished this task.

We congratulate our contributing authors for their rational, coherent, and constructive contributions. We thank Mr. Richard Zorab of the W.B. Saunders Company for his efforts in shepherding this book to completion.

RICHARD M. EHRLICH, M.D.

Preface

This book is a compendium of surgical approaches to a wide range of genital reconstructive and aesthetic deformities by leading surgeons in their fields. I thank these contributing authors for their excellent contributions.

Over the years, many traditional plastic surgical operations have become the exclusive domain of the urologist (e.g., hypospadias) or the gynecologist, who have applied and adapted plastic surgical techniques. Unfortunately, most plastic surgeons are now inexperienced in genital anatomy and surgery, whereas urologists are limited in tissue-transferring surgical principles. Medicine, like society, has become more specialized; no single person or specialty can achieve the highest standards. Therefore, a team approach among all the disciplines is mandatory to ensure maximum creativity to these challenging problems. My personal experience illustrates this point, because my limitations as a urologic surgeon partially motivated me to become a plastic surgeon.

I have been blessed to train under and operate with some exceptionally gifted and innovative surgeons in both urology and plastic surgery. I appreciate the Mayo Clinic plastic surgeons for taking a chance on training a 42-year-old urologist from Beverly Hills, California.

I thank Charles Horton, MD, who encouraged me to seek this training in middle age. His landmark book in the early 1970s was the last similar multidisciplinary textbook in this area. His contributions, along with those of Charles Devine, standardized the teamwork approach to genital reconstruction. During my genital reconstructive fellowship at Eastern Virginia Graduate School of Medicine, Drs. Charles Horton, Charles Horton, Jr., David Gilbert, and Gerald Jordan provided me with the necessary knowledge and genitourinary surgical training to pursue this subspecialty. They have become good friends as well as cherished mentors. The experience in Norfolk, Virginia, illustrates the amazing accomplishments that can be achieved by the multidisciplinary approach of plastic surgeons and urologists.

My greatest thanks to to my co-editor, Richard Ehrlich, MD. He realized that combining our skills would make us both better, thereby benefiting patients and inspiring new innovations. I have learned greatly from him and am lucky to have him for a friend and surgical comrade. It was largely Richard's foresight and perseverance that enabled this book to be developed and completed.

I thank the W.B. Saunders Company, and especially Richard Zorab, for giving us the opportunity to compile this unique book. It has been a long, worthwhile process.

Many of the surgical advances outlined in this book resulted from the combined efforts of plastic surgeons, pediatric urologists, and reconstructive urologists and gynecologists. As newer plastic surgical innovations are developed, more imaginative techniques will evolve to solve these surgical challenges.

GARY J. ALTER, M.D.

NOTICE

Medicine is an ever-changing field. Standard safety precautions must be followed, but as new research and clinical experience broaden our knowledge, changes in treatment and drug therapy become necessary or appropriate. Readers are advised to check the product information currently provided by the manufacturer of each drug to be administered to verify the recommended dose, the method and duration of administration, and the contraindications. It is the responsibility of the treating physician relying on experience and knowledge of the patient to determine dosages and the best treatment for the patient. Neither the publisher nor the editor assumes any responsibility for any injury and/or damage to persons or property.

THE PUBLISHER

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CHAPTER

1

Principles of Plastic Surgery

R. KENDRICK SLATE

Plastic surgery involves repair of acquired defects, correction of deformities, improvement of form, and restoration of function. The principles of plastic surgery include diagnosing the surgical problem, preparing a surgical plan, and then properly executing the plan. The surgical problem may deal with wound care, closure, and coverage with grafts or flaps. Other areas involving plastic surgery include removal of skin lesions and reconstruction of the head and neck, trunk, breasts, external genitalia, and extremities. Plastic surgeons also treat burn injuries, correct craniofacial deformities, and perform aesthetic surgery. Indeed, the field of plastic surgery is extremely broad based. This chapter discusses the principles of wound healing and management as well as the transfer of tissue grafts and flaps.

WOUND HEALING

Wound healing is a necessary process by which the body repairs disrupted tissue. The healing process begins at the time of injury and lasts for several years. Wounds heal in three classic stages or phases, which include the inflammatory phase, the fibroplastic phase, and the maturation phase. Healing may be arrested at any phase, causing clinical problems. Repair begins after the acute inflammatory phase subsides.

The inflammatory phase begins at the time of injury and usually lasts 1 to 5 days. The response is nonspecific and begins with a vascular reaction. An initial transient period of vasoconstriction lasts several minutes and decreases blood flow through the area, thereby aiding hemostasis. Retraction of blood vessels, formation of platelet plugs from platelet aggregates, and clot formation occur through the intrinsic and extrinsic cascades. After vasoconstriction follows a period of vasodilation in which blood flow increases. Margination and migration of leukocytes, platelets, and red blood cells occur in the small vessels. Endothelial cells enlarge and leave gaps allowing swelling of the interstitial space. Vasoactive amines, such as histamine, and kinins are released. Prostaglandins and fibronectin are released, with fibronectin being very abundant in the first 24 to 48 hours. Fibronectin functions in cell migration and adhesion and is a major constituent of granulation tissue.

A cellular response follows, with the migration of polymorphonuclear leukocytes and mononuclear leukocytes into the wound. Polymorphonuclear leukocytes appear early but are short lived, and they serve to help control infection. With prolonged inflammation, mononuclear leukocytes tend to predominate. Macrophages are important for angiogenesis, phagocytosis of local debris, and chemotaxis of fibroblasts. During this period, the tissue is red, hot, swollen, and painful and may lose function. As phagocytosis continues, bacteria, debris, clot, and foreign material are removed. Inflammation subsides while wound healing progresses. This phase continues until the wound is closed.

The fibroplastic phase begins on the second to fifth days and lasts from approximately 2 to 6 weeks, depending on the size of the wound. During this phase, fibroblasts migrate into the wound and produce glycosaminoglycans, which form an amorphous gel, called ground substance, which helps suspend and orient collagen fibers. Collagen is synthesized by the third day and increases for 3 to 4 weeks, until degradation equals production. Wound tensile strength increases as collagen content increases. Peak tensile strength is gained in 2 to 3 months; however, it never entirely reaches the tensile strength of the original skin.

The maturation phase begins at approximately 3 weeks with the maturation and remodeling of collagen. Collagenases appear, and collagen degradation and production are increased, with no net increase in collagen. The collagen fibers become more oriented and organized, and the intermolecular cross-linking of collagen becomes more stable. The raised, indurated, pink scar transforms into a mature, flat, soft scar. This phase may last for a year or more.

Wound healing may be divided into three types: primary, secondary, and tertiary healing. Primary healing (first intention) is uncomplicated healing of a wound after wound closure. The closure may be by direct approximation of epithelial edges or by closure with tissue coverage such as a graft or a flap. The wound should be cleaned and debrided, and the dermis accurately approximated. The scar then heals through the phases of wound healing until a mature scar forms.

Secondary or spontaneous healing (second intention) involves the healing of an open wound by formation of

granulation tissue with wound contraction and epithelialization. The inflammatory phase continues until the wound is closed. Contraction of the wound decreases the size of the wound and is probably related to myofibroblast activity. Epithelialization is a process of covering the wound with new epithelium. This process involves mobilization of epithelial cells from the wound edges, their migration across the wound bed, mitosis of the cells to thicken the new layer, and finally differentiation of the cells to form basal to surface layers. Epithelialization and contraction are normal healing processes; however, contractures are deformities caused by the contraction of a scar or by fibrosis.

Tertiary healing (third intention) is delayed closure of a wound with the approximation of two granulating surfaces. The wound in this type of healing was healing by secondary healing when it was closed. Before delayed closure is performed, the bacterial level in the wound should be less than 10^5 bacteria per gram of tissue.

Factors Affecting Wound Healing

Many factors affect wound healing. Adequate oxygen tension levels in the wound environment are important for fibroblast functioning and therefore collagen synthesis. Collagen production needs oxygen partial pressures of 30 to 40 mm Hg or greater. Local oxygen levels depend on adequate inspired oxygen, effective transfer of oxygen by hemoglobin, sufficient hemoglobin, and ample tissue vascularity. Severe anemia may hinder wound healing. Edema may reduce capillary blood flow.

Drugs and vitamins may affect wound healing. Steroids, for example cause a decrease in the inflammatory response, inhibit macrophage activity, and delay angiogenesis, fibrinogenesis, and wound contraction. Vitamins A and C are needed for collagen synthesis, and vitamin A reverses steroids' effects on wound healing. Trace metals such as zinc, copper, magnesium, pyridoxine, riboflavin, and thiamin are cofactors in collagen production and cross-linking. Appropriate nutrition not only supplies essential cofactors, such as vitamins and trace metals, but also provides essential proteins, carbohydrates, and fats for wound healing.

Surgeons can control some local wound factors by handling tissues gently, avoiding tight sutures, using cautery appropriately, avoiding hematomas, decreasing tissue ischemia, and carrying out debridement properly. The wound should be kept warm and the tissue well hydrated with adequate blood supply. Favorable local wound factors should promote proper wound healing and keep the risk of infection to a minimum.

WOUND CLOSURE

Wounds should be thoroughly cleaned and irrigated with isotonic saline, which is preferably delivered as a pulsatile lavage. Sharp debridement rids the wound of foreign material, clot, and devitalized tissue. After adequate hemostasis, the wound should be closed without tension, possibly requiring undermining of the skin edges. The closure should follow skin tension lines and natural skin folds if possible. Important principles of closure technique include obliteration of dead space, layered closure, careful and gentle tissue approximation without tension, and eversion of skin edges. Wounds that cannot be closed by direct approximation may also be closed with skin grafts or flaps.

Sutures are absorbable or nonabsorbable. Deep sutures usually are absorbable, whereas most skin sutures are nonabsorbable. Monofilament nonabsorbable sutures, such as nylon, are preferred for closing skin because they cause less tissue reaction than multifilament sutures. Sutures in the face are usually removed in 3 to 5 days, whereas those on the rest of the body are usually left for 7 to 10 days. The technique of skin closure is more important to the final scar appearance than the type of suture material used.

SKIN GRAFTS

A skin graft is skin that has been completely detached from its original donor site and transferred to another site, where it will develop a new blood supply. Grafts may be classified according to species or to thickness. According to species of origin, grafts may be autografts, isografts, homografts, or heterografts. Autografts are taken from one site and placed on a different site in the same individual. An isograft is taken from one individual and placed on another individual with the same genotype, as with an identical twin. A homograft, or allograft, is taken from one individual and grafted to another individual of the same species but of a different genotype. A xenograft is a graft taken from one individual and grafted to an individual of a different species. According to thickness, grafts may either be split thickness or full thickness.

Split-Thickness Skin Grafts

Split-thickness grafts include the complete epidermis with a variable thickness of dermis. The grafts may be thin, medium, or thick. Thin split-thickness grafts are usually 10 to 12 thousandths of an inch thick, medium grafts are 13 to 17 thousandths of an inch thick, and thick grafts are 18 to 20 thousandths of an inch thick. Donor skin for grafting may be obtained with a knife or with a mechanical dermatome. Some dermal appendages remain in the original donor bed, including sweat glands, sebaceous glands, and hair follicles. From these remaining skin appendages and wound edges, the donor site heals by epithelialization. The thicker the graft, the longer the time required for complete donor site healing. Most split-thickness graft donor areas heal in approximately 2 to 3 weeks. With thin grafts, the donor site may heal within 10 to 14 days and may be used again if necessary.

Thin split-thickness skin grafts more easily survive grafting, and the donor site heals faster than with thick split-thickness grafts. However, thick grafts contract less, are more like normal skin, resist trauma, and aesthetically are more acceptable than thin grafts. Thick graft donor sites heal more slowly with more scarring than thin graft donor sites. Donor sites usually include the thigh, buttock, and abdomen. Split-thickness grafts may be meshed in order to expand them from one and one-half to nine times their original size.

Full-Thickness Skin Grafts

Full-thickness skin grafts include the epidermis and the entire dermis. These grafts provide good coverage because they are full-thickness skin. They resist trauma better, are aesthetically more pleasing, and contract less than split-thickness skin grafts. Full-thickness grafts vascularize more slowly and are less likely to survive than split-thickness skin grafts because of their greater thickness. Donor sites for full-thickness grafts must be closed primarily or with a split-thickness skin graft. Donor sites for full-thickness grafts are usually areas of thin skin such as the postauricular, supraclavicular, and inguinal areas. In addition to graft durability and donor site morbidity, color match is also very important, especially on the face.

Skin Graft Survival

Initially, both split-thickness and full-thickness skin grafts adhere to the recipient bed by fibrin bonding. This usually lasts approximately 72 hours. If fibrin is absent or dissolves, the graft fails. During the first 2 days, the graft is nourished by fluid from the recipient bed. This is the phase of plasma imbibition. The graft initially gains weight from the diffusion, absorption, and capillary action of fluid movement. Revascularization of the graft occurs between the third and fifth days. The revascularization may occur by reanastomosis of vessels between the recipient bed and the graft or by the growth of new vessels into the graft. The circulation in the graft is usually restored by 4 to 7 days. Lymphatic circulation usually parallels the restoration of the blood supply.

In grafted skin, the epidermis initially undergoes a period of depressed epidermal cellular function until vascular ingrowth occurs. By 4 to 8 days, proliferation and thickening of the epithelial cell layers with gross desquamation occur. Fibroblasts migrate into the dermis by the third day and outnumber those of normal skin by 8 days. Most of the collagen in the graft is replaced; a split-thickness skin graft replaces less collagen than a full-thickness skin graft.

Both split-thickness and full-thickness grafts assume the sensory innervation pattern of the recipient site. Split-thickness grafts usually have less return of innervation than full-thickness grafts. Reinnervation follows the neurolemma sheaths of the graft. Sensory recovery usually takes 1 to 2 years and returns in the order of pain, light touch, and temperature.

Split-thickness skin grafts contain almost no glands or skin appendages. However, full-thickness skin grafts show hair growth, as well as sebaceous and sweat gland activity. The skin gland function follows the pattern of the recipient bed.

Skin grafts undergo both primary and secondary contraction. Primary contraction occurs immediately on harvesting of the graft. Full-thickness grafts contract by about 40%, and split-thickness grafts contract by about 10% to 20% of their original volumes. Secondary contraction occurs after the graft is vascularized and is related to the amount of dermis in the graft. Therefore, full-thickness grafts undergo very little secondary contraction whereas split-thickness grafts tend to contract more.

Skin grafts may undergo pigmentation changes with a variable response. Thinner grafts usually undergo more color changes. Ultraviolet light induces hyperpigmentation in immature grafts. Grafts in darker-haired individuals may progressively darken, whereas in lighter-haired individuals they may lighten.

Several dressings for the skin graft donor site have been described. These include such dressings as scarlet red ointment, petroleum jelly gauze, pigskin heterograft, Op-Site, and exposure techniques. Op-Site is probably associated with less pain, whereas a heterograft has increased infection and scarring.

The most common cause of skin graft failure is hematoma or seroma under the graft. This inhibits adherence and vascularization of the graft. Another cause of graft failure is inadequate immobilization of the graft. After the graft is transferred to the recipient site, it should be completely in contact with the bed and adequately immobilized and covered with a pressure stent dressing to decrease shearing forces. If the wound has a large amount of serous drainage, the graft may be treated open. Infection is another cause of graft failure. The bed should be debrided and well vascularized and should have a bacterial count of fewer than 10^5 organisms per gram of tissue. If the wound bed is poorly vascularized, the wound must be debrided until vascularized tissue is obtained or it must be covered with a flap.

OTHER TYPES OF GRAFTS

Another type of graft is a composite graft, which is a combination of a full-thickness skin graft with fat or cartilage. Composite grafts revascularize in the recipient area and therefore must be small, usually less than 1.0 to 1.5 cm. The recipient site must have adequate vascularity. Examples include dermal fat grafts, hair transplant grafts, and skin and cartilage ear grafts.

Other grafts include tendon, bone, and cartilage. Soft tissue deficits may be corrected with fascia, dermis, muscle, or fat grafts. Conduits using nerve or vessel grafts may be used to replace or bridge nerve or vascular gaps.

FLAPS

A flap is tissue that is transferred from one area of the body to another area with its original blood supply intact. Flaps may consist of skin, subcutaneous tissue, muscle, fascia, bone, nerve, omentum, or other tissues (such as intestine). Classification of flaps may be according to their blood supply or to their positioning.

Blood supply to flaps may arise from segmental, anastomotic, and axial vessels that have perpendicular muscle perforations terminating in the dermal-subdermal plexus of the skin. Random-pattern flaps are based on this blood supply. Random cutaneous flaps are perfused through this dermal-subdermal plexus in the dermal and perifollicular layers of the skin. Random myocutaneous flaps have these perforator-musculocutaneous vessels that enter the base of the flap, supplying a small skin area.

Flap blood supply may also be supplied by vessels that

penetrate the underlying muscle fascia and lie in the subcutaneous tissue. These longitudinally oriented vessels supply the dermal-subdermal plexus directly. Axial pattern flaps are based on this blood supply. Axial pattern flaps not only have an arterial pedicle portion but also distally have a random-pattern portion of the flap.

Random Flaps

Random flaps are based on musculocutaneous perforating vessels. They have a limited length-to-width ratio because of their blood supply. In the head and neck area, random-pattern flaps may have a length-width ratio of 2:1 or 3:1. In the rest of the body, length-width ratios of 1.5:1 or 1:1 may be safely designed. The dermal-subdermal plexus should be maintained when designing these flaps.

Random cutaneous flaps may be divided according to their design and positioning. Two types of random flaps are rotation flaps, which rotate around a pivot point, and advancement flaps to close local defects.

Flaps that rotate are rotation flaps and transposition flaps, both of which are positioned into a defect. They are generally rotated from an area that has enough laxity to allow primary closure of the donor site (secondary defect). The donor site may require the use of a back cut (relaxing incision) or skin graft for closure. Secondary defects should not be closed under tension. True rotation flaps are semicircular and rotate around an axis into the defect for local closure.

Transposition flaps are advanced laterally along an axis that is at an angle to the original axis of the flap. These flaps are generally rectangular. They are usually used for local coverage of a triangular defect. The flap should be made longer than the side of the defect so that the actual diagonal length from the pivot point before transfer and the estimated length after transfer are similar. This flap may also require a short back cut across part of the base to reduce tension. The secondary defect must be closed, and therefore a graft may be necessary. The flap donor site may also be closed by transposition of a secondary flap from the most lax skin at right angles to the primary flap. This technique is known as a *bilobed flap*.

Another transposition flap is a Z-plasty. With a Z-plasty, two triangular flaps are raised (undermined) and transposed. This increases the length of the scar and the length of the tissue in the direction of the original central member (scar). A Z-plasty has one central member or limb and two angled limbs from the central limb, which together resemble a Z. The limbs are equal in length to the central limb and are usually angled at 60 degrees. The greater the angle, the greater the theoretic gain in length. Multiple Z-plasties may be designed in a series when not enough tissue is available for one large Z-plasty and when aesthetic result is of primary concern. Other transposition flaps include a Limberg flap and an interpolation flap. The Limberg flap is useful for closure of rhomboid defects with angles of 60 and 120 degrees. The sides are the same length as the short axis of the rhomboid defect.

An interpolation flap is a skin and subcutaneous flap that is transposed into a local but not immediately adjacent defect. The pedicle must pass over or under adjacent tissue to be placed into the defect. A common interpolation flap is a deltopectoral flap.

Advancement flaps are designed and moved directly forward to close a defect. In a single-pedicle advancement flap, a rectangle of skin is incised on three sides, undermined, and moved forward. With bipedicle advancement flaps, two incisions are made parallel to the defect to create a bipedicle flap that is undermined and advanced forward to close the defect. V-Y flaps are another advancement flap in which a V-shaped incision is made and closed in the shape of a Y.

Axial Flaps

Axial pattern flaps or arterial flaps are based on direct longitudinal vessels lying in the subcutaneous tissue. These flaps carry their own direct artery and vein, which branch into the dermal-subdermal plexus. Because these flaps include their own major blood vessel, they can have large length-width ratios, with long, narrow flaps created. If the flap has its artery and veins and skin intact in its pedicle, it is called a *peninsular flap*. If the skin in the pedicle is cut and the flap is connected to the body by only its intact vessels, it is called an *island flap*. An island flap in which the artery and veins are divided, the flap transferred to a new site, and the vessels reanastomosed to the recipient vessels is called a *free flap*.

Microsurgical techniques allow for large segments of tissue to be detached and transferred to a recipient site. Using microsurgery, the arterial and venous axial vessels are anastomosed to the recipient vessels. Anastomoses of vessels 0.5 to 2.0 mm in diameter can routinely be successfully performed. With vessels in the 2.0- to 4.0-mm range, the vessel can be anastomosed using a coupling device. Successful free transfer of cutaneous, muscle, musculocutaneous, fascial, fasciocutaneous, osteocutaneous, and osteomusculocutaneous flaps and free vascularized bone grafts are some of the free flaps that have been constructed. Sensory and motor flaps can restore sensation and function. These microtechniques have also allowed for successful reattachment of traumatically amputated body parts, such as fingers.

Musculocutaneous Flaps

Musculocutaneous flaps are compound flaps consisting of skin, subcutaneous tissue, and muscle. In these flaps, the muscle receives its blood supply predominantly by a dominant vascular pedicle. The overlying skin on the muscle is perfused by perforating vessels arising from the underlying muscle. These flaps are reliable and can be moved in wide arcs. The muscle flaps resist infection better than random flaps and are more viable in poorly vascularized areas such as wounds caused by radiation or osteomyelitis. Muscle flaps may be transferred and covered with a skin graft for coverage. Many of these flaps may be transferred as free flaps. Examples of musculocutaneous flaps include rectus abdominis, pectoralis major, latissimus dorsi, tensor fasciae latae, and gluteus maximus.

Fasciocutaneous Flaps

Fasciocutaneous flaps are composed of fascia and skin based on the vascular systems of the deep fascia. The deep fascia is supplied by perforating arteries from underlying muscle, subcutaneous arteries in the fat, and subfascial arteries from the intermuscular septa. Blood vessels extend along the fibrous septa between muscles or compartments and then branch out at the deep fascia to form plexuses. From the plexuses, branches radiate to the skin. Based on the blood supply, fasciocutaneous flaps may be either pedicle or free flaps, depending on the fasciocutaneous system involved. Some flaps such as forearm free flaps may also include tendons, muscle, and vascularized bone. Fasciocutaneous flaps are generally very simple and quick to raise and are highly reliable.

TISSUE EXPANSION

Skin expansion is a technique that has been in use for the past 40 years. Expanders are made of silicon elastomers, available in different shapes and sizes including round, rectangular, and crescentic. They are usually placed in a subcutaneous position through an incision that is at the edge of a defect. The expanders have internal or remote injection ports through which the expander may be gradually and incrementally enlarged by saline injections. The injections are generally performed weekly and should be painless.

Histologically, during expansion, the epidermis thickens or changes minimally while the dermis thins, especially in the first few weeks. A fibrous capsule forms around the expander, and it may be of variable thickness. Fat is very sensitive and may atrophy and even undergo necrosis if expansion is too rapid or intense. Muscle also thins with expansion but remains functional if no necrosis develops. Bony erosion and reabsorption may be caused by expanders; on the skull, however, restoration of contour usually occurs several months after removal of the expander. The vascularity of expanded tissue increases, with an increase in the number of blood vessels.

Areas of the body in which tissue expanders are useful include the scalp, forehead, face, and neck for head and neck reconstruction and the breast, abdomen, and back for trunk reconstruction. Expanders may be useful in the extremities but should be avoided in the hands and feet and cautiously used in the lower extremities and forearm.

Various complications may occur with the use of expanders; many of these can be avoided. The expander may become exposed, or the wound may undergo dehiscence because of inadequate dissection or closure. Tissue ischemia or necrosis may develop because of improper placement or vigorous expansion. The ports may fail, or implants may leak secondary to the use of large needles or improper needle placement. Postoperative hematomas, seromas, or infections may occur. Antibiotics should be given perioperatively, and external injection reservoirs avoided if possible. Discomfort and pain may also result from expansion, especially early in the expansion process and during forceful expansion.

In preparation for tissue expansion, the site for expansion should carefully be selected in terms of which tissue would best reconstruct the defect. The proper expander should be placed through an incision that can be used in the reconstruction. Base size rather than volume is important in selecting the proper expander. Tissues should be overexpanded to yield additional tissue if needed for the reconstruction. When expansion is complete, the expander should be removed, the tissues widely mobilized, and reconstruction of the defect carefully performed as planned.

CONCLUSION

Plastic surgery is a broad specialty based on the foregoing principles, which are applied to all areas of the body including the genitalia.

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CHAPTER

2

Anatomy of the External Genitalia

FRANK HINMAN, JR.

THE PENIS

Coverings of the Penis

The shaft of the penis is surrounded by five layers of tissue: the penile skin, the superficial layer of the penile fascia, the tela subfascialis, the deep layer of the penile fascia, and the tunica albuginea (Fig. 2–1).

The skin over the penis is particularly movable and expandable to accommodate erection. The penile skin adapts readily to prolonged contact with urine, making it suitable material for urethral replacement. Other advantages of this skin for urethral construction are its distensibility and abundant vascularity, as well as its ready availability.

The superficial fascia of the penis, or dartos fascia, is a part of the membranous layer of the superficial fascia of the groin and perineum (Colles' fascia). Embedded in it are the vessels that supply the skin, the superficial penile arteries and the superficial dorsal vein. This layer is only loosely attached to the one beneath it and hence is quite mobile. It separates the superficial from the deep dorsal veins.

Beneath the dartos fascia and Colles' fascia lies a very thin connective tissue layer, the tela subfascialis (Eberth), more prominent at the base of the penis, where it covers the extracorporeal segments of the cavernous arteries, veins, and nerves.

The deep layer of fascia is the penile fascia or Buck's fascia (Fig. 2–2*A*), a heavy elastic layer that covers not only the two corpora cavernosa but, in a somewhat separate compartment, the corpus spongiosum as well. It also encloses the deep dorsal vein and the dorsal arteries and dorsal nerves. The fascial layers of the penis and scrotum are continuous with similar layers in the perineum and the lower abdomen. The ischiocavernosus and bulbospongiosus muscles lie beneath the superficial penile fascia and its extension as Colles' fascia but are superficial to Buck's fascia.

The tunica albuginea (Fig. 2–2*B*), enclosing the corpora cavernosa, has two layers, an outer longitudinal coat and an inner circular coat. The intercavernous septum, separating the two corpora cavernosa, is perforated by the pectini-

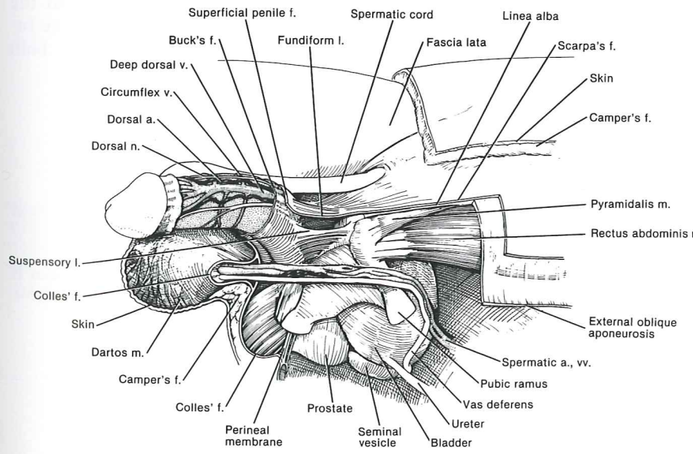


Figure 2–1
Superficial and deep fascias about the penis. (From Hinman F: Atlas of Urosurgical Anatomy. Philadelphia, WB Saunders, 1993.)

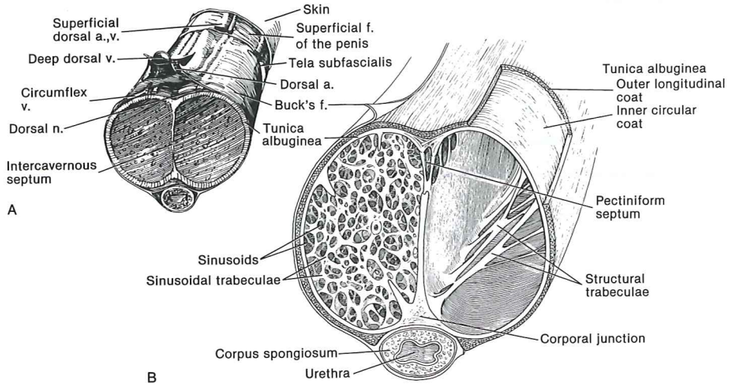


Figure 2–2
Structural layers of the penis. (From Hinman F: Atlas of Urosurgical Anatomy. Philadelphia, WB Saunders, 1993.)

form septum, providing free vascular communication between the corpora. Flattened columns or sinusoidal trabeculae within the corporal bodies surround the endothelium-lined sinusoids or cavernous spaces. A row of structural trabeculae traverse each intracorporeal space.

Ligaments

The root of the penis is suspended by two ligaments. The superficial fundiform ligament, a thickening of Scarpa's fascia, originates at the linea alba and, after splitting to pass around the base of the penis, joins Colles' fascia. Beneath the fundiform ligament is the suspensory ligament proper, attached to the symphysis pubis in continuity with Buck's fascia. Its function is maintenance of penile position during coitus.

Arterial and Nerve Supply

The penis is supplied by two sets of arteries, a superficial system of two more or less symmetrically arranged, longitudinally oriented vessels, the superficial penile arteries that originate from the external pudendal arteries and a deep system that arises from the internal pudendal arteries.

Superficial Arterial System. The superficial penile arteries supply the penile skin and prepuce (Fig. 2–3). The arteries lie in the superficial layer of the superficial fascia of the penis overlying Buck's fascia and divide on each side, usually into a dorsolateral and a ventrolateral branch. At intervals, these vessels give off fine branches to the skin, which is well vascularized with a very flexible cutaneous blood supply of coiled vessels extending along the shaft. The only point of connection between the deep and superficial systems is an anastomosis at the coronal sulcus, where the superficial vessels circle back dorsally to join the dorsal artery of the penis.

Deep Arterial System. The deep arterial supply to the penis, through the penile artery, is derived from the anterior branch of the internal iliac artery by way of the internal pudendal artery (Fig. 2–4). It pierces the urogenital diaphragm and divides into four branches: the bulbourethral artery, the urethral artery, and the cavernous artery; the terminal branch is the dorsal artery of the penis.

The bulbourethral artery supplies the bulb of the urethra through a posterior group of branches, the proximal quarter of the corpus spongiosum through an anterior group, and the glans.

The urethral artery, the second branch, passes on the ventral surface of the corpus spongiosum beneath the tunica albuginea. It may arise from the artery to the bulb

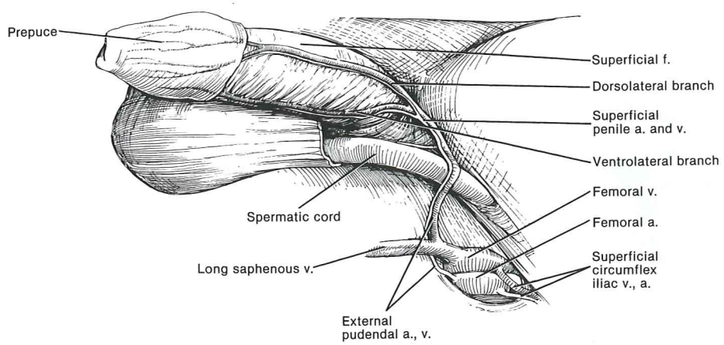


Figure 2–3
Superficial arterial supply. (From Hinman F: Atlas of Urosurgical Anatomy. Philadelphia, WB Saunders, 1993.)

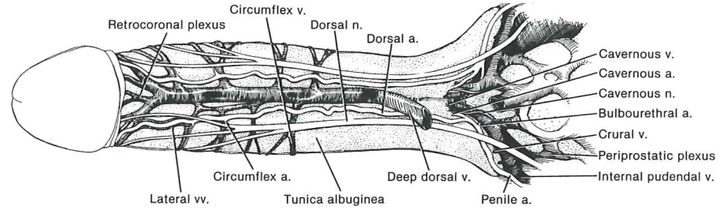


Figure 2–4
Relation of the cavernous and dorsal nerves to the arterial and venous systems of the penis. (From Hinman F: Atlas of Urosurgical Anatomy. Philadelphia, WB Saunders, 1993.)

but, if present, more commonly takes origin directly from the penile artery or from the cavernous or dorsal artery.

The cavernous artery (deep artery of the penis) usually arises before the penile artery terminates as the dorsal artery of the penis. It passes lateral to the cavernous vein along the dorsomedial surface of the crus of the corpus cavernosum to enter the erectile tissue where the two corpora fuse and then continues in the center of the corpus almost to its tip.

The dorsal artery, as the termination of the penile artery, extends over the respective crus and then along the dorsolateral surface of the penis as far as the glans between the deep dorsal vein medially and the dorsal nerve of the penis laterally. As it nears the glans, it passes ventrolaterally before entering it.

Neural. The dorsal nerve lies on each corpus cavernosum within Buck's fascia in the same plane as the dorsal arteries. It runs superficial to the circumflex arteries and veins, the lateral veins, and the retrocoronal plexus. The cavernous nerve enters the perineum deep to the prostatic venous plexus and enters the base of the corresponding corpus lateral to the cavernous artery.

Penile Venous Drainage

The *superficial drainage system* for the prepuce, skin, and subcutaneous tissue is carried in multiple superficial veins that are distributed somewhat randomly on the dorsolateral surface of the penis under the superficial penile fascia to join a single or double superficial dorsal vein that drains into either saphenous vein, usually that on the left (Fig. 2–5).

An *intermediate drainage system*, consisting of the deep dorsal vein and the circumflex veins, drains the glans penis, the corpus spongiosum, and the distal two thirds of the corpora cavernosa. The retrocoronal plexus acquires many small veins that leave the glans penis, and it drains in turn into the deep dorsal vein.

The deep dorsal vein passes through the suspensory ligament and between the puboprostatic ligaments to drain into the prostatic plexus, which in turn drains into the vesical plexus and then into the internal iliac veins. The circumflex veins receive blood from the corpora through the emissary veins, ultimately becoming multiple trunks passing under Buck's fascia before emptying obliquely into the deep dorsal vein.

The *deep drainage system* is composed of the cavernous veins, the crural veins, and the bulbar veins. Blood collected from the sinusoids of the proximal third of the penis by the emissary veins drains directly into cavernous veins at the periphery of the corpora cavernosa, forming the principal drainage system for the corpora. The cavernous veins unite between the crura into one or two large thin-walled main cavernous veins that lie under the cavernous arteries and nerves, making them less readily accessible for surgical ligation. The cavernous veins in turn pass between the bulb and the crus to drain into the internal pudendal

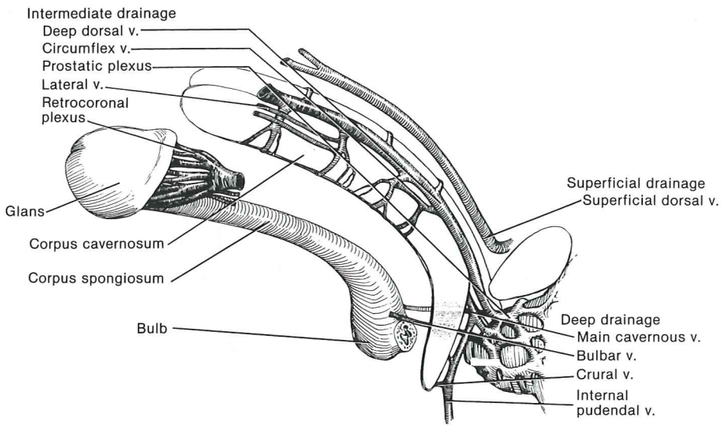


Figure 2–5
Penile venous drainage systems. (From Hinman F: Atlas of Urosurgical Anatomy. Philadelphia, WB Saunders, 1993.)

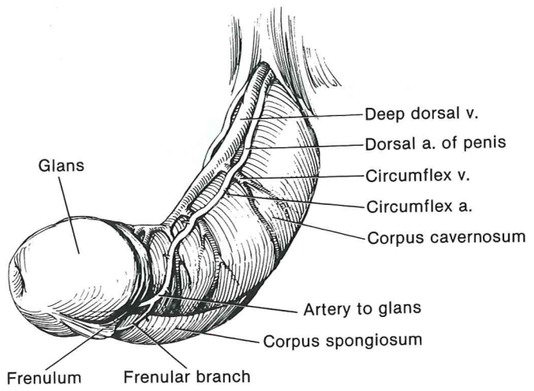


Figure 2–6
Blood supply to the glans and frenum. (From Hinman F: Atlas of Urosurgical Anatomy. Philadelphia, WB Saunders, 1993.)

vein. A few crural veins arise from the dorsolateral surface of each crus and unite to drain into the internal pudendal vein, with some contribution to the prostatic plexus. The bulb itself is drained by the bulbar veins, which empty into the prostatic plexus.

Blood Supply to the Glans and Frenulum

The principal destination of the dorsal artery is the glans, where it turns to a ventrolateral position near the coronal sulcus before its entrance as the artery to the glans (Fig. 2–6). The frenulum has a separate blood supply from the frenular branches of the dorsal artery that curve around each side of the distal shaft to enter the frenulum and glans ventrally.

Preputial Blood Supply

Arterial. The prepuce is supplied by the superficial penile arteries, which are two branches from the inferior external pudendal arteries (Fig. 2–7*A*). These usually divide into anterolateral and posterolateral branches. On reaching the preputial ring, the vessels become tortuous and minute and turn circumferentially before ending at the coronal sulcus. The superficial penile arteries do not communicate with the circulation to the rest of the penis.

Venous. The multiple small veins in the skin of the shaft join one or two superficial penile veins that drain through the inferior external pudendal vein into the saphenous vein (Fig. 2–7*B*).

THE URETHRA

The urethra has three segments. The bulbomembranous urethra comprises the approximately 2 cm of urethra lying in the so-called urogenital diaphragm and within the striated urethral sphincter, in addition to the proximal few centimeters of the bulbous urethra. The bulbospongy urethra extends from within a few centimeters of the anatomic membranous urethra distally to the level of the suspensory ligament. The pendulous or penile urethra extends from the suspensory ligament to the meatus. The prostatic urethra is part of the prostate.

THE TESTES AND ADNEXAE

The left testis has a longer spermatic cord and is lower than the right. Each adult testis is approximately 4 cm long, 3.5 cm wide, and 3 cm thick, with a volume of about 30 ml.

Scrotum

The scrotum has two layers. One is an outer layer of richly vascularized rugous skin that contains well-developed sweat glands, which assist in testicular temperature regulation, and sebaceous glands. The other is a thin, nonstriated dartos muscle (tunic) that serves to regulate scrotal temperature.

Coverings of the Testes

The testes are covered by three layers of fascia, all derived from layers of the anterior abdominal wall: the external

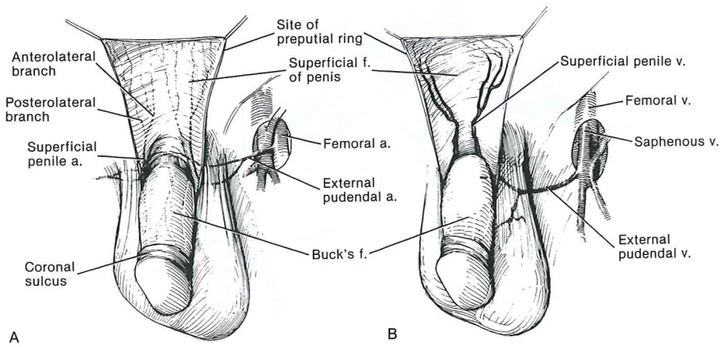


Figure 2–7
Preputial blood supply. *A:* Arterial. *B:* Venous. (From Hinman F: Atlas of Urosurgical Anatomy. Philadelphia, WB Saunders, 1993.)

spermatic fascia, continuous with the innominate fascia covering the aponeurosis of the external oblique; the cremasteric fascia and muscle, an extension of the internal oblique and transversus abdominis; and the internal spermatic fascia, which is related to the transversalis fascia.

The testes are also enclosed in the parietal and visceral layers of the tunica vaginalis and in the tunica albuginea. The visceral layer of the tunica vaginalis covers the testes on all aspects except posterolaterally. This very thin layer of flattened cells of peritoneal origin is not separable from the tunica albuginea proper and thus surgically is considered as a single coat. The tunica albuginea is a thick, tough fibrous layer that tightly encloses the testicular substance, giving it a firm, somewhat rubbery feel on palpation.

Structure of the Testis and Epididymis

Trabeculae (septa) project into the testicular substance from the tunica albuginea, dividing the seminiferous tubules into lobules. The tunica vasculosa lies beneath the tunica albuginea, to which it is closely applied. The mediastinum of the testis is a continuation of the tunica albuginea that extends vertically for a short distance along the posterior border of the testis. It resembles a hilum as it conducts the vessels and nerves supplying the gland. Septula divide the testis, not always completely, into 200 to 300 conical lobules, each containing one or more convoluted seminiferous tubules that empty into 20 or 30 straight seminiferous tubules or tubuli rectae, which in turn enter the mediastinum to form the rete testis, a collecting network of anastomosing ducts.

Efferent ductules pass directly from the rete testis through the tunica albuginea into the head of the epididymis, where they enlarge and become convoluted, each forming an epididymal lobule. Together, the lobules form the head of the epididymis (caput, globus major). The ducts from the lobules then join to form a single, highly convoluted epididymal duct, which measures some 5 to 6 m length. It follows a convoluted path down the body (corpus) of the epididymis to the tail of the epididymis (cauda, globus minor), where it becomes larger. After some terminal convolutions, it emerges as the vas deferens, which passes through the inguinal rings within the spermatic cord, crosses in front of the ureter and behind the medial umbilical ligament, and passes behind the bladder, where it becomes dilated to form the ampulla of the vas. A narrow segment, the ejaculatory duct, enters the prostate accompanied by vessels, lymphatics, and nerves after receiving the seminal vesicle on its lateral border.

Testicular Arterial Supply

As it approaches the testis, the testicular artery divides into two tortuous main branches, an outer one, the internal testicular artery, and an inner one, the inferior testicular artery.

The outer branch, from the internal testicular artery, passes obliquely through the tunica albuginea to enter the tunica vasculosa. Branches form an aggregation, appearing as a vascular hilum. The inner, larger branches, from the inferior testicular artery, pass between the testis and the epididymal body to enter the posterior border of the testis, medial to the epididymis, at several points. The distribution of these vessels under the tunica albuginea is not uniform; the superior anterior and all inferior aspects have the most major branches, and the superior medial and superior lateral portion of the tunica have the fewest, an important point in biopsy or suture of the testis.

The outer and inner arterial branches ramify in the tunica vasculosa over the lateral and the medial curvatures of the testis as coiled centripetal arteries. These extend toward the rete and in turn put out branches that reverse the course and return as centrifugal arteries. Both sets end as intertubular arterioles.

The epididymal artery supplies the head and body of the epididymis through one or more capital arteries. The tail is vascularized by a complex arrangement of vessels involving the epididymal, vasal, and testicular arteries, with supplementation from the cremasteric artery. This system, which provides an extensive anastomotic loop among these vessels, is important when the testicular artery must be divided to achieve scrotal placement of the testis. The sum of the diameters of the cremasteric and vasal arteries is equal to the diameter of the testicular artery in a third of cases.

The vasal artery along its course on the vas provides small branches, some of which may join the testicular artery in the cord just above the epididymis. The artery branches to join the posterior epididymal arteries to form an epididymal-deferential loop. Anastomoses between the testicular and vasal arteries do not follow a regular pattern, accounting for the variable results of long-loop orchiopexy.

The cremasteric artery passes outside of the internal spermatic fascia and so supplies an extremely limited

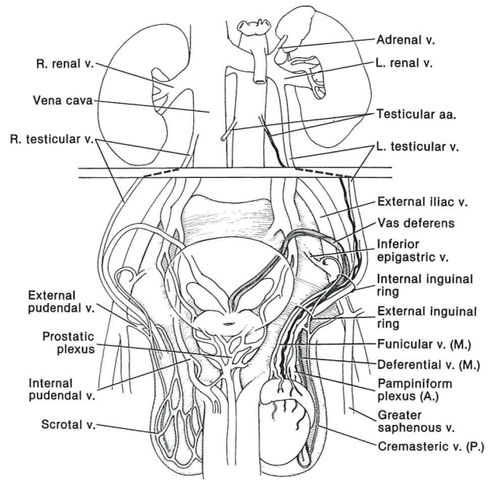


Figure 2–8
Extratesticular venous pathways. (From Hinman F: Atlas of Urosurgical Anatomy. Philadelphia, WB Saunders, 1993.)

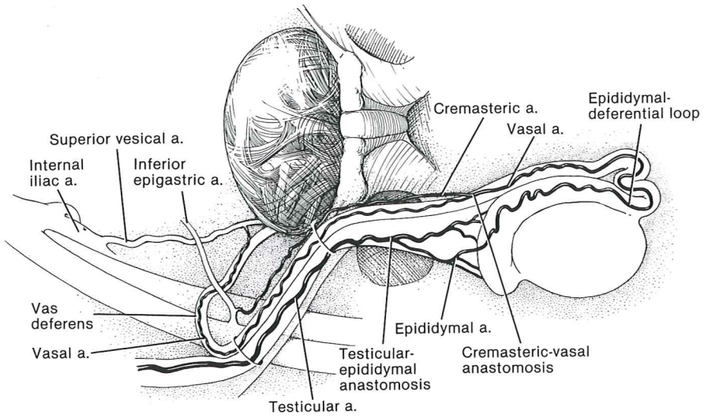


Figure 2–9
Collateral circulation to the testis. (From Hinman F: Atlas of Urosurgical Anatomy. Philadelphia, WB Saunders, 1993.)

amount of blood to the structures within. However, some terminal branches may reach the lower pole of the testis and anastomose with the epididymal-deferential loop, with a terminal branch of the testicular artery, or with branches of the epididymal artery.

Testicular Venous Pathways

The veins of the testis arise diffusely from a dense microvascular bed about the tubules (Fig. 2–8). They join collecting venules that pass either peripherally or centrally, in contrast to the arteries, which are organized peripherally in the testis. The peripherally directed veins reach the tunica vasculosa and continue on the anterolateral aspect of the testis, where they form large channels on the surface. The centrally directed veins, providing the principal drainage of the testis, extend to the rete testis, pass through the posterior surface of the tunica albuginea at the mediastinum, and are joined by veins from the anterior portion of the epididymis before they reach the pampiniform plexus.

The variable number and distribution of veins draining the testis, epididymis, and vas deferens connect with a deep and a superficial venous network. The *deep venous network* is composed of an anterior set of the pampiniform plexus and the testicular vein, a middle set of the deferential vein, and a posterior set of the cremasteric vein. The pampiniform plexus, a meshlike complex of large veins, is formed from as many as 10 branches of veins emerging from the testis and from the superficial plexus. The system becomes reduced to two veins as they pass through the external inguinal ring to end as a single vein that ascends as the testicular vein. The left vein enters the left renal vein, usually lateral to the adrenal vein, joining it most often at a right angle. The right testicular vein enters the anterolateral surface of the vena cava obliquely at a site below the renal vein. The *superficial venous network* drains the scrotal veins and collects the cremasteric vein. Anastomosis is frequent between the superficial and deep systems.

Collateral Circulation to the Testis

The three vessels (the testicular-epididymal, vasal, and cremasteric arteries) that supply the testis, vas, and cremaster have separate origins (Fig. 2–9). The testicular artery comes from the upper aorta, the vasal artery from a branch of the superior vesical artery, and the cremasteric artery from the inferior epigastric artery. Numerous anastomoses normally exist between these peripheral arteries.

In cryptorchidism with a long-loop vas, arterial anastomoses are found distally between the loops of the vas. If the vasal and cremasteric bundles are preserved, the testicular artery can usually be divided without causing testicular ischemia. In the usual case, a terminal branch of the vasal artery and the posterior epididymal artery forms the epididymodeferential loop, and after division of the main artery, the testis becomes dependent on the anastomoses between the epididymodeferential loop and the terminal part or distal branches of the testicular artery.

APPLICATION

Understanding the structure of the penis allows an anatomic approach for such operations as orchiopexy; testicular biopsy; simple, extracapsular, epididymis-sparing, and radical orchiectomy; epididymectomy; and varicocele ligation.

HYPOSPADIAS

CHAPTER

3

History of Hypospadias Repair

NORMAN B. HODGSON

Through the millennia, correction of hypospadias has been the work of dedicated innovators. There have been no easy solutions. The chilling choices of antiquity seem to have emerged from the art of circumcision. That art was necessitated by balanitis caused by the bite of the desert sand fly and other small insects, leading then to its place as a religious ritual. Similar rituals exist around the globe where small biting insects flourish (between the 30th parallels and under 6000 feet elevation).

About 3500 years passed from the time the Egyptians (3500 B.C.) began (and the Hebrews [1300 B.C.] extended) the practice of circumcision without mention of hypospadias. Even Celsius (25 B.C. to 50 A.D.), in his compilation *De Medicina*, did not mention the defect, perhaps because of cultural verbal prudery.

Oribasius' *Works* (25 to 103 A.D.), translated from the Greek by Bussemakers and Daremberg[1] into French, gave credit to Heliodorand Antyl (100 to 200 A.D.) for the first description of surgical management of hypospadias. This was in essence a curvilinear sculpting amputation of glans chordee to simulate normalcy.

Shortly thereafter, Galen (129 to 200 A.D.) reintroduced from Celsus and the First Book of Maccabees (200 B.C. to 70 A.D.) the idea of skin stretching over the glans with a circumferential incision at the base, which was allowed to granulate and epithelialize. The skin over the glans was secured in place over a voiding stent. This method was revived in the 1500s.

During the next 600 years, recordings (basically unchanged) continued in Alexandria, Egypt. Some of these were by Paul of Algina (625 to 690 A.D.) and by the Islamic physician Albucasis (936 to 1013 A.D.). He used knives and cautery to reshape or groove the glans.

Through the 1100s and 1200s, surgical expression became disreputable and was not respected or recorded for 300 years. Adaptation rather than revision remained the primary advice. Trocars and eschars (of fistula) were the mainstays.

At this point, Johannes Gutenberg's printing press (1448) facilitated the vast revelations of the Renaissance. Paré (1510 to 1590)[2] continued the glans sculpting but added release of chordee by transecting the ventral bands. He was a Huguenot barber surgeon who compiled a work of surgery, attitudes, and devices of the age and thus was a father of surgery.

Meanwhile in Portugal, canalization of the glans (by a silver probe) had been carried out by Lusitanus (1511 to 1568),[3] but medical care had again disavowed surgical care (as had Hippocrates), which was left to "the barbers, specialists in that art." (Both the skin stretching and glans grooving were reinstituted by Fabricius of Aquapendente,[4] 1533–1619). Henri II of the Orleans Valois married Catherine de Medici in 1533, when both were 14 years old.[5, 6] She was childless for 10 years and competed "amicably" with an older consort, Diane de Poitiers. Henri had hypospadias with chordee. A physician, Jean Fernel, recommended rear-entry intercourse, which resulted in 10 children in 10 years—three kings (Francis II, Charles IX, and Henry III), a lifelong retainer for Fernel, and a reduction in state support (originally 25% of revenues) of Diane—along with a chain of regal and religious tragedies.[5, 6]

The previously mentioned operations and accommodations continued for another 300 years until an eruption of knowledge and techniques in the 1800s, when fine suturing and tissue management were introduced by J. F. Diffenbach. He was known for the pursestring suture for fistula repair. This was done after preoperative chemical blistering and abrasion of the surrounding tissue.

Surgical revision and direction for hypospadias repair was finally provided by Mettauer at Prince Edward County Hospital, in Sarmville, Virginia (1842) (a few miles west of Appomattox Courthouse*). He had been educated by P. Syng Physick and other great physicians assembled in Philadelphia at the turn of the nineteenth century. He also introduced wire sutures (lead), which were so prominent in the successful repair of vesicovaginal fistula by Sims, who used silver.

In a reported series, Mettauer preferred foremost canalization with a trochar and stent but also presented a case with meatal stenosis and severe urethral elongation with

*Where Lee, of the Army of Northern Virginia, surrendered to Grant's Army of the Potomac, on April 9, 1865, ending the American Civil War, 1861 to 1865.

ballooning.[7] This required a urethral collar excision and repositioning of the glans to the corpora. He also joined Liston, of London, in tubularization by apposition.[8]

Anesthesia (nitrous oxide in 1844, ether in 1846, and chloroform in 1847) allowed the age of innovation.

Pancoast's *Treatise of Operative Surgery*, published in 1844, contains lithographs that are a joy to behold.[9] The original number of plates was expanded by 50% without a book price change ($4). Within the text, vertical-to-horizontal dorsal ellipses to correct chordee are credited to Physick and vertical-to-horizontal (now called Heineke-Mikulicz) incisions are described by Pancoast.

CHORDEE REPAIR: BITS AND PIECES

Chordee repair was successful before other types of such operations (Fig. 3–1). In 1861, ventral dissection (Mettauer) was extended by Bouisson.[10] He used a ventral transverse incision with fibrous excision and vertical closure.

It shortly became widely known that chordee tended to re-form after its initial correction. As a result, generations of surgeons were committed to various two- or three-stage procedures.

In the early 1900s, Ombredanne described removal of fibrous bands and covered the defect with a buttonholed flap.[11] As the decades passed, chordee correction was advanced to include closure of skin with Z-plasties (Barcat[12]), dorsal ellipses (Reed Nesbit), ventral reverse incisions, Heineke-Mikulicz (J. Saafield, Richard Erlich, Gross), ventral transverse incisions of the tunica albuginea (Sir Richard Turner-Warwick), dorsal glans tilt tipping (Norman Hodgson), tunica vaginalis parietalis testes supplement of penile tunica (Brent Snow, S. Das), and dorsal plication (John Duckett).

A major advance in chordee correction was provided by Gittes and MacLaughlin in 1974, with their intraoperative saline inflation of the corpora caverosa.[13] This guided and ensured successful orthoplasty (straightening). Even this has been refined with Normosol and transglanular needle placement (Frank Hinman, Jr.).

ADVANCING THE TUBE

Thiersch repaired epispadias with a pants-over-vest repair in 1869.[14] The vest was tubed, and the pants gave cover. Then Theophile Anger (1874) applied Thiersch's concepts for epispadias to hypospadias.[15] In the same *Bulletin of the Surgical Society of Paris*, 1874, Duplay of Paris described three-stage release of chordee and the ventral tube, which was later joined to the functional meatus.[16] These steps guided the efforts of surgeons for generations.

The years 1900 to 1950 were spent in refining the various proposals. Surgeons were choosing multiple-stage procedures stoutly defended by their various advocates. Advocated were ventral tubes (Duplay[16]), flip-flaps (Beck, 1916[17]; Mathieu, 1932[18]; and Ombredanne, 1911[11] and 1932[19]), free grafts (Nove-Josserand, 1987[20]; McIndoe, 1937[21]), scrotal burying (R.T.H. Buchnall, 1907; J. Leveuf, 1936; Cecil,[22] Ormond Culp, 1952), and urethral mobilization (Beck[23]).

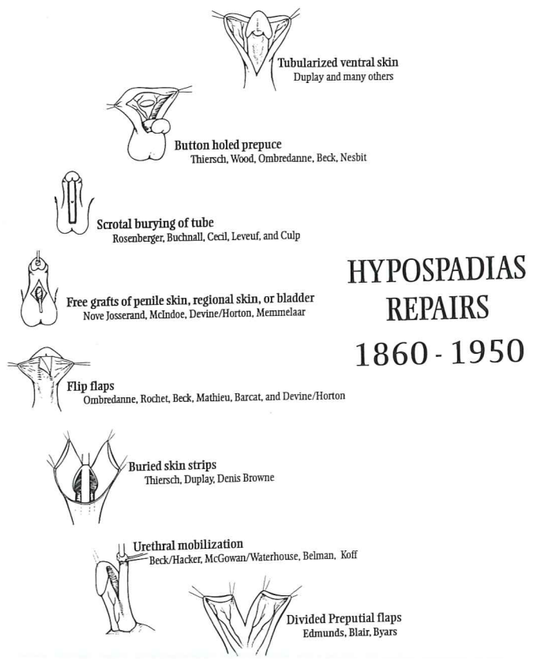


Figure 3–1
Most of the repairs of the 90 years between 1860 and 1950 are illustrated in these sketches. Thiersch initially offered apposition of a skin strip over a tube with ingeniously offset suture lines. Anger extended this to hypospadias. Duplay then tubed the strip and staged the care. Buttonholed prepuces gave a double-pedicle blood supply but left tissue bulk on the ventral aspect. As the character of the deep external pudendal vascular supply was realized, the double pedicle became a moot choice. To overcome fistula and generate a urethral tube, scrotal burying was next pursued, initially by Rosenberger then Buchnall. The scrotum functioned reasonably well, but healing problems, fistulas, and poor meatus persisted. Nearly simultaneously, free grafts were pursued, with unpredictable results. Flip-flaps became the next trend. The Ombredanne was too baggy and so was gradually trimmed and then hinged by Rochet-Beck-Mathieu-Barcat, with slight modification. The goal always was advancement to the glans tip. Stenosis and fistulas were frequently the price. Buried skin strips led to multiple fistulas and could not compete with constructed tubes. Urethral mobilization never quite lived up to its promises. Meatal retraction and suboptimal length limited applicability. Thus the scene was set by inclusion of all the learned qualities and limitations of these procedures to move on with some surety to one-stage procedures.

In the 1930s Blair and Brown[24] of St. Louis and subsequently their associate, Byars (1940s and 1950s),[25] championed the vertically split dorsal hood rotated to the ventral aspect and advanced onto a split glans for later tubularization. Browne's 1953 article in *Surgery* is a proud statement of advocacy of the buried epithelial strip.[26]

VASCULATURE

The axial nature and branching of the deep external pudendal vessels was not fully explored until this century.

Earlier, in 1889, Manchot had initiated this detailed work through dissection.[27] Salmon (1936, 1988) carried out a fine postmortem study by intraarterial lead solution and radiography.[28, 29] This defined the arteries of the skin, complementing an early work by Gras (1902) on the veins of the penis.[30] These advancements were furthered by Juskiewenski and colleagues (1982), who used angiograms.[31] Quartey (1983) developed a vascularized preputial flap for treatment of stricture disease.[32] On a pedicle, the dorsal cutis flap could be transferred to the perineum for lumen supplement or replacement.

Interprofessional communication in the early 1900s improved substantially, allowing trials (and errors) of a wide variety of cutaneous techniques. The limits of tissue mobilization, applied skin utility, and variable distribution of the blood vessels, as well as most aspects of healing, were gradually explored. Instrumentation and sutures were limited. Silk, cotton, horsehair, and erratic catgut (plain and then chromic) were used. Bolsters with beads were introduced in the 1940s and discarded when parallel fistulas developed. Also transiently, fine steel wire was used subcuticularly and intracuticularly (Nesbit[33]—see Mettauer[7]). In essence, surgical principles and tissue limits within the available technical resources were defined and used. These have changed. Swaged fine sutures (5, 6, 7, and 8) of monafilament (and braided), absorbable, and nonabsorbable synthetics, which provide predictable tissue response, are now used. Dressings were legion, and some got along without them (Van der Muelen). Urethane adhesive membranes currently dominate. Hemostasis was achieved by ligature but has become electrical (unipolar or bipolar). Tubes evolved from reeds to rubber to silicone and polyvinyl chloride. Antibiotics (systemic and topical) have helped, along with truly homeostatic irrigants.

ONE-STAGE REPAIRS

The first one-stage repair was performed "by mistake" by Russell, of Melbourne, in 1900.[34] He mobilized a skin strip like a clergyman's stole from the coronal margin and joined edge to edge for a tube that was tunneled through the glans. It failed, and a fistula formed ("an artistic blemish"). Subsequent use by others caused stenosis of the tube.

Having observed many reoperations necessitated by inadequate correction of chordee or impaired healing of the neourethra, Ormond Culp of the Mayo Clinic and advisor to the *Journal of Urology* was particularly loath to consider or foster one-stage repairs. The onus of residual or recurrent chordee forestalled other one-stage attempts until the ventures of J. D. DesPrez and colleagues[35] and Broadbent and associates[36] in 1961. They offered and promoted a dartos-based rolled tube advanced onto a split glans. In the early 1970s, Hinderer,[37] of Madrid, used a similar flap through a generous glans tunnel. (The tunnel has been abandoned.)

Meanwhile (1961), free preputial (and other donor sites) grafts were reintroduced by Devine and Horton,[38] who developed an admirable record of success. One contribution was triangularization of the glans, which furthered our confidence in glans dissection. This initially was with a glans tunnel and V and later a tripartite central V with glans wings.

The prepuce is a two-faced flap with a mobile dartos vascular support. The shaft skin, dartos, and faces, either or both, may be shifted right or left with an island attached. This follows surgical mobilization of the prepuce and shaft skin to the penile base as though a sleeve were pushed back. (This is sometimes called degloving). The dartos may act as a pedicle and be moved as a unit or separately from the covering penile skin sleeve. This is the lesson of the past 30 years.

One-stage repairs dominated in the 1970s. Nearly simultaneously in 1970 and 1971, surgeons from half a world apart (Hodgson,[39] of Milwaukee, Wisconsin, and Asopa and colleagues,[40] of Agra, India) presented a rotated inner face island as a patch or a tube with the outer face for cover. These were moved as a unit. Other buttonholed choices were also considered but have since become obsolete. The hinged lateral rotation flap has survived the test of time.

A short while later (1975), Duckett[41] and Standoli[42] developed and then presented the dissociated (separately mobilized) preputial island flap. Duckett's was an inner face flap, whereas Standoli's was lifted from the outer face. These were then rotated to the ventral aspect for tubes or patches. Some buttonholes (double pedicle) were used. Hinderer[37] contributed a dartos-based ventral tangential tubed flap and glans tunnel. This is somewhat akin to the Broadbent procedure. Perovic and Vukadinovic[43] used the Duckett flap as a tube in the middle and a patch on either end.

Thus, various tubes and patches were available to facili-

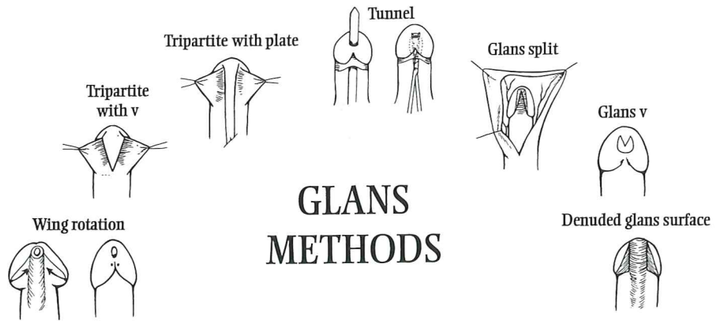


Figure 3–2
Creation of the glandular portion of the neourethra is an artistic variable. Canalization, tunneling, and coring are essentially the same, with progressively larger channels. These are a testimony to glans stenosis, which has been a challenge for 500 years. There are current advocates of this (Duckett). Glans vs (Devine) try to offset this but are not widely used. Triangularized glans (a midline urethral plate with a glans wing) is currently the choice of many (including the author). Split glans (kippered) has been used for 1000 years and continues to find a place.

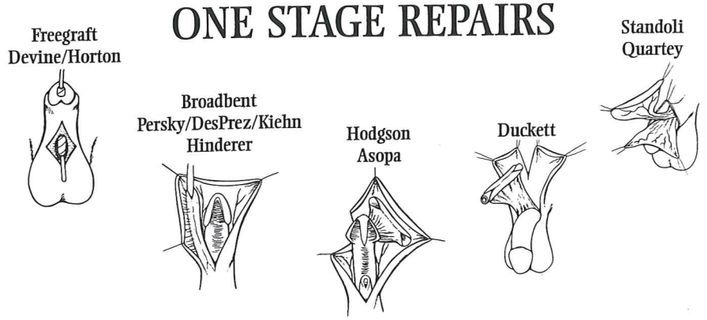


Figure 3–3
One-stage procedures are either free grafts or vascularized islands. The free grafts are preputial or buccal, and bladder or other regional sources are commonly used. The islands depend on the quality of the inferior superficial pudendal vessels, which can be bilateral or unilateral. These have variable dorsal and ventral branches. Estimation of their distribution and dominance is essential. Vascularized islands are devised anteriorly (Broadbent, Hinderer) on a dartos pedicle. Preputial islands can be rotated as a unit with overlying skin (Hodgson-Asopa) or separated from the skin (Duckett-Standoli). They are used on the ventral aspect to add lumen to a urethral plate (strip) or as a tube to bridge a deficiency. A denuded preputial dartos is occasionally used to cover a ventral neourethra (Belman). A verge island is frequently selected.

tate the next step to the top of the glans. The glans had always posed a challenge and had largely not been found amenable to tunneling.

Hinderer[44] had limited success with prolonged intubation, as had the surgeons of the Renaissance. Beck[17] chose the glans split, which was reintroduced by Humby[45] and Turner-Warwick[46] in later years (kippered glans).

Devine and Horton[38] and Mustarde[47] initiated the glans V, which led to triangularization and then to carving out the interior to produce a generous tunnel.

The evolution of glans dissection again elevated the art. It complemented the newly refound urethral plate. This had been largely ignored for 100 years. The plate had not received the attention it deserved during the attack on chordee and had been falsely accused as being too often a part of the problem. Hollowell and colleagues[48] reawakened interest in and added to the popularity of longer patches. If the plate is not an element in chordee, then its preservation will, with a vascularized patch, form part of the neourethra and facilitate a glans tip meatus.

Persky and colleagues[49] showed that the plate could remain intact and serve in the repair. It could also be mobilized if deemed necessary for dissection of fibrous bands and then replaced. Mollard and colleagues[50] soon confirmed the plate's utility and mobility. Some deny that subplate dissection is indicated. The tips of the glans wings could be swung distally to avoid meatal and fossa stricture and ensure meatal definition.

As the shape of the meatus took on importance, a urethral plate incision (hinging) granted a vertical meatus.

Snodgrass[51] chose plate hinging for the neourethra in distal repairs (recently extended more proximally). This was a modification and extension of the earlier fine suture tubes in the fossa navicularis made by Mark Zaontz and Sami Arap. Gilpin and associates[52] chose to preserve the prepuce as a societal solution.

Repair of hypospadias continues to be a singularly demanding form of surgical expression with considerable artistic latitude. The work of the past 100 years has provided the framework for these operations. One-stage repairs have allowed a new era for corrective surgery. Judicious use of the infrastructure has provided the reality of outpatient surgery with a smooth postoperative course.

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CHAPTER

4

Timing of Genital Surgery

DOUGLAS E. COPLEN
CHARLES B. MANLEY

Some time during my ninth year one of my testicles apparently decided it had enough of life down in the scrotum and began to make its way north.—by pressing a finger in the crease between my groin and my thigh, I could still, in the early weeks of its disappearance, feel the curve of its jellied roundness; but then came nights of terror, when I searched my guts in vain, searched all the way up to my rib cage—alas, the voyager had struck off for regions uncharted and unknown.

For some 6 months, until its absence was observed by the family doctor during my annual physical examination, I pondered my mystery, more than once wondering—for there was no possibility that did not enter my head, none.*—what if my penis went dry and brittle, and one day, while I was urinating, snapped off in my hand? Was I being transformed into a girl? Or worse, into a boy such as I understood (from the playground grapevine) that Robert Ripley of* Believe It or Not *would pay 'a reward' of $100,000 for: "Believe it or not, there is a nine year old boy in New Jersey who is a boy in everyway, except he can have babies."*

PHILIP ROTH: PORTNOY'S COMPLAINT. NEW YORK,
ALFRED A. KNOPF/RANDOM HOUSE.

The foregoing fictional account of an acquired undescended testicle dramatically illustrates the body image concerns that can result from even minor aberrations of the genitalia in older boys. Until a generation ago, however, elective surgery to correct congenital malformations of the genitalia was delayed as long as possible, often until a boy was approaching puberty. The deformity was readily concealed and of no immediate functional consequence, except perhaps in the need for surreptitious use of the school bathroom or locker room. For anesthetic and technical reasons, surgery at an earlier age was not considered feasible.

The hospital experience was another important consideration. A boy undergoing an orchiopexy for an undescended testis could expect to remain in the hospital for as long as a week, confined in the recumbent position with the testicle held in position by means of a rubber band taped to his thigh. For boys undergoing hypospadias repair, one could expect the discomfort of an indwelling catheter and the likelihood of two or more stages separated by 6 months. This required that the child be old enough to understand and at the very least acquiesce, if not desire, to undergo the operation.

EMOTIONAL CONSEQUENCES OF GENITAL SURGERY IN OLDER BOYS

In 1967, Cytryn and colleagues studied the behavior of boys between the ages of 3 and 14 years (mean 7 years) before and after orchiopexy.[1] A pattern that was observed included depression, passivity, anxiety, denial, poor self-concept, and confusion over body image and sexual identity. A mechanism of parental anxiety was noted and was often dealt with by denial and secrecy. The researchers concluded that boys with cryptorchidism seemed to be susceptible to emotional disturbance in far greater measure than the average population.

Berg and associates reported a well-controlled adult follow-up study of men who had hypospadias surgery during school age.[2] A psychologic difference existed between the hypospadias group and an age-matched control group who had undergone appendectomy. Despite similar social backgrounds and intellectual abilities, the men with hypospadias had less well-qualified professions and were less competitive. Interestingly, the observed differences were of a psychologic (self-esteem) rather than a physical nature, because the men with hypospadias had equally satisfactory sexual function, even with imperfect surgical results! These boys have been frequently characterized as hypospadias "cripples," the term applying to psychologic rather than physical detriments. Consideration of surgery at an earlier age, however, raised concerns about separation anxiety.

ATTACHMENT AND SEPARATION ANXIETY

Attachment is generally acknowledged to be an all-important event in the psychosocial development of children, and theorists have suggested that infants' early bonding to their parents may constitute the basis of all later social relationships.[3] Attachment occurs in all human cultures and in a wide range of animal species. In all cases, the

young actively strive to seek the *proximity* of their parents or other specific individuals, the feature that gives rise to the term *attachment*.[4] Attachment is intensified by anxiety. The crucial presence of the attachment object and not the comforting actions of a responsive adult promotes adaptive responses. Thus, the presence of even a bad mother is more important than that of a good nurse. Human infants show evidence of specific attachment at about the third quarter of the first year, but the variation is considerable, ranging from 3 to 15 months.

Separation anxiety becomes apparent in the latter part of the first year. It tends to peak at 18 months of age and then gradually diminishes. The extent of separation anxiety appears to be primarily related to the security of the infant's attachments but also seems to be a function of the child's cognitive capacity to appreciate the transience of the separation and to maintain a relationship over a period of absence. At all ages, boys are somewhat more likely than girls to show marked separation anxiety, perhaps, in part, because boys are more delayed in their development.[5]

In 1952, Robertson and Bowlby described the sequence of reactions in young children admitted to hospitals without their parents.[6] At first, the children were tearful, angry, and upset. They then became quietly miserable and apathetic, and they finally appeared detached and no longer caring about their parents. This intense emotional disturbance was vividly portrayed by James and Joyce Robertson in a film *A Two-Year-Old Goes to the Hospital*, which served to focus concern on separation anxieties in young children and had a strong influence on the subsequent improvement of care in children's hospitals.[7]

In 1975, based on the foregoing concerns about separation anxiety, an ad hoc committee of the American Academy of Pediatrics for the first time addressed the issue of timing of elective genitalia surgery. This committee advised avoidance of elective surgery between the ages of 6 months and 3 years. Scheduling before age 6 months was considered hazardous for anesthetic and technical reasons, leaving the preschool years as the optimal time. Surgery would be completed before starting school, and the emotional complications observed at a later age would be avoided. Thereafter, these recommendations became standard practice, but it soon became apparent that problems remained.

PROBLEMS IN PRESCHOOL YEARS

Initially, our surgical practice routinely scheduled operations during the preschool years of ages 3 to 5. Repeated instances of overt postoperative emotional distress that seemed inappropriate to the circumstances were observed. In 1979, a prospective study of boys between 2 and 6 years of age undergoing repair for hypospadias showed a distinctive pattern of difficult postoperative behavior characterized by anger, aggression, and negative interactions as compared with children undergoing other types of operations.[8] Blotcky and Grossman found a significant association between genitourinary surgery in children and subsequent emotional disturbances as compared with a control group having ear, nose, and throat surgery.[9] This continuing evidence that boys operated on in the preschool years suffered the same problems as in later childhood led to a review of other psychologic influences.

PSYCHOSEXUAL DEVELOPMENT AND GENDER IDENTITY

Psychoanalytic theory identifies states of psychosexual development (oral, first year; anal, second year; phallic, third to fifth years; and latency period, middle childhood) with characteristic links to subsequent personality and emotional functioning. Psychosexual development is undoubtedly a consequence of many influences including biologic factors (prenatal hormones), situational and social factors, cognitive maturation, and more subtle innate drives as well. Gender identity, or self-concept of being male or female, is well established by age 3 to 4 years,[10] with some awareness as early as 18 months.

The preschool years are a peak age for concerns about bodily integrity. The effects of illness, hospitalization, and surgical procedures in accentuating castration anxieties have been well documented in the past.[11] In our own practice, it is evident that boys have an awareness of genital normality (or lack thereof) at an early age if they have an older male sibling or playmate with whom to compare. A 5-year-old boy with congenital anorchia and a flattened, undeveloped scrotum described being embarrassed and "wanted something done" to look like his older brother. Even more striking was a 3-year-old boy with perineal hypospadias. He would not undress in front of his siblings and verbalized that he wanted to be able to stand to urinate.

ANESTHETIC AND SURGICAL FACTORS

Infants are capable of experiencing and responding to pain.[12] This response is influenced by age, prior experiences, psychosocial development, and parental responses. During the past decade, the safety and efficacy of pediatric outpatient anesthesia have been confirmed. Intraoperative and perioperative anesthetic techniques continue to improve, and the period of parent-child separation is minimized.

It is difficult to determine the exact anesthetic risk in infants because most studies are not stratified by age. A prospective review performed in France revealed a pediatric anesthetic mortality rate of 1 in 40,000.[13] Mayhew and Guiness[14] reviewed more than 30,000 anesthetics in pediatric patients and found only two instances of cardiac arrest (1 in 16,800). A study of anesthetic-related morbidity showed a lower incidence of complications when pediatric fellowship-trained anesthesiologists were involved in operations on patients younger than 1 year.[15]

A greater number of premature infants now survive and may require urologic procedures. Because apnea and bradycardia are usual responses to physical stress, these infants are at higher risk for development of respiratory complications in the perioperative period. Prospective evaluation of perianesthetic complications in preterm and term

infants younger than 60 weeks postconceptual age reveals a 50% incidence of complications (apnea, bradycardia, and so on) in both groups.[16] However, the term group had no adverse events after discharge from the postanesthesia care unit. Infants younger than 49 weeks postconception should be monitored overnight for apnea and bradycardia.

Regional anesthesia is efficacious and safe and has advantages over general anesthesia alone. Postoperative pain is controlled without depression of respiration or consciousness,[17] resulting in an earlier return to an alert state, decreased postoperative analgesic requirements, and an earlier return to the parents.

These data taken together suggest that after 6 months of life, age is not the major risk factor as long as the anesthetic is administered by appropriately trained pediatric specialists.

Surgical Factors—Hypospadias and Cryptorchidism

Because a normal penis grows only about 0.8 cm between the ages of 1 and 3 years,[18] the size of the phallus is not an important technical consideration. There can be considerable variation in phallic size, but a penis that is small at 1 year will be a small penis at age 3. The most important surgical factors are attention to detail, optical magnification, and careful hemostasis.

The postoperative experience of the infant and parents is a critical component of the repair. Regional anesthesia with either a penile or caudal block (bupivacaine) allows for smooth, pain-free emergence from a general anesthetic and usually eliminates any need for parenteral analgesics postoperatively. The hypospadias dressing should be easy to apply and remove, should provide reproducible penile compression and urinary drainage, and should allow free movement of the infant (including ambulation). It is clear that any type of catheter drainage is better tolerated while an infant is still in diapers.

Several pathophysiologic features support early repair of cryptorchidism. Spontaneous descent is unlikely after 6 months of age, and controlled trials have not shown that hormonal treatment is effective. After 1 year of age, significant developmental delay in germ cell maturation may occur in the cryptorchid testicle, as evidenced by progressive histologic abnormalities.[19] Timely intervention with surgery will likely prevent these histologic changes, but whether this will alter ultimate fertility is unknown. The complication rate for orchiopexy in young children is no greater when the procedure is performed by trained pediatric subspecialists.[20]

CONCLUSIONS

The developmental, psychosocial, anesthetic, and surgical factors just considered suggest that the window between 6 and 18 months is the optimal time for elective genital surgery in boys, assuming minimal separation from attachment figures. A deformity should be corrected before a child is old enough to perceive his genital defect and his parents' anxieties in order to prevent influences on his self-image and emotional development. During this time, children are relatively impervious to trauma. They have little or no apprehension or recollection of the operation and cry or are in distress only in response to specific disagreeable events such as dressing changes. Otherwise, they often allow the doctor or nurse to hold them, in great contrast to the fearful reactions noted in preschool boys.

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CHAPTER

5

Penile Curvature (Chordee)

LAURENCE S. BASKIN

INCIDENCE

Hypospadias occurs in approximately 1 in 300 newborn boys. It is estimated that one third of these boys will have significant penile curvature, the more severe forms of hypospadias exhibiting the greatest penile deformities.[1] Congenital penile curvature can also exist in association with a normal urethral meatus, so-called chordee without hypospadias, in which the glanular urethra is normal but the spongiopenile urethra is deficient.[2] Penile curvature may also exist in association with a completely normal urethra, estimated to occur in 0.6% of newborn boys.[3] Penile curvature associated with hypospadias typically is in the ventral direction, whereas congenital penile curvature with a normal urethra can be in either a ventral or lateral direction. This is in contrast to epispadias, in which the curvature is in the dorsal direction.[4]

ETIOLOGY

Penile curvature has historically been labeled *chordee*; however, this term implies a strand of connective tissue stretched like a cord between the meatus and glans, giving rise to bow stringing. In 1842, Mettauer identified a rudiment of the urethral corpus spongiosum as a fibrous tissue causing penile curvature.[5] Paul and Kanagasuntheram have suggested that the chordee tissue that fans out on the ventral aspect of the penis is probably the rudimentary vestige of the urethral plate.[6] We have come to realize that this strand, or chordee, which, in the past was beautifully depicted by medical illustrators, rarely causes curvature of the penis.[1, 7] In normal penile embryogenesis, the penis progresses through various stages of ventral curvature, ultimately becoming straight. Kaplan, in 1975, proposed that ventral curvature is a normal stage of embryogenesis and that penile curvature may represent an arrest of development at this earlier stage.[8] This arrest in development may also involve the corpus spongiosum, resulting in an inadequate urethra and fibrosis from excessive growth of ectodermal tissue. This failure at some stage of urethral or penile development may be attributable to androgen deficiency or insensitivity, although investigators have shown no changes in androgen-coding genes in patients with hypospadias.[9] The observations by Cendron and Melon that penile curvature with a normal spongiosum can slowly disappear during extrauterine life and that penile curvature is more common in premature infants support this theory.[10]

Congenital penile curvature may be due to abnormal formation of the skin or Buck's fascia or to corporeal disproportion, which is an abnormal differential growth of the tunica albuginea of the corpora cavernosa typically found on the ventral aspect of the penis.

The role of skin deficiency in the formation of curvature seems especially striking in the manipulation of the penis without an artificial erection. It is very easy to pull the skin downward and create considerable ventral curvature. However, with release of the skin, the penis is quite straight on artificial erection. An infrequent skin component of the ventral curvature is resolved when the ventral skin attachments are dissected free of the parameatal area.

The dartos fascia may have various degrees of fibrous development. Release of the dartos fascia fibrosis likewise straightens the apparent bend in the penis and even straightens out an obvious curvature with artificial erection before its resection.

True fibrous chordee is considered a deficiency or fibrous replacement of the normally elastic urethral plate. This tissue must be divided transversely in a broad extent to release the tethering of the distal penile shaft. This resection of the fibrous chordee must be carried proximally, elevating the urethra off the tunica albuginea along with its rudimentary spongiosum back to sound normal urethra surrounded by corpus spongiosum. This fibrous chordee is most often encountered when the penis is fixed between the bifid scrotum with the glans near the perineal meatus.

Finally, the most difficult to correct, the corpora cavernosa deficiency itself, may be present after all of the fibrous tissue is resected from the ventral aspect of the penis. The penis will still have a corporal disproportion or rotation that leads to ventral curvature.[11] Various techniques have been proposed for this release and are subsequently reviewed.

In summary, the three explanations for penile curvature are (1) abnormal development of the urethral plate, (2) abnormal condensation of the mesenchymal tissue at the urethral meatus that forms chordee tissue,[8, 12] and (3) growth differential between the normally formed dorsal corporeal tissue and the abnormal ventral urethral plate.[13]

ORTHOPLASTY IN CHILDREN

Treatment of penile curvature should result in a straight penis, thereby logically designating this surgical technique *orthoplasty*, the Greek root for "straight" being *orthos*. *Release of chordee*, however, is currently the more common term, although it implies that the bend is caused by a fibrous band, which is not always the case. The concept of chordee remains debatable, whereas penile curvature accurately describes the pathology.

Artificial erection, introduced in 1974 by Gittes and McLaughlin, has been a very significant contribution to orthoplasty.[14] A tourniquet is placed at the base of the penis, and a corpus cavernosum is injected with saline. Both corporeal bodies fill so that it is possible to determine the extent of curvature and the success after resection of the fibrous tissue. The assurance of complete correction is essential to proceed to further urethroplasty and one-stage repair. No reports have described damage to the cavernous tissue with this technique, as long as care is taken to ensure that injectable saline is used. Penile necrosis has occurred when epinephrine or distilled water was injected inadvertently into the corporeal bodies.

In true fibrous chordee, the penis is curved ventrally and the distance between the meatus and the glans is short. An incision is made in a circumferential manner around the corona and is carried well below the glans cap, just distal to the urethral meatus and down to the tunica albuginea of the corpora cavernosa. Proximal dissection is then achieved, freeing the fibrous plaque of tissue closely adherent to the tunica albuginea. Sharp scissors dissection is used, moving from side to side and proximally as the ventral curvature is released. The urethra is elevated from the corpora in this en block dissection. In most cases, the chordee tissue surrounds the urethral meatus and extends proximally along the urethra for a distance. This tissue should be freed completely down to the penoscrotal junction and often into the scrotal or perineal area. Once this urethral mobilization is accomplished, the shaft of the penis should be stripped of any fibrous tissue, extending out to the lateral aspect of the penis. Careful tangential cuts are made with the convex curve of iris scissors. Artificial erection is used to check the success of this excision.

Several further maneuvers have been offered for releasing the last bit of bend. Lateral incisions of the outer tunica albuginea in the groove between the dorsal corpora and the ventral segment of corpora in a stepwise manner may be effective. Corporal rotation as described by Koff and Eakins for epispadias may be useful in hypospadias curvature.[4] Theoretic concern about this correction for hypospadias arises from the fact that the permanent suture may impinge on the neurovascular bundle, causing pressure necrosis or subsequent erectile dysfunction. Unlike epispadias, in which the neurovascular bundle is located laterally and out of harm's way, in hypospadias, the neurovascular bundle lies in an unstrategic position directly under the plication sutures. A midline incision along the septum between the two corpora cavernosa, in some cases, has also been effective.[15]

In rare cases, the tunica albuginea on the ventral aspect is so deficient that excision of the tunica is required with replacement by an elastic graft of tunica vaginalis,[16, 17] dermal graft,[18] or lyophilized dura.[19] The tunica vaginalis patch is the one we prefer and is obtained by exposing the testis and removing a patch of tunica from around the testis.

Once the curvature has been straightened, a urethroplasty may proceed in the one-stage repair.[20] Some still prefer to resurface the ventral aspect of the penis with preputial skin to await a second-stage urethroplasty. This approach has several disadvantages, and the one-stage techniques are much preferred today.

In patients with a normal urethra, treatment depends on the direction of the deviation and whether one believes that true chordee tissue is responsible for the ventral bend.[21] Devine and Horton reported good results with resection of fibrous dartos fascia beneath and beside the mobilized normal urethra.[21] However, this rather extensive dissection does not offer consistent results.[22] We have come to realize that the urethral plate is usually healthy and is not the cause of penile curvature that was the conventional wisdom proposed many years ago by Mettauer.[5] Even in severe hypospadias, the urethral plate may not require division to produce a straight penis (Fig. 5–1). The evolution of this concept required multiple experiences of dividing the urethral plate and performing extensive ventral corporeal dissection, only to have significant penile curvature persist with artificial erection (Fig. 5–2).[1] In these cases, the penile curvature is due to corporeal disproportion and not an abnormal urethral plate. Nor do we agree that there is fibrotic tissue beneath the urethral plate that must be dissected, as Mollard and Castagnola, Perovic and Vukadinovic, and Monfort and colleagues have indicated.[23–25] Although all of these surgeons have adopted the concept of preservation of the urethral plate with an onlay urethroplasty, they advocate lifting the plate and dissecting fibrous tissue beneath. We believe that this is unnecessary and jeopardizes the blood supply to the urethral plate. In only 24% of our patients undergoing reconstruction with island flaps onlay and tubes did we find significant penile bend after releasing the skin and dartos.[1] These cases were corrected by dorsal tucks, as described later.

More accepted for the correction of penile curvature has been Nesbit's concept, described in 1965, of taking tucks or plicating the disproportionately longer tunica albuginea.[26] This technique was first described by Syng Physick, the father of American surgery, in the early 19th century, who treated chordee by shortening the dorsal tunica albuginea.[27] When the arc of maximum curvature is identified during artificial erection, wedges of tunica albuginea are excised in a stepwise fashion. These diamond wedges are closed transversely with permanent suture until the penis is straight. We have modified Nesbit's technique of dorsal tunica albuginea plication (TAP) for the correction of penile curvature in the setting of corporeal disproportion as well as hypospadias.[28]

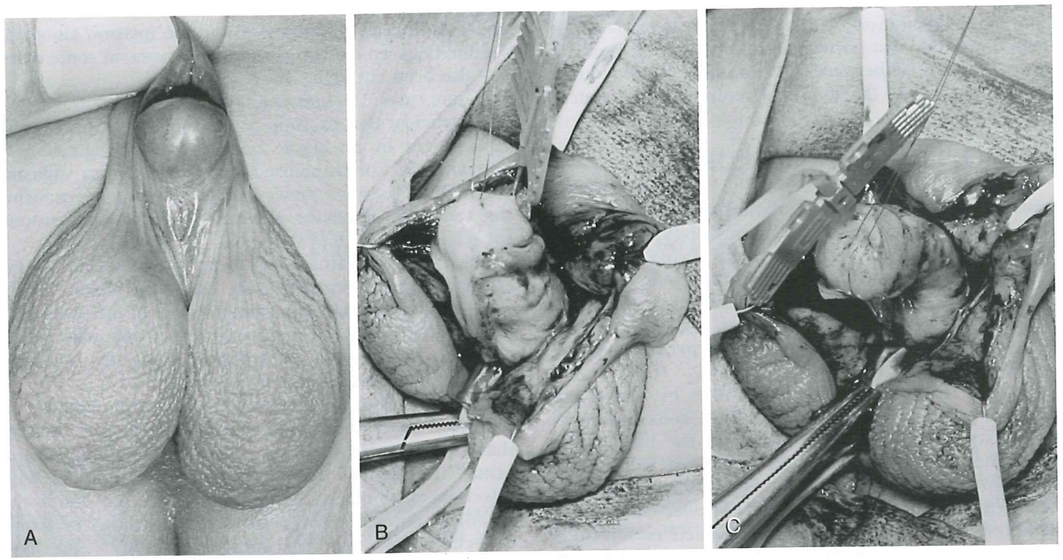


Figure 5–1
A: Penoscrotal hypospadias. *B*: Artificial erection after releasing the skin and dartos fascia with preservation of the urethral plate demonstrates penile curvature. *C*: Straight penis after dorsal tunica albuginea plication with preservation of the urethral plate. (From Baskin LS, Duckett JW, Ueoka K, et al: Changing concepts of hypospadias curvature lead to more onlay island flap procedures. J Urol 151:191, 1994.)

TUNICA ALBUGINEA PLICATION TECHNIQUE

A 5-0 Prolene traction suture is placed in the glans, and epinephrine (1:100,000 in 1% lidocaine) is injected along the proposed lines of incision to minimize bleeding. A subcoronal (5-mm) circumferential incision to facilitate dropping back of the penile shaft skin is used in most cases. In all primary hypospadias, we initially preserve the urethral plate. The plane of dissection is kept just outside of Buck's fascia in order to preserve the vascular pedicle to

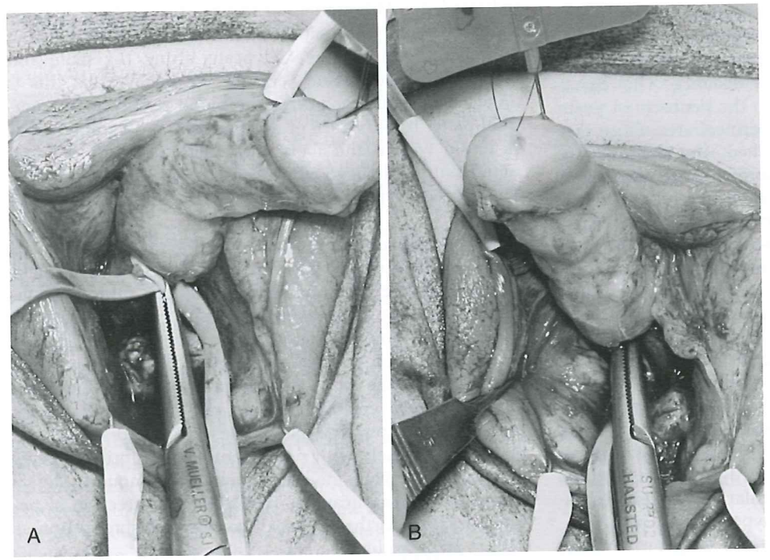


Figure 5–2
A: Penile curvature after complete surgical resection of the skin, dartos fascia, and urethral plate. *B*: Straight penis after dorsal tunica albuginea plication.

the dorsal hooded foreskin. Before urethroplasty, intraoperative artificial erection is performed by placing a tourniquet at the base of the penis and injecting the corpus cavernosum with normal saline using a 25-gauge scalp vein needle.[14] At this point, the quality of the urethral plate is assessed. If the urethral plate is adequate and the penile curvature significant after complete takedown of the skin and dartos fascia, we proceed to penile straightening. If the urethral plate and associated spongiosum are abnormal or the urethra short, then it is divided and resected back to healthy spongiosum.

To straighten the penis, we use a modification of Nesbit's dorsal plications (Fig. 5–3). To perform the dorsal TAP with the penis in the erect state, we determine the point of maximum bend dorsally. Buck's fascia is elevated on either side of the midline (10 and 2 o'clock) to avoid damage to the neurovascular bundle. Parallel incisions approximately 4 to 6 mm apart and about 8 mm long are made through the tunica albuginea. The outer edges of the incisions are approximated with permanent sutures (5-0 polypropylene in infants) in a manner that buries the knot. A straight penis is confirmed by repeat intraoperative artificial erection.

Urethral replacement is then performed with preputial island onlay or tube flaps.[1, 29] In cases of complicated hypospadias revision in which penile skin is scarce, we prefer a buccal free graft onlay or tube for urethroplasty.[30]

It is also possible to plicate the fascia without cutting the tunica by placing several rows of sutures at the site of maximum convexity. Nesbit, however, reported his long-term follow-up with this method as disappointing.[31]

The age at which chordee without hypospadias should be corrected is important. Cendron and Melin believe it should not be done too early for two reasons: The curvature may improve spontaneously with age, and there is risk of disturbing the growth of the phallus by altering the tunica of the corpora.[10] When the curvature is pronounced, we have corrected it with the TAP procedure in the first year of life.

PENILE CURVATURE WITHOUT HYPOSPADIAS

Primary curvature with a hypoplastic urethra accounts for about one third of penile congenital curvature cases.[2, 10] In this type, the urethral meatus is well situated on the glans but the foreskin is incomplete and the ventral penis is not normal (Fig. 5–4). The skin covering the urethra is very thin, and there is no spongiosal tissue for a long portion. Chordee is present with erection. Lengthening the frenulum and eliminating the penoscrotal web does not alter the curvature (Fig. 5–4*B*). Because the segment of urethra is hypoplastic, it may be considered a concealed hypospadias. Congenitally short urethra may be a variant of this condition.

Treatment for the hypoplastic urethra or short urethra variant of congenital curvature requires a chordee release with division of the midportion of the hypoplastic urethra (Fig. 5–4*A* to *C*).[22] Urethroplasty using the same techniques applicable to the usual hypospadias anomaly follows. We prefer to replace the midurethral segment with an island flap from the dorsal prepuce, making two oblique anastomoses with the remaining healthy proximal and distal urethral segments, leaving the meatus naturally on the glans.[2]

RESIDUAL CURVATURE

Before the use of the artificial erection, residual curvature was much more common. This problem is corrected by

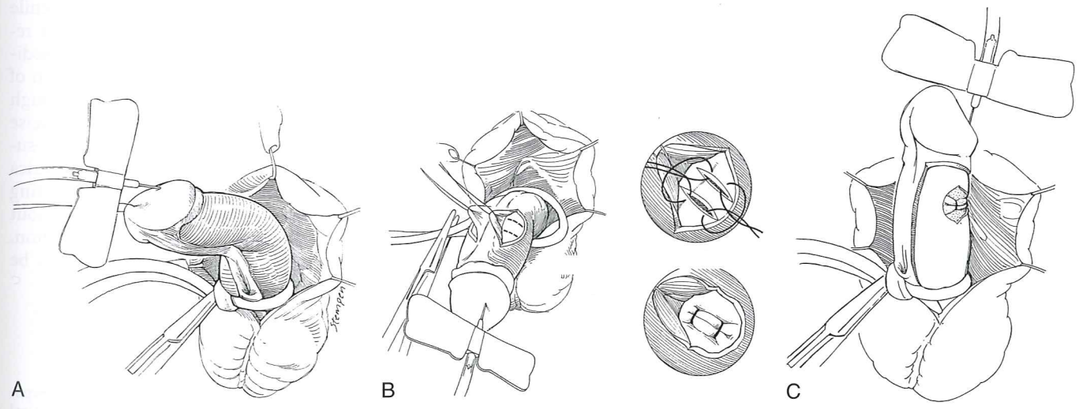


Figure 5–3
Tunica albuginea plication. *A*: Penoscrotal hypospadias with penile curvature after surgical release of the skin and dartos fascia to the penoscrotal junction. Note preservation of the urethral plate. *B*: With the penis erect, Buck's fascia is elevated at the point of maximum curvature on either side of the midline at the 10 and 2 o'clock positions to avoid damage to the neurovascular bundle. Parallel incisions 4 to 6 mm apart and about 8 mm long are made through the tunica albuginea. Outer edges of incisions are approximated with permanent sutures (5-0 polypropylene in infants) in a way that buries the knot. *C*: Straight penis is confirmed by repeat intraoperative artificial erection. (From Baskin LS, Duckett JW: Dorsal tunica albuginea plication for hypospadias curvature. J Urol 151:1668, 1994.)

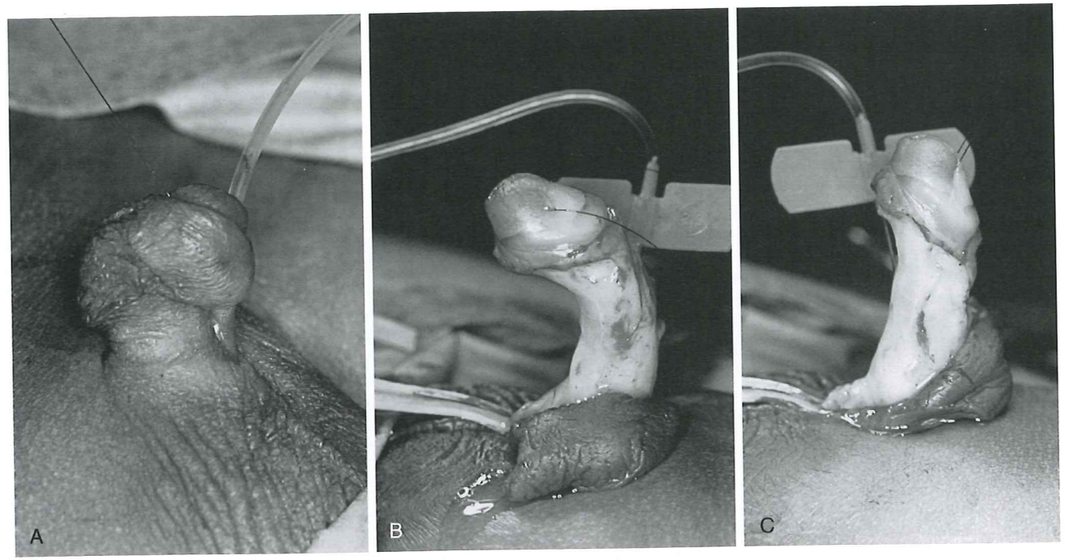


Figure 5–4
A: Chordee without hypospadias. *B*: Artificial erection shows significant curvature after complete resection of the urethral plate and fibrous tissue. *C*: Straight penis after tunica albuginea plication.

mobilizing a sleeve of urethra and overlying skin down to the penoscrotal junction. Any residual scar tissue is resected until the penis is straight during artificial erection. In some cases, extension of the urethroplasty is possible by mobilizing a skin flap on the ventral aspect, similar to a Mustarde procedure. A glans channel may be used to place the meatus at the tip of the penis. Other innovative techniques for more extensive urethroplasty may be required.[32] Slight ventral chordee can be repaired with dorsal plication with a permanent suture.[28, 33]

Rarely, extensive scarring of the ventral aspect of the penis requires excision of the tunica albuginea with replacement grafts of dermis,[21] lyophilized dura mater,[19] tunica vaginalis,[34] or venous graft.[35] If dermal grafts are to be used, care should be taken to be certain that all epidermal elements are removed; otherwise, dermal cysts can develop. Hendren and Keating demonstrated that using a dermal graft in conjunction with a free urethral graft was successful in revascularizing the graft.[36]

The long-term result of dorsal plications in children is not well documented. This procedure has been extensively used in the adult population for congenital curvature, with satisfactory results that have withstood the test of time.[37–39] In 1965, Nesbit was the first modern surgeon to describe the use of dorsal plication sutures (check-rein effect) to straighten the penis in adults.[26] In his original description, elliptic segments of the tunica albuginea were removed from the lateral aspect of each corpus cavernosum, spaced to leave 1.5-cm intervals of tunica between the defects. Nesbit initially described a similar technique of plication sutures without excision of the tunica albuginea. The early results in his patient were satisfactory, but the late results revealed recurrence of the penile curvature, subsequently corrected by excision of several elliptic fascial segments and plication.[40] We have avoided elliptic excisions in favor of plicating the incised tunica albuginea, fixing the outer edges with permanent sutures, and dunking the intervening tissue.

CONCLUSION

The final chapter on the correction of congenital penile curvature has not been written. In children, excellent results have been achieved using the TAP procedure, a modification of Nesbit's original technique for the correction of curvature both with and without hypospadias. Although controversy exists about whether it is necessary to incise the tunica albuginea as opposed to placing plication sutures alone, we believe that it is necessary for the tunica to be cut so that the raw edges can heal together, correcting the deformity. Experience with plication alone (without incising the tunica) in children has led to reoperation. The long-term outcome of this technique remains to be prospectively confirmed.

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CHAPTER

6

Chordee Without Hypospadias

JOSEPH Y. DWOSKIN

A number of researchers since Sievers first described chordee without hypospadias in 1926 have written various descriptions and expressed their ideas about treatment.[1–11] This short chapter summarizes these efforts, in light of my experience with this anomaly.

Excellent photographs from embryo-fetus autopsies were obtained by Jan Jirasek. These photos show the fusion and growth of the genitals in both males and females up to 3 months of intrauterine life. From these photos, it is clear how defects can occur at various stages of development and can persist. The embryology of chordee without hypospadias is well described by several investigators.[3, 10, 12] The frequency is variable according to the researcher,[2, 3, 6, 10, 13] but the condition occurs approximately 1/10 or less as often as hypospadias.

Chordee without hypospadias, according to Devine and Horton,[3, 4] occurs in three forms:

1. Deficient spongiosum with the urethra being a thin mucous membrane tube, the most severe form
2. Normal corpus spongiosum with abnormal Buck's fascia and dartos fascia
3. Urethra, corpus spongiosum, and Buck's fascia normal; abnormal dartos fascia causing chordee

Most cases have a hooded prepuce, much like a hypospadiac penis. In very mild cases, the frenulum causes the chordee[7] or glanular tilt.

Other researchers[6, 8, 13] have minor disagreements about the anatomy and frequency of the types, but in summary, the forms progress from glanular tilt in an uncircumcised boy to an almost folded ventral curve in others. Variable amounts of prepuce and urethral or corporal disparity can be present. Although most curves are ventral, they can also be lateral or dorsal. The meatus is on the glans but may be slightly dislocated or retracted. It is not coronal, which would be defined as hypospadias. The glans is intact in these cases.

A combined description may be clearer (Fig. 6–1):

A. Distal chordee caused by tethering of the dartos layer or frenulum

B. More severe chordee with abnormal dartos and Buck's fascia, with variable degrees of spongiosum abnormality

C. The above with significant absence of spongiosum and thin mucosal distal urethra of various lengths

D. All of the above, with severe chordee that requires a urethral substitution for correction and occasionally a tunica vaginalis or other graft to correct the tunica albuginea contraction

Surgical correction is almost always requested by the parents in medical systems that have the capacity for this surgery. The psychological sequelae for these boys is quite

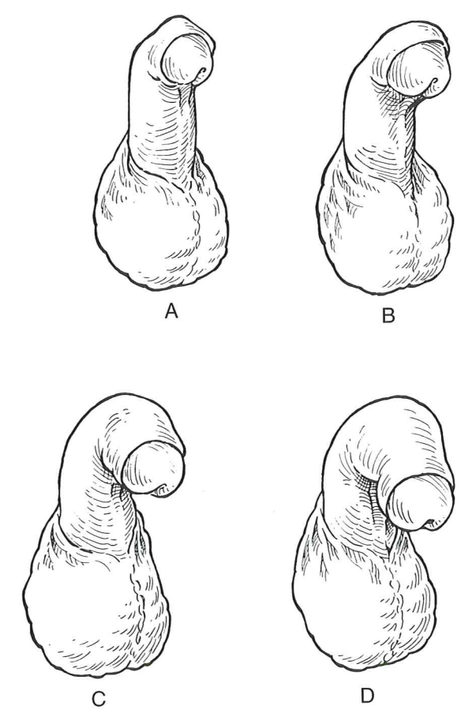


Figure 6–1

serious if the condition is not corrected. The diminished self-image caused by abnormal genitalia has a significant influence on the socialization of these males in today's society.

In school, from the earliest days, boys void in much less than private circumstances, and the comments of peers have an enormous effect. Affected individuals also have difficulty with sexual relationships because performance is often impaired by the abnormality.[14]

OPERATIVE CARE

Surgical care varies with the degree of chordee. Three basic techniques are very useful in the correction of this abnormality:

1. A small traction suture in the posterior glans, 4 to 6 inches long, held with a small hemostat, is very useful for control. Use of 5-0 or 6-0 monofilament suture results in less bleeding when removed at the end of the procedure (Fig. 6–2*A*).
2. A circumferential mucosal incision starting behind the corona of the glans is the first step in degloving the penis. Degloving is necessary to assess the degree of chordee and to free the penis from its attachments at and under the symphysis. This dissection allows freeing of the shaft, which is necessary to compensate for slight posterior shortening if sutures are placed to correct some of the chordee.
3. The Gittes-McLaughlin[15] pseudoerection technique places a tourniquet at the base with the penis stretched. A cut sterile rubber band stretched and held with a small hemostat is satisfactory. A butterfly intravenous catheter (25 gauge) is inserted into a corporeal body on one side of the shaft just above the tourniquet. This is important, because long needles inserted through the glans into the corpora tend to give a false-negative impression of the amount of distal chordee or its degree of correction (Fig. 6–2*B*).

The tourniquet should be released as soon as it is not needed and reapplied as necessary to assess progress during the procedure.

The sequence of the operation for this disorder is the usual anesthesia and prepping and draping. Then a small traction suture is placed in the glans. The penis is again assessed to try to determine which variant is present.

Intubating the urethra is often very helpful by using a piece of 8 or 10 French smooth catheter. The circumferential incision is started beneath the corona posteriorly. Bring the incision circumferentially, a little on each side at a time, undermining proximally for approximately 0.5 cm while coming around. When the sides of the urethra are reached, two small skin hooks are useful to tent the skin away from the urethra. This helps define the dissection plane between the skin and the often thinned urethra and avoids injury (Fig. 6–2*C*).

The shaft should be completely degloved, and the attachments at the base of the penis should be lysed to bring the shaft forward into the operative field. A centimeter or two of added length is usually obtained with this maneuver. Enough preputial skin is usually available to cover the ventral defect even with prior circumcision.

At this point, apply the tourniquet and use the pseudoerection procedure. Pull the penis upward to apply the rubber band at the base; then relax the tension on the traction suture. Injecting after this is done allows a clearer view of the chordee.

The anatomy of the defect is now clear, and the following can be done:

1. For a skin and dartos-type defect, the chordee is usually corrected with degloving. Skin coverage (discussed later) completes the repair for a patient with minimal chordee.

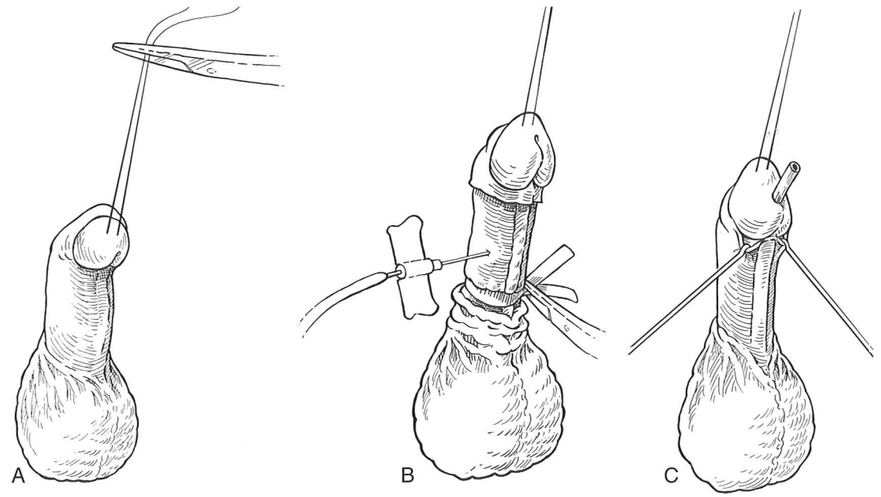


Figure 6–2

2. For patients with what appears to be a short urethra that is fairly well covered with spongiosum, several steps, in sequence, may be useful.
   a. Dissect the *peri*urethral and *para*urethral fibrous tissue, including the dense fibrous band on either side of the urethra, from a point on the straight part of the shaft up to the glans, leaving the sulcus between the corpora and the urethra clean. This may be all that is necessary, when evaluated at this time with a pseudoerection.
   b. If the penis is not straight, there are several choices. Nesbit or elliptic defects in the tunica albuginea can be made in the posterolateral aspects of the shaft opposite the greatest part of the curve. It is not usually necessary to dissect down to the corporeal tissue. These defects can be made with the needle tip cautery and closed with 4-0 absorbable sutures (Fig. 6–3*A*). Dexon, which has a longer dissolving time, is preferred. The incisions are posterolateral to stay away from the neurovascular bundle. The shortening posteriorly is compensated for by the lengthening achieved with the degloving procedure.
   c. If the penis is still not straight, after another pseudoerection, undermining the urethra and freeing the attachments under it to the corporeal bodies expose an often very dense band of fibrous tissue on top of the septum of the corpora. Removing this band down to the tunic albuginea is often helpful but may not always allow the shaft to straighten. The remaining chordee can usually be corrected at this point by making several posterolateral defects in the posterior fascia (described earlier) and reapproximating them (Fig. 6–3*B*).[16]
   d. Another problem that can remain is glanular tilt. Correction is by undermining the posterior subcoronal mucosa and placing subcutaneous sutures, picking up the edge of the glans and the fascia. Slight undermining of the glans posteriorly may be necessary, and avoiding the midline and the neurovascular bundle is extremely important (Fig. 6–3*C*). Reassessment with a pseudoerection at this point usually shows the degree of improvement.
3. The most serious form, with a paper-thin urethra that has little elasticity, can be corrected with the dissections discussed earlier and the posterolateral Nesbit plications. This causes shortening in some but works most of the time, without the need for a urethral repair, and dissection under the spongiosum-covered urethra may allow some additional untethering.
4. The most difficult anomaly requires resection of the abnormal urethra, straightening of the chordee, and placing a graft to reconstruct the urethra. It may also need a tunica albuginea or other graft to correct the chordee. These urethral graft/repair techniques are well described in other chapters of this book.

SKIN COVERAGE

After the penis is straightened, one step is important in maintaining the length gained by the degloving procedure. Most cases have a ventral skin deficiency, which is now used to advantage.

Two small skin hooks are placed in the lateral aspects of the end of the preputial skin, just as it starts to become mucosa. With traction on the hooks, the entire sleeve of penile skin is put under slight tension and lifted upward. The traction suture in the glans is gently pulled upward until it stops and then is pulled down to expose the posterior base of the shaft. Absorbable 5-0 or 6-0 sutures are placed about 0.5 cm from the base of the penis, approximating the subcutaneous tissue of the shaft skin to the tunica albuginea (Fig. 6–4). Two, one on either side of the neurovascular bundle, are usually sufficient to hold the

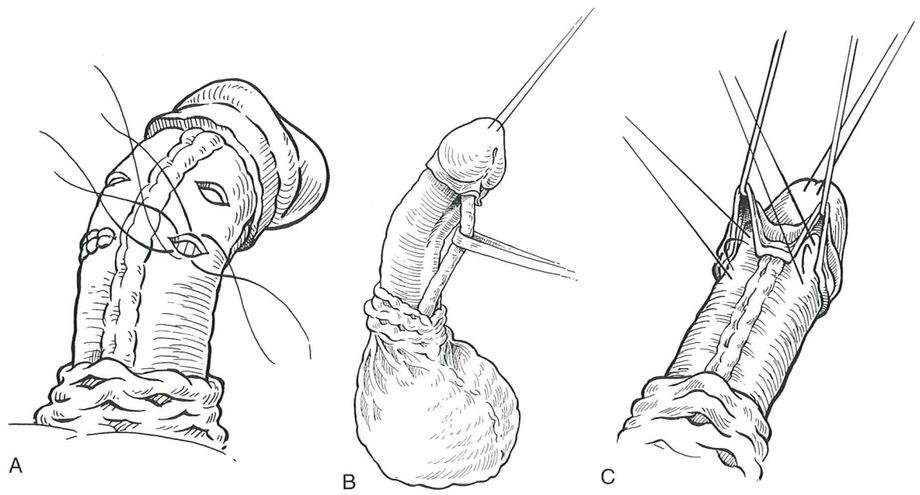


Figure 6–3

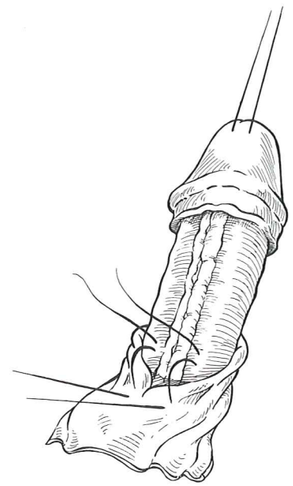


Figure 6–4

shaft forward and retain the length gained. A smooth forceps is useful to push the selected skin toward the site at which the sutures are to be placed.

Byars flaps[12] are made from the residual prepuce and used to cover the ventral defect. The excess is removed, leaving the shaft in the circumcised state. Number 5-0 or 6-0 mild chromic sutures have been found most useful for the skin.

Patients with lateral or dorsal curves face the same psychosexual difficulties if the problem is not corrected.[17] These curves are corrected by degloving the penis as described earlier and are assessed with the aid of the pseudoerection technique. Corporeal rotation can help in severe cases.[18] The Nesbit procedure works in most situations. These abnormalities, aside from being congenital, are often secondary to improper circumcisions and other traumatic causes. Skin coverage after the operation is the same as in the other repairs. The urethra is usually covered with spongiosum and accommodates the straightening of the shaft without further surgery.

To summarize, a variably, usually ventrally, curved penis without abnormality of the glans or meatus has been described, and various repairs discussed. The serious psychosexual implications of not repairing this abnormality must be emphasized. This genital defect should be repaired to allow affected boys a chance for a normal life.

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CHAPTER

7

The Subcoronal Meatus

EDMOND T. GONZALES, JR.

During the evolution of techniques for correction of hypospadias, there was a temptation to describe certain defects as minor abnormalities and others as major abnormalities. Major abnormalities might have been considered to be those anomalies that required a local or preputial flap to accomplish the repair. A meatus at the coronal margin was believed to be functionally adequate, and surgical repair was often directed only at correction of chordee, transposition of dorsal foreskin to the ventral surface of the penis, and circumcision.[1] In fact, chordee was often described as "skin chordee," and an artificial erection was not a routine part of the surgical procedure. With the description of the MAGPI procedure (meatal advancement and glansplasty) by Duckett, this concept of "easy" versus "hard" repairs seemed to be even more clearly distinguished.[2] It was common in that era to hear residents or practitioners who generally practiced adult urology comment that they only wanted to do MAGPIs but would refer all other and presumably more complex reconstructions.

In 1983, Gibbons and Gonzales wrote an article warning about the pitfalls one might encounter when evaluating and operating on the subcoronal meatus.[3] Our contention was that meatal position alone was a poor basis for assessing the appropriate surgical technique. Additional factors of importance included the degree of chordee, the development of the corpus spongiosum, the thinness of the urethra, the elasticity and thickness of the ventral shaft skin, and the depth of the glanular groove. Two patients may have hypospadias anomalies that appear similar, but one ultimately requires only a meatal advancement whereas the other requires a formal takedown of the urethra and complete neourethral reconstruction. Therefore, our conclusion at that time was that any surgeon choosing to perform hypospadias repair should be familiar and comfortable with a range of techniques that would allow for repair of any degree of abnormality.

At the time of that manuscript, our premise was to lay out the initial incision as though one was going to do a Mathieu (flip-flap) procedure.[4] This approach left the surgeon with the option to perform a meatoplasty, a meatal-based flap procedure, or a formal preputial flap, and for many years, I and perhaps others would admit that this principle served well in dealing with many hypospadias problems.

Much, though, has changed from a technical perspective since that article was published. First, I currently perform very few Mathieu procedures or any kind of meatal-based flap. For a distal defect without significant chordee and a satisfactory corpus spongiosum up to the location of the meatus, an adequate neourethra can be made by tubularization of the natural glanular groove in nearly all cases. When the groove seems shallow, there often is a deep, blind pit passing dorsal to the urethra that, when incised, provides sufficient surface area to roll a neourethra primarily. In many ways, this current approach respects the principles for repair of distal hypospadias advocated two decades ago by King.[5] In certain circumstances, when the groove is truly too shallow, application of the principle proposed by Snodgrass allows for primary tubularization, thereby obviating the need to bring in new tissue to complete the neourethral reconstruction.[6]

Second, I rarely feel the need anymore to transect the urethral plate to correct chordee when the meatus is positioned on the distal shaft. It was previously thought that transection of the urethral plate was the primary maneuver necessary to correct chordee. With the introduction and routine use of the artificial erection, however, it became clear that significant chordee was often still present after transection of the plate and that, in many situations, the chordee was due to disproportion between the length of the dorsal (longer) and ventral (shorter) surfaces of the corpora cavernosa.[7] To correct this anomaly, most surgeons who perform hypospadias corrections now do dorsal plications of the tunica albuginea to correct the chordee. This maneuver works whether the urethral plate has been transected or not.[8] In only the most severe cases of chordee, when distal plication would deform and significantly shorten the penile shaft, is it necessary to transect the plate. In these situations, correction of chordee is best performed by incision of the corpora cavernosa for 180 degrees on the ventral surface of the shaft, interposing a graft of dermis or tunica vaginalis between the separated edges.[9]

Third, since the urethral plate is now generally left in continuity, a neourethra can be reconstructed by tubularization of local tissues or by onlay patch urethroplasty, either a preputial flap or a graft in primary cases. Fashioning a tubularized neourethra has become distinctly less

common. By avoiding the circular anastomosis between the original urethra and the neourethra, the incidence of stricture associated with hypospadias surgery has been significantly reduced. Also, because a tubularized neourethra is used less often, I find myself performing a patch urethroplasty more often with a graft than with a flap. Using a graft minimizes the bulk transferred with a preputial flap, and I find that it generally achieves a better cosmetic result.

A discussion of the issues involved in evaluating and managing the subcoronal meatus embraces the full spectrum of hypospadias anomalies and challenges the surgeon to be prepared to deal with an anomaly whose correction may require only the most straightforward glansplasty or a formal preputial flap (or graft). Although careful preoperative assessment identifies the appropriate approach in most instances, even the most experienced surgeon, on occasion, finds that a different procedure than originally intended is more appropriate.

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CHAPTER

8

The M Inverted V Glansplasty: A Variation of the MAGPI Procedure

ROSS M. DECTER

The MAGPI (meatoplasty and glanuloplasty) was a uniquely innovative procedure when Duckett described it in 1981.[1] The MAGPI represented a significant advance in hypospadias surgery because it allowed the surgeon to correct glanular, coronal, and subcoronal hypospadias without the need for a formal urethroplasty. Initial results with the MAGPI assessed in the short term were excellent; however, longer-term reappraisals suggested some difficulties in the technique. The M inverted V (MIV) glansplasty was developed to address problems with the MAGPI procedure that were appreciated in delayed follow-up.[2]

Duckett reported his initial experience with more than 200 MAGPIs and noted that only one fistula had occurred. No other complications were observed.[1] The lower complication rate made the MAGPI preferable to other procedures for distal hypospadias such as the Mathieu flip-flap,[3] Mustarde,[4] or Horton-Devine flip-flap,[5] all of which required a urethroplasty. Naturally this innovative procedure with its negligible complication rate was widely adopted. In 1986, Duckett updated his MAGPI experience with more than 500 cases. Only two boys developed fistulas, and in 11 cases, approximately 2%, there was a "breakdown of the meatal advancement."[6] In the Philadelphia group's most recent review of the MAGPI procedure in 1111 patients, the investigators noted five fistulas (0.45%), seven meatal retractions (0.6%), one residual chordee, and no meatal stenosis.[7] No explanation for the discrepancy in the number of meatal retractions reported was offered, but difficulty in adequately retrieving data on such a large number of patients is understandable. The average follow-up of these patients was only 2.3 months, which the researchers believed was adequate to assess the outcome.

In order to illustrate the MIV glansplasty, our variation of the MAGPI, it is important to understand the nuances of the original procedure. The initial illustrations of the MAGPI and the description of the technique were published in 1981,[1] and both were reiterated in 1986[6] (Fig. 8–1). The basic elements of the procedure are a meatoplasty that advances the meatus and a glanuloplasty to support the advanced urethra. The described components of the meatoplasty were a "generous longitudinal incision" from inside the dorsal meatal edge to the distal end of the glans groove. This incision divided the bridge of tissue distal to the meatus that deflects the urinary stream and corrected any meatal stenosis. The diamond-shaped defect

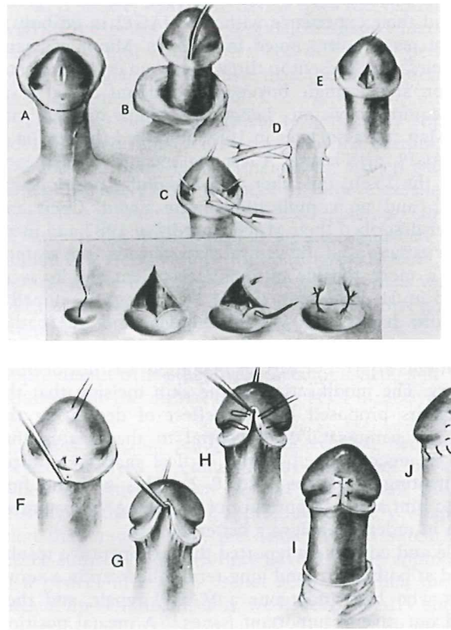


Figure 8–1
The meatoplasty of the MAGPI illustrated in *C*, *D*, *E*, and the inset under *C* advances the dorsal urethral wall. The circumcising incision in *A* is placed 6 to 8 mm from the coronal sulcus. When the tissue ventral to the meatus is pulled distally as in *F* and *G*, the closure illustrated in *H* and *I* must plicate the parameatal skin and thus no true glans-to-glans approximation is achieved. (From Duckett JW: MAGPI (meatoplasty and glanuloplasty). Urol Clin North Am 8:513, 1981.)

that resulted was closed in a Heineke-Mikulicz style of transverse closure of the vertical incision. At the completion of the meatoplasty, the dorsal meatal edge was flattened and the meatus was enlarged and advanced. The penile shaft skin was dropped down by placing a circumferential incision 8 mm from the coronal edge and proximal to the meatus, in order to prepare for the glanuloplasty. It was emphasized that the dissection required care to avoid inadvertent urethral injury. The glanuloplasty was performed by placing a stitch on the ventral meatal edge and retracting it toward the glans. This maneuver was described as bringing the lateral edges of the glans together in the midline beneath the meatus to advance and support it. The glanular skin was then approximated by two or three vertical mattress sutures, and a buried Vicryl suture was occasionally used. Skin closure was by sleeve approximation or limited Byars rotation of preputial skin. No urinary diversion was used.

Shortly after the initial presentation of the technique, other surgeons reported their initial experience. Hensle and colleagues in 1983 described 25 cases of subcoronal hypospadias without chordee treated by the MAGPI with a single fistula as the only complication at 6 months of follow-up.[8] In the same year, Gibbons and Gonzales described subtleties of the subcoronal meatus and noted that the MAGPI may not be the ideal reconstructive procedure if a boy had any of the meatal variants they described or fibrous chordee.[9] The following year, the same group published their experience with the MAGPI in 66 boys.[10] Excellent results were noted in 63 boys. Minor cosmetic deficiencies were present in three boys, two cases of meatal regression and a single boy with redundant dorsal skin. None required revision. Length of follow-up was not stated. Man and associates in 1984 described the results of their MAGPI in 15 boys.[11] A terminal meatus was achieved in 13 of the 15. In the other two, a glanular position was achieved, and no complications were noted. Ozen and Whitaker described their MAGPI results in 1987 and mentioned a variation on the ventral skin incision that seemed to give a more reliable closure.[12] Excellent results were achieved in 61 of 67 boys (91%). No patient developed a fistula, one had some residual chordee, and one had a stenotic meatus. The meatus dropped back to an extent in four patients (6%), but further operation was not deemed necessary. The modification of the skin incision that the investigators proposed had the effect of decreasing the amount of parameatal skin ventral to the meatus that had to be encompassed in the vertical mattress sutures approximating the glans (Fig. 8–2). This was the first report to hint at the importance of excluding the parameatal skin in order to achieve a better closure.

Hastie and coworkers reported the postoperative results assessed at both short- and long-term follow-up in a series of boys who had undergone a MAGPI repair, and they pointed out several important issues.[13] A meatal position at the glanular tip was documented at the 3-month follow-up visit in 40 of their 45 patients. Twenty-eight of their patients were then assessed in subsequent long-term follow-up (mean of 2.9 years) after their repair. The parents of all these boys were happy at the time of long-term review, with the exception of the parents of one boy who had required secondary surgery for a fistula. Although the

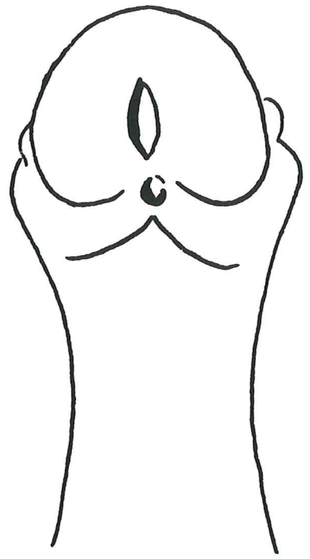


Figure 8–2
The modified skin incision of Ozen and Whitaker effectively decreases the amount of parameatal skin that is encompassed in the glansplasty. (From Ozen HA, Whitaker RH: Scope and limitations of the MAGPI hypospadias repair. Br J Urol 59:81–83, 1987.)

parents were pleased with the cosmetic result and the direction of the urinary stream, the researchers objectively noted that in 26 of 28 cases (93%), the meatus had partially regressed. They observed that the ventral support of the urethra provided by the glansplasty at the time of surgery had disappeared, causing regression of the meatus. Despite the meatal regression observed at long-term follow-up, the direction of the urinary stream was adequate. This suggested that the division of the bridge of tissue in the subglanular groove was the main reason for improved direction of urinary stream rather than the final meatal position.

Personal observation of the late postoperative results of a number of MAGPIs performed by several competent pediatric urologists leads us to conclusions similar to those reported by Hastie and coworkers. Although the parents were almost uniformly happy with their sons' surgical outcome, meatal regression seemed to be the rule rather than the exception. A procedure for distal hypospadias that could avoid a urethroplasty was a uniquely innovative idea, but there were several aspects of the MAGPI which it seemed might be altered to further improve on the long-term outcome. The meatoplasty of the MAGPI had three stated objectives: to open a stenotic meatus, flatten the glanular groove, and advance the meatus.[1] We observed that when the long glanular incision was closed in the Heineke-Mikulicz fashion, the tip of the glans tended to flatten out and look somewhat snub-nosed. Although this glanular deformation is partially corrected later by the glansplasty, it seemed aesthetically undesirable and probably unnecessary. We reasoned that opening the meatus, if

stenotic, and flattening the shelf of tissue distal to the meatus to improve the direction of urinary stream were advantageous but that a long meatal advancement of the dorsal urethral wall seemed counterproductive in terms of the glans configuration. The problem of meatal regression that we had observed and others reported as being evident only after prolonged follow-up was interesting. How could one decrease the likelihood of this phenomenon? It seemed that two aspects of the repair could be specifically addressed to lessen the probability of meatal regression. Distal fixation of the advanced ventral urethra at the final meatal position would make it less likely to retract, and excision of the skin ventral to the meatus and on the adjacent glans would facilitate a more secure glanular approximation ventral to the meatus. Both of these components should decrease the likelihood of meatal retraction. The MIV glansplasty was developed with these thoughts in mind as a modification of the original MAGPI procedure. The MIV was presented in 1990 and published in 1991.[2]

The incision for the meatoplasty of the MIV is placed in the ventral glanular groove (Fig. 8–3). The bridge of tissue

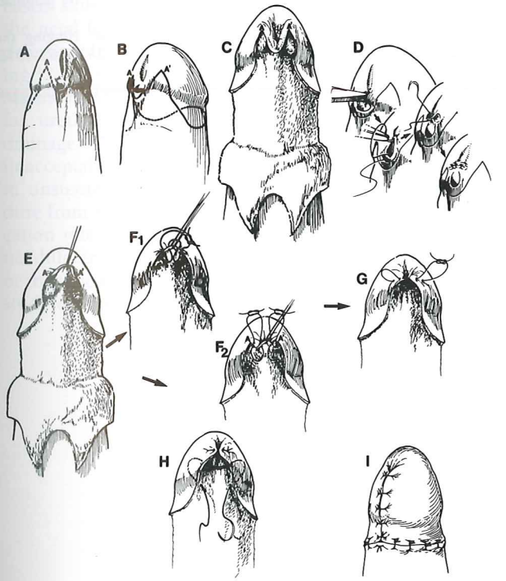


Figure 8–3
The meatoplasty of the M inverted V (MIV) seen in *D* is designed only to flatten the shelf of tissue distal to the meatus or to open a stenotic meatus. The tissue within the confines of the M-shaped incision illustrated in *A* and *B* is deepithelialized, and the shaft skin is dropped down in *C*. The tissue ventral to the meatus is pulled distally into an inverted V configuration in *E*. In F_1, a perfect inverted V is achieved and the advanced ventral urethral wall is fixed at the peaks (*A* and *A′* in F_2) of the M-shaped incision. We no longer use the MIV if the configuration in F_2 is achieved. The ventral aspect of the meatus is matured in *G*, and a deep glans-to-glans approximating stitch is placed in *H*. This supports the advanced ventral urethral wall. Final closure is shown in *I*. (From Decter RM: M inverted V glansplasty: A procedure for distal hypospadias. J Urol 146:641–643, 1991.)

distal to the meatus that deflects the urinary stream is incised, and if the meatus is stenotic, the distal lip of it is also incised. The Heineke-Mikulicz closure flattens the groove and opens the stenotic meatus, but it is not intended to advance a dorsal urethral wall. The incision of the meatoplasty is therefore shorter than in the MAGPI, and its closure does not tend to flatten the glans tip.

A key element of the MIV glansplasty is the M-shaped incision and deepithelialization of the tissue within the confines of that incision. Once the ventral parameatal skin is removed and the glans deepithelialized, one can truly achieve glans-to-glans approximation ventral to the meatus with no intervening tissue to compromise that approximation. This idea of removing some of the ventral parameatal skin was obliquely alluded to by Ozen and Whitaker, who described their modified incision for the MAGPI, which they used to give a "more reliable closure."[12] Duckett and Snyder recognized the importance of this concept in their 1991 update on the MAGPI. In their modified description of the MAGPI, they state, "skin adjacent to the glanular edges must be excised . . . to approximate the glandular wings."[7] After the M-shaped incision is deepithelialized, a stitch is placed on the ventral lip of the meatus and it is pulled toward the distal end of the penis. This reconfigures the M-shaped incision into an inverted V—thus, the name M inverted V and the acronym MIV. Distal fixation of the ventral wall of the urethra is then accomplished with a 7-0 Vicryl suture, which effectively fixes the ventral urethral wall to the peaks of the original M-shaped incision. The ventral urethral wall is advanced during the performance of the MIV glansplasty rather than the dorsal urethral wall, as is advocated in the MAGPI.

The glans closure is critical to adequately support the advanced and fixed ventral aspect of the urethra. Because the glanular tissue is deepithelialized, a deep glanular suture of 6-0 Vicryl can be placed to achieve excellent glans-to-glans approximation. Superficial glanular closure and closure of the mucosal collar are accomplished by interrupted 7-0 Vicryl sutures. In the original MAGPI, the skin ventral to the meatus and on the ventral glans was simply plicated in the closure. In the short term, that glansplasty supported the urethra, but in longer-term follow-up, we believe these tissues relaxed because precise glans-to-glans approximation had not been accomplished, and this accounted for the meatal regression seen in delayed follow-up.

In our original report, we noted that occasionally a perfect inverted V configuration could not be achieved when the stitch on the ventral meatal wall was pulled distally. At that time, we approximated the W-shaped incision that resulted with the distal fixation stitch and two other sutures. We no longer advocate this approach, and if a perfect inverted V is not achieved when the ventral meatal lip is pulled distally, we believe the MIV should not be performed. In these instances, we currently approximate the inside arms of the original M-shaped incision in a Thiersch-Duplay or GAP[14]-style urethroplasty. If the ventral glanular groove is shallow, we deepen it, using a modification of Rich and colleagues' hinging of the urethral plate[15] described by Snodgrass[16] to create a neourethra of adequate caliber. The urethroplasty is covered with a pedicle of subcutaneous tissue, and the glans is closed over

the repair. We emphasized in our description of the MIV technique that the parameatal skin must have adequate compliance to allow a reconfiguring of the M-shaped incision into an inverted V. We have become even more restrictive in our application of the MIV, as noted earlier, and now believe the MIV is best suited to defects in which the meatal position is located on the glans or corona. In general, applying the MIV to a subcoronal meatus is probably stretching its reliable application, and we do not believe the MIV will correct even the occasional meatus 1 to 2 cm proximal to the corona, for which the MAGPI has been recommended.[1]

Hypospadias surgery is an evolving art. The MAGPI represented a significant advance in distal hypospadias surgery in the early 1980s. We developed the MIV glansplasty in the late 1980s to improve on shortcomings of the MAGPI recognized over time. Our application of the MIV glansplasty in the mid 1990s has become even more restrictive than we originally proposed. We currently use the MIV in cases of glanular hypospadias when the meatal configuration allows us to be virtually assured of an ideal result. Subcoronal hypospadias defects are currently corrected by techniques using a urethroplasty. This further evolution in the approach to distal hypospadias has occurred as we recognize that formal distal urethroplasty is no longer as daunting as it was in the late 1970s and 1980s. Current suture materials and optical magnification facilitate the performance of these repairs with negligible complication rates and excellent cosmetic results.

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CHAPTER

9

Meatal-Based Flap Mathieu Procedure

RONALD RABINOWITZ
WILLIAM C. HULBERT, JR.

In 1928, Mathieu described a surgical technique to repair distal penile or anterior hypospadias in a single operation. This was reported in more detail in 1932, with emphasis on preservation of the blood supply of a ventral meatal-based skin flap.[1] Subsequent publications have reported the need for catheter drainage, stent drainage, or urinary diversion for 2 to 10 days to allow for satisfactory healing.[2–4] In 1987, Rabinowitz described a modification of the Mathieu repair using a continuous subcuticular suture for urethroplasty and no catheter, stent, or suprapubic drainage.[5] In 1994, Busson and associates reported an unacceptably high complication rate (approximately 20%) in unstented Mathieu repairs.[6] An analysis of this procedure from four centers confirms an extremely low complication rate (approximately 3%) with this procedure, with no difference between the stented and unstented repairs or the type of adjunctive analgesia.[7] This large retrospective study of more than 300 consecutive boys undergoing this modified Mathieu repair also found no statistical difference between a one-layer and a two-layer urethroplasty, although a two-layer repair has been reported to produce a superior anastomosis.[8]

Virtually all of these repairs are performed on an outpatient basis in the ambulatory surgery center. Patients are given no solids after midnight but are encouraged to drink clear liquids until 3 hours before the surgery. After the induction of general anesthesia, penile nerve block is placed with 0.5% bupivacaine without epinephrine for preemptive analgesia. A traction suture of 4-0 Prolene is passed through the dorsal aspect of the glans, and a ventral meatal-based skin flap is outlined (Fig. 9–1). After skin incision, in which the urethra is protected with a small indwelling feeding tube, the penile shaft is degloved using blunt and sharp dissection and ophthalmic cautery (Fig. 9–2). Tissue causing chordee is excised, and any residual chordee or ventral glans tilt is corrected with dorsal teth-

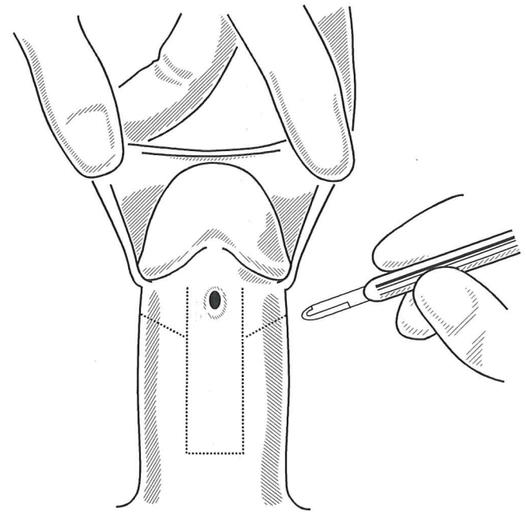


Figure 9–1
Ventral meatal-based skin flap is ready for incision using number 64 Beaver knife blade.

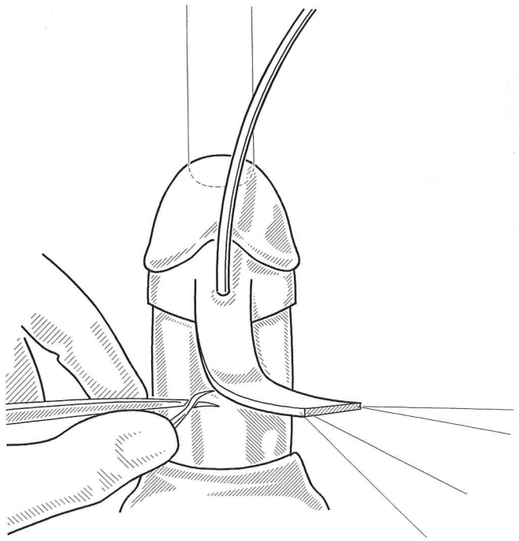


Figure 9–2
Meatal-based skin flap is elevated from the ventral surface of shaft. Any ventral chordee tissue is excised. Stay suture passes through the dorsal glans.

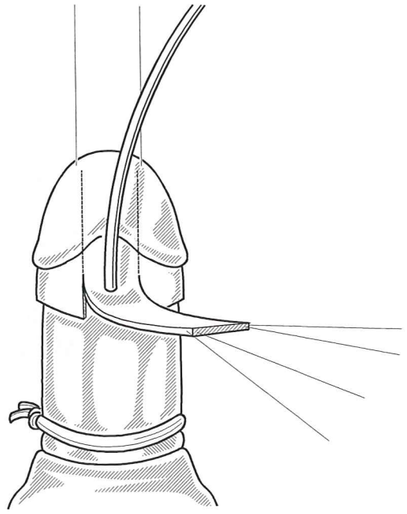


Figure 9–3
With a tourniquet at the base of the penis, parallel balanic incisions are made.

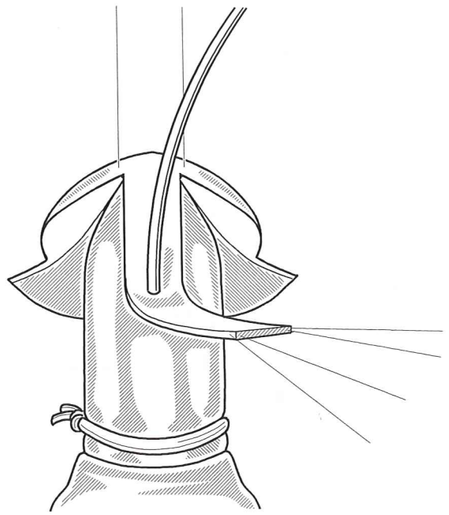


Figure 9–4
Lateral glans flaps are elevated.

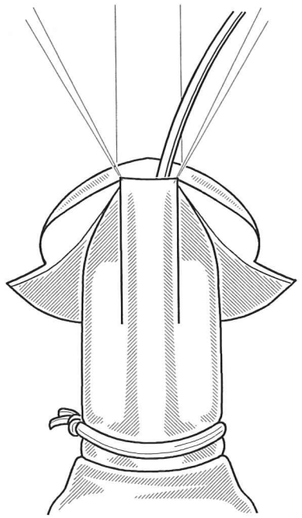


Figure 9–5
The meatal-based flap is flipped distally, and stay sutures of 6-0 Vicryl or 6-0 PDS attach the distal end of the balanic incisions to the distal tips of the meatal-based skin flap.

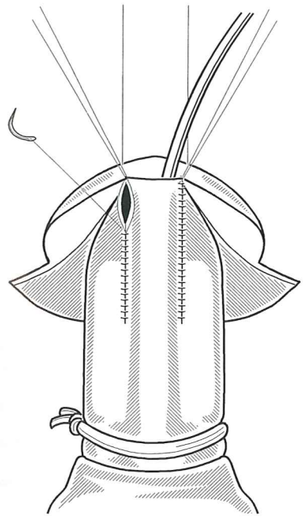


Figure 9–6
Urethroplasty is performed with continuous subcuticular 6-0 or 7-0 Vicryl or PDS, approximating the lateral edge of the meatal-based skin flap to the lateral edges of the urethral plate.

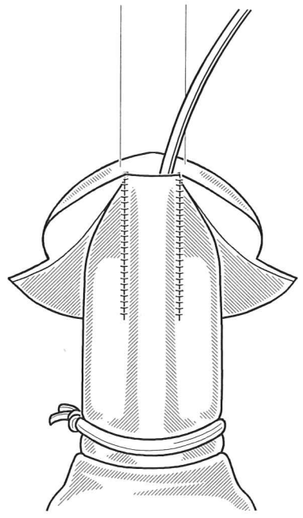


Figure 9–7
Urethroplasty completed.

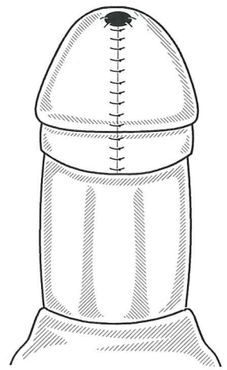


Figure 9–8
Lateral glans flaps reapproximated in midline with interrupted sutures of 6-0 or 7-0 Vicryl or PDS to give a rounded glans with a midglanular meatus.

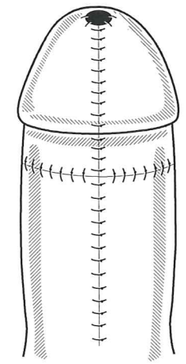


Figure 9–9
Redundant dorsal hood divided in midline and rotated ventrally and trimmed appropriately for skin coverage.

ering sutures of 5-0 Ethibond. A tourniquet is then placed at the base of the penis with an 8 French red rubber catheter,[9] and parallel balanic incisions are made (Fig. 9–3). Lateral glans flaps are elevated (Fig. 9–4), and the meatal-based flap is flipped distally (Fig. 9–5). Urethroplasty is carried out on each side by suturing the lateral aspect of the meatal-based skin flap to the lateral edge of the urethral plate with continuous subcuticular suture (Fig. 9–6).

Depending on the abundance of subcutaneous tissue, a second layer can be added. Once the urethroplasty has been completed on both sides (Fig. 9–7), the glans flaps are reapproximated in the midline over the neourethra to form a rounded glans with a midglanular meatus (Fig. 9–8). The distal lip of the neourethra is attached to the lateral glans flaps with two interrupted sutures on each side. The redundant dorsal skin is divided in the midline, and flaps are rotated ventrally and trimmed appropriately for skin coverage (Fig. 9–9). An additional penile nerve block is placed with bupivacaine for postoperative analgesia. The bladder is emptied using a small feeding tube, the feeding tube is removed, and a small amount of 2% Xylocaine jelly is instilled into the urethra for additional postoperative analgesia. A Tegaderm dressing is placed,[10] and the stay suture is removed. The boys are discharged from the ambulatory surgery center approximately 2 hours later.

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CHAPTER

10

The Glans Approximation and Modified Thiersch-Duplay Repairs

A. THE GLANS APPROXIMATION PROCEDURE

MARK R. ZAONTZ

HISTORY

In the mid 1980s, in preparing to perform a Thiersch-Duplay (Firlit) urethroplasty on a child presenting with coronal hypospadias and a deeply grooved glans, it became evident that by merely approximating the glans between my fingers, a normal cosmetic appearance resulted. Hence the thought occurred that this form of hypospadias might be more simply handled by deepithelialization of the glans skin just lateral and proximal to the glanular urethral plate and hypospadiac meatus, respectively, to essentially finish what nature had already started. The avoidance of significant glanular wing mobilization and the ability to achieve an adequate urethral lumen without significantly increasing tissue bulk during glans closure made it ideal to go ahead with what became the glans approximation procedure (GAP). As with all new procedures, the technique underwent some minor modifications along the way. Initially, suture closure of the neourethra involved a single running subcuticular 7-0 polyglycolic acid suture, followed by an interrupted imbricating second layer with the same suture. Today, a double running layer is used to create a more watertight closure, because this repair does not incorporate any urinary diversion.

GLANS APPROXIMATION PROCEDURE

The GAP[1, 2] is a highly selective repair designed for glanular or coronal hypospadias. Patients with deep/wide glanular grooves and an associated fish-mouth or noncompliant meatus are ideal candidates. This technique is essentially a modification of the Thiersch-Duplay principle (see later in this chapter, Part B) without the need for fashioning large glanular flaps. Hence, the procedure is based on minimal mobilization of the glans wings and essentially deepithelialization of that portion of the glans to be brought together. I prefer to perform all hypospadias repairs using a microscope at 6 to 10× power magnification. Bupivacaine is administered via either dorsal penile or caudal analgesia block at the beginning of the procedure. With the operative field set up, a stay suture of 4-0 polypropylene is placed through the distal glans and held on mild cephalad traction. A rubber band tourniquet is placed at the base of the penis and released every 20 to 30 minutes to allow some circulation to the penis. No electrocautery is used in order to avoid peripheral tissue necrosis, which could potentially impede healing. Also, ice cold saline-filled syringes with plastic angiocatheters are used liberally to keep the tissues moist and to minimize edema. A bioocclusive dressing is simply applied at the end of the procedure to prevent bleeding.

Before beginning the actual GAP, attention is turned to the glans groove, inspecting for any transverse cleft (Fig. 10–1). If seen, the cleft must be incised longitudinally and the resulting defect closed transversely with 7-0 or 8-0 polyglycolic acid suture in order to smooth out the posterior urethral plate (see Fig. 10–9, later in this chapter). This avoids potential problems with urinary stream deflection. Care must be taken to avoid overzealous advancement of the posterior urethral plate, or else one risks possible flattening or ventral tilt of the glans. The urethra is calibrated, and calipers are used to measure the depth and width of the glanular groove. Next, the information gleaned from these measurements is incorporated, and a marking pen outlines the lateral glanular wings on each side of the glans groove, making sure the overall distance marked allows the equivalent of a size 10 or 12 French neourethra. The marked outline is U shaped and skirts below the hypospadiac meatus (Fig. 10–2). Tenotomy scissors incise the indelible ink mark on a bias to leave more skin for the neourethral closure (Fig. 10–3*A*). This maneuver leaves a U-shaped deepithelialized rim of glans (Fig.



Figure 10–1
Appearance of typical candidate for GAP. Note the wide, deep glanular groove with a coronal meatus.

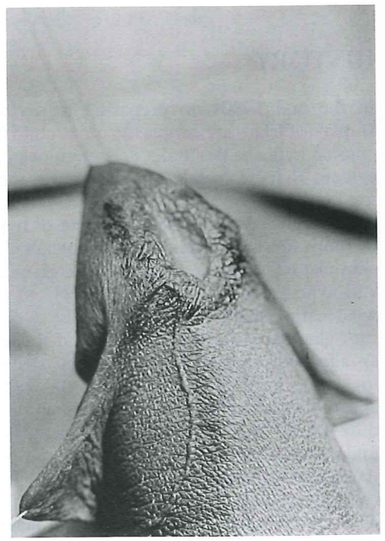


Figure 10–2
Indelible ink marks the area to be incised. Note that the marking line extends lateral to the urethral groove to ensure adequate lumen size on closure.

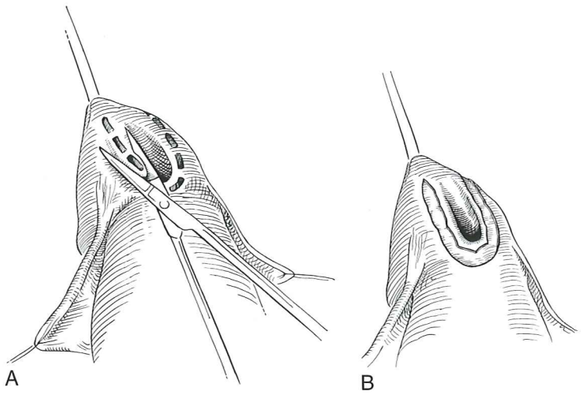


Figure 10–3
A: The incision to deepithelialize the glans. *B*: Appearance of the glans after a U-shaped incision is made.

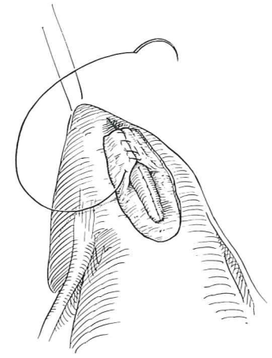


Figure 10–4
Double running layer subcuticular closure of the neourethra.

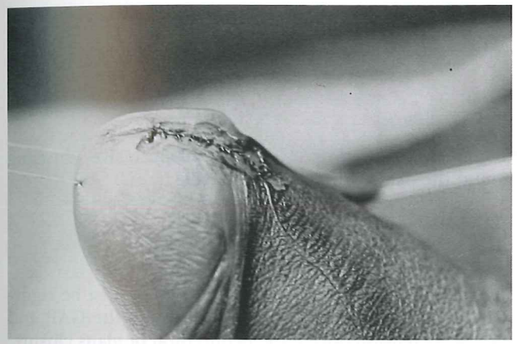


Figure 10–5
The third layer of closure.

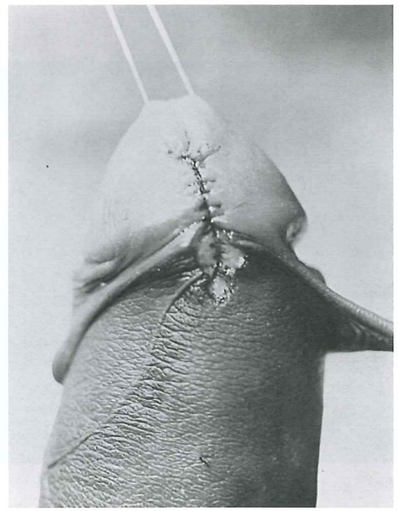


Figure 10–6
The glans is approximated with a slitlike meatus in an appropriate distal location.

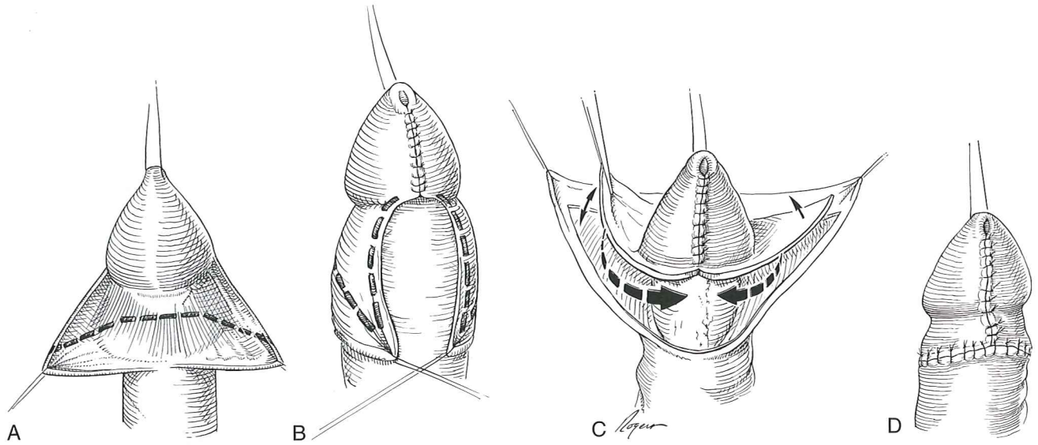


Figure 10–7
A mucosal collar is created. *A*: Inner shiny prepuce is marked in chevron fashion dorsally for future incision. *B*: Frontal view demonstrates continuation of the marking line from the dorsum as well as ventral extension toward the glans. *C*: Elevation of incised flaps and direction of tissue transfer (large marked arrows). *D*: Mucosal collar complete.

10–3*B*). The neourethra is created by using 7-0 polyglycolic acid suture in double running subcuticular fashion (Fig. 10–4). A third interrupted layer of 7-0 polyglycolic acid suture is used to approximate the subcutaneous tissue just beneath the skin (Fig. 10–5). As a direct result of having a deeply grooved glans, no compromise of the urethral lumen size results from the subsequent closure of the glans. Therefore, no attempt is made to significantly mobilize the glanular wings or to excise glanular spongiosum tissue before glans closure. The glans is reapproximated with interrupted 7-0 or 6-0 polyglycolic acid suture (Fig. 10–6). At this point, the urethra is gently calibrated to ensure an adequate size (10 to 12 French). The mucosal collar[3] is then created (Fig. 10–7*A* to *D*), followed by skin closure, which provides an excellent cosmetic and functional result (Fig. 10–8). A bioocclusive dressing around the penis completes the repair.

POINTS TO REMEMBER

This technique uses very strict criteria that must be rigorously adhered to. Should one proceed with the GAP and find excess tension during the neourethral or glans closure, then one should not hesitate to convert to a Thiersch-Duplay type of repair (see later in this chapter, Part B) by deepening the glanular wing incisions to allow better mobilization and less tension. Additionally, divots of glanular spongiosum tissue may be excised for a tension-free closure.

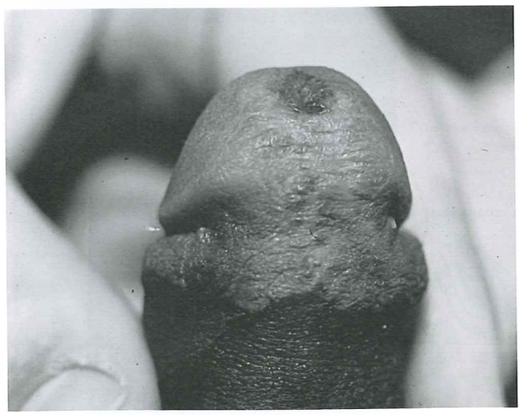


Figure 10–8
Appearance 4 months after surgery.

CONCLUSION

The GAP represents an alternative hypospadias repair for the proximal glanular/coronal meatus. As with other techniques for this degree of hypospadias, each has advantages and disadvantages, which depend on such factors as parameatal compliance, the appearance of the meatus, the configuration of the glans, the depth/width of the glans groove, and the available tissue to do the work. Understanding these factors ultimately leads to the excellent results we now enjoy.

Acknowledgments

I would like to thank Paul Rogers for his outstanding illustration work and Kelley Mylan for her invaluable help in the preparation of this manuscript.

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B. THIERSCH-DUPLAY PROCEDURE

MARK R. ZAONTZ

HISTORICAL PERSPECTIVE

In the modern era of hypospadiology, the Thiersch-Duplay hypospadias repair has endured the test of time, albeit with modifications that have significantly enhanced this technique. Historically, Thiersch[1] and later Duplay[2] in the late 1800s developed the concept of a U-shaped incision for epispadias and hypospadias repair in which they tubularized a neourethra made of vascularized skin from the penile shaft. In this era and continuing well into the second half of the 20th century, the standard of care was to bring the neomeatus up to the level of the coronal sulcus. King[3] extended the Thiersch-Duplay principle in 1970 by incorporating the Spence-Allen technique[4] and covered the repair with preputial skin. Using King's modification as a template, the natural progression was to actually extend these incisions into the distal glans and tubularize them. Closure of the glans itself over this repair created a more cosmetically appealing phallus. Although this latter development has been credited to no specific pediatric urologist, I refer to this today as the Firlit procedure,[5] for my mentor and former associate, who taught me this technique in 1984. At that time we changed from optical 2.5× to microscopic magnification. Surgical technique has likewise been modified since those early days. Changes have also occurred in our choice of suture material, stents, and dressings.

TECHNIQUE

The Thiersch-Duplay (Firlit) procedure is applicable for cases of hypospadias associated with a glanular groove in the presence of a relatively flattened glans with minimal or no chordee. The development of the hinge procedure[6] and subsequently the Snodgrass technique[7] has greatly broadened the applicability of the Thiersch-Duplay principle.

To begin, a stay suture of 4-0 polypropylene is placed through the distal glans and retracted cephalad. Likewise, stay sutures are placed on the dorsal hooded foreskin wings and pulled caudad. The microscope is adjusted to the appropriate setting (usually 10× magnification). A rubber band tourniquet with an interposed dental roll is placed at the penile base and released approximately every 20 to 30 minutes to allow some circulation to the penis. Iced sterile saline is used liberally for irrigation to minimize edema, to keep the tissue moist, and to keep the operative field clear. Electrocautery is not used, to avoid peripheral tissue necrosis, which may impede healing. The urethra is calibrated with bougies, and if a stenotic meatus is encountered, a ventral meatotomy is performed, with lateralizing running sutures of 7-0 polyglycolic acid suture securing the raw mucosal edges to their ipsilateral skin side. It is important to start off with an adequate urethral channel of at least 10 French. Additionally, if a transverse cleft of tissue is found between the glans groove and hypospadiac meatus, it is incised and closed with 7-0 or 8-0 polyglycolic acid suture in Heineke-Mikulicz fashion (Fig. 10–9). Once these steps have been completed, the actual reconstruction may commence.

A U-shaped line marked with indelible ink is made with the aid of calipers to measure a width on the glans/shaft equal to at least an ultimate urethral luminal size of 10 to

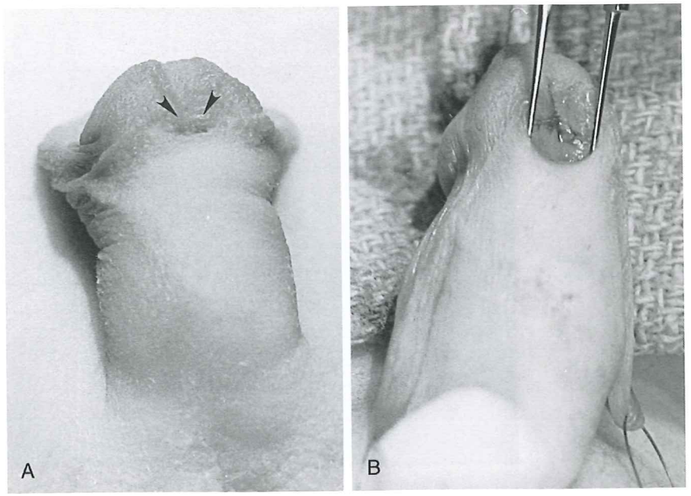


Figure 10–9
A: Subcoronal hypospadias in a 6-month-old boy. Note the subtle cleft between the meatus and the glans groove (arrows). *B*: Flattened appearance of urethral plate after a Heineke-Mikulicz procedure.

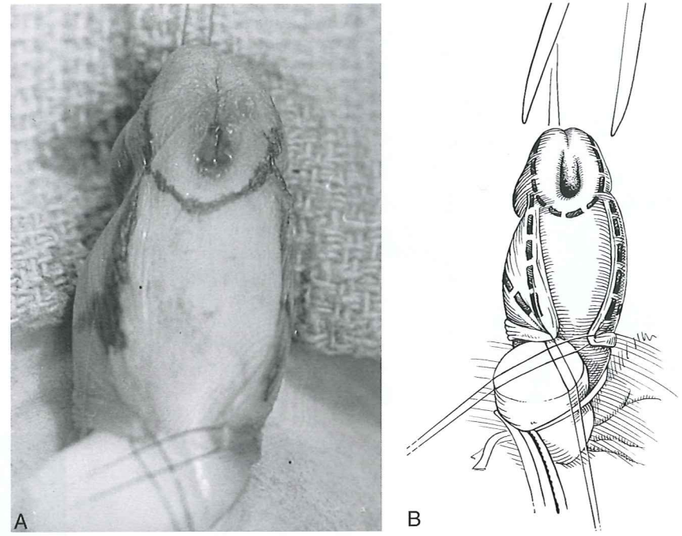


Figure 10–10
A: Indelible ink marks areas of the penis to be incised. *B*: Illustration highlighting marking lines and calipers used to measure glanular incisions.

12 French. The marking line is continued down the lateral edges of the inner shiny dorsal prepuce and extended dorsally in chevron fashion to outline what will ultimately be the mucosal collar (Fig. 10–10). All marked lines are then incised, first starting with the glanular incisions. Care must be taken to try to achieve a clean single cut deep into the glans to allow for adequate lateral mobilization of the glans wings (Fig. 10–11). Using a Silastic stent as a temporary mold, the neourethra is closed (using 7-0 polyglycolic acid suture in a no-touch technique) starting from the proximal hypospadiac meatus and working distally in a continuous subcuticular fashion (Fig. 10–12*A*). Once the desired level for the neomeatus is reached, the same suture is reversed in a continuous Lembert-style second layer back proximally to the starting point and tied (Fig. 10–12*B*).

The neourethra is now complete, and attention turns toward tissue coverage. Using the technique of Belman[8, 9] as modified from Smith,[10] a deepithelialized subcutaneous pedicle flap is then created. Ideally, when dorsal prepuce is present, this flap is created by first incising the prepuce at 6 o'clock proximally until the proximal limit of the mucosal collar is reached (Fig. 10–13*A*). A stay suture of 5-0 chromic catgut secures the shaft skin at 6 o'clock to the mucosal collar. The Byars flaps are then swung ventrally. One flap is chosen and draped over the glans, marking the skin transversely where it crosses the proximal limit of the mucosal collar (Fig. 10–13*B*). This marked line is incised just down to the subcutaneous tissue, which is then carefully but sharply separated off of the overlying skin (Fig. 10–13*C*). The final result is a well-vascularized pedicle that drapes over the entire neourethra. The lateral

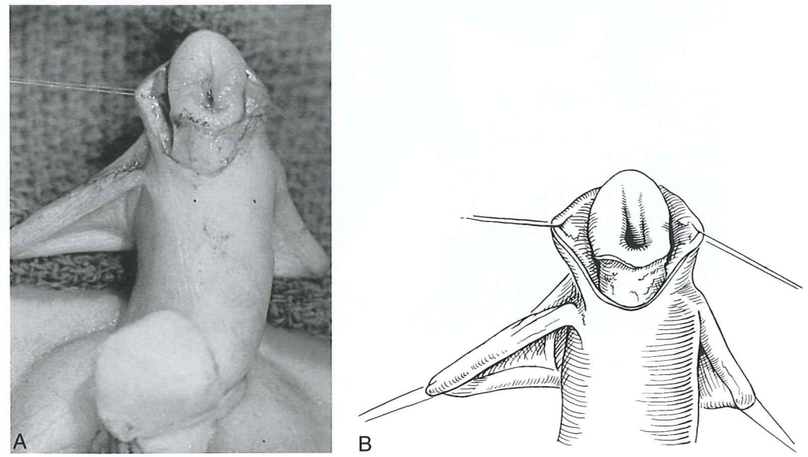
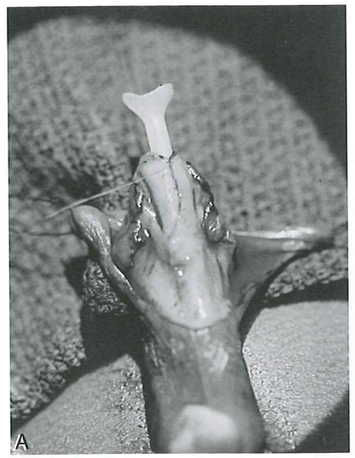


Figure 10–11
A: Appearance after deep glanular incisions. *B*: Illustration depicting depth of incision and glanular wing mobilization.



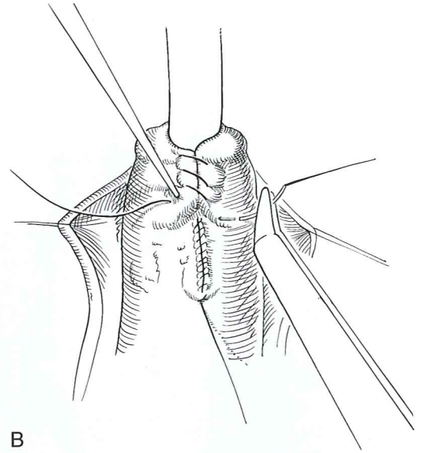
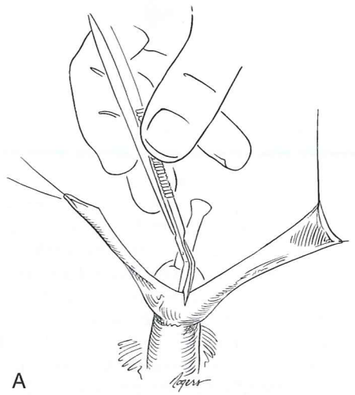
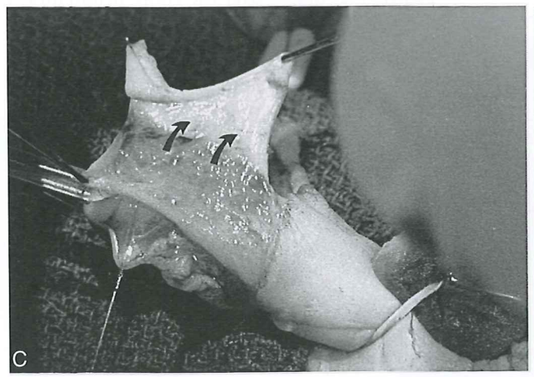


Figure 10–12
A: Initial first layer suture line completed. *B*: Illustration of second Lembert-type suture line.







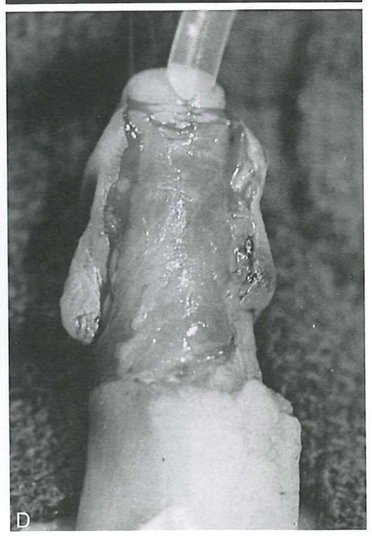


Figure 10–13
A: Illustration demonstrating the development of Byars flap. *B*: Transverse marked line representing incision site to begin subcutaneous pedicle flap. *C*: Skin being dissected off sharply from underlying tissue. *D*: Subcutaneous vascularized pedicle secured in place. Note the distal midline sutures, which the pedicle will completely cover.

edges of this flap are secured in running fashion along its entire length using 7-0 polyglycolic acid suture (Fig. 10–13*D*). When completed, the neourethral midline closure is covered completely by a well-vascularized pedicle with lateralized sutures. Should no prepuce be available, Hill and colleagues'[11] modification of the deepithelialized pedicle flap using the principle of Mathieu[12] is used (Fig. 10–14). The opposite Byars flap remaining is then excised or, if necessary, used for ventral skin coverage.

The glans and mucosal collar are closed in two layers, again using 7-0 polyglycolic acid suture (Fig. 10–15*A*). Meatoplasty completes the glans closure. The circumcision defect is closed with interrupted 5-0 chromic catgut suture (Fig. 10–15*B*). In children who are not yet toilet trained, the stent is removed and the urethra calibrated gently to ensure adequate lumen size. In toilet-trained children, a 6 to 8 French Zaontz urethral stent (Cook Urological, Inc., Spencer, IN) is used and the parents dress the child in diapers or Pull-Ups for the 3 or 4 days during which the stent remains. A bioocclusive transparent dressing is used for penile compression (Fig. 10–16) and removed on postoperative day 3. Antibiotic ointment is applied to the meatus daily for 10 days. All procedures are performed as outpatient surgery. Analgesia is supplied by either the caudal route using 0.25% bupivacaine or via deep dorsal penile nerve block using plain 0.25% or 0.5% bupivacaine at the outset of the procedure. Antibiotics are provided both perioperatively and for a number of days postoperatively, depending on whether a stent is used. Anticholinergic medication is provided as needed for those children requiring stents.

Experience has shown that patients who are unstented

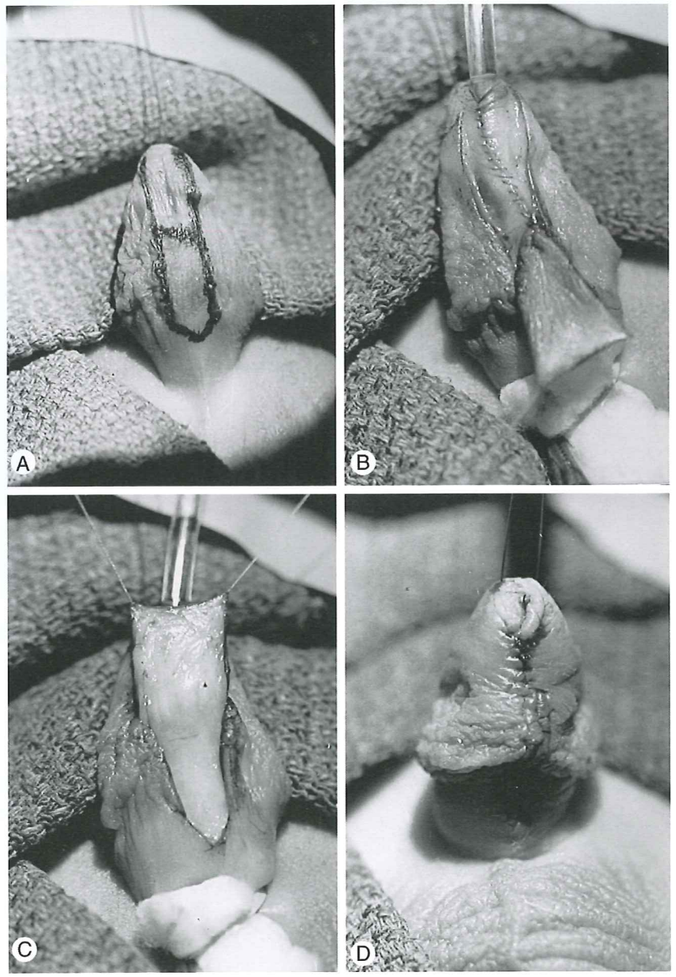


Figure 10–14
A: Distal hypospadias in a boy with no prepuce. Note the marking pen lines extending toward the penoscrotal junction, representing the future harvest site for a subcutaneous pedicle flap. *B*: Thiersch-Duplay repair is complete, and the proximal skin flap is being dissected distally on a vascularized pedicle. *C*: The pedicle flap is now completely mobilized distally. *D*: Immediate postoperative appearance.

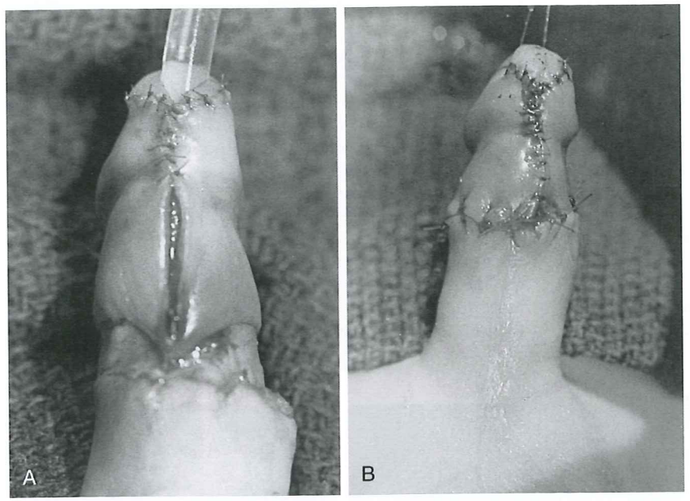


Figure 10–15
A: Meatoplasty and glansplasty are completed, and a mucosal collar is approximated in the midline. *B*: Immediate postoperative appearance with the temporary stent removed.

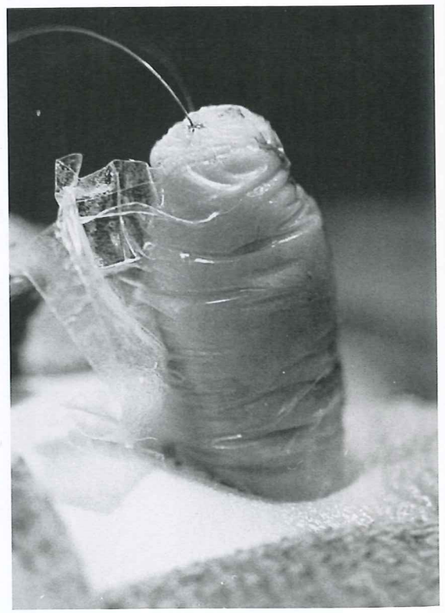


Figure 10–16
Bioocclusive dressing in place.

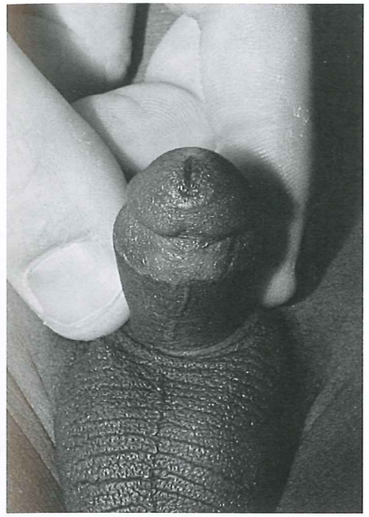


Figure 10–17
Example of postoperative penile appearance 15 months later. Note the normal circumcised look with a collar and slitlike glans.

and are not yet toilet trained fare remarkably well with minimal if any discomfort, as related by their parents at the postoperative follow-up. The ultimate cosmetic outcome with a terminal slitlike meatus and mucosal collar is now the standard that all hypospadias repairs must strive to obtain (Fig. 10–17).

SUMMARY

The Thiersch-Duplay principle has stood the test of time, and modifications as presented have achieved the cosmetic and functional result that Mother Nature had intended.

Acknowledgments

I would like to thank Paul Rogers for his outstanding illustration work and Kelley Mylan for her invaluable help in the preparation of this manuscript.

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CHAPTER

11

Urethral Plate Mobilization: The Modified Barcat Hypospadias Repair

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STEPHEN A. KOFF

For the repair of distal hypospadias, many would advocate the use of a meatal-based flap of proximal penile shaft skin. Such a flap, when used as an onlay onto the urethral plate as described by Mathieu, has several advantages that result in good succes rates. These advantages, verified in several series,[1–3] include availability of skin, a predictable blood supply that can be preserved through minimal dissection, and lateral suture lines. Although the risk of fistula formation and stricture is low with the Mathieu-type repair, this type of operation has some real and potential disadvantages. The cosmetic and functional results are determined by the shape of the glans and the urethral groove and may be less than ideal. Depending on anatomy, the resulting meatus may be irregular in appearance, may be located proximally or ventrally on the glans, and may emit a spraying stream. Furthermore, adequate ventral glanular coverage over the neourethra may in some cases be difficult to achieve without tension. This may explain the delayed meatal retraction described by Duckett.[4]

Barcat described a modification of the Mathieu urethroplasty.[5, 6] In his procedure, the urethral plate distal to the meatus is mobilized off of the glans. By incising the glans beneath and distal to the plate deeply in the midline, the neourethra is buried deep within the glans and advanced to its tip. Barcat, however, reported a 20% rate of fistula formation. This very high complication rate may have been due to the surgical technique, in which the urethral flap may have been devascularized.

Redman subsequently reported on a series of 105 patients who underwent this technique.[7] He documented the excellent cosmetic results achievable but noted a 15% rate of fistula formation. This high rate of fistula formation may also have been due to ischemia because "no conscious attempt was made to preserve the vascularity of the flap regardless of its length." He furthermore described the flap as being analogous to a free skin graft.

Koff and colleagues presented a series of 168 patients who underwent a modified Barcat procedure.[8] The modifications included creation of a wide-caliber meatus measuring 20 French in size and placement of a second layer of vascularized subcutaneous tissue over the neourethra for ventral coverage. These modifications resulted in a decrease in the rate of complications to 3.5%, half of which occurred in patients who had undergone previously failed hypospadias repairs.

The following discussion reviews the technique of the modified Barcat procedure and comments on the advantages and disadvantages of urethral plate mobilization in hypospadias repair.

SURGICAL TECHNIQUE

Potential candidates for the modified Barcat procedure are boys who have distal hypospadias with sufficient healthy, mobile, ventral penile skin proximal to the meatus (Fig. 11–1). Chordee itself is not a contraindication as long as the urethral plate does not require transection and as long as sufficient meatal-based skin remains after release of chordee. The initial steps of the procedure are no different from those of a Mathieu-type repair. The urethral meatus is calibrated, and if stenotic, the dorsal or ventral lip is incised in the midline and the apical mucosal edges are approximated with 7-0 polydioxanone suture. The distal urethral plate is measured and outlined, and a flap of proximal penile shaft skin of identical size is mapped out and marked. This flap may extend to the scrotal border if needed but must not include hair-bearing skin. This proximal flap is then sharply developed until mobility is adequate to lay this onto the urethral plate. The meatal-based onlay flap may also be derived from lateral penile shaft skin or even preputial skin when proximal ventral midline shaft skin is deficient.

The next step involves mobilization of the urethral plate and deep lateral and distal incisions to ensure a full-thickness, well-vascularized flap. Intermittent use of a tourniquet may be required. Dissection is facilitated by squeezing the dorsolateral glans between the index finger

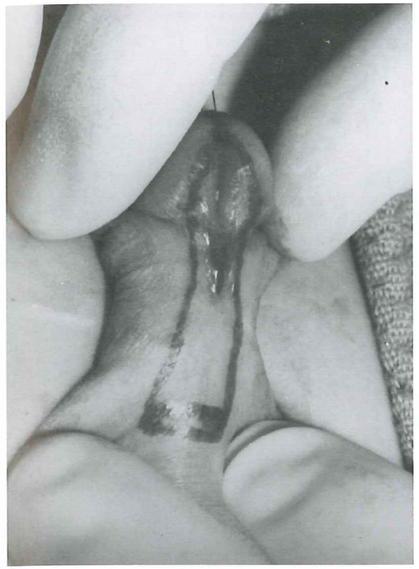


Figure 11–1
Typical case with proximal parameatal-based flap and urethral plate flap outlined.

and thumb with a piece of dry gauze. This compression allows the urethral plate to bulge away from the underlying glans to better define and visualize the sites of incision. This lateral compression also helps prevent excessively thin lateral glans wings. Once the urethral plate is fully separated from the glans, it must be able to reach the tip of the glans without tension. To do this, the urethral plate usually needs to be mobilized to the meatus. Mobilizing the urethra and urethral plate proximal to the meatus is occasionally required (Fig. 11–2). Once the urethral plate is mobilized, the glans wings are developed by sharply dissecting them off the corpora. Incisions must then be extended along the corpora proximal to the meatus on either side of the urethral plate and urethra to create a tissue layer of superficial subcutaneous tissue, which is later used to cover the neourethra. The neourethra is then formed by approximating the two meatal-based flaps with a running 7-0 polydioxanone suture (Fig. 11–3).

The next step involves incising the glans distal to the urethral plate in the midline to allow the neourethra to reach and be located at the precise tip of the glans (Fig. 11–4). It is important also to incise the glans deep to the course of the neourethra in the midline. This both allows the urethra to course straight through the glans and provides adequate glanular coverage for the neourethra. After the glans is incised, the resulting small triangles of tissue need to be excised to prevent redundant dog-ears of glanular epithelium from marring the final glans appearance.

After the flaps have been approximated, the dorsal lip of the neourethra is fixed to the apex of the glanular incision, the site of the future meatus, with a 6-0 polydioxanone suture (Fig. 11–5). The glans wings are then brought around the neourethra with deep full-thickness sutures of 6-0 polydioxanone. To prevent meatal stenosis, the meatus is formed with a circumference of 18 to 20 mm. To achieve this, the ventral skin flap may be incised and spatulated and an oblique anastomosis performed. The meatus is formed with interrupted 6-0 polydioxanone suture. Once the glans has been reconstructed, the previously developed subcutaneous tissue layers are approxi-

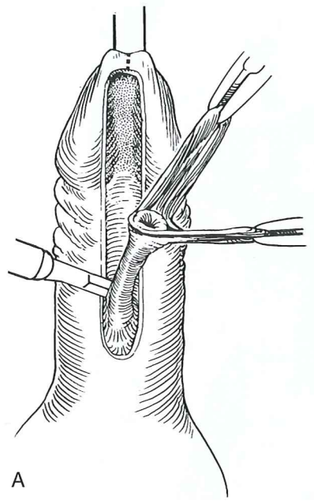




Figure 11–2
The flaps and the distal urethra have been mobilized.

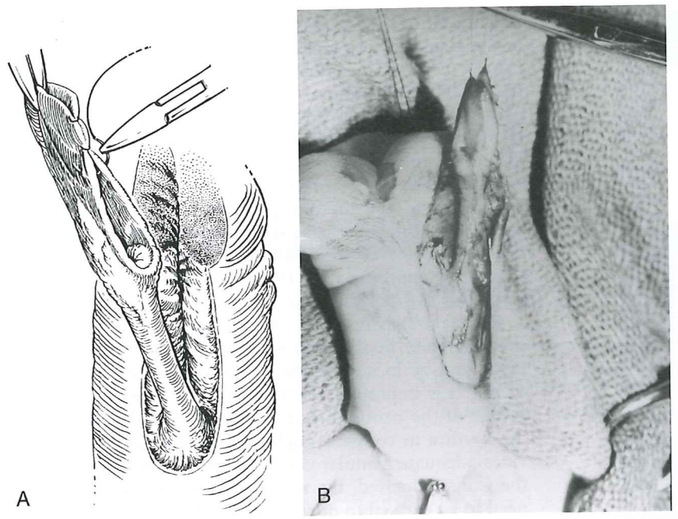


Figure 11–3
The two flaps are sewn together to create the neourethra.

mated in the midline with a running suture of 6-0 polydioxanone to provide the fistula-preventing second layer of coverage over the entire nonglanular neourethra and distal penile shaft (Fig. 11–6). Excess foreskin if present is excised, and the skin edges are approximated (Fig. 11–7). A 5 French feeding tube is left indwelling for 4 to 6 days, and a light compression dressing applied.

Mild chordee is usually corrected before mobilizing the urethral plate by dividing proximal subcutaneous attachments. If necessary, the shaft skin may be degloved, and rarely, tunical plications may be required.

RESULTS

During a 7-year period, 300 patients underwent a modified Barcat procedure. The average age at surgery was 20.8 months (range 5 to 192 months). The average follow-up was 16 weeks (range 1 week to 57 months). Of these 300 patients, 13 had undergone prior hypospadias repairs. Complications were infrequent. Eight boys developed fistulas (2.6%). Three of these boys had undergone previous hypospadias repairs. Three boys required meatal revisions, two for a deviated stream and one for meatal stenosis.

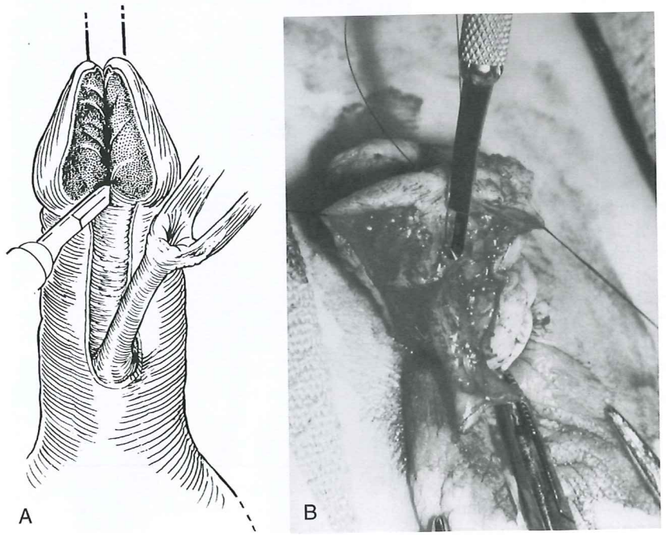


Figure 11–4
The glans is incised in the midline to form a channel within which the neourethra will lie.



Figure 11–5
The neourethra has been fixed to the tip of the glans.

Overall, the total reoperative rate was 3.7%. Minor complications not requiring surgery occurred in nine patients. In two patients, a small fistula closed spontaneously. Two boys developed postoperative bleeding, and two had urinary tract infections. One boy had cellulitis that responded to oral antibiotics, one had postoperative dysuria, and one had sebaceous cyst formation. The early and late cosmetic appearance was uniformly excellent.

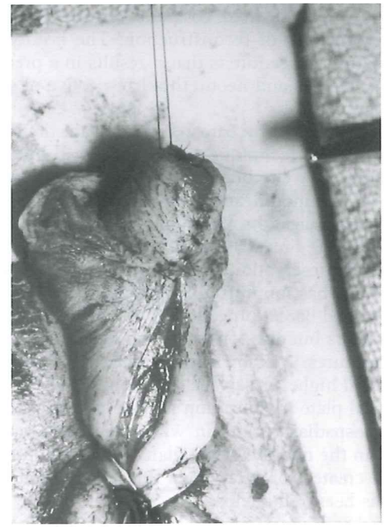


Figure 11–7
The finished hypospadias repair.

DISCUSSION

Onlay procedures such as the Mathieu urethroplasty leave the urethral plate in continuity with both the tissue underneath and the distal glans. Thus, the final cosmetic appearance depends to a great extent on the initial glanular anatomy and is influenced by the depth of the urethral groove and the shape of the glans. By detaching the urethral plate and rebuilding a neourethra before reattachment to the glans, the surgeon takes full charge and has full

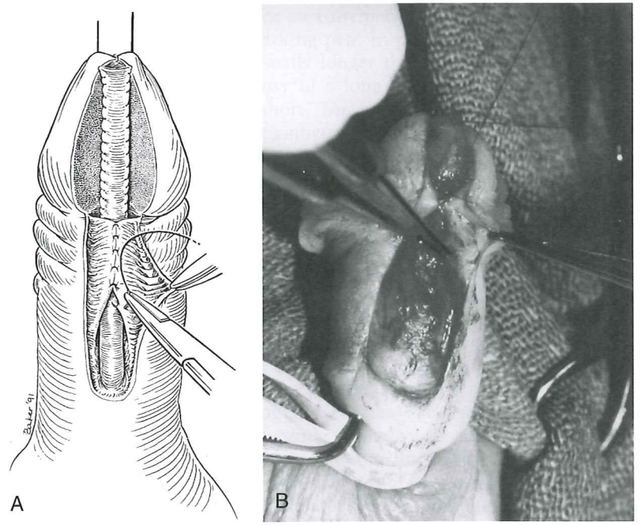


Figure 11–6
A second layer of vascularized subcutaneous tissue is brought over the repair.

responsibility for the final cosmetic result. This satisfies the basic principles of reconstruction. The beauty of the modified Barcat procedure is that it results in a predictably satisfactory meatus and neourethra irrespective of glanular morphology.

In previous reports by Barcat and Redman, the theoretic advantages of this technique were outweighed by the high complication rate. Urethral plate mobilization, when performed with the modifications described herein, results in a very low complication rate. Making the urethral meatus wide caliber (20 French) has virtually eliminated meatal stenosis, and preservation of flap vascularity and second-layer coverage has minimized fistulization.

The modified Barcat procedure is applicable not only for primary repairs but also for those who have had previously failed procedures. Acknowledging that complication rates are in general higher in salvage situations, this series shows that urethral plate mobilization may be performed even in repeat hypospadias repairs in which the glans may have been split in the midline, when glans wings may previously have been created, or even when the skin proximal to the meatus has been remodeled.

Mills and colleagues, more than a decade ago, in describing the price of perfection for hypospadias repair, wrote, "the drive for a meatus at the tip of the glans is admirable but must be tempered by the risk of fistula formation or meatal stenosis, requiring further surgical procedures."[9] This series of 300 patients demonstrates that the goal of a normally placed and normal-appearing meatus and a normally functioning neourethra can be reached with no increased morbidity, and at this time, the price for perfect correction of distal hypospadias is indeed small.

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CHAPTER

12

The Barcat Balanic Groove Technique for the Repair of Distal Hypospadias

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JULIA SPENCER BARTHOLD

All who perform hypospadias surgery can agree at some time with Bevan, who said in 1917, "In my surgical work I have tried out a number of operations for hypospadias and found none entirely satisfactory." He proceeded to describe a single case in which he used a flip-flap, which in all likelihood was the progenitor of the genre of so-called flip-flap techniques.[1] In 1932, Mathieu described a method of repair of distal hypospadias in which the neourethra was constructed of equal parts of a flap of penile skin and a stationary urethral plate.[2] Regardless of the contour of the urethral plate, parallel incisions were made on either side of the plate, and the glanular tissue lateral to the plate was undermined and then brought together over the neourethra. In 1969, Barcat described a modification of the Mathieu repair in which he completely elevated the urethral plate and then simply incised the glans in the midline without elevation of flaps or coring of the glans.[3] In 1983, Redman began to use an almost identical procedure, unaware of Barcat's contribution, while attempting to modify a variant of the Mathieu technique described by Gonzales and associates in which tissue from beneath the urethral plate was excised.[4, 5] Redman's modification occurred during the course of carrying the parallel incisions to the tip of the glans. When it was noted that the plate would be attached only by the meatus proximally and a narrow band of epithelium at the tip, it became apparent that the plate could be detached distally and the glanular tissue could simply be incised in the midline, rather than excising glanular tissue. The reasoning was that the spongy tissue of the glans would compress much like a sponge. In retrospect, Barcat must have had much the same thoughts as he modified Mathieu's procedure. Indeed, the credit goes to Barcat and Gonzales for this most utilitarian technique.

SURGICAL TECHNIQUE

The procedure is initiated with the transverse placement of a traction suture of 4-0 silk on a round needle in the dorsum of the glans, 5 mm proximal to the tip. The tip of a lubricated mosquito hemostatic clamp is introduced into the meatus in the manner of a small sound, which lubricates the meatus and facilitates the passage of a short segment of a 10 French red rubber catheter. The catheter is inserted to the region of the urethral bulb. If by calibration meatal stenosis is present, a dorsal meatotomy may be performed if the anatomy permits, and it requires no suturing. If a ventral meatotomy is needed, the urethra is approximated to the skin with 7-0 polyglycolic acid suture.

The length of the flap of penile skin that will be needed to form the ventral portion of the neourethra is then measured from the proximal lip of the meatus to the tip of the glans (Fig. 12–1*A*). If the penile skin is adherent to the urethra, which is obvious when the red rubber catheter is in place, the proximal point of adherence becomes the proximal point for measurement. The proximal flap is then traced with a marking pen. In practice, the flap measured in this way is usually longer than needed, but it is better to have the luxury of a long flap than the frustration of one that is too short. The width of the flap is marked on either side of the catheter so that the width equals half the circumference of the catheter. Incision of the penile skin is with a 67 Beaver blade and is carried to just proximal to the meatus. If the incisions are carried alongside the meatus or more distally, they may not coincide with those made later for elevation of the urethral plate. Caution should also be exercised with this incision, particularly as one nears the meatus, so that the immediately underlying divergent corpus spongiosum is not incised, because bleeding from the spongiosum is difficult to control.

The inner leaf of the prepuce is then incised circumferentially to meet the parallel incisions ventrally, leaving a wide collar along the corona.[6] The penile skin is then reflected to the penile base by dissecting in the plane between the dartos tunic and Buck's fascia. Although the reflection of the skin may not always need to be carried to the base, it is mandatory when torsion or curvature is present. The catheter is then removed and an artificial

erection is created by injecting the corpora cavernosa with saline (Fig. 12–1*B*). If the penis is straight, a 0.1 × 1.3 cm rubber band tourniquet is placed around the base of the penis and secured with a hemostatic clamp. If curvature is present, Buck's fascia is resected from the ventral aspect and an erection test performed. If curvature is still present, the neurovascular bundle is elevated and appropriate Nesbit ellipses are excised opposite the curvature. When the penis is confirmed to be straight, attention is turned to elevation of the urethral plate.

The glans is flattened, and the urethral plate everted ventrally by compressing the glans on either side with finger and thumb. This maneuver is aided by placing a sponge under the finger and thumb on either side to prevent slippage. The urethral plate, which usually appears smooth in contrast to the more textured glanular tissue proper, is outlined with the marking pen. The incision is carried out with a 67 Beaver blade and is made only through the epithelium (Fig. 12–1*C*). An Agrikola retractor is set in place, with the teeth of the retractor retracting the glans. Elevation of the plate is accomplished by sharp dissection with the knife and does not include any spongy tissue. As the meatus is neared, the red rubber catheter is reinserted and passed proximal to the position of the tourniquet. The catheter converts the thin-walled, often diaphanous urethra from a flattened ellipse on cross section to a circle and prevents inadvertent buttonholing. The dissection is carried dorsal to and well proximal to the position of the meatus. The glans is then incised in the midline to the depth of the tips of the corpora cavernosa and distally to the tip of the glans (Fig. 12–1*D*). At times, to obtain adequate depth, the incision is carried carefully into the septum between the corpora, which is easily done without entering either corpus. The two resultant triangles of glanular epithelium are excised to facilitate the formation of the meatus. No attempt is made to remove any glanular tissue.

The formation of the neourethra is initiated by suturing the distal end of the urethral plate to the tip of the glans using 7-0 polyglycolic acid suture (Fig. 12–1*E*). The proximal flap, which has been carefully measured before the dissection, is often found, after mobilization, to be longer than needed. When excising the excess, however, it is important to leave at least 2 mm of flap distal to the tip of the glans to avoid eventual difficulty in creating the meatus. With care, residual subcutaneous tissue is excised from the tip of the flap. The distal corners of the flap are sutured to the glans at the lateral borders of the urethral plate using 7-0 polyglycolic acid suture. The flap and urethral plate are then approximated on either side using a running 7-0 polyglycolic acid suture (Fig. 12–1*F*). No attempt is made to invert the edges, and a second layer closure is not attempted.

The glans is then approximated over the neourethra using one or more horizontal mattress sutures of 6-0 polyglycolic acid suture. The sutures are placed just beneath the epithelium. The epithelium is closed with either 7-0 polyglycolic acid or chromic catgut suture in either a running or interrupted vertical mattress fashion. A critical suture is that which approximates the distal edges of the glans halves and the ventral flap. This is accomplished with a horizontal mattress suture of 7-0 polyglycolic acid suture. The remainder of the circumference of the meatus is closed with interrupted 7-0 polyglycolic acid suture.

It will be noted that the glanular tissue is contiguous with the divergence of the corpus spongiosum and that Buck's fascia continues lateral to the divergent corpus spongiosum. This tissue provides for a substantial closure over the neourethra. The closure is begun with 5-0 chromic catgut suture, with the first tissue bites being in the proximal glanular tissue at the level of the corona and then proceeding proximally in a running fashion to approximate the divergent spongiosum (Fig. 12–1*G*). The tourniquet is then removed. Any minimal bleeding that occurs from the glans or around the meatus usually stops spontaneously.

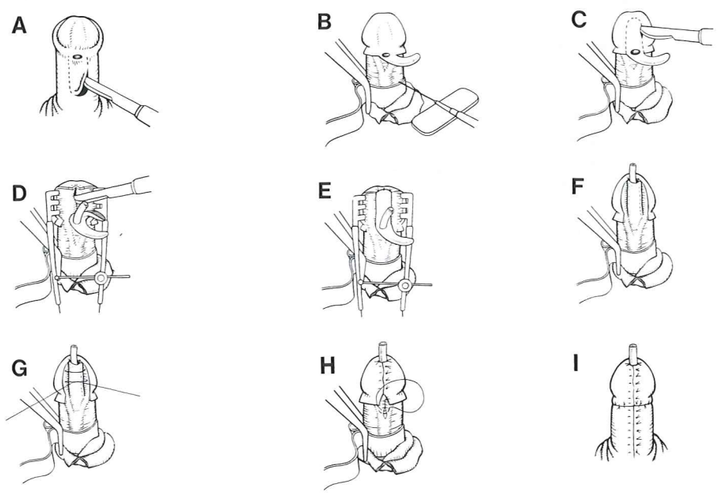


Figure 12–1
Technique for balanic groove repair of distal hypospadias. *A*: Technique of creating a proximal penile skin flap. *B*: Injection of the corpora to access penile straightness. *C*: Elevation of the urethral plate. *D*: With the Agrikola retractor in place, the glans is incised in the midline to the depth of the corpora. *E*: The urethral plate is sutured to the tip of the glans. *F*: Construction of the neourethra is completed. *G*: Glans halves reapproximated and divergent corpus spongiosum closed over the neourethra. *H*: Completed repair. (*A* to *H* modified from Redman JF: Barcat balanic groove techniques for repair of distal hypospadias. J Urol 137:83, 1987.)

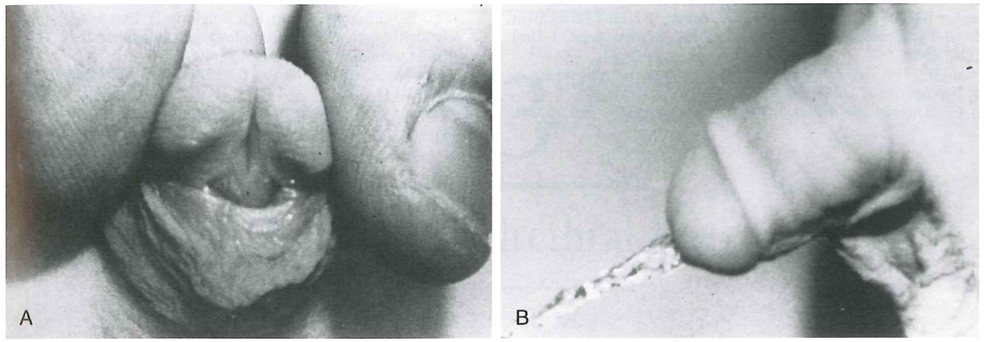


Figure 12–2
A: Preoperative appearance of coronal hypospadias with a megalomeatus variant. *B*: Postoperative voiding with normal appearance of the stream.

The skin is then marked in preparation for resection of the prepuce by holding the penis vertically with the traction suture to approximate erectile length. The skin is closed over the ventral aspect of the penis with toothed forceps held by an assistant, and the line of resection of the dorsal redundant prepuce is marked. Considerable innovation and conceptualization are often involved in tailoring the skin for the shaft, particularly when marked curvature or torsion of the penis has been corrected. Skin closure is with fine chromic catgut suture material in an interrupted fashion (Fig. 12–1*H*).

Urinary diversion is with an 8 French feeding tube that is secured with the traction suture and then is incorporated in the dressing with the final taping.

DISCUSSION

The advantages of the technique, which have been noted by others, are the applicability to various hypospadiac presentations and the normal final cosmetic result[7, 8] (Fig. 12–2). With the Barcat technique, no particular consideration need be given to the configuration of the glans or the urethral meatus. In distal hypospadias, there is considerable variation in the appearance of the urethral plate, which may be associated with an accessory channel of various depths or a baffle of epithelium. The urethral plate dissection is simply carried dorsal to the accessory sinus, and the baffle may be incised. The flap may be made as long as necessary to bridge the distance from the meatus to the tip of the glans; however, we do not extend the flap into the scrotal skin unless it is glabrous. Penile curvature has also not been a consideration in the use of the Barcat repair, because straightening that does not result after reflection of the skin or resection of Buck's fascia from the ventral aspect can be without exception effected by the resection and closure of Nesbit ellipses opposite the curvature.[4]

Because the proximal flap of penile skin is relatively narrow and therefore little penile skin proper is sacrificed, the shaft can be covered without using preputial skin. The result is normal-appearing penile skin, which is enhanced by the use of a generous Firlit preputial inner leaf collar.

The disadvantages of the technique are the requirement for a catheter and possible fistula formation. In some cases, we have not used a catheter in children younger than 1 year; however, the dressing was difficult to maintain in proper place because of wetness. With a catheter and dressing in place, edema is minimal after 2 days and discomfort on voiding is minimal. A 2-day catheter has been well accepted by parents. Although not using a catheter may have no deleterious effects, we have noted no adverse effects and certain advantages to its use.

Our fistula rate for distal hypospadias (i.e., coronal and glanular repair) was 5% in a recent 6-year series of 178 patients in which the divergent corpus spongiosum was closed over the neourethra. However, in patients with penile hypospadias in which such a closure could not be accomplished (97 patients), the fistula rate was 18%. Twenty patients who underwent a secondary repair had a 25% fistula rate. Koff and associates in a similar series reported an overall fistula rate of only 3.5%.[7] They too used a secondary closure over the neourethra but used a combination of "subcutaneous and lateral spongy tissue," which they developed by making incisions lateral to the urethral plate and urethra itself.[7, 9] They also used an indwelling catheter that remained in place for 6 days. Whether or not a shorter period of catheter drainage would result in an increased fistula rate in their patients remains to be determined. It seems probable that even better techniques of closure of the neourethra and techniques to secondarily cover the repair will result in even less fistula formation.

A gratifying consequence of the Barcat repair as described for distal hypospadias is the rarity of meatal stenosis. This was evident in our patients as well as in the extensive experience reported by Koff and colleagues.[7]

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CHAPTER

13

Hinging the Urethral Plate

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Surgical correction of hypospadias remains one of the most challenging and rewarding problems faced by urologists. In the past, although functional improvement was the accepted goal of reconstruction, current operations strive to attain functional and cosmetic normalcy. A number of innovative surgical procedures and technical modifications for distal hypospadias have been developed and refined through the years and allow for a simple single-stage repair with lessened patient discomfort, decreased complications, and cost-effectiveness without sacrificing functional and cosmetic results.[1, 2] To meet these goals, hypospadiologists must be proficient and up to date with a number of surgical procedures and modifications. Even more important, they must have a working knowledge of the spectrum of the anomaly and flexibility with the surgical methods most applicable for a successful repair for each individual case.

Hinging the urethral plate was developed as a modification of hypospadias reconstruction to improve the cosmetic appearance of the neomeatus for repairs that preserve the plate.[3] The urethral plate is the shiny, smooth, hairless epithelial surface distal to the hypospadias meatus believed to represent the embryologic remnant of the corpus spongiosum. A number of operations that have been developed preserve and incorporate the urethral plate in hypospadias reconstruction. We have noted that one of their drawbacks is a horizontally oriented meatus that often projects short of the penile tip. We modified the technique of meatal and glans reconstruction with repairs that preserve the urethral plate, including the Thiersch-Duplay,[4, 5] Barcat,[6, 7] King,[8] island onlay,[9] Mathieu,[10] flip-flap,[11] glans approximation procedure (GAP),[12] and pyramid procedure for the repair of the megameatus intact prepuce (MIP)[13] variant, to mention a few. Experience with hinging the plate as a modification of urethral plate repairs facilitates glans folding during glansplasty, extends the meatus to the tip of the penis, provides generous mobilization of the urethral plate for tubularization with or without additional skin flaps, and helps create a cosmetically normal, centrally located, vertically oriented urethral meatus.[3]

SURGICAL TECHNIQUE

A traction suture is placed in the dorsal glans. The penile skin, urethral plate, and, when a Mathieu repair is planned, the corresponding meatal-based skin flap are outlined with a surgical marking pencil. Epinephrine (1:100,00) with 1% lidocaine is injected along the lines of incision. This aids in dissection and control of hemostasis. The skin incision is extended circumferentially 3 to 5 mm proximal to the coronal margin, with preservation of the meatal-based skin flap. The proximal meatal flap is elevated, and the penile shaft skin is dissected to the base of the phallus. An artificial erection is created, and superficial chordee tissue is excised from the ventral corporal bodies to correct any penile curvature that remains.

The urethral plate is the epithelial strip that extends along the ventral penile shaft and glans distal to the hypospadiac meatus. Many distal and proximal hypospadias variants have a well-preserved plate suitable for reconstruction.[9, 14] The parallel longitudinal incisions defining the urethral plate extend from the hypospadiac meatus to the tip of the glans. The two parallel incisions outlining the sufficient plate should be kept as wide as possible (6 to 8 mm) to provide a template for anastomosis of an onlay or perimeatal-based skin flap or, alternatively, tubularization without a skin flap as described by Snodgrass. The glans is infiltrated with 1:100,00 epinephrine along the lateral margins of the urethral plate. The glans and plate are injected after the penile skin has been degloved and all chordee tissue excised by sharp dissection. This decreases the chance of hematoma development beneath the skin flaps due to inadvertent puncture of the vascular spongiosum, which is often splayed out lateral to the margins of the urethral plate. Glans wing mobilization by sharp dissection defines the plane between the glans cap and corporal bodies and facilitates later glans reapproximation and closure. It is important not to extensively undermine the margins of the urethral plate during glans dissection in order to preserve an intact base and vascularity for

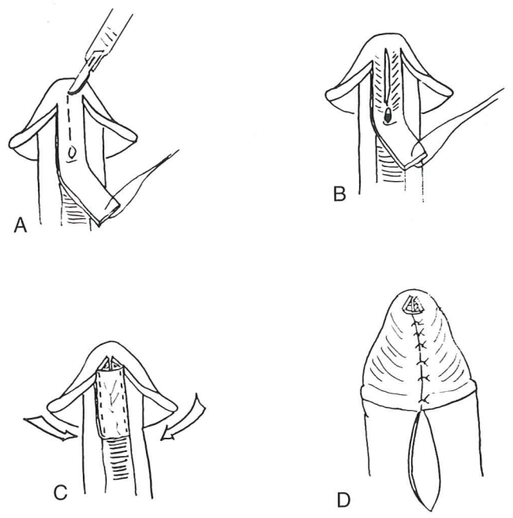


Figure 13–1
A: Urethral plate incised in the midline from the glanular tip to the hypospadias meatus. *B:* Meatal-based flap advanced distally and anastomosed to the lateral margins of the split urethral plate. *C:* Glanular wings rotated to cover the urethroplasty. *D:* Glansplasty completed with creation of a vertically oriented slit urethral neomeatus.

subsequent hinging. A vessel loop can be used as a tourniquet around the base of the penis during glans dissection and hinging to preserve visualization in a dry, bloodless operative field.[15] The distal urethral plate is hinged or broken by sharply incising the plate in the midline to the level of the corporeal bodies (Fig. 13–1*A*). The incision extends from the level of the hypospadiac meatus and projects to the distal margin of the urethral plate and tip of the penis (Fig. 13–1*B*). The hinging incision functionally deepens the glans groove and mobilizes the split halves of the urethral plate to facilitate folding and coaptation, creating a dorsal V-shaped vertical urethral meatus. The lateral margins of the split urethral plate are then anastomosed to the lateral margins of the meatal-based or island onlay flap to complete the urethroplasty (Fig. 13–1*C* and *D*). A second layer of coverage can be obtained from a tunica vaginalis blanket wrap or dorsal subcutaneous dartos flap rotated around the penile shaft on its own vascular pedicle.[16, 17] This additional tissue layer can be interposed between the neourethra and penile skin as an adjunct maneuver to prevent urethrocutaneous fistulas. Glansplasty is then completed by reapproximation of the glans wings to cover the neourethra (see Fig. 13–1). Excess dorsal foreskin is split in the midline down to the coronal margin as a relaxing incision, and the skin flaps are approximated in the ventral midline to recreate the cosmetic appearance of a median raphe. Excess distal foreskin is trimmed. Benzoin is applied to the penis, and an elastomer foam dressing is applied as an occlusive dressing. An 8 French urethral drip stent (Silastic tubing) is passed through the neourethra into the bladder and secured to the glans with a 5-0 polypropylene suture. The drip stent is placed into a double diaper to prevent urine saturation of the repair. The stent and dressing are removed in the office in 5 to 7 days. This technique is a simple modification for distal hypospadias variants that is well suited for boys of 6 months of age and older and is performed as an outpatient procedure.

DISCUSSION

Preservation of the urethral plate in hypospadias reconstruction has been expanded to include even the more severe proximal forms of hypospadias.[9, 14, 18, 19] We expect this trend to continue. Hodgson commented, "The preservation of the urethral plate and island patches will most probably come to dominate the practice in the future."[20] Experience has shown that correction of penile chordee without division of the urethral plate is possible for most cases of hypospadias.[9, 18, 19] In cases in which chordee persists, some surgeons also combine a dorsal corporoplasty to correct penile curvature without dividing the urethral plate, thus preserving the technical benefits of plate-preserving techniques.[18, 21]

As the urethral plate becomes more widely used in hypospadias urethroplasties, surgeons must be cautious not to overextend its indications. The location of the urethral neomeatus and its final cosmetic appearance are predetermined by the initial shape of the glans and the depth of the urethral plate and groove. The initial configuration of the glans, whether flat, conical, or grooved, has received little attention in relation to the ultimate appearance of the meatus. However, it is becoming increasingly apparent

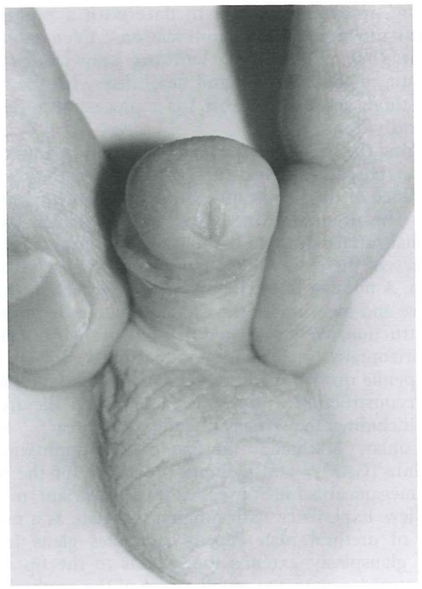


Figure 13–2
Postoperative result of hinging the urethral plate, with a normal-appearing vertical slitlike urethral meatus.

that it is a key factor in the cosmetic outcome of any repair. A flat glans with a shallow glanular groove is often associated with a flat nonpliable urethral plate that maintains its initial configuration even after glansplasty and produces a functionally adequate but cosmetically less desirable horizontally oriented urethral meatus. In other cases, the urethral plate projects inadequately to the glans tip. The modification of hinging deepens the urethral groove, extends it distally, and mobilizes or "breaks" the epithelial strips of the split plate to produce a central meatal location with a more normal-appearing vertical slitlike meatus (Fig. 13–2). Hinging the urethral plate closely reproduces normal urethral, meatal, and glans relationships. By applying this technique to glans configurations not associated with deep glanular grooves, the flat urethral plate can be reconfigured to create a more cosmetic and functional neomeatus. Epithelialization progresses normally, and meatal stenosis has not been a problem. In certain cases, we have also found that hinging the urethral plate mobilizes the split halves of the urethral plate to produce a functionally wider-diameter template. In these cases, the hinged plate can be tubularized without the need for additional skin flaps, further extending the application of the GAP,[12] pyramid,[13] and Snodgrass[22] procedures. The choice of operation for repair of distal hypospadias is determined by a number of factors, including the configuration of the glans and meatus, position and location of the meatus, and associated degree of penile curvature. Although the glans retains a normal conical configuration with Horton-Devine,[11] Barcat,[7] Mathieu,[10] and other operations preserving the urethral plate, the cosmetic appearance of the neomeatus, which is often triangular, round, or horizontal, can be suboptimal. Hinging the distal urethral plate allows hypospadiologists to improve on these results and represents another refinement aimed at recreating a functionally and cosmetically normal penis, glans, and meatus.

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CHAPTER

14

Tubularized, Incised Plate Urethroplasty

WARREN SNODGRASS

The tubularized, incised plate (TIP) repair corrects hypospadias by tubularizing the urethral plate. This procedure extends the concept of hinging, discussed in the preceding chapter, by incising the entire urethral plate in the midline from the hypospadiac meatus distally. This incision widens the plate so that it can be tubularized without additional skin flaps. The resultant neourethra has a normal diameter, and the meatus is vertically oriented and located at the tip of the glans. TIP urethroplasty was originally described for distal hypospadias.[1] Further experience has demonstrated the versatility of this operation, which has now been used successfully to repair midshaft and even penoscrotal defects.

SURGICAL TECHNIQUE

The procedure is illustrated in Figure 14–1. A circumscribing incision is made 2 mm proximal to the hypospadiac meatus, and the penis is degloved to the penoscrotal junction. Artificial erection tests for chordee, which is corrected as needed by dorsal plication to preserve the urethral plate.

Next, the ventral glans is infiltrated with 1:100,000 epinephrine along the borders of the urethral plate (Fig. 14–1*A*). Parallel longitudinal incisions are then made approximately 6 to 8 mm apart to separate the glans from the lateral margins of the plate (Fig. 14–1*B*). The glanular wings are mobilized to facilitate subsequent glans closure.

Then, the edges of the urethral plate are gently retracted laterally with fine forceps. This maneuver delineates the midline, which is incised with tenotomy scissors from the hypospadiac meatus distally to the end of the plate (Fig. 14–1*C*). This incision is the key step of the procedure and usually results in division of the urethral plate into two epithelial strips.

The lateral edges of the urethral plate are now quite mobile. Interrupted 7-0 chromic sutures are used to close the plate over a 6 French Silastic catheter (Fig. 14–1*D*), which provides urinary drainage into diapers for 7 to 10 days. The dorsal incision into the urethral plate is not sutured and reepithelializes spontaneously.

Next, vascularized subcutaneous tissue is dissected from the dorsal prepuce and shaft skin and rotated ventrally to cover the neourethra before glans closure (Fig. 14–1*E*). Alternatively, tunica vaginalis can be used if the subcutaneous tissues are inadequate. The glanular wings are then closed in the midline with 6-0 chromic horizontal mattress sutures (Fig. 14–1*F*). It is not necessary to suture the glans to the end of the neourethra.

Attention to details of skin closure optimizes the cosmetic result (Fig. 14–1*F*). First, the ventral subcoronal prepuce is sutured together below the glans to complete the mucosal collar. Then the dorsal prepuce is split longitudinally. This relaxing incision allows midline skin closure ventrally, simulating the median raphe. Excess rugated skin is excised so that the final result is a normal-appearing circumcised penis.

RESULTS

Distal Hypospadias

The majority of boys undergoing TIP urethroplasty have had distal hypospadias. The largest experience reported to date involved 148 patients from six institutions.[2] Midline incision of the urethral plate was found to widen it reliably for primary tubularization (Fig. 14–2), with no case requiring additional skin flaps. This created a functional neourethra with a diameter greater than 10 French. Included in this report were 11 patients with failed meatoplasty and glansplasty (MAGPI), glans approximation procedures (GAP), and Mathieu procedures. Although all of these repairs use the urethral plate, this tissue was healthy at reoperation. Cystoscopy was performed in a few patients who were subsequently anesthetized for other procedures. In each case, the neourethra appeared normal and showed no visible scarring from dorsal incision of the urethral plate.

The meatus in all cases was vertically oriented and slitlike. In a few patients, it looked small postoperatively, although calibration demonstrated no stenosis. This appearance may have resulted from overzealous closure of either the urethral plate or ventral glans. A typical example of the superior cosmetic result achieved by this repair is shown in Figure 14–3.

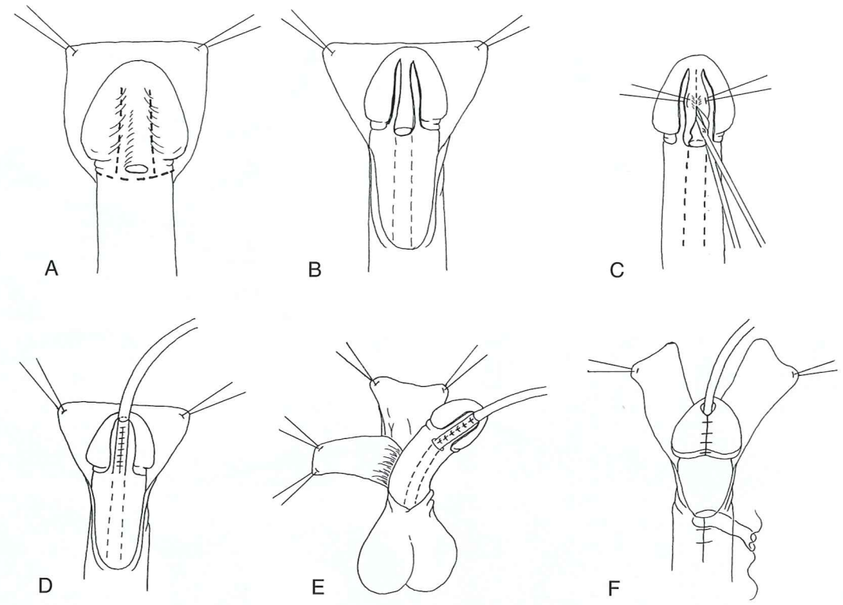


Figure 14–1
TIP urethroplasty. *A:* Horizontal dotted line indicates the circumscribing incision to deglove the penis. Vertical dotted lines indicate lateral borders of the urethral plate. *B:* Urethral plate separated from the glans by parallel longitudinal incisions. *C:* Midline incision of the urethral plate from the meatus to the glanular tip. *D:* Urethral plate tubularized over a catheter. *E:* Dorsal subcutaneous tissue mobilized to cover the neourethra. *F:* Glanular wings, mucosal collar, and ventral shaft skin closed. (From Snodgrass W: Tubularized, incised plate urethroplasty for distal hypospadias. J Urol 151:464, 1994.)

Few complications were reported by this multicenter experience. A total of 10 patients (7%) had fistulas, meatal stenosis, or partial glans dehiscence. It is noteworthy that all of the fistulas occurred on the distal penile shaft, without involving the glans.

Proximal Hypospadias

TIP urethroplasty has also been used to correct midshaft and penoscrotal hypospadias. The operative technique is the same as for distal repairs, with care taken to preserve the longer urethral plate when degloving the penis. Midline incision of the plate in these cases often opens it to a remarkable width, as shown in a representative example of midshaft hypospadias (Fig. 14–4). Despite tubularization of longer urethral plates, complications have been similar to those described with distal hypospadias repairs.

The TIP procedure can be combined with other techniques for complex reconstructions. If the proximal aspect of the urethral plate is dysplastic or scarred from prior surgery, pedicle or free grafts are used to construct the proximal urethra and the glanular segment consists of the incised and tubularized distal urethral plate. Advantages of this approach include reduction in the length of the proximal graft and superior cosmetic appearance of the meatus.

DISCUSSION

The majority of boys with hypospadias have a distal meatus with minimal chordee. Various surgical procedures to correct such defects are described elsewhere in this book. The choice among these repairs for an individual case depends on specific meatal and glanular configurations. For example, the MAGPI operation is best limited to the small, pliable subcoronal or glanular meatus with a flat glans.[3] The GAP repair is designed for a patulous meatus with a deep glanular groove,[4] and meatal-based or onlay island flap procedures are used for a noncompliant meatus associated with a flat glans.[5, 6]

Decision making is simplified by TIP urethroplasty. The designation of the meatus as compliant or a so-called variant does not affect the surgical technique. In addition, midline incision of the urethral plate consistently enables tubularization regardless of whether the glans is grooved or flat. Complications, such as meatal stenosis or retraction, which may occur if specific indications for other procedures are not met, are largely avoided with use of the TIP repair.

Other factors also influence the selection of operative procedures. Meatal-based flaps extending near the scrotal junction could result in hair growth at the meatus during puberty. Prior circumcision or a failed hypospadias repair usually leaves insufficient skin to construct flaps. TIP urethroplasty may be indicated in these situations because it does not require skin flaps and the urethral plate often remains healthy despite prior surgery.

Another important consideration in hypospadias surgery is the final cosmetic result. The ultimate goal is a penis that is not only functionally normal but also appears to have been only circumcised. In that regard, one criticism

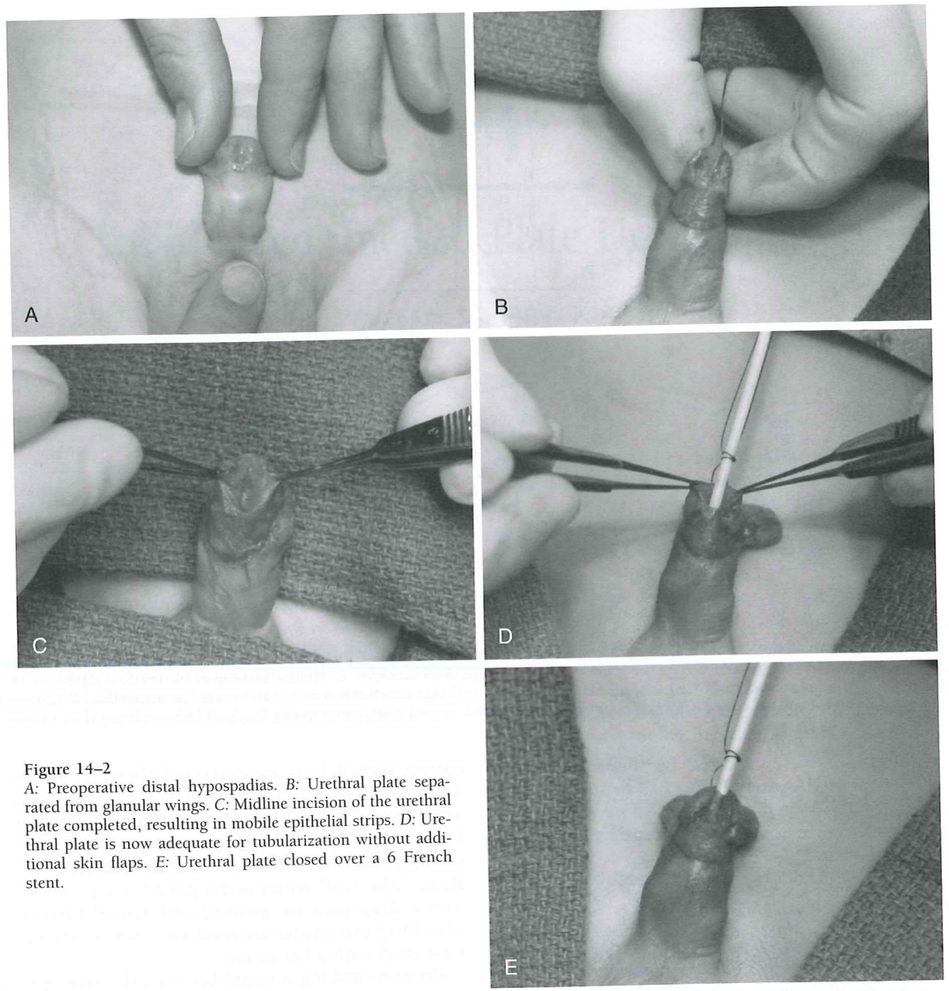


Figure 14–2
A: Preoperative distal hypospadias. *B:* Urethral plate separated from glanular wings. *C:* Midline incision of the urethral plate completed, resulting in mobile epithelial strips. *D:* Urethral plate is now adequate for tubularization without additional skin flaps. *E:* Urethral plate closed over a 6 French stent.

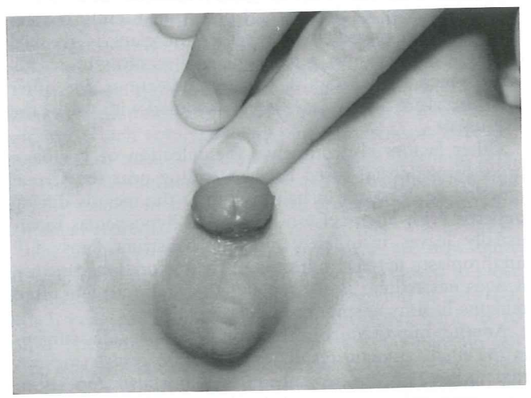


Figure 14–3
Postoperative meatus. Note the vertical orientation and slitlike appearance.

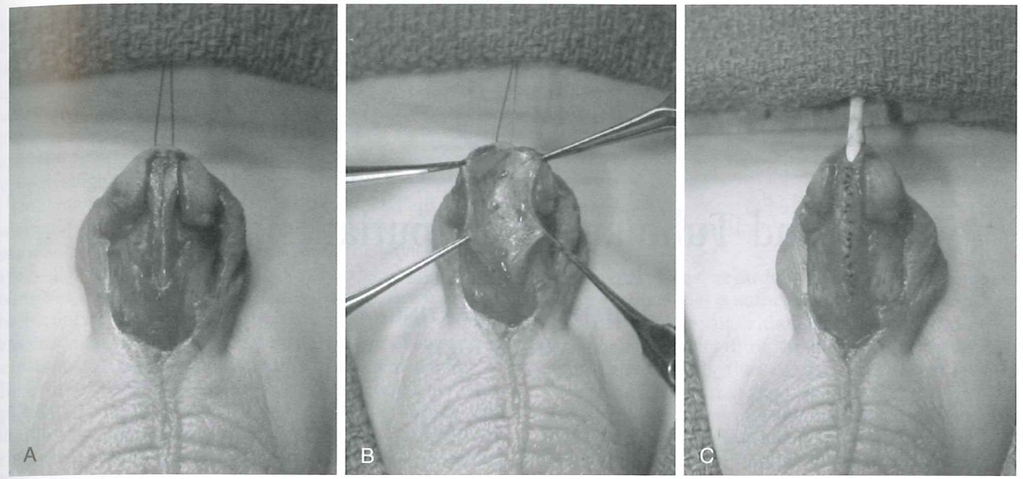


Figure 14–4
Proximal hypospadias. *A:* Entire urethral plate preserved to the midshaft meatus. *B:* Opened plate after midline incision. *C:* Urethral plate tubularized.

of meatal-based and onlay island flap repairs is the horizontally oriented, rounded meatus that often results, especially when the ventral glans is flat.[7] In contrast, TIP urethroplasty creates a meatus that is vertically oriented and slitlike, closely resembling a normal meatus.

Success with distal hypospadias has led to use of the TIP repair for more proximal defects. The extent to which midline incision widens the urethral plate is surprising and often allows simple tubularization to create a functional neourethra. The options of pedicle flaps or free grafts remain if the urethral plate is thought to be dysplastic. In this situation, the combination of TIP urethroplasty with other techniques may be advantageous.

Few complications have resulted from TIP urethroplasty. The risk of fistulas is minimized by covering the entire neourethra with vascularized subcutaneous tissues. Meatal stenosis is uncommon, and no strictures of the neourethra have been recognized. The dorsal incision into the urethral plate reepithelializes without obvious scarring, so the neourethra has appeared normal at cystoscopy after both distal and proximal hypospadias repairs. This procedure evolved from hinging the urethral plate, which, as described elsewhere in this text, does not increase the morbidity of meatal-based or onlay island flap repairs.

Hypospadias results from incomplete fusion of the urethral folds. Experience with the TIP repair demonstrates that the tissue that should have completed urethral development is largely preserved in the urethral plate. Midline incision widens the plate so that simple tubularization creates an adequate neourethra. Because this step essentially completes normal closure of the urethral folds, additional skin flaps are unnecessary and the meatus is properly located and vertically oriented. Therefore, TIP urethroplasty is a versatile procedure offering excellent cosmetic results and a low complication rate for the majority of boys with hypospadias.

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CHAPTER

15

Onlay and Tubularized Preputial Island Flaps

MICHAEL A. KEATING
MARK A. RICH

Continued experience shows that no single type of urethroplasty is uniformly applicable to the spectrum of penile anomalies known as hypospadias. As a consequence, contemporary urologists must be able to offer various technical solutions to the gamut of anatomic nuances that are inevitably encountered. Surgeons who habitually apply one favorite operation to hypospadias or who plan to repair just distal variants are not acting in their patients' best interests. There is no substitute for surgical expertise and experience, but technique selection is probably the factor most crucial to successful repair, regardless of severity. Flexibility on the part of the surgeon is key. More than 300 types of urethroplasties have been described in the literature, and new techniques and modifications continually appear. Although the trials of our predecessors are better documented than their errors, each contributes in some way to the science and art we now know as hypospadiology. Condensing this body of knowledge into rigid algorithms offering cookbook solutions is of equivocal value because of the nature of the anomaly. Instead, identifying technical paradigms that can be adapted to general anatomic patterns appears to offer the best chances for success.

Conceptually, reconstruction of the dystopic urethra that accompanies hypospadias can be completed using one of three types of urethroplasties. *Mobilizations* or partial mobilizations of the urethra are the simplest of the three because the native urethra is left undisturbed. Meatal advancement and glanuloplasty (MAGPI)[1] and its modifications are typical examples. Mobilizations can be used to correct some distal variants, although not as many as initially supposed because use is limited by tissue mobility and glanular configuration.[2] Any dissatisfaction with these types of repairs undoubtedly stems from their overapplication in unsuitable candidates.[3] *Tubularizations* of the urethral plate offer another option for midshaft and distal hypospadias. The King repair[4] (glans approximation procedure)[5] and pyramid procedures[6] all use this concept. Applicability depends on the quality, width, and projection of the urethral plate (the ventral penile skin distal to the meatus) onto the glans. Mobilizations and tubularizations or hybridizations of these two types of urethroplasties[7] are commonly used because the majority of cases of hypospadias are distal variants. The results are excellent when, as with any urethroplasty, the repair is properly tailored to the anatomic constraints of the individual anomaly.

Extensions of the native urethra make up the third classification of urethroplasty. These can be constructed solely of other tissue as complete tubular extensions of the native urethra or can be combined with the urethral plate as ventral onlays to complete its distal projection. Despite the fact that extensions are the most technically challenging repairs, they are not regarded as last-resort techniques to be applied only when all else fails. Instead, extensions become the logical response to most cases of proximal hypospadias, variants accompanied by severe chordee, and hypospadias of any level with glanular and plate characteristics that render them unsuitable for mobilizations or tubularizations. Various tissues can be used to construct extensions, including free skin grafts, buccal and bladder mucosa, and penile skin or prepuce. When enough is available, genital skin is our preference because it most closely resembles the native urethra. Although the results with free preputial grafts are commendable,[8, 9] it seems logical to use vascularized preputial flaps whenever possible rather than tissues devoid of their blood supply. The former are the focus of the remainder of our discussion.

HISTORICAL PERSPECTIVES

Two decades ago, Hodgson popularized the use of one-stage vascularized flap urethroplasties with a series of operations that used the entire prepuce and left its inner and outer layers in continuity. The first used the inner prepuce (the so-called mucosal layer) in a vertical orientation combined with a tumble-flap technique (Hodgson I).[10] Subsequent configurations used vertically oriented dorsal penile skin, which was transferred ventrally by creating a buttonhole in the pedicle, to create an onlay-type or tubularized neourethra (Hodgson II and III).[11] Using a somewhat different modification, Asopa and colleagues[12] spiraled the prepuce ventrally, constructed a neourethra from the inner prepuce, and covered the repair with its outer layer. Duckett's double-faced island flap is a similar repair. This type of approach is attractive, because the vascularity of the two components vital to any successful urethroplasty, the neourethra and its skin coverage, is preserved. Unfortunately, however, when both are left in continuity, the tailoring can be challenging at best. In addition, the cosmetic outcome is often bulky, and fistula rates have been unacceptably high, for reasons that remain unclear.[13]

Duckett was the first to demonstrate that flaps can be isolated from the mucosal layer of the prepuce with a vascular pedicle without compromising the adjacent outer layer of prepuce.[14] Despite some concerns about overall tissue viability because of the distribution of vascularity to the prepuce that occurs with hypospadias,[11, 15] the concept remains valid. In most cases, the aborization of superficial vessels in the subcutaneous tissue is sufficient enough to allow the prepuce to be split into its mucosal and outer epithelial layer, each with its separate blood supply. The tubularized preputial island flap (TPIF) was originally offered as a solution to most cases of midshaft and proximal shaft hypospadias. The island onlay flap (OIF) urethroplasty,[16] which was originally introduced as an alternative to the perimeatal-based flap for anterior hypospadias, has gained popularity for many of the same variants, a change enacted by our dramatically altered perception of chordee and its relationship with the urethral plate (discussed later).

PREOPERATIVE EVALUATION

A thorough history and physical examination are completed for every child. Radiographs are unnecessary unless the child has a midline defect such as cleft lip or anomalies of the heart, rectum, limbs, or spine that suggest a global insult in embryogenesis. Karyotypes to rule out an intersex state are obtained when an undescended testicle is identified. During the examination, the different components of hypospadias are pointed out to the family. It is usually unnecessary to convince most parents that surgery is indicated because of the cosmetic drawbacks of the anomaly. Its functional implications are also discussed. Regardless of the severity of the anomaly, no attempt is made to underscore the complexity of any method of urethroplasty during this discussion. A frank summary of possible complications is also included. Nevertheless, families are always reassured that the benefits of surgery should outweigh its risks. Finally, the decision to apply any particular technique is never made until the anatomic nuances of the variant can be fully appreciated at the time of surgery. Families are also prepared for the requirements of different urethroplasties (length of surgery, urinary diversion, differences in complications, and so on) that might need to be addressed to correct the problem fully.

ANATOMIC CONSIDERATIONS

Penile Size

Most penises affected by hypospadias are large enough to correct during infancy. Six to 18 months of age is an optimal window for repair. Infants at this age are not yet aware of their genitalia, do not remember their surgery, and are easier to manage. Testosterone can be given to a patient with a small penis to provide for some additional growth and technical advantage. Neovascularity is unavoidable, however, and perioperative bleeding sometimes poses a problem.

Preputial Quality

Most hypospadias, regardless of its severity, is associated with a prepuce that is sufficient both to create a neourethra and cover the repair, although there are exceptions. In some cases, the length of the deficit to be bridged by the neourethra exceeds that of the inner layer of prepuce, which assumes a trapezoid shape when fanned out. In others, the prepuce is globally inadequate, having marginal epithelial surface and deficient subcutaneous tissue. When this is the case, other options in repair must be pursued.

Urethral Plate/Glans Configuration

When healthy and pliable, the urethral plate is not the contributor to chordee once supposed. Plate width and projection onto the glans dictate the degree of glans clefting, which in turn determines glans configuration (Fig. 15–1). A normal penis has a conical glans with a centrally positioned meatus. Hypospadias with a glans that retains a similar shape typically has a narrow urethral plate with little distal extension. This results in minimal glans clefting. As a consequence, recessing a neourethra into the normal position using simple mobilizations or repairs that preserve the plate is hazardous. Because glans tissue cannot be effectively mobilized to buttress the repair ventrally, the likelihood of glans breakdown or meatal regression

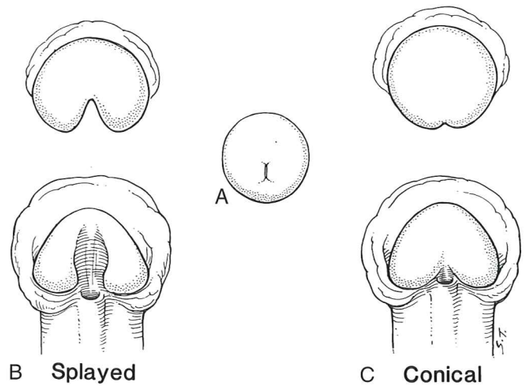


Figure 15–1
Glans configuration. *A:* A normal meatus is positioned in the center of the glans. The degree of clefting and plate projection is crucial to technique selection. *B:* A clefted glans and distal plate projection allow neourethras to be normally repositioned. *C:* A distal variant without distal plate projections requires splitting the glans to achieve the same result.

increases considerably. In addition, the cosmetic result, which leaves the neomeatus positioned ventrally on the glans, is suboptimal. As an alternative, if the urethral plate is salvageable, it can sometimes be effectively advanced using the hinging technique for distal hypospadias[17] or Barcat's modification for more proximal variants.[18, 19] Otherwise, the glans should be split and a tubularized neourethra centrally positioned. In contrast, hypospadias with a clefted glans tends to have a wider, healthier urethral plate with better distal projection. This configuration is more conducive to ventral mobilization of the glans and techniques that preserve the plate.

Chordee

Our understanding and management of chordee has changed dramatically in recent years. Historically, preoperative chordee was addressed by initial skin incisions that routinely divided the urethral plate. This allowed circumferential mobilization of the urethra to complete pericorporeal dissections for dysgenetic tissue. It is now apparent that most chordee is caused by superficial tethering from dysgenetic skin, abnormal underlying dartos fascia, and the aberrant insertions of the hooded prepuce. This is especially true of distal variants (as many as 90%) but also commonly occurs with proximal hypospadias. In one series of largely distal and midshaft variants, for example, only one half of 374 patients had chordee and fewer than one third of these had curvature that persisted after taking down the penile shaft skin.[20] Chordee that persists after skin takedown is caused by a dysgenetic urethral plate, corporeal disproportion, intrinsic corporeal dysgenesis, or elements of all three. Unfortunately, dividing the plate to complete pericorporeal dissections in this setting sometimes does not make a difference, and it is impossible to predict beforehand which child might benefit from the manuever. As a result, some surgeons have recommended dorsal plications for persistent chordee, thus maintaining the technical benefits of urethroplasties that preserve the plate, such as the OIF (Fig. 15–2). This seems a reasonable approach for mild degrees of curvature when the urethral plate is healthy and its projection acceptable. Nevertheless, the long-term implications of preserving a potentially dysgenetic urethral plate remain unclear. Excision of the plate or its mobilization to clear the corpora of chordee is recommended for boys with severe curvature, despite the fact that additional measures (dorsal plications, dermal graft) might still be needed to straighten the penis completely in some cases and that a tubularized neourethra is now required to complete the repair.

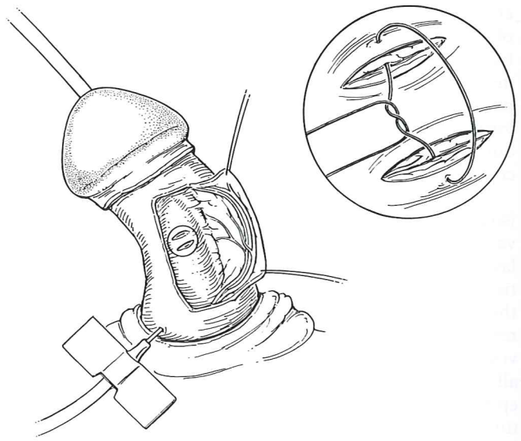


Figure 15–2
Dorsal plications for persistent chordee. The neurovascular bundles are elevated with Buck's fascia. Nonabsorbable sutures (inset) approximate parallel incisions in the tunica.

TECHNIQUE SELECTION

Our evolving understanding of chordee, the urethral plate, and glanular plasticity has had a significant impact on technique selection. Presurgical chordee is rarely a factor. Instead, virtually every urethroplasty is now begun by preserving the urethral plate, taking down the penile shaft skin, and only then performing an artificial erection. Once the presence or absence of chordee has been assessed, the different types of urethroplasties assume position in a logical sequence dictated by the patient's anatomy. Each repair predisposes to the next without burning any technical bridges. When noncompliant tissues, a dysgenetic urethra, or narrow urethral plate eliminates the option of mobilization or tubularization, their incisions can be segued into those of an extension. The presence of chordee and the quality of the plate, in turn, dictate whether an OIF or TPIF is required.

When the penis is effectively straightened and the tissues of the urethral plate well developed, the OIF offers definite advantages over its more technically challenging tubularized predecessor. These include ease in sizing and simplification in construction of the neourethra; immobilization of the repair by the plate, which minimizes kinking; and avoidance of a circumferential anastomosis, which makes stricture less likely. The OIF also offers advantages over perimeatal-based flaps that might be used to correct similar variants. These include predictable vascularity rather than reliance on perimeatal tissues that are sometimes deficient; spatulation and revision of the meatus; preservation of ventral skin, which makes midline reapproximation at closure more likely; and no limitations of flap length because the incorporation of hair-bearing skin is not a consideration.[21]

GENERAL PRINCIPLES IN TECHNIQUE

Although their benefit has never been proved, broad-spectrum perioperative antibiotics (a cephalosporin) are given to maximize prophylaxis. Postpubertal males also take antiseptic showers for 2 or 3 days to lessen the colonization of perineal flora. Because most infections probably result from skin loss or hematoma rather than primary inoculation, additional attention is paid to minimal-touch tissue handling and hemostasis. Loupe magnification, ophthalmic instruments (Castroviejo needle holders, iris scissors, 0.5 jeweler's forceps), and selective low-current cautery help limit tissue trauma. In addition, epinephrine (1:100,000) is injected into the subcutaneous tissues of the shaft and the glans along the proposed lines of incisions with a 25-gauge needle to diminish bleeding. The medication is not infused beneath the tissue intended for creation of a flap. Tourniquets are rarely required. Bleeding that occurs late in the operation is often caused by a full bladder rather than the loss of epinephrine's vasoconstricive effect. Caudal or local penile blocks serve to blunt perioperative erections that can initiate bleeding.

Fine chromic (6-0 and 7-0) suture is preferred for skin because it is quickly absorbed. A running mattress stitch everts the skin edges and exits the wound within a few days. This seems to lessen the incidence of epithelialized suture tracts and gives an excellent cosmetic result. Subcutaneous stitches can also be placed. Polydioxanone (6-0 or 7-0) is used to construct neourethras. The suture is minimally reactive and easy to work with. Closures are inverted luminally whenever possible, because eversion may be a risk factor for fistula formation. Several layers of healthy tissue are also an invaluable aid in minimizing fistulas.[22] This tissue is obtained from redundant preputial pedicle in most cases. Deepithelialized shaft skin or tunica vaginalis of an adjacent testis can also be used. Neourethras are constructed to a caliber of 8 to 10 French in infants, 12 French in adolescents, and at least 20 French in teens and adults. Red rubber catheters provide a useful template for size during reconstructions.

TECHNIQUE—ONLAY ISLAND FLAP (Fig. 15–3)

Preparation, Incisions, and Dissection

The urethral plate is preserved by making two parallel incisions (width 5 to 7 mm) that extend from around the meatus to the tip of the glans. These are joined by a circumferential skin incision that is made 7 to 10 mm below the sulcus. This preserves the cosmetic integrity of the corona when the shaft skin is repositioned at completion.[23] The shaft skin is taken down by sharply defining the avascular plane between Buck's fascia and the corpora, a manuever crucial to preserving the pedicle to the proposed flap. This plane is entered by incising the ventrolateral subcutaneous attachments of the prepuce to the glans and gently spreading the scissors against the corpora. Little bleeding should be encountered. Glans wings are freely mobilized by sharply defining the plane between the glans cap and corpora along the parallel incisions that define the urethral plate. An artificial saline erection is completed after excising any dysgenetic tissues on both sides of the plate. The native urethra is revised with a generous ventral spatulation, and any deficient tissues of its distal extent excised. The length of the defect to be bridged by the neourethra to the tip of the glans is then measured.

Harvesting the Flap

A transverse flap of appropriate length and width is mobilized from the mucosal layer of the prepuce. Flap width depends on the width of the plate. The two in combination should total approximately 12 mm in infants. It is safest to harvest more flap than necessary and to leave exact sizing until the actual reconstruction. Grasping the prepuce with the index finger and thumb and distracting the flap with gentle traction using fine (5-0 silk) sutures help define its midline subcutaneous pedicle, which is taken down to the base of the penis. This should be released laterally to avoid torsion when the flap is transferred ventrally.

Constructing the Neourethra

After its transfer, the onlay is approximated to one side of the urethral plate. Closure can be accomplished by various methods. One choice is to start a double-armed suture at the spatulation that is extended from within (to invert the suture lines luminally) down both sides to the neomeatus. Excess flap can be trimmed after completing one side of the repair. A 10 or 12 French catheter serves as a useful template for gauging size when tailoring the flap and closing the glans. Redundant subcutaneous tissues of the pedicle are fanned out with interrupted or running sutures to provide an additional layer of coverage for the neourethra.

Completing the Glanuloplasty

The glans wings are closed in the midline in two layers. Deeper glanular tissue is approximated initially with one or two 6-0 polyglycolic sutures. When tension is suspected, spongiosal tissue is excised from the deep medial borders of the wings to create additional room for the neourethra. In many instances, epithelial remnants of the preputial insertions remain as ruffles of the ventral glans and submucosal collar. These should be excised before reapproximating the skin with a running horizontal mattress chromic suture (7-0).

Penoplasty

A simple midline sleeve closure of the shaft skin can be used to complete most repairs. If significant chordee is corrected or a dysgenetic raphe or ventral skin excised, Byars flaps are sometimes required to cover the ventral defect that remains.[24] However, the risks of skin loss and fistula formation increase with the complexity of skin coverage.

TECHNIQUE—TRANSVERSE PREPUTIAL ISLAND FLAP (Fig. 15–4)

Preparation, Incisions, and Dissection

Once the decision to perform the TPIF is made, the urethra is circumferentially mobilized by dividing the urethral

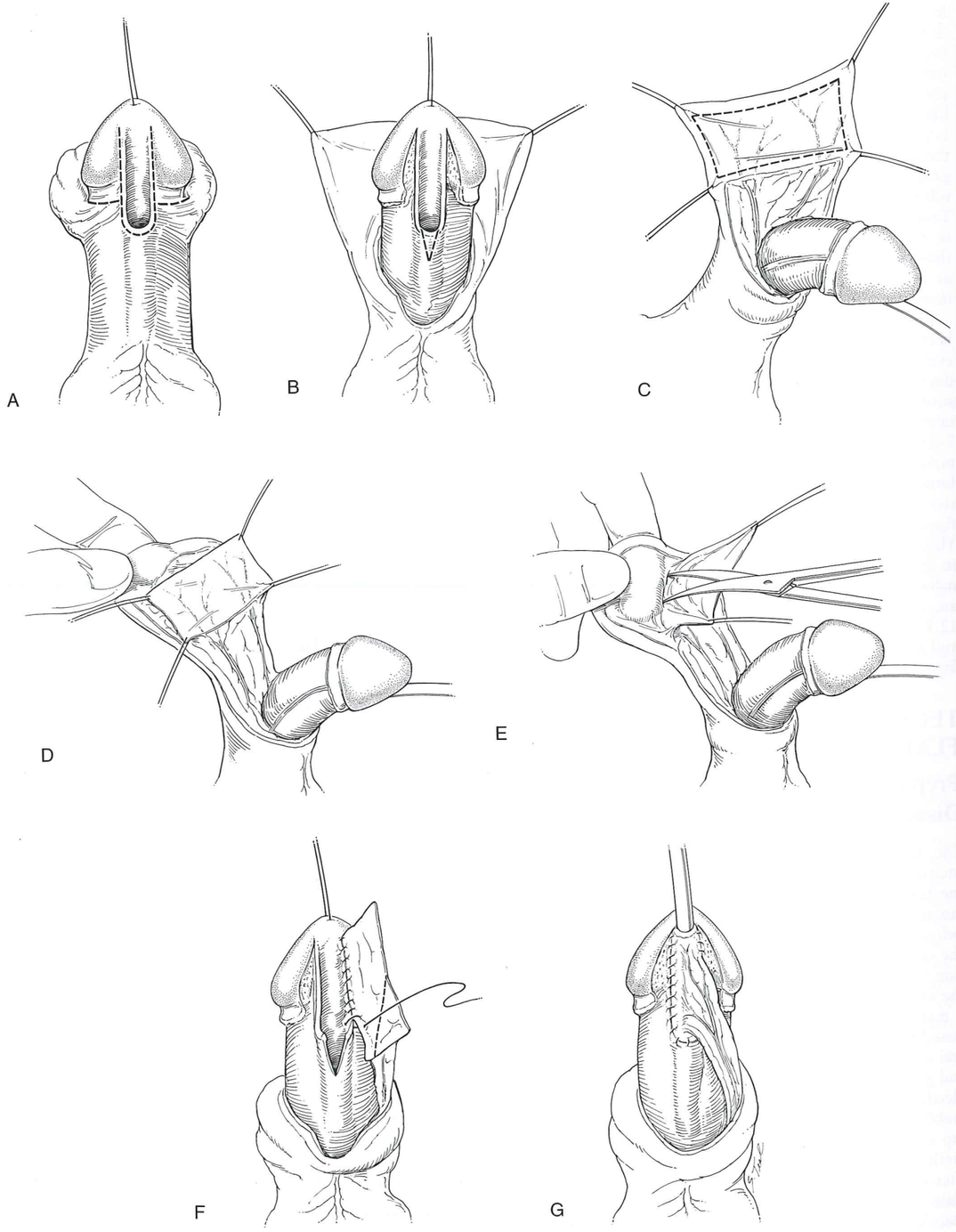


Figure 15–3
Onlay island flap technique. *A:* Lines of incision define the urethral plate. *B:* The urethra is spatulated after taking down the shaft skin. *C* to *E:* The island flap is harvested from the inner prepuce using traction sutures and sharp dissection. *F* and *G:* After being swung ventrally, the island is tailored and anastomosed to the urethral plate. A two-layer glans closure and coverage of the shaft complete the repair.

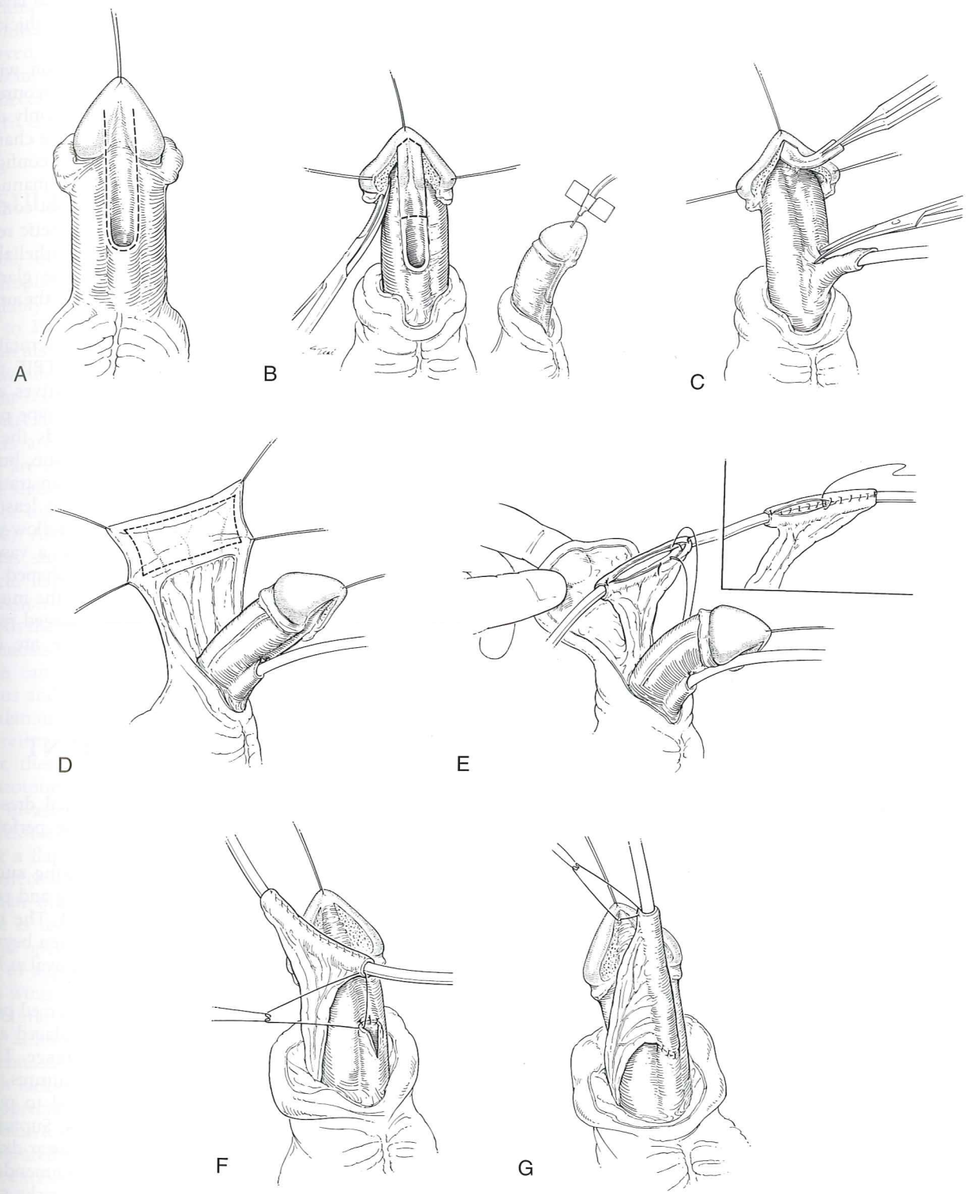


Figure 15–4
Transverse preputial island flap (TPIF/Duckett) technique. *A:* Lines of incision outline and preserve the urethral plate. *B* and *C:* Saline erection documents persistent curvature with the plate intact, which requires its excision (dotted lines) and further urethral mobilization. *D:* After correction of chordee, the inner preputial flap proposed for mobilization is outlined. Mobilization is similar to that in the previous figure. *E:* The flap is tubularized in two layers (inset). *F* and *G:* The native urethra is tacked back to the corpora and spatulated before anastomosing the neourethra between widely splayed glans wings. Two-layer glans closure and skin reapproximation complete the repair.

plate and excising its distal extent. Because maldeveloped corpus spongiosum can contribute to curvature, the proximal urethra is also mobilized from the corpora. Chordee tissue that should be removed often projects well into the glans to tether its wings and fans out far more laterally from the ventral aspect than originally thought. After this is excised and an erection simulated by injection of saline, any additional techniques (plications or corporeal grafts) are completed. The now mobilized urethra is spatulated to healthy tissue and tacked back to the corpora at a more proximal position with fine interrupted poylglycolic acid sutures. This helps to create an oblique anastomosis and eliminates proximal kinking of the neourethra. The length of the urethral defect is then measured.

Harvesting the Flap

A transverse preputial flap of appropriate length and width is outlined on the mucosal layer of the prepuce with tacking sutures. After the epithelial borders of the flap are incised, it is easiest to tubularize the flap before it is mobilized and its pedicle defined. Closure is completed with two running layers. The first, which approximates the epithelium, is run from the inside. The second buttresses the first with redundant pedicle. Interrupted sutures can be used on one side to allow for any tailoring in length that might become necessary. The neourethra and its pedicle are then mobilized to the base of the penis in a fashion similar to that of the OIF. Placing the catheter on gentle traction and distracting the prepuce with stay sutures help define the blood supply of the pedicle.

Completing the Repair

After its ventral transfer, the neourethra is positioned with its suture line abutting the corpora. The two are joined by two or three interrupted sutures along their length to provide fixation of the flap. The proximal anastomosis can be completed with a running suture or interrupted sutures. Redudant pedicle is fanned out to cover the anastomosis with a second layer of tissue. This also helps eliminate unsightly bulkiness from the ventral shaft. Distally, the new urethra is positioned between the glans wings, where its meatus is matured with fine interrupted chromic sutures. Ventral reapproximation of the glans is performed in two layers, and skin coverage is completed using either a sleeve reapproximation or the Byars method.

ADDITIONAL COMMENTS

Some hypospadias variants are not good candidates for either the TPIF or OIF. After taking down the penile shaft skin, it becomes apparent that the subcutaneous tissues are deficient or virtually nonexistent. Creating a preputial flap places the skin coverage in jeopardy or risks devascularizing the neourethra, which by default becomes a free graft still covered by subcutaneous tissues that can retard neovascularity. When this is the case, the mucosal layer of prepuce should be harvested and treated as a full-thickness skin graft and the repair completed accordingly.

The TPIF was originally used in combination with a glans channel (tunnel) technique to deliver the neourethra to the tip of the penis. We now recognize that only occasional cases of hypospadias are appropriate for the channel. Most do not have the type of glanular cleft and configuration that warrant its preservation with this manuever. Glans wings are much easier to construct, do not compromise the neourethra, and give an excellent cosmetic result. When a tunnel is used, a generous button of epithelial and spongiosal tissue should be removed from the glans to permit a broad channel that does not compress the underlying repair.

Finally, the length necessary to correct most scrotal and perineal hypospadias cannot be bridged by a TPIF, given the available shaft skin. A number of alternatives exist. One option is to create a tubularized Thiersch-type proximal extension of the shiny skin that surrounds the meatus.[25] This is, in theory, non–hair-bearing tissue, but we have some concerns. Hair follicles can be demonstrated in this tissue in some boys, and we have seen at least one "bearded" urethra with calculi after long-term follow-up of the technique. Another solution is to harvest a vascular flap from the outer preputial skin. This is shaped as a rectangle rather than the shorter trapezoid of the mucosal layer to allow for some additional length.[26] Staged repairs and urethral replacement with another tissue are other options that could be considered.

POSTOPERATIVE MANAGEMENT

Thorough preoperative teaching and simplified dressings and drains enable virtually every repair to be performed on an outpatient basis.

Dressings. A transparent, permeable dressing such as Op-Site is simple and effective. Penile bleeding and edema are contained, and undue pressure is avoided. The repair is kept dry for 4 or 5 days. Warm baths are then begun to loosen the adhesive and facilitate dressing removal at home or in the office.

Drains. A soft 6 French Silastic stent (reinforced peritoneal shunt tubing) or polyurethane stent is placed across the repair to provide continuous urinary drainage. This is stitched to the glans with 5-0 polypropylene sutures. Double diapering is unnecessary but can be used to protect the repair from an infant's wandering hands. Suprapubic tubes are used for older boys who refuse to wear diapers, although stenting of the repair is still recommended to allow secretions to drain. Premature voiding risks suture line disruption and fistula formation. Seven to 10 days of diversion is recommended for the OIF. Two weeks of drainage is required of the TPIF. When skin loss occurs, stents are left until healthy granulation tissue covers the damaged area.

Other. A broad-spectrum antibiotic (sulfonamide, cephalosporin, or nitrofurantoin) is taken to minimize urinary colonization and is continued for a few days after the catheter is removed. Oxybutynin chloride suspension is recommended if bladder spasms pose a problem. After the initial postoperative visit, when the drainage tube is removed, follow-up evaluations are planned at 6 weeks and 6 months. Meatal calibrations or urethral dilations are not necessary if the child is faring well and the voiding pattern is normal.

RESULTS AND COMPLICATIONS

Despite improvements in management, complications with urethroplasties, especially those of this complexity, still inevitably occur. We cite an overall complication rate of 10% to 15% for the OIF and 15% to 20% with the TPIF to parents of afflicted children. We suspect that a critical review and compilation of most other series would yield similar results. Fistulas are the most common of these, the majority being small and positioned proximally. Secondary repairs are successful in more than 95% of cases when these are unaccompanied by other problems with healing. More significant complications that include glans disruption or total breakdown of the repair are uncommon (1% to 2%). Although the complications generic to any hypospadias surgery exceed the scope of this review, island pedicle flaps are prone to two that warrant additional discussion—stricture and diverticula.

With the exception of meatal stenosis, urethral strictures or stenosis usually occurs at the level of the native meatus. These can be minimized by generously spatulating the meatus and creating an oblique anastomosis with the flap. Angulation of the two is avoided by fixing the native and neourethra to the underlying corpora. When strictures do occur, they are rarely amenable to dilation or cold-knife urethrotomy. Repeated attempts at correction with these "less invasive" measures should be discouraged to avoid progressive corporeal scarring. In most cases, open revision using a flap of redundant penile skin is usually required to correct the problem.[27] Distal strictures that involve the glanular urethra are uncommon if the glans wings technique is used. When these do occur, the glans must be filleted open and an onlay island or perimeatal-based flap used to augment the stricture. This is then covered with glans wings that have been more generously mobilized.[28]

Urethral redundancy is commonly seen with pedicle flaps, although it is rarely clinically significant. Mild to moderate degrees of ventral ballooning of the neourethra, which lacks the investing layers of a normal urethra, can be appreciated on voiding in many boys after surgery. Full-blown diverticula formation or more severe "acquired megalourethra" is less common.[29] Contributing factors include excess flap caliber, urinary extravasation with epithelialization of a localized urinoma, and distal obstruction causing aneurysmal dilatation. Most can be exposed by making a circumcision incision and dropping back the penile shaft skin to the penoscrotal junction. A longitudinal taper and repair avoids overlapping suture lines. Finally, small diverticula cause turbulence and are underappreciated risk factors for fistula formation. These should be identified and corrected in concert with fistula closure.

CONCLUSIONS

Vascularized pedicle flaps represent a landmark contribution to the repair of hypospadias and will assume a major role in its correction for years to come. Nevertheless, the anomaly remains a surgical enigma. Despite decades of technical innovation, the few crucial millimeters of ventral shaft skin that separate the afflicted child from his normally developed peers remains one of the more perplexing challenges in reconstructive urology. A healthy respect for the anatomic variability of hypospadias and the ability to provide alternative solutions to its nuances will always provide the keys to surgical success.

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CHAPTER

16

Use of the Operative Microscope to Repair Hypospadias and the Technique of the Hodgson XX (Modified Asopa) Hypospadias Repair

JEFFREY WACKSMAN

MICROSCOPIC REPAIR

The use of optical magnification to perform surgery is not new. In 1984, I reported my initial results in early hypospadias surgery using optical magnification.[1, 2] The editorial comment by Dr. Norman Hodgson states quite concisely the advantages of optical magnification:

This concept (optical magnification) is important since magnification does more than just make the tissues larger. It develops a conscious awareness of fine vessels and their handling in insuring the ultimate best result. With the delicate instrumentation and technology now available one can assure the successful result in the majority of patients in this early age group.

After experience with 4.5× magnification, I decided to use the operative microscope. The microscope allows for variable magnification, a principle expanded in the repair of hypospadias since my original report. I have used this technique for the past 10 years.

SURGICAL TECHNIQUES

I now use the Zeiss OPMI 6CH operative microscope on a Crontraves stand (Fig. 16–1*A*). This microscope is available in most hospitals with major neurosurgical services that use microscopic techniques for tumor or aneurysm surgery. The main advantage of this particular microscope is that a power-assisted mouthpiece is located just underneath the eyepiece. This bit (Fig. 16–1*B*), when depressed, releases the microscope so that it can be shifted in all directions. When the mouthpiece is released, the microscope becomes stationary (Fig. 16–1*B*). The foot pedal controls both magnification and focus, but it is just as convenient to focus with the mouthpiece once the desired magnification is achieved. The entire scope is placed in a sterile plastic drape. Therefore, the only nonsterile areas are the ends of the eyepiece and the bit. The assistant sits opposite the surgeon, and if the correct eyepiece (Fig. 16–1*C*) is used, the assistant sees exactly what the surgeon views.

The patient is positioned at the foot end of the operating table (Fig. 16–1*D*), with the scrub nurse to the side of the surgeon. One can also place the patient on a hand board off to the side of the operating room table. This position is not routinely used. Because the patient is positioned at the foot of the table, the anesthesiologist needs to intubate most patients, and the tubing from the endotracheal tube to the anesthesia machine needs to be extra long.

Draping the patient is standard. We usually place the feet in the frog position and tape the patient's heels together (Fig. 16–1*E*). The penis is draped with towels. Next, I prefer to use the thyroid drape as a lap sheet. The end going to the head is short, and when placed in the upside-down position, a small amount of the drape hangs over the foot of the table. The longer end goes up to and over the ether screen. The cautery and suction come in from the top and are anchored with a towel clip or Allis clamp to both the drape and the horizontal part of the either screen. This helps to stabilize the drape so that a hemostat placed on the penile traction suture can be secured to the above drape.

The instruments used are standard microsurgical instruments. The forceps used are nontoothed instruments—Adson, jeweler's, or Bishop-Harman. Scissors are usually small tenotomy, Wescott, or microscissors, and needle holders are Castroviejo microtips or Webster. Hemostats used for traction sutures are usually Jacobsen (Jake) microhemostats. A needle-tip Bovie with hand-held control or, on occasion, the eye cautery is routinely used for hemostasis. Suction is usually a small Frazier tip with a small bulb-tip irrigating syringe. For sutures, I routinely use a 5-0 silk or Prolene glans traction sutures on a C-1 tapered needle. Routine sutures are usually 7-0 Maxon for the urethral anastomosis and deep suture lines and 6-0 or 7-0

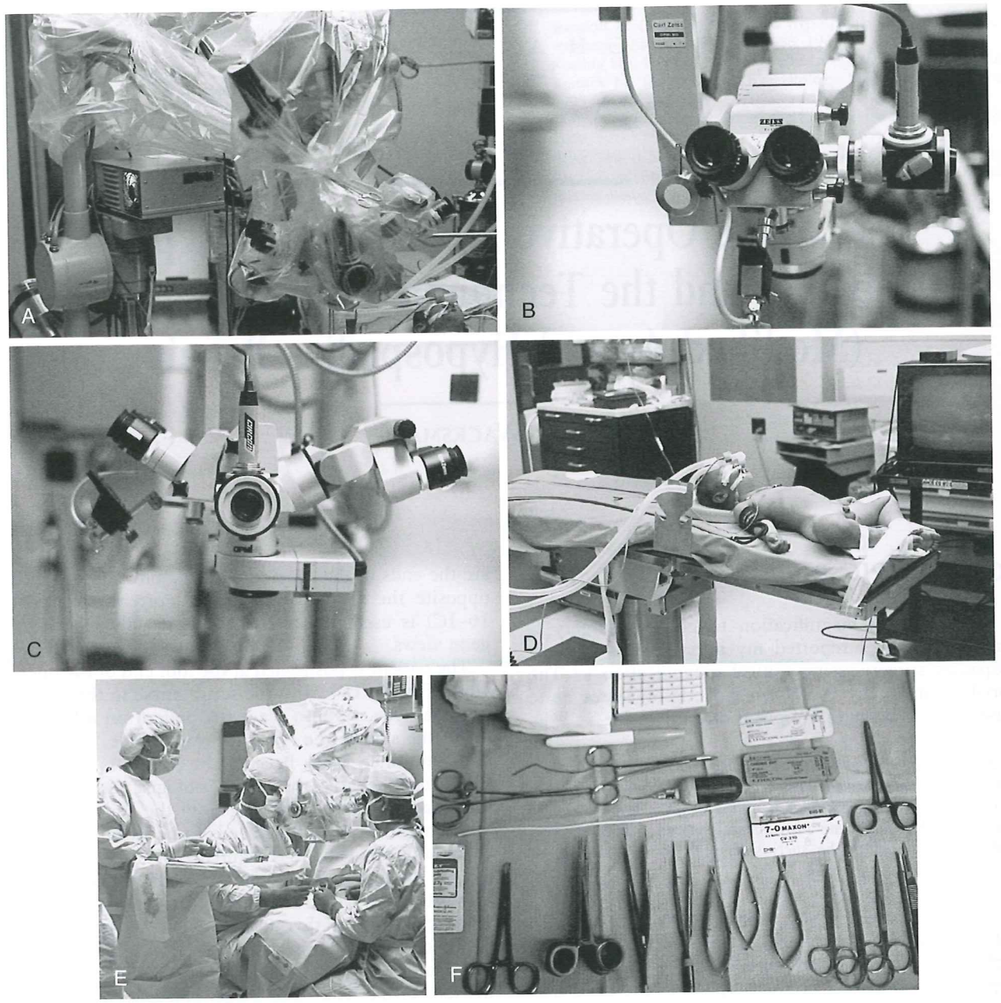


Figure 16–1
A: Microscope in plastic sterile wrap. *B*: Operator's head with releasing bit below eyepiece. *C*: Assistant's eyepiece. *D*: Positioning of patient at foot of table. *E*: Position of surgical team. *F*: Instruments and sutures.

chromic on small microcutting tips for the skin closure (Fig. 16–1*F*).

HODGSON XX (MODIFIED ASOPA) PROCEDURE

In the past 20 years, I have become convinced that chordee that causes a ventral deflection of the penis may be either superficial (skin and dartos tissue) or deep (dysplastic urethra and corpus spongiosum). Most superficial chordee can be corrected by dividing the skin and dartos tissue, but because the urethra is well formed, the urethra itself does not need replacement. However, patients with deep chordee or a markedly dysplastic urethra causing ventral curvature should have this tissue resected.[3–6] This maneuver provides increased penile length. This occasionally does not totally correct the chordee; therefore, a modified Nesbit procedure needs to be accomplished. Because of my beliefs and experience, I recommend some type of urethral tube graft to bridge this defect. I previously used the Duckett[6] preputial tube graft, but during the past 10 years I have used the Hodgson XX (modified Asopa) repair. I reserve the onlay, as popularized by Duckett, to repair only those cases that have no deep chordee and are not believed

to be candidates for the flip-flap, meatoplasty and glansplasty (MAGPI), or glans approximation procedures.

Surgical Techniques (Fig. 16–2)

A traction suture of 5-0 silk is placed in the glans, and a transverse incision is made in the urethral plate between the distal end of the urethra and the glans. The dysplastic tissue is removed, and the penis is *lengthened* and *straightened*. An artificial erection is accomplished, and if the penis is straight, no further dissection is needed. Next, the preputial skin is dissected dorsally back to the penopubic area. The entire foreskin is mobilized. This is very important so that when the foreskin is rotated ventrally, no torsion is created. Next the underneath surface of the foreskin is tented out with 6-0 chromic catgut stay sutures. An 8 French Silastic stent is used for the neourethra. Several small holes are made in the end of the tubing to be placed in the bladder. The underneath surface of the prepuce is cut and rolled loosely over the 8 French Silastic catheter. This is done loosely but not so loosely that it creates a diverticulum. To start the skin tube, 6-0 chromic or 7-0 Maxon sutures are placed at each end and at the midpoint of the neourethra. Next, the neourethra is closed watertight with running 7-0 Maxon, either locking or inverting. At either end of the skin tube, several interrupted sutures are placed so either end of the neourethra can be resected without jeopardizing the running suture. If possible, a second layer of tissue is brought over the neourethra and secured with interrupted 7-0 Maxon. Next, the neourethra is dissected from the prepuce but left well attached. This step is different from the Duckett procedure. With the Duckett procedure, the neourethra is dissected on its pedicle in an attempt to create two blood supplies, one for the neourethra and one for the preputial skin. With the Hodgson XX technique, the neourethra is left attached to the underneath surface of the foreskin. Therefore, the skin and the neourethra share a common blood supply. *The next step is crucial.* The preputial skin is cut on a *bias*. The right side of the prepuce can be rotated onto the ventral surface. The proximal end of the neourethra is sutured to the distal end of the ventral urethra. After the distal end is freshened (removal of the devitalized tissue) and spatulated (usually ventral), an anastomosis is created with 7-0 Maxon over the previously placed 8 French Silastic tubing. The suture line is either interrupted or trifurcated and closed with several running 7-0 Maxon sutures. A second layer of tissue is developed and closed over the anastomosis with interrupted 7-0 Maxon.

Our attention is next directed to the glans. The glans is split in the midline, and two large glans flaps are created. These are brought together in the midline in two layers over the neourethra. An inner layer of 6-0 or 7-0 Maxon followed by an outer layer of interrupted 6-0 chromic is used for this closure. The distal end of the neourethra is sewn to the glans with interrupted 6-0 or 7-0 chromic catgut. The entire repair is covered ventrally with a large flap of foreskin and closed with a running 6-0 chromic. The small flap of preputial skin is also rotated and closed laterally. This maneuver helps lessen the likelihood of penile torsion. The coronal sulcus is also closed with 6-0 chromic.

For a dressing, either one or two layers of Tegaderm are loosely wrapped around the penis. The urethral stent is advanced into the bladder and sutured in place at the tip with three interrupted 5-0 Prolene sutures. The patient is discharged, because all patients, unless medical conditions warrant, are scheduled as outpatients. All are placed on full-strength trimethoprim-sulfamethoxazole. The Tegaderm usually remains in place for 3 to 5 days. The parents are instructed to remove the Tegaderm if it becomes too tight or rolls up at the bottom of the penis. The stent drains urine into the diaper and is left in place until all suture lines are healed (usually 2 weeks). Meatal care is usually unnecessary once the stent is removed.

In my own experience, this repair shows excellent re-

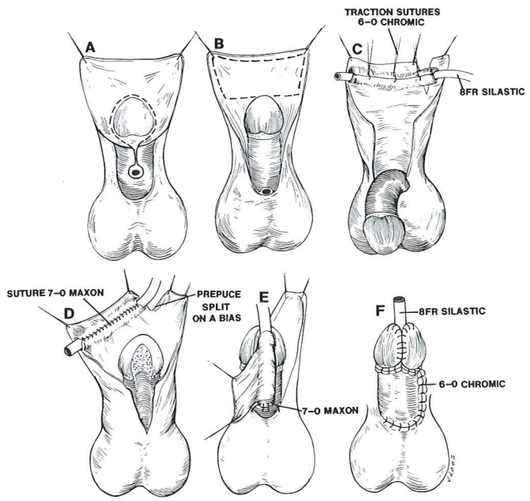


Figure 16–2
A: Incision lines for penile hypospadias. *B*: Underneath surface of foreskin tented out. *C*: Traction sutures to roll tube. *D*: Complete neourethra over 8 French catheter. Foreskin split on a bias after complete mobilization. *E*: Anastomosis completed with proximal urethra. Glans split—not tunneled. *F*: Completed repair. Stent not sewn in place.

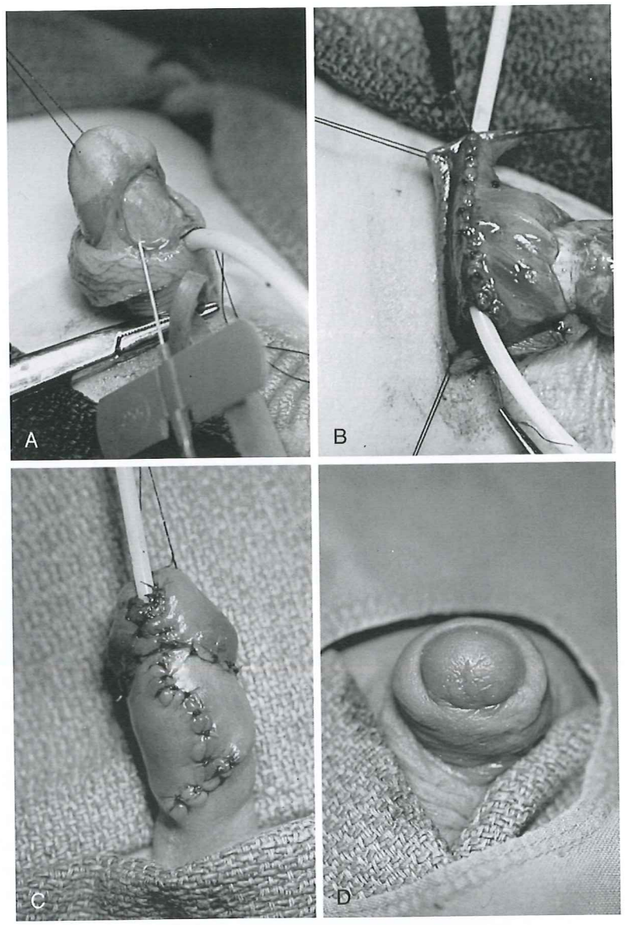


Figure 16–3
A: Chordee release. *B*: Neourethra created. *C*: Completed repair—no torsion. *D*: Appearance of penis 2 months after operation.

sults (Fig. 16–3). The penile edema and fullness usually resolve in 6 to 12 months, and the fistula rate remains around 5%. We have resected an occasional diverticulum and have removed some excess skin, but penile torsion is not a problem as long as the surgeon adheres to the techniques outlined.

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CHAPTER

17

Preputial Graft in Hypospadias

HAL SCHERZ

Proximal hypospadias constitutes somewhat of a reconstructive challenge to most surgeons experienced in treating this problem. Although most of the more recently described procedures and modifications have dealt almost exclusively with distal hypospadias, in contrast, the techniques that are currently most popular in addressing proximal hypospadias have remained unchanged for the past decade—free grafts and island pedicle flaps. As surgeons, we have become increasingly critical in terms of our surgical expectations. A straight penis is one of these expectations, as is a terminal meatus and a good cosmetic result achieved with a single operation (i.e., few or no complications).

Devine and Horton first reported the use of the free preputial graft in hypospadias surgery.[1] The concept of the preputial pedicle graft has previously been described for neourethral construction and for ventral skin coverage as a double-faced repair.[2–4] Kaplan described a modification of this technique by combining the free preputial graft with a preputial pedicle flap for ventral skin coverage.[5] Since this initial report, the application of the free preputial graft with pedicle flap has been extended, and onlay free grafts are currently being performed as frequently as the tubularized repairs.[6]

SURGICAL TECHNIQUE

A circumferential incision is made approximately 0.5 cm proximal to the corona, beginning dorsally, and the incision is carried ventrally down to the native meatus. After the shaft skin is completely dissected proximally to the penile base, chordee is assessed with an artificial erection. If chordee can be corrected with preservation of the urethral plate, as is often possible using dorsal plications, then an onlay free graft is used. However, when it becomes necessary to divide the urethral plate to straighten the penis, a tubularized free graft is constructed.

The graft is harvested from the inner face of the prepuce by first unfolding the prepuce and then amputating the appropriately sized graft, which has been premeasured (Figs. 17–1 and 17–2). The graft is prepared by excising the subcutaneous tissue to create a thin, full-thickness strip of skin. This step is most easily done by pinning the skin strip to a board to stretch it out. To construct the free graft tube, the skin strip is tubularized over a 10 French red rubber catheter using a combination of interrupted and running 7-0 polyglycolic acid (PGA) sutures (Fig. 17–3). The proximal end of the tube is left open as spatulation. The catheter is removed and replaced with an 8 French silicone Foley. The native urethra is spatulated, and the Foley is introduced into the bladder. The balloon is inflated, and the catheter is left indwelling. The proximal end of the graft is anastomosed to the native urethra with interrupted 7-0 PGA suture. The tube is constructed and anastomosed so that the seam of the neourethra is positioned against the corpora cavernosa. The glans is then

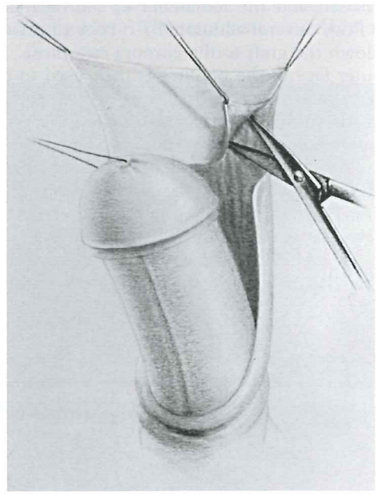


Figure 17–1
Inner preputial skin is dissected and unfolded. (From Stock JA, Cortex J, Scherz HC, et al: The management of proximal hypospadias using a 1-stage hypospadias repair with a preputial free graft for neourethral construction and a preputial pedicle flap for ventral skin coverage. J Urol 152:2335, 1994.)

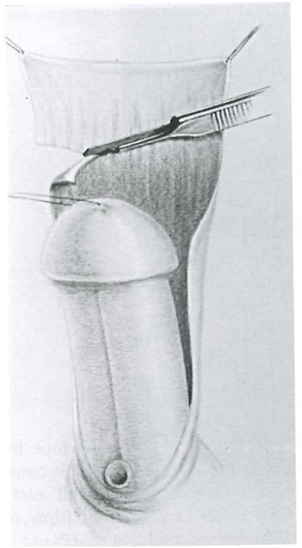


Figure 17–2
The graft is harvested. (From Stock JA, Cortex J, Scherz HC, et al: The management of proximal hypospadias using a 1-stage hypospadias repair with a preputial free graft for neourethral construction and a preputial pedicle flap for ventral skin coverage. J Urol 152:2335, 1994.)

split, and the distal end of the neourethra is anastomosed to the glans at the glans tip, also with interrupted 7-0 PGA (Fig. 17–4). The glans wings are brought together ventrally with several deep 5-0 PGA sutures, and the glans epithelium is closed and the remainder of the meatus secured with 7-0 PGA. Several additional 7-0 PGA sutures are used to tack down the graft to the corpora cavernosa.

The outer face of the prepuce is then used to cover the ventral skin defect by fashioning the pedicle flap. An incision is made through the dermis of the outer prepuce at the approximate level of the corona. This distal skin is mobilized on its vascular pedicle by dissecting the more proximal dorsal skin from the subcutaneous tissue and continuing the dissection to the base of the penis (Fig. 17–5). The distal strip of dorsal skin that now sits on this vascular pedicle can be transposed ventrally by either rotating the flap or bringing the glans through a buttonhole

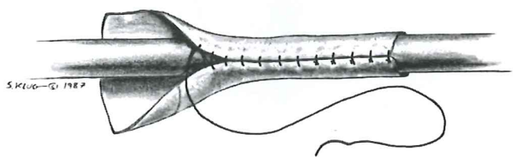


Figure 17–3
The graft is tubularized over a 10 French rubber catheter. (From Kaplan GW: Repair of proximal hypospadias using a preputial free graft for neourethral construction and a preputial pedicle flap for ventral skin coverage. J Urol 140:1271, 1988.)

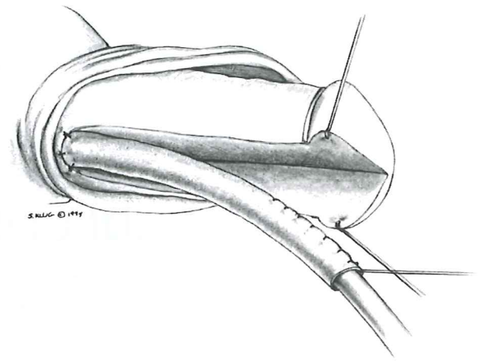


Figure 17–4
The glans is split, and the graft is anastomosed to the native urethra proximally and to the glans tip distally. (From Stock JA, Cortex J, Scherz HC, et al: The management of proximal hypospadias using a 1-stage hypospadias repair with a preputial free graft for neourethral construction and a preputial pedicle flap for ventral skin coverage. J Urol 152:2335, 1994.)

in the vascular pedicle in an avascular space. The latter technique may result in less penile torsion. The pedicle is secured over the graft with interrupted 7-0 PGA, which is also used as skin sutures for the remainder of the repair. Finally, the ventral skin of the pedicle flap is trimmed to fit, and the resurfacing of the shaft is completed (Fig. 17–6). A Tegaderm and silicone prosthetic foam dressing is applied.[7] Both are left in place for 1 week, with the patient immobilized.

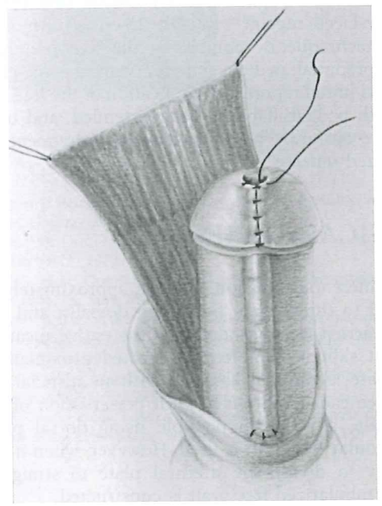


Figure 17–5
The pedicle flap is developed from the outer preputial surface. (From Kaplan GW: Repair of proximal hypospadias using a preputial free graft for neourethral construction and a preputial pedicle flap for ventral skin coverage. J Urol 140:1271, 1988.)

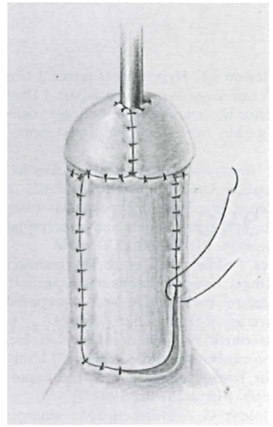


Figure 17–6
The pedicle flap has been transposed ventrally and trimmed and sutured to cover the shaft. (From Kaplan GW: Repair of proximal hypospadias using a preputial free graft for neourethral construction and a preputial pedicle flap for ventral skin coverage. J Urol 140:1271, 1988.)

When the urethral plate is preserved and an onlay free graft is used to reconstruct the urethra, the graft is sutured to the native urethra with interrupted 7-0 PGA sutures at the meatus, and each lateral border is anastomosed with a running subcuticular 7-0 PGA suture. Distally, we have used the Barcat balanic groove technique to advance the neourethra farther distally to achieve an improved cosmetic appearance.[8]

It has generally been accepted that vascularized island flaps are superior to free grafts based on the assumptions that the flap is better vascularized and hence will grow better and may result in fewer complications than a free graft. Kaplan reviewed the various reported series of one-stage proximal hypospadias repairs using either a tubularized flap or free graft of preputial skin. He found no statistical difference in the reported complication rates of the techniques. The fistula or stricture rate requiring another procedure varied from 7% to 53%, with a compiled rate of 103 such complications in 368 cases (28%). In the series reported by Stock and colleagues, 77 patients underwent a free graft repair with pedicle flap coverage. Twelve required a repeat operation (16%). Of the 77, 44 underwent a tubularized free graft and 33 underwent an onlay free graft. The complication (reoperation) rate in the former group was somewhat higher (20%) than in the latter (9%).[6] Nonetheless, whether analyzed together or separately, the applicability and success of this technique compare favorably with others described for repair of proximal hypospadias.

The conditions necessary to ensure successful free graft survival were enumerated by Devine and associates. These include having a well-vascularized host bed, rapid onset of imbibition, close apposition of the graft to the host bed, immobilization of the graft, and rapid onset of inosculation.[9] In imbibition, the graft absorbs nutrients from the host bed, and this phase lasts approximately 48 hours. Inosculation involves reestablishment of vascularization to the graft by anastomosis of the exposed vessels of the host bed with the vessels of the graft. This phase is usually complete by 96 hours.

Movement of the graft on its bed before inosculation is likely to interfere with graft survival; consequently, immobilization is an important ingredient for success. This previously meant hospitalization for 1 week in soft restraints. Unfortunately, economics has made this type of management difficult to justify, especially when other proximal hypospadias repairs can be performed as outpatient surgery. We have recently discharged the patients on the same day of surgery by having a spica cast applied at the end of the procedure to maintain immobilization. The cast is open over the genitalia to make diaper changes relatively simple (Fig. 17–7). The cast is removed on postoperative day 7, on the same day as dressing and catheter removal. We have not noted a rise in complications since changing to this type of management.

Another possible reason for the good success of free graft with preputial flap may be the result of improved inosculation because the graft is sandwiched between two well-vascularized beds. The vascular pedicle also covers the repair, and this is a well-accepted technique in reducing the rate of fistula formation.

The lower complication rate in the onlay fee grafts compared with the tubularized free grafts may be explained by the better blood supply of the urethral plate than the corpora cavernosa. Further, urethral reconstruction of the onlay is accomplished using a running subcuticular closure compared with a running simple closure used for tubularized repairs. In studies of urethral healing, fewer complications (i.e., fistulas) can be expected when techniques that exclude urothelium are used in closure.[10] The complications that have been encountered are either strictures or fistulas. No cases of graft loss have occurred in the series of Stock and colleagues.[6] The treatment of urethral strictures



Figure 17–7
Spica cast showing immobilization of the patient after free graft repair.

should initially be by either dilation or internal urethrotomy. If this fails, subsequent attempts short of open urethroplasty are unlikely to succeed.[11]

The use of the free graft repair may be relatively contraindicated when chordee is severe and a tunica vaginalis or dermal graft is required to bridge the defect created by incision of the tunica albuginea to accomplish penile straightening. In this situation, the host bed may be unsatisfactory to support imbibition and insoculation. Patients who have had previous failed hypospadias repairs may similarly have an unsatisfactory host bed and blood supply to allow graft survival.

In patients who have a proximal hypospadias and who have not undergone previous operation, the preputial free graft with pedicle flap is an excellent choice. First, the success rate as reported is excellent and is perhaps superior to that of other proximal hypospadias repairs. The neourethra and penile skin can be handled separately, which is technically easy to do, but more importantly, because the blood supply to one does not affect that to the other, the entire repair is less likely to fail. Finally, the cosmetic appearance may be superior because of less bulk and less chance of penile torsion, especially with the buttonhole technique of flap transposition.

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CHAPTER

18

Yoke Hypospadias Repair

BRENT W. SNOW
PATRICK C. CARTWRIGHT

Repair of severe hypospadias in one stage is among the most difficult challenges a reconstructive surgeon may face. Most procedures in the past relied on several stages, each of which had its own complication risks. More recent attempts have relied on multiple stages or combinations of other well-described repairs.[1, 2] Each repair having been designed for a specific purpose may not necessarily be easily combined with another. The combination of different techniques also often introduces another anastomosis to heal and another potential location for complications to occur.

In an attempt to solve this dilemma for patients with severe hypospadias, a repair with dual blood supply would offer many advantages. Two of the most common categories of hypospadias repairs are parameatal-based flaps and island pedicle flaps. Each flap has a rich blood supply from opposite sides of the phallus. Therefore, these two types of procedures seem to be an ideal combination of repairs to correct severe hypospadias. The problem of adding an additional anastomosis could be eliminated by using opposite-side blood supply to each part of the repair and then not dividing the urethral plate so the blood supply can be continuous and from both sources simultaneously. With these concepts in mind, the yoke hypospadias repair was conceived.[3] This new procedure combines urethral plate, parameatal-based flap, and pedicle flap techniques into one procedure without the need for an intervening anastomosis. The name comes from the appearance of the initial incision when outlined (Fig. 18–1). This looks similar to the yoke draped around the neck of work animals—that is, a continuous band around the glans penis extending down to the hypospadiac urethral meatus.

TECHNIQUE

The inner incision is drawn around the glans penis where a circumcision incision is normally made. As the incision approaches the ventral midline, it dips modestly toward the urethral meatus but not too severely. The outer incision begins proximal to the hypospadiac urethral meatus and extends parallel distally along the shiny urethral plate tissue (see Fig. 18–1). The incisions should be marked sufficiently wide to make a urethra of adequate caliber by rolling the urethral plate into a tube with a millimeter or two extra to allow for suturing the anastomosis. Remember that the width of the neourethra in centimeters will equal the neourethra French size. As the marker approaches the coronal margin, the ink then parallels the circumcision incision, being the width of half of the neourethra on each side plus 1 to 2 mm allowed for suturing purposes. This mark is taken completely around the glans penis just as the circumcision incision was.

Once marked, the circumcision incision is made first adjacent to the coronal margin. The shaft skin is dissected down to Buck's fascia and degloved, and chordee is re-

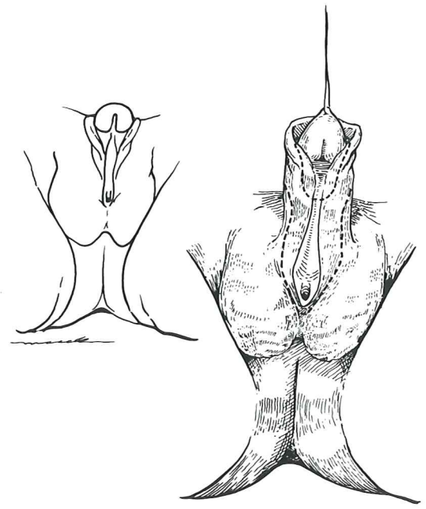


Figure 18–1
Severe hypospadias is depicted, and the outline of the incisions is marked by a broken line. (From Snow BW, Cartwright PC: The yoke hypospadias repair. J Pediatr Surg 29:557–560, 1994.)

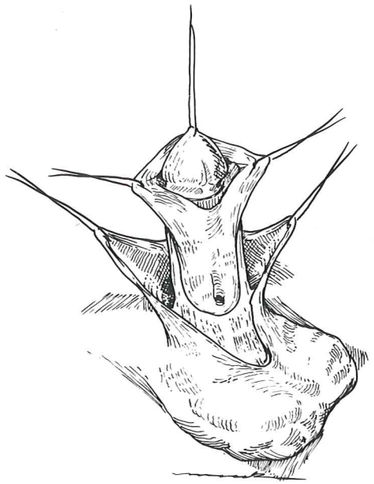


Figure 18–2
Incisions have been made, and chordee has been corrected. (From Snow BW, Cartwright PC: The yoke hypospadias repair. J Pediatr Surg 29:557–560, 1994.)

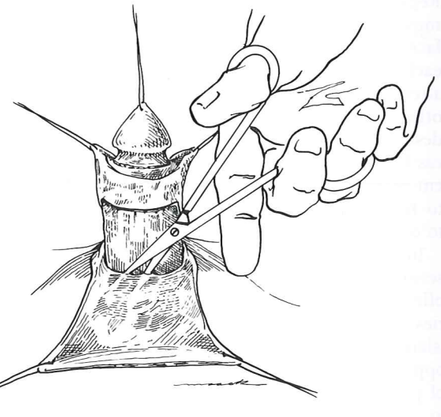


Figure 18–3
Care is taken to dissect the shaft skin away from the neourethra and its vascular pedicle. (From Snow BW, Cartwright PC: The yoke hypospadias repair. J Pediatr Surg 29:557–560, 1994.)

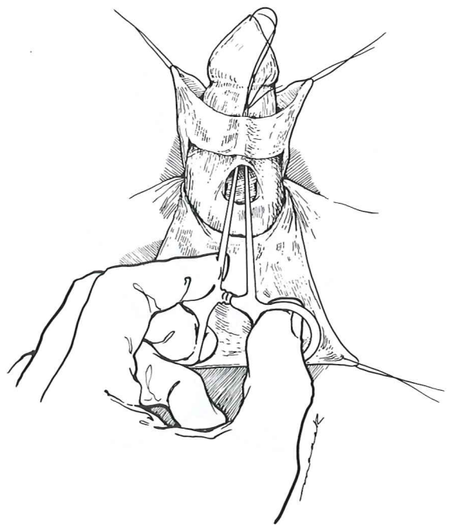


Figure 18–4
A dorsal view of the penis after the buttonhole has been made and the glans penis is about to be drawn through this site. The neourethra is then ventrally located. (From Snow BW, Cartwright PC: The yoke hypospadias repair. J Pediatr Surg 29:557–560, 1994.)

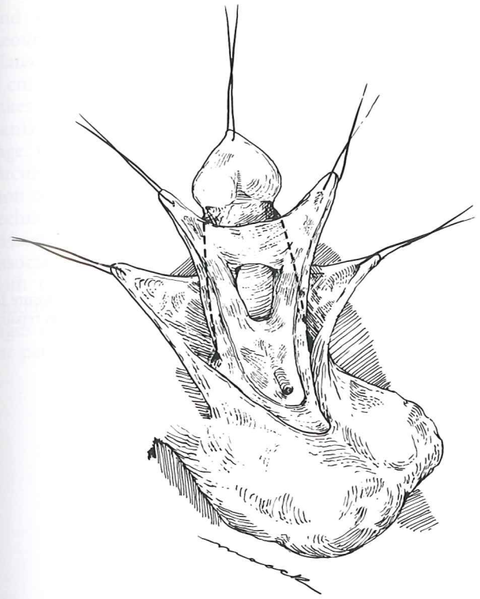


Figure 18–5
A ventral view after the glans penis has been passed through the buttonhole. Note that all the neourethra tissue is now ventral, with an opening in the posterior neourethra where the glans previously was located. (From Snow BW, Cartwright PC: The yoke hypospadias repair. J Pediatr Surg 29:557–560, 1994.)

paired. The urethral plate may be elevated if necessary to aid the chordee correction. Once the chordee is corrected, the outer incision is begun, starting ventrally. The incision is made just through the dermis layer but not deep enough to disrupt the blood supply from the surrounding tissue (Fig. 18–2). Dissection is then begun away from the neourethra, elevating the surrounding skin for 0.5 to 1 cm. This leaves the adjacent blood supply intact (Fig. 18–3). Next, over an appropriate-sized stent, the urethra is tubularized using fine absorbable suture in two layers. This tubularization continues to near the coronal margin before further dissection is necessary. The parallel circumferential incision is then made again just through the dermis. The proximal shaft skin is elevated just as is done during an island preputial pedicle flap.[4] The major difference is that the dissection is seldom necessary for more than 1 to 1.5 cm from the coronal margin toward the base of the penis. This makes this blood supply more reliable. Then the dorsal collar of the yoke is passed ventrally by making a buttonhole in the dorsal pedicle near the shaft skin margin (Fig. 18–4). The glans penis is then pulled through the buttonhole. This transfers all of the neourethra tissue to the ventral aspect (Fig. 18–5). The previously tubularized segment reaches part of the way to the tip of this neourethra. Before more tubularization takes place, the posterior wall of the neourethra requires a midline closure with fine absorbable suture. This opening is the original hole where the glans penis was initially located. When the posterior wall has been closed, the anterior wall is closed over the same stent to tubularize the neourethra to near the tip (Fig. 18–6). This is again done in two layers with the same suture material. At the tip of the neourethra, a hood always develops and needs to be trimmed but should await this trim until the neourethra is in place. A glans channel is formed by dissecting over the corpora cavernosa to the tip of the glans penis. The neourethra is passed through this channel. The ventral edges are sutured to the glans to begin forming the new meatus. The epithelium of the hooded tip can then be trimmed to fit the new meatus. This hood ensures a good blood supply, and trimming the epithelium only maintains this advantage (similar to a Turnbull modification of an ileal conduit stoma).[5] A drainage tube is left in place and sutured securely. The shaft skin is now near its final location and has had very little mobilization. It should be trimmed and closed around the coronal margin like a circumcision and down the ventral midline to simulate the median raphe (Fig. 18–7). Scrotoplasty is often necessary to complete the repair.

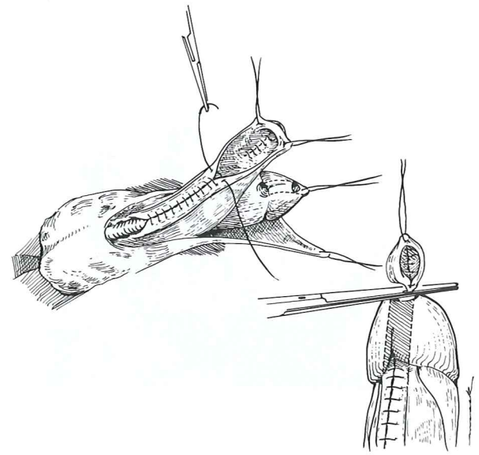


Figure 18–6
With the posterior opening in the neourethra closed, the anterior neourethra is sutured closed. The redundant hood is then trimmed. (From Snow BW, Cartwright PC: The yoke hypospadias repair. J Pediatr Surg 29:557–560, 1994.)

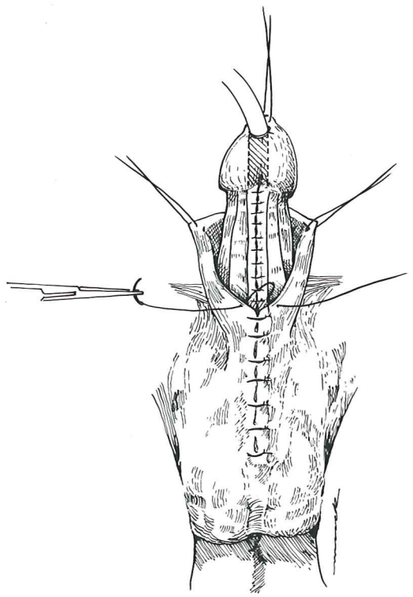


Figure 18–7
The shaft skin is then closed with a median raphe closure and a circumcision closure for a good cosmetic result. (From Snow BW, Cartwright PC: The yoke hypospadias repair. J Pediatr Surg 29:557–560, 1994.)

Previous surgeons have had similar ideas, but none have attempted to preserve the blood supply in this fashion. Russell reported parallel circumferential incisions he called a *stole procedure* in 1900.[6] The operation was staged and failed to maintain a pedicle blood supply, and the inner urethral incision was not sutured closed. Koyanagi and colleagues subsequently developed a wing flap-flipping urethroplasty.[7] Exceedingly long parameatal-based flaps were obtained by making parallel circumferential incisions dividing the collar in the dorsal midline and not preserving the dorsal pedicle blood supply.

This repair has been reserved for severe hypospadias; therefore, experience with it is limited. Functionally and cosmetically, the results have been excellent (Figs. 18–8 and 18–9). We have yet to see the occasion that the neourethra formed as described did not reach the tip of glans penis with ease. The repair has been used to create 9 cm of neourethra without difficulty. This new technique takes advantage of the blood supply of each side of the penis and combines these to the neourethra's best advantage. Only longitudinal suture lines are required, avoiding circumferential anastomoses of combined procedures. Torsion of the penile shaft is avoided by using the buttonhole technique for the vascular pedicle. Minimizing pedicle dissection also limits the possibility of pedicle damage associated with the more aggressive mobilization required with other techniques. We believe that by preserving a unique blood supply, the yoke repair has distinct advantages over combination repairs and can be recommended for patients with severe hypospadias.

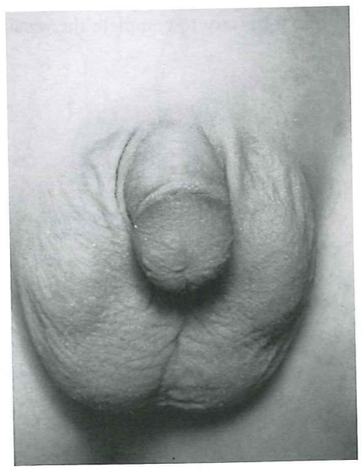


Figure 18–8
The dorsal view of the completed procedure 3 months later. (From Snow BW, Cartwright PC: The yoke hypospadias repair. J Pediatr Surg 27:557–560, 1994.)

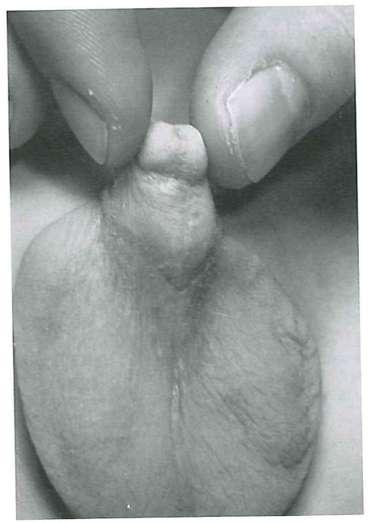


Figure 18–9
The ventral surface of the penis 3 months later. (From Snow BW, Cartwright PC: The yoke hypospadias repair. J Pediatr Surg 27:557–560, 1994.)

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CHAPTER

19

Hypospadias Repair: One-Stage Urethroplasty with Parameatal Foreskin Flap for All Types of Hypospadias

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KATSUYA NONOMURA

Numerous operative techniques have been reported for the repair of hypospadias. Those who confront this difficult and challenging problem have long been advised to be well acquainted with various such techniques. The one-stage repair that has evolved during the past two decades is now popular and has withstood the test of time.[1] In the majority of cases of distal hypospadias, remarkably high success rates can be expected with various types of single-stage repair.[2–4] Nonetheless, in the repair of proximal hypospadias, in which the deformity is much more severe, these techniques have a limited role, and only a few have been established as suitable for correction of all the concurrent abnormalities (e.g., hypospadiac urethra with severe chordee, ventrally tilted globular glans with dorsal skin hood, and propenile bifid scrotum) in one stage with a reasonable rate of success.[5, 6] Many still advise staged repair in this difficult setting.[1] Admittedly, repair of hypospadias is one of the most complex and demanding procedures of reconstructive urologic surgery, and the advice that hypospadiologists should be well armed with all these operative techniques as their options is well taken. Nevertheless, a simple single-stage method that is universally applicable to all types of hypospadias, from very mild (glanular and coronal) and moderate (penile and distal to penoscrotal) to more severe ones (scrotal and perineal), would immensely benefit both these children and the hypospadiologists alike. The technique of one-stage urethroplasty with parameatal foreskin flap (OUPF),[7] which would conform to these criteria, is described here.

OPERATIVE TECHNIQUE

The technique follows steps 1 to 7, summarized in Figure 19–1.

Step 1: Outlining the Skin Incision and Dartos Mobilization. A traction suture is placed on the most distal edge of the glans. Any foreskin adhesion is gently released from the glans. The meatus is dilated with the tip of a fine curved mosquito clamp, or ventral meatotomy is made close to the intact spongy tissue if necessary. A fine 6 French urethral silicon catheter (Cliny, Create Medic/Japan) is introduced into the bladder. Gentian violet is used to mark the skin incision before incision. Regardless of the type of hypospadias, this encircles proximal to the hypospadiac meatus and extends laterally and dorsally to the penile foreskin until it meets with its counterpart at 12 o'clock (Fig. 19–2, Step 1A; Fig. 19–3, Step 1A). In proximal hypospadias, lateral incision extends on both sides along the medial edge of the scrotal raphe as it is adhering to the penile shaft by virtue of a bifid or propenile scrotum (Fig. 19–4, Step 1A; Fig. 19–5, Step 1A). Lateral parameatal skin marking should be wide enough to form a base for a parameatal foreskin flap but in proximal hypospadias to stay medial to the scrotal raphe so that potentially hair-bearing scrotal skin is not incriminated in the flap. Similarly, circumcoronal outlining of the dorsal foreskin should be away from the sulcus so that enough preputial foreskin is included, because this is where the parameatal-based pedicle foreskin flap, whether in the form of a unilateral manta-wing foreskin flap in distal hypospadias or a fully extended bilateral circumferential foreskin flap in the proximal type, is harvested for eventual urethroplasty, OUPF-II and OUPF-IV, respectively. With fine curved iris scissors, a shap incision is made along the full circumference of the previously defined skin marking. While the glans and shaft are held under a fine dressing gauze, the penile foreskin proximal to the incision is mobilized by dissecting sharply in the plane between the Buck's and the dartos fascia. This dartos mobilization of the skin should be adequate or extensive enough in both the dorsum and ventral aspect of the penis so that when it is completed the penile shaft is degloved, being freed from the penile foreskin in distal hypospadias (Fig. 19–2, Step 1B; Fig. 19–3, Step 1B) or from lateroventrally adherent bivalved scrotum in proximal hypospadias (Fig. 19–4, Step 1B; Fig. 19–5, Step 1B). Minimal bleeding is usually encountered because all the vessels in the skin extend axially.[8] Thus, when brisk bleeding is encountered, the dissection is too deep in either the skin or the corporeal body and must be corrected in due course. The mobilized skin is gently protected under moistened gauze until its later use (Step 6).

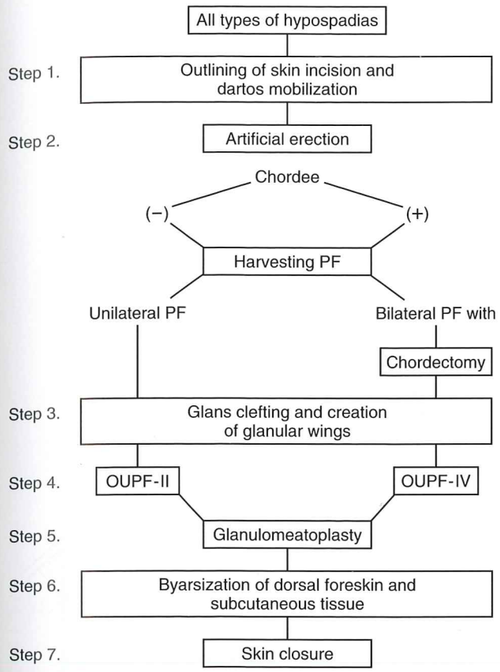


Figure 19–1
Flow chart of operative technique. PF, parameatal foreskin flap; OUPF-II, one-stage urethroplasty with meatal-based manta-wing foreskin flap; OUPF-IV, one-stage urethroplasty with parameatal-based and fully extended circumferential foreskin flap; (−), chordee released; (+), chordee remaining.

Step 2: Artificial Erection, Harvesting Parameatal Foreskin Flap(s), and Chordectomy As Needed. In distal hypospadias, the urethra is not fibrously atretic but its spongy tissue is merely splayed out distally, lacking Buck's fascia and loose subcutaneous tissue. Skin adheres not only to the edges of hypospadiac urethra but most prominently to the ventral part of the urethral wall proximal to the hypospadiac meatus.[9, 10] These are etiologically significant factors in the genesis of its chordee deformity.[11] Thus, when the penile shaft is degloved by adequate dartos mobilization, it ought to be straightened, and straightness can easily be confirmed by artificial erection (Fig. 19–2, Step 2A; Fig. 19–3, Step 2A). Then the stage is set for harvesting the parameatal flap and OUPF-II. Further skin markings are placed in the remnant distal foreskin, which is still attached to the urethra and glans. The marking for the meatal-based manta-wing foreskin flap starts from the dorsum of either side, courses circumcoronally down to the subglanular edge of the urethral plate, and extends all the way along its edge to the most distal end of the glans where the traction suture was placed. When designing the skin flap, care should be taken to make it wide and long enough to cover the urethral plate without undue tension. Another line in the other side of the foreskin extends from the meatus to the glanular tip, coursing longitudinally along the side of the urethral plate. The lines in the meatal groove should be parallel to each other so that an intact meatal plate remains with the urethral plate. By cutting the proposed lines of incision, the parameatal-based manta-wing foreskin flap is elevated and the urethral plate is fashioned (Fig. 19–2, Step 2B; Fig. 19–3, Step 2B). Unlike distal hypospadias, dartos mobilization alone is not sufficient to restore ventriflexion of the penis in proximal hypospadias, which is easily confirmed by an artificial erection (Fig. 19–4, Step 2A; Fig. 19–5, Step 2A). In proximal hypospadias, a hypospadiac urethra distal to the meatus is laterally atretic and fibrotic, adhering tightly to the ventral aspect of the penile corpora, thus resulting in its ventriflexion or chordee deformity.[10] The atretic urethra must be sharply excised, freed, and mobilized proximally enough to encounter a dorsum of intact spongy urethra. Before proceeding to this classic chordectomy by excising buried tissue,[12] however, another marking for the flaps for urethroplasty is made on the distal foreskin, which was intentionally left attached to the distal shaft during dartos mobilization. This starts from the dorsal midline at 12 o'clock, securing enough width, and extends circumcoronally along the sulcus on both sides of the glans until it comes to meet in ventral midline at 6 o'clock the subfrenulum by crossing the atretic urethral plate.

Again using fine iris scissors, a flap is harvested on both sides by cutting along the proposed skin marking (Fig. 19–4, Step 2B; Fig. 19–5, Step 2B), transecting the urethral plate (Fig. 19–4, Step 2C; Fig. 19–5, Step 2C), and then mobilizing the urethra (Fig. 19–5, Step 2D) while the flaps are gently protected under the moistened gauze. This essentially combines the classic chordee release with harvesting of parameatal-based and fully extended circumferential foreskin flaps. When the urethra is mobilized enough, chordee is usually corrected, and this can be confirmed by another artificial erection (Fig. 19–4, Step 2E). A fibrous tissue in the intercorporeal septum must occasionally be excised (Fig. 19–5, Step 2E), and very rarely dorsal plication under the neurovascular bundle is necessary to complete the chordectomy.

Step 3: Glans Cleavage and Creation of Glanular Wings. When chordee is absent at the outset or has been released by dartos mobilization alone, an incision is made, parallel to both sides of the urethral groove, and the glans is cleaved, thus preserving the urethral plate (Fig. 19–2, Step 3; Fig. 19–3, Step 3). When the urethra is severed, the glans is cleaved by a vertical midline incision. After the glans has been split thus, the incision is deepened to the level of the corpora and glanular wings are created by judicious lateralization of the glanular substance, literally kippering the glans (i.e., splitting it and splaying it out laterally, to flatten it) (Fig. 19–4, Step 3; Fig. 19–5, Step 3).[14] Because of the separate origins of the glans, urethra,

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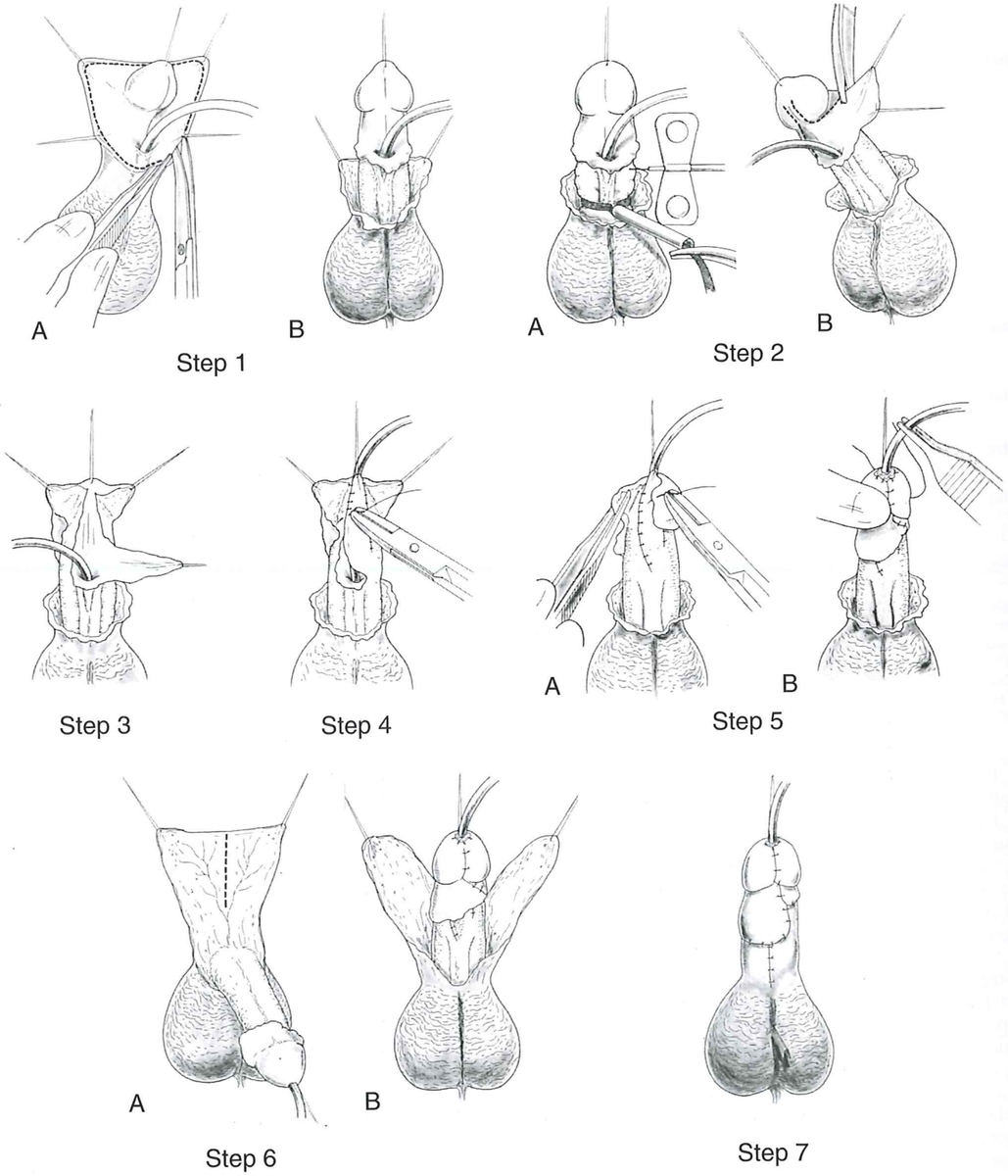


Figure 19–2
The technique of onlay urethroplasty with parameatal foreskin flap (OUPF-II). A detailed description is given by Koyanagi and colleagues.[17]

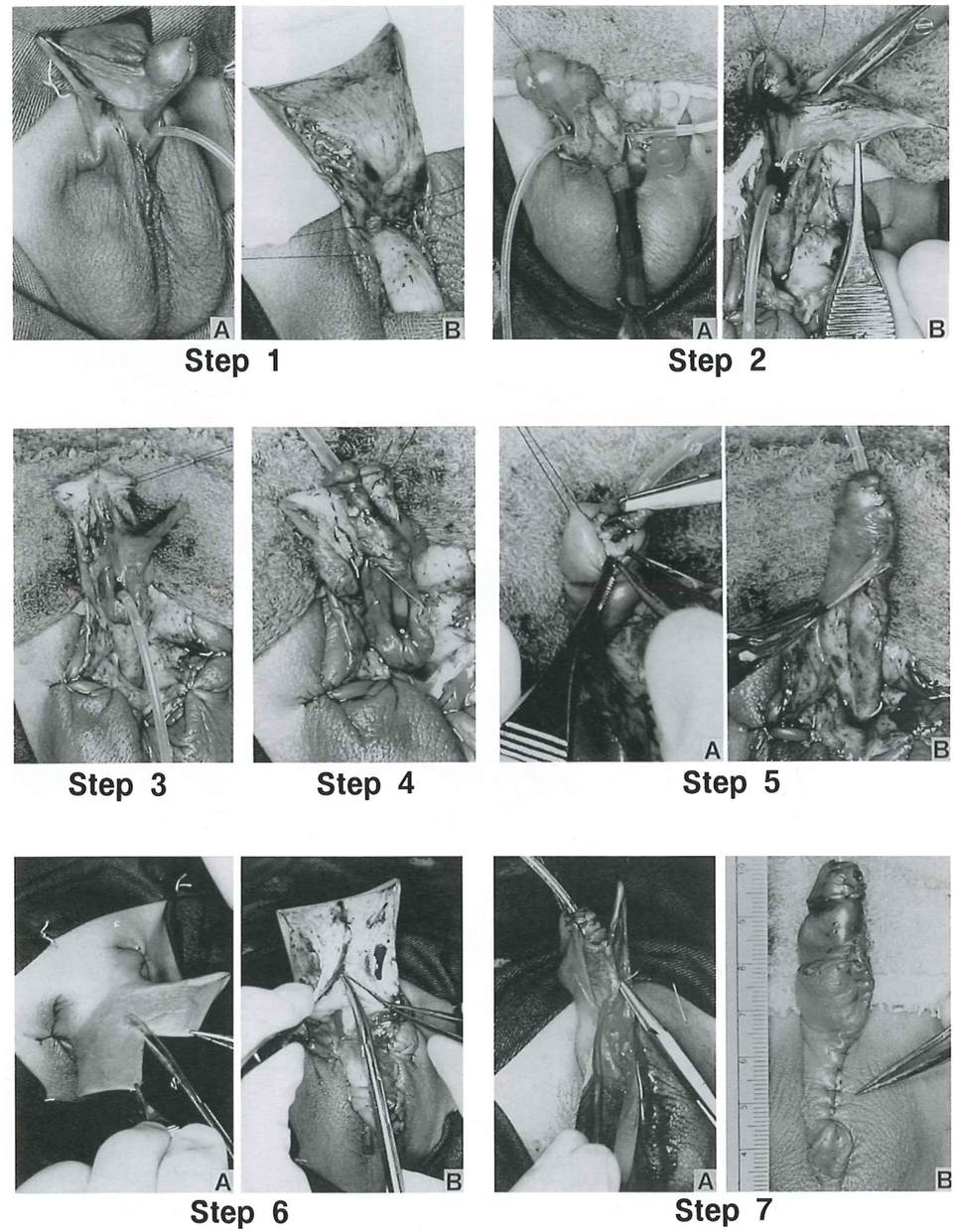


Figure 19–3
The technique of onlay urethroplasty with parameatal foreskin flap (OUPF-II). A detailed description is given by Koyanagi and colleagues.[17]

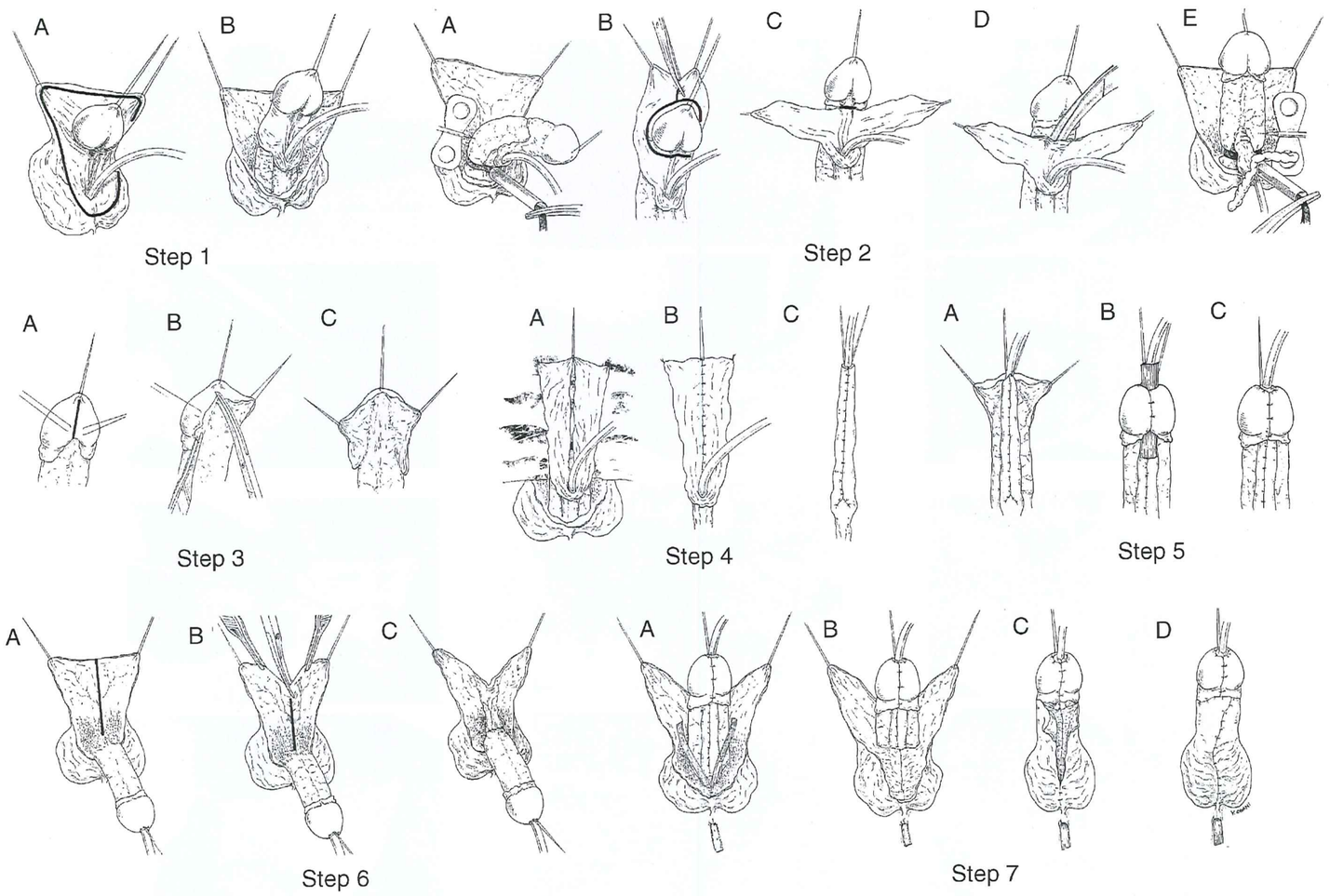


Figure 19–4
The technique of one-stage urethroplasty with bilateral parameatal foreskin flaps (OUPF-IV). Details are described by Koyanagi and colleagues.[18]

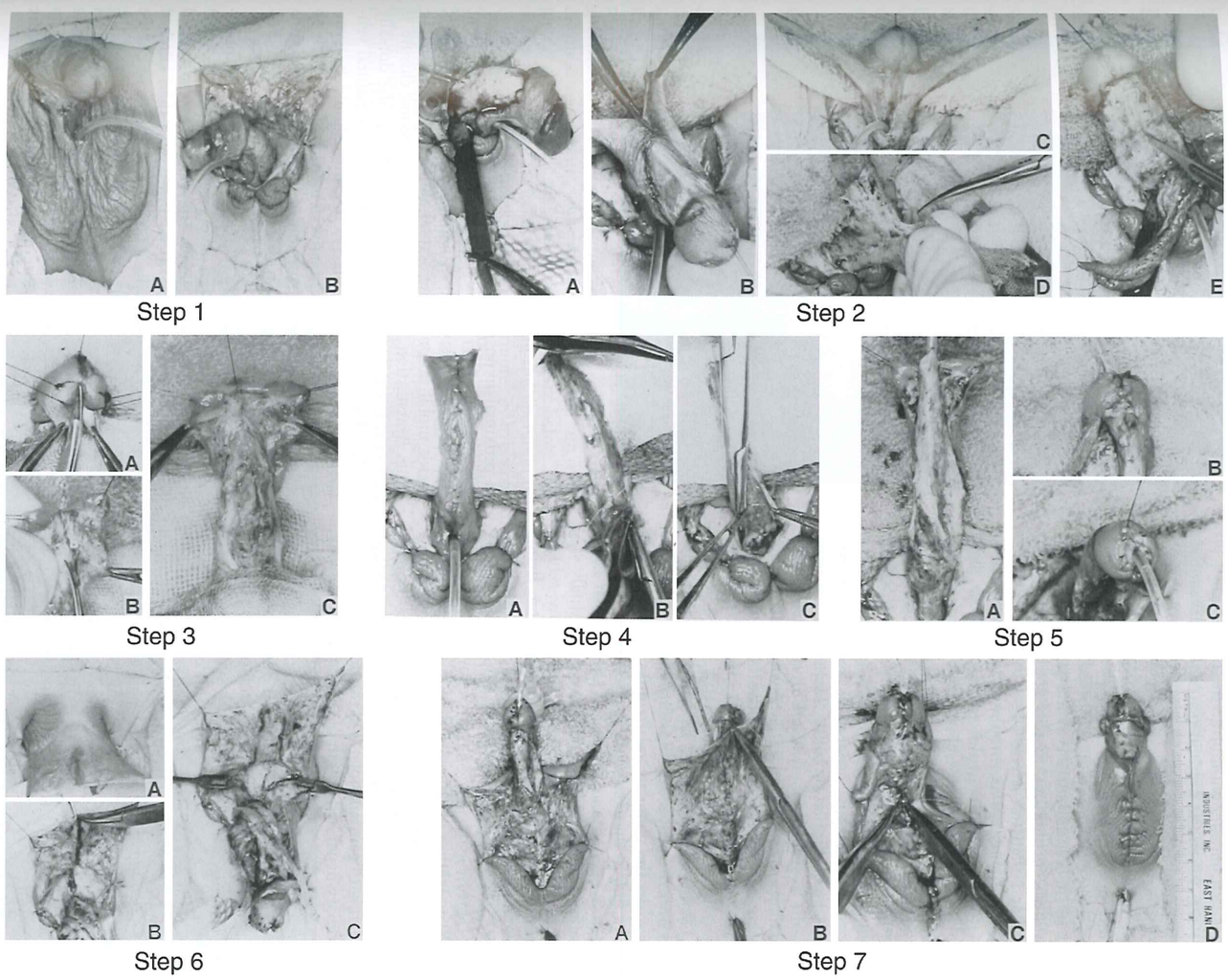


Figure 19–5
The technique of one-stage urethroplasty with bilateral parameatal foreskin flaps (OUPF-IV). Details are described by Koyanagi and colleagues.[18]

and corporeal body,[15, 16] this dissection can usually be accomplished anatomically without undue bleeding.

Step 4: OUPF. When the urethral plate is preserved, the elevated parameatal foreskin flap is simply laid on top of it to form the neourethra (one-stage urethroplasty with meatal-based manta-wing foreskin flap, OUPF-II) (Fig. 19–2, Step 4; Fig. 19–3, Step 4).[17] When the urethral plate is transected and severed, parameatal-based foreskin flaps are brought to the ventral surface of the penile shaft and fashioned into the neourethra, first by approximating the medial edges and then the lateral edges over the inlying urethral catheter (one-stage urethroplasty with parameatal-based and fully extended circumferential foreskin flap, OUPF-IV)[18] (Fig. 19–4, Step 4; Fig. 19–5, Step 4). All stitches are interrupted 7-0 PDS II (polydioxanone). Free movement of the urethral catheter must be ensured by occasionally sliding it up and down while fashioning the urethra. Two-layer closure by approximating loose subcutaneous tissue of the flaps secures its water tightness, which should be confirmed by saline flushing of the neourethra. Axially extending blood vessels in the flaps should be avoided from inadvertent bite. Several reenforcing stitches are to be added as needed. The neourethra thus formed is now anchored to the distal edge of the cleft glans.

Step 5: Glanulomeatoplasty. The glans wings are approximated over the neourethra as well as the paraglanular foreskin to cover the glanular and frenular portion of the distal urethra, while the rest of the somewhat protruding urethral edge is everted and sutured to the glanular edge in a semicuffed fashion. When completed, a vertically slit meatus opens at the most distal end of the glans, which has been restored to a normal conical shape from being somewhat ventrally tilted and globular in shape (Fig. 19–2, Step 5; Fig. 19–3, Step 5; Fig. 19–4, Step 5; Fig. 19–5, Step 5).

Step 6: Byarsization of Dorsal Foreskin and Its Subcutaneous Tissue. The protecting moistened gauze dressing is removed from the dorsal penile foreskin. Before Byarsizing this flap for wound closure, another midline vertical mark is added with gentian violet. On the dorsal cutaneous side, an ordinary distal half length of the flap is satisfactory (Fig. 19–2, Step 6A; Fig. 19–3, Step 6A; Fig. 19–4, Step 6AB; Fig. 19–5, Step 6A, B). On the subcutaneous portion of the flap, however, this should extend deep, particularly in proximal hypospadias, enough to include the subcutaneous layer of the dorsally displaced scrotal tissue. By cutting along the proposed outline, the foreskin flap is bivalved and a proximal subcutaneous layer is lateralized judiciously so that the subcutaneous trough thus created is wide enough to enfold the penile shaft with no tension at later skin closure (Fig. 19–2, Step 6B; Fig. 19–3, Step 6B; Fig. 19–4, Step 6C; Fig. 19–5, Step 6C). Needless to say, care should be taken not to injure the axially running branches of the superficial dorsal arterial system during this Byarsization.

Step 7: Skin Closure. A Penrose tube is left in the subcutaneous space as a drain and is brought out through a separate incision in the perineum. The wound is closed in several layers. While the penis is held in dorsiflexion, the subcutaneous tissue is approximated ventrally over the penile shaft proximally to distally (Fig. 19–3, Step 7A).

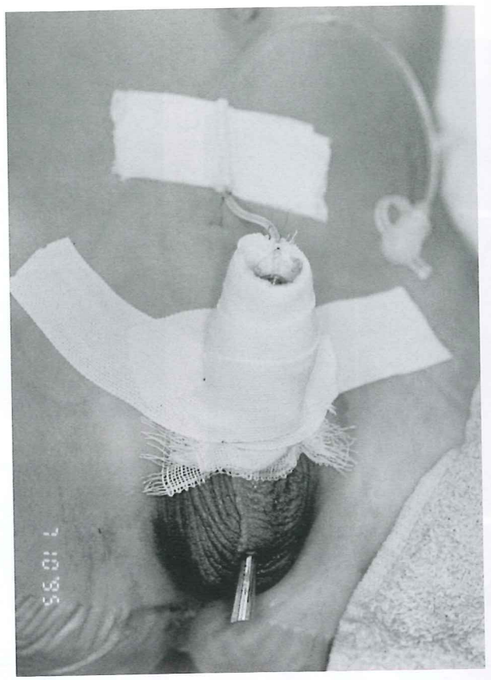


Figure 19–6
Wound dressing.

In proximal hypospadias, the most proximal part of the subcutaneous layer is not that of the penile foreskin but rather dorsally displaced scrotal skin. Thanks to adequate dartos mobilization of the scrotal skin (Step 1) and judicious Byarsization (Step 6), this subcutaneous closure is performed without any tension. In so doing, the dorsally displaced scrotum is now replaced to a more natural ventral position (i.e., scrotoplasty). Closure should be symmetric and should avoid inadvertent bite of the shaft so that it will not cause any torsion of the shaft or restrict its free movement on erection (Fig. 19–4, Step 7A, B, C; Fig. 19–5, Step 7A, B, C).

The coverage of the distal shaft is done similarly, proximally to distally in several layers (usually three to four) with Byarsized foreskin flaps. The ventrally repositioned subcutaneous layer of the distal foreskin is then stitched to the subcutaneous tissue of the glans underneath the frenulum, thus securing coverage of this portion of the urethra, which is potentially the most possible site of fistula formation. Once multilayered subcutaneous closure is completed, the skin edges are approximated loosely to avoid edema of the foreskin, thus concluding skin closure (Fig. 19–4, Step 7D; Fig. 19–5, Step 7D).

The traction suture on the tip of the glans is tied around the inlying urethral catheter, thus securing its position during the postoperative period. A fluffy dressing is applied to the wound, and the penis is held in dorsiflexion under the compression coverage. An antibacterial ointment is applied over the glans and around the meatus to prevent surface drying before the child is awakened (Fig. 19–6).

Postoperative Care

The Penrose drain is removed on the third postoperative day. The compression coverage is released on the fourth or fifth postoperative day, and the child is helped to take a warm sitz bath three times a day during hospitalization. Similarly, meatal flushing with a jet stream of normal saline should be continued to prevent crust formation around the meatus. The inlying urethral catheter, which should be checked daily for patency, is removed on the seventh postoperative day in OUPF-II or 10th postoperative day in OUPF-IV. No attempt should be made to manipulate the urethra with a catheter or a sound once it has been removed.

COMMENTS

Chordee is either absent or is relieved by dartos mobilization alone; however, it is difficult to predict the severity of chordee preoperatively. In glanular or coronal hypospadias, it is absent in most cases, enabling repair to be undertaken by the meatoplasty and glanuloplasty (MAGPI)[3] or flip-flap techniques.[19] In other types of hypospadias, distal to penoscrotal, dartos mobilization alone is often adequate to alleviate chordee,[9] thus clearing the way for various types of one-stage repair with preservation of the urethral plate.[20, 21] Artificial erection under anesthesia before the skin incision may be helpful in selecting the operation of choice but seems cumbersome. Furthermore, in hypospadias that is apparently distal to penoscrotal, dartos mobilization alone fails to relieve chordee in one third of cases.[7] Nevertheless, urethral mobilization[10, 22, 23] or dorsal tunica albuginea plication of the corpora, as judiciously used by Baskin and colleagues,[13] may prove beneficial; if this is of no avail, then it is necessary to transect the urethra before carrying out a transverse preputial island flap urethroplasty for proximal hypospadias.[5, 24] Faced with the possibility of encountering these unexpected situations, the hypospadiologist is well advised to be armed with various technical options.[1] Nevertheless, a simple method applicable to all types of hypospadias should be available.

The OUPF technique described here is unique in this regard. The planned skin incision that is necessary in most repair procedures is not required, except at the initial skin incision (Step 1), which is essentially the same no matter what the type or severity of hypospadias. The technique differs only at Step 4. After dartos mobilization, only two basic methods are used for formation of the neourethra (with meatal-based manta-wing flap, OUPF-II; and with parameatal-based and fully extended circumferential foreskin flap, OUPF-IV), the choice of which is made on the basis of artificial erection. Allowing this intraoperative choice of either OUPF-II or OUPF-IV, depending on the degree of chordee remaining, considerably simplifies the procedure and enables all types of hypospadias to be surgically corrected with confidence. Viability of the parameatal foreskin flap even in cases treated with parameatal-based and fully extended circumferential foreskin flap is well established. When blood flow measured on laser Doppler was compared at the tip of the parameatal flap before and after harvesting, only an 18% reduction was observed with parameatal-based and fully extended circumferential foreskin flap. In comparison with the meatal-based ventral midline flap, the parameatal flap also has considerably better microcirculatory parameters (e.g., flow reduction rates with the flip-flap and with meatal-based manta-wing flap were 73% and 33%, respectively).[25] The neourethra is in natural continuity with the old urethra, allowing less risk of complication at their junction. Urethras constructed in this way continue to grow, as seen in the oldest of the children (now older than 15 years) we treated. Compared with the glans-piercing technique, this glanulomeatoplasty appears to be embryologically as well as anatomically more sound,[15, 16] and it is instrumental in obtaining a cosmetically and functionally satisfactory result (Fig. 19–7). More-

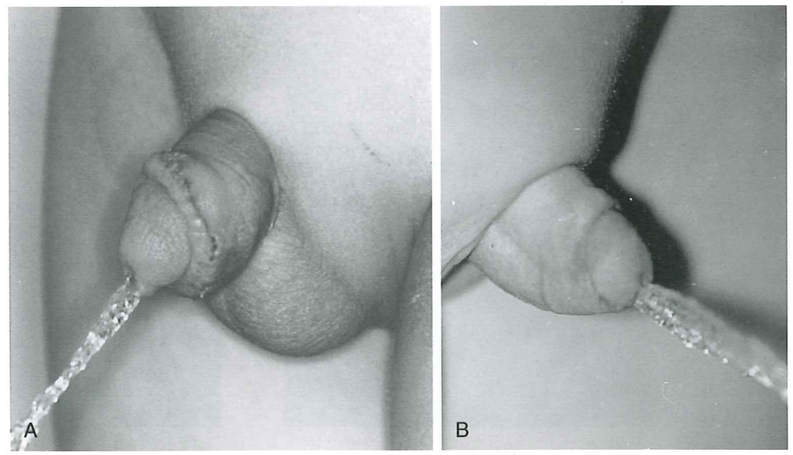


Figure 19–7
Outcome of OUPF-II (*A*) and OUPF-IV (*B*).

over, on skin closure, the propenile scrotum can be repositioned ventrally and posterior to the penile shaft, thus enabling substantial correction of concurrent anomalies to be made, even in the severest forms of hypospadias, all in one stage. The OUPF technique should be added to the hypospadiologist's armamentarium as a simple yet reliable one-stage method of correction of all types of hypospadias, with a reasonable rate of success.

SUMMARY

Hypospadias is a severe anomaly, the repair of which was previously a formidable task, even with multistage operations. In the past two decades, however, great progress has been made both in the basic understanding of this deformity and in its surgical repair, which has culminated in the discipline aptly termed *hypospadiology.*[1] In 1941, Humby wrote, in a prophetic foreword: "If, however, one could succeed in remodeling the urethra in one operation, the gain would be manifest."[26] This now seems to be a reality. Much of the current success is attributable to delicate tissue handling, the basic principles of plastic surgery, excellent microscopic instruments and materials, improved perioperative and postoperative care, and numerous other factors.

In our experience, the long-term outcome of single-stage repair has been satisfactory, both functionally and cosmetically. Incomplete chordee release has been eliminated by assessment with artificial erection. The reconstructed urethra grows with the patient. On puberty, most of the testicular deficiency[27] appears to become normalized and testicular function shows sudden increase. Psychologic anxiety, which was the probable outcome of multistage operations, is now less of a problem with the single-stage operation, although a recent analysis has reported that in some cases of severe proximal hypospadias, psychosomatic adjustment has been poor.[28] Nevertheless, parents of the majority of children with hypospadias can now be counseled with optimism and confidence.[1] The day has come when all types of hypospadias are amenable to complete repair in a single-stage operation with a reasonable rate of success.

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CHAPTER

20

Neourethra with Rectum Posterior Sagittal Approach

LUIS F. GUZMAN

The incidence of urinary tract trauma has increased owing to automobile accidents, wounds caused by guns and cutting instruments, and minor abuse.

Automobile accidents, especially those involving pedestrians and motorcycles, are noted for their high incidence of pelvic fracture and urethral rupture. Pelvic fractures imply severe closed trauma and organic lesions; mortality is variable (5% to 20%).

The incidence of urinary bladder or urethra lesions associated with pelvic or pubic symphysis fractures is 0.7% to 25%. Injuries of the posterior urethra affect continence because of lesions of the urinary sphincter and postoperative urethral strictures. For cases of urethral stricture or absent urethra due to multiple operations or traumatic lesions, a new way to rebuild the urethra has been developed.

Lesions of the pubis and a gap in the urethra of approximately 7 cm (Fig. 20–1) are clearly seen in a combined urethrogram (Fig. 20–2). In such cases, a sagittal posterior approach provides greater exposure than an anterior approach. Also, when the rectum is used in a pediculated flap, the flap is more vascularized; when great lesions of the urethra are found, using the rectal mucosa as a free flap adds length to the neourethra. Using this technique, neourethras longer than 20 cm can be constructed.

The technique involves placing the patient in a ventral decubitus position (Figs. 20–3 and 20–4). A cushioned support is placed under the patient's abdomen to allow a better view of the sacrococcygeal area. The anal margins are then marked with methylene blue to facilitate posterior closure and to ensure rectal continence (Fig. 20–5). An incision is then made from the coccyx to the perineum or scrotum, dissecting the skin to the anterior and posterior surfaces of the rectum. This usually exposes the urethral lesion, allowing identification of the proximal and distal ends of the urethra (Fig. 20–6).

This sagittal approach affords better field exposure of the urethral lesion and its treatment. Once the lesion has been identified, it is measured to determine the amount of urethra that needs to be created from the rectum (Fig.

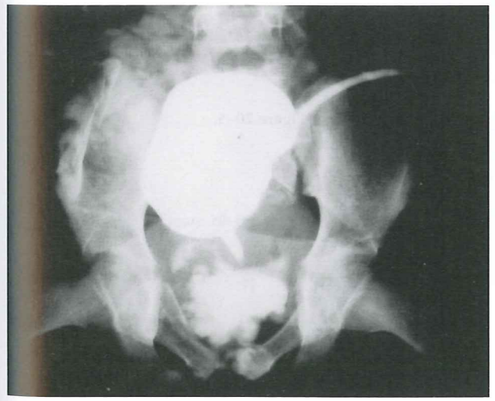


Figure 20–1.



Figure 20–2.

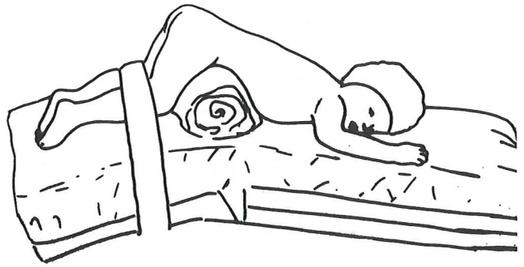


Figure 20–3.



Figure 20–4.

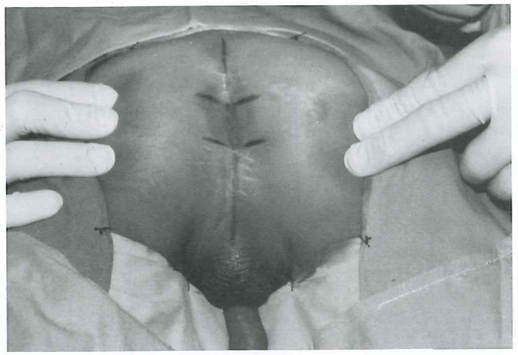


Figure 20–5.

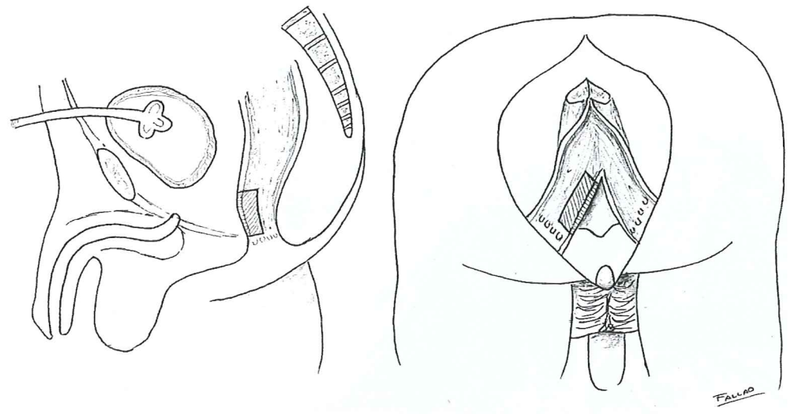


Figure 20–6.

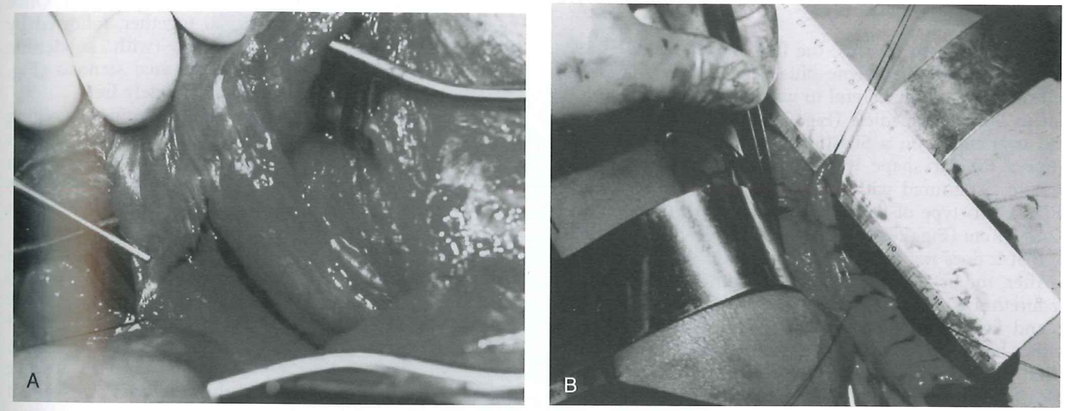


Figure 20–7.
A: The rectum is designated with methylene blue to create the urethra. *B*: The flap is taken full thickness and marked every centimeter.

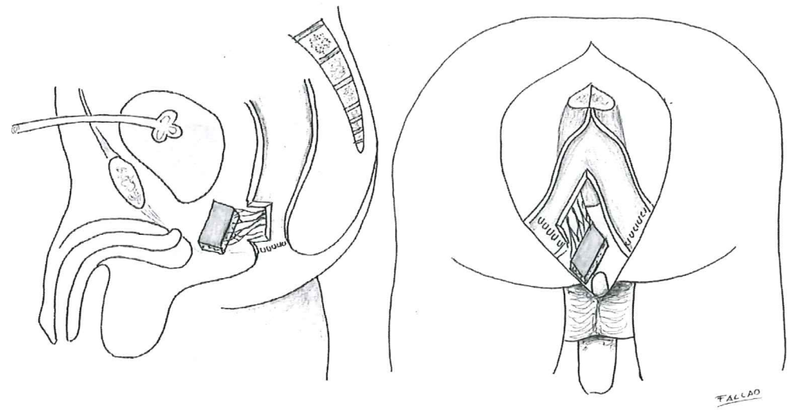


Figure 20–8.

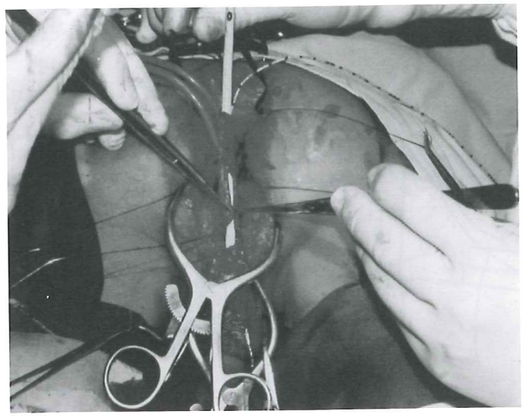


Figure 20–9.

20–7*A* and *B*). To do this, the flap site on the rectum is designated with methylene blue. The flap is taken with full thickness, being careful to maintain its vascularity and not to injure the pedicle (Fig. 20–8). This flap is rotated and overlapped on a Silastic Foley catheter (Fig. 20–9). After a tubular shape is created, the flap on the Foley catheter is sutured with Dexon or polydioxanone suture (PDS). This type of flap can be used to create urethras of 12 to 14 cm (Fig. 20–10). The pedicle is handled carefully so that it does not twist and compromise the procedure.

After the rectal flap is tubularized (Fig. 20–11), the neourethra is anastomosed to the true urethra in an end-to-end fashion; the neourethra is almost always shaped with a break end to avoid later stenosis (Fig. 20–12). The distal end is anastomosed with the same technique. Figure. 20–13 shows the newly formed urethra with its anastomosis. For patients who have extensive lesions of the urethra or who have undergone multiple procedures with lesions greater than 14 cm, a free rectal mucosal graft is recommended, which provides another 12 to 14 cm, Figure 20–14 shows a free flap (approximately 9 cm) of rectal mucosa that is anastomosed to the previous pediculated flap with Dexon or PDS to create a neourethra that is 19 cm in total length.

This rectal mucosa free flap usually is not of the same quality and thickness as the pediculated flap; therefore, it is used only with obvious extensive lesions of the urethra. Large quantities of rectal mucosa are always available; this is not true of a pediculated flap.

Rectal closure is the next step in this procedure. We always leave an open-type drainage (Penrose), which exits lateral to the wound (Fig. 20–15); rectal closure poses no risk of stenosis, even with extensive flaps. Reference stitches are placed around the anal margin at the beginning of the procedure to avoid problems that may result in stenosis.

The closure is carried out plane by plane. A neurostimulator (Fig. 20–16) is used to identify muscular and sphincter fibers (several types of neurostimulators are available). A stimulus is applied, and the sphincter fibers are clearly identified by their typical contractions (Fig. 20–17). Once identified, the sphincter is stitched together, followed by the subcutaneous tissue and skin (with subdermic stitches). A finger is used to test for anal stenosis (Fig. 20–18), and the anus should feel completely free.

Our patients are faring well; they are continent, voiding without complications, and, except for one patient, exhibit no signs of stenosis. The patient who was the exception was treated with urethral calibration, had 12 previous procedures, and had no remaining urethra with which to work.

Cystostomy is always used as a safety standard. Patients initially produced some mucous secretions, but after the epithelial metaplasia is complete (in a few months), the mucus disappears. A urethrocystogram taken 3 to 4 months after surgery is used to evaluate the urethra. (Fig. 20–19 shows the caliber of the urethra and the absence of stenosis.) A control cystourethroscopy is an excellent procedure for complicated cases; no changes in the neourethral epithelium were noted. The rectum is a good substitute for a urethra with a large lesion. If the urethral lesion is not significant, this procedure still offers excellent expo-

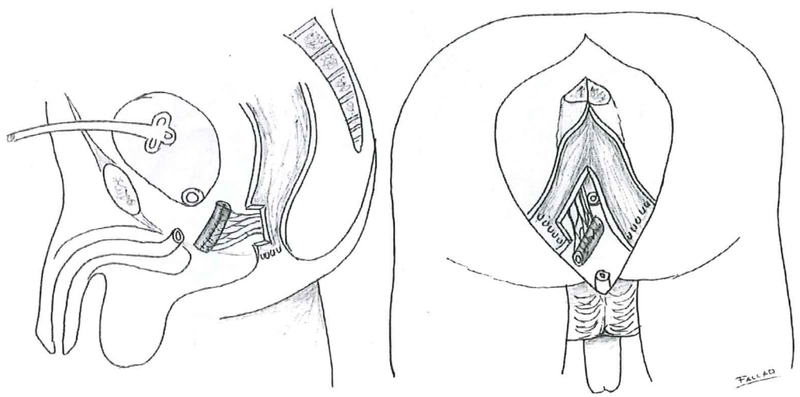


Figure 20–10.

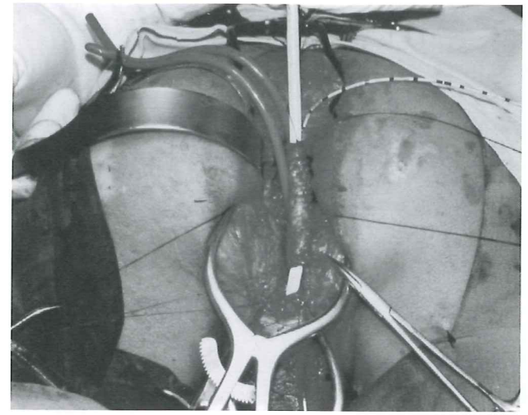


Figure 20–11.

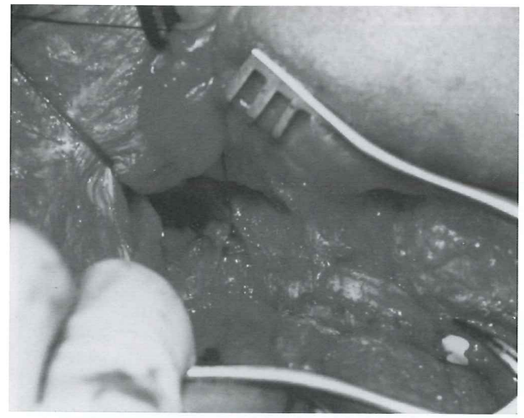


Figure 20–12.

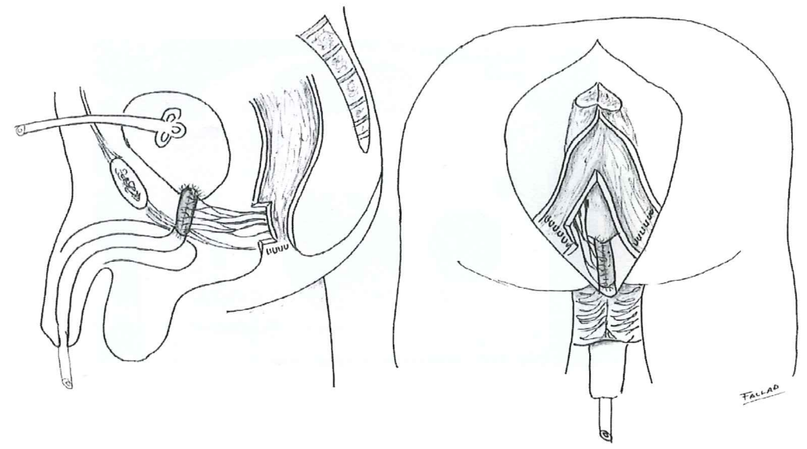


Figure 20–13.



Figure 20–14.

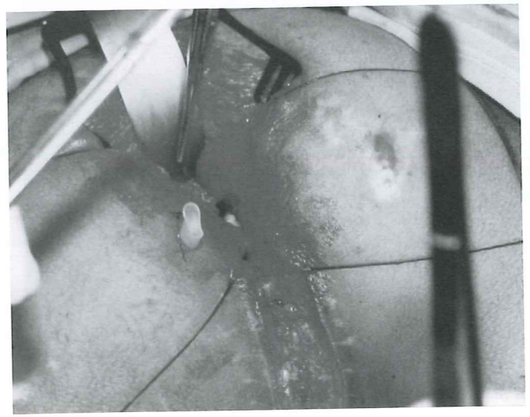


Figure 20–15.



Figure 20–16.

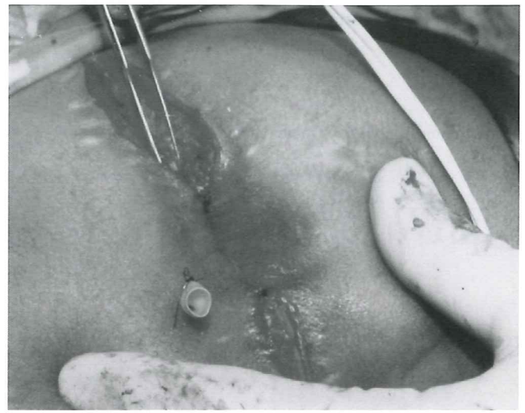


Figure 20–17.



Figure 20–18.

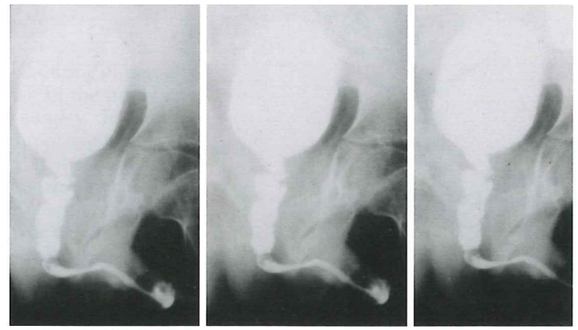


Figure 20–19.

sure and allows an end-to-end primary anastomosis or pediculated or free flaps.

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CHAPTER

21

Tunica Vaginalis Blanket Wrap

BRENT W. SNOW
PATRICK C. CARTWRIGHT

Urethrocutaneous fistulas have long been spoilers of good outcomes of hypospadias surgery. They occur regardless of the location of the meatus, procedure performed, or experience of the surgeon.[1] The importance of complications of all varieties is magnified in hypospadias surgery because almost every occurrence requires a repeat operation rather than a conservative solution. Fistulas are the most common complications following all types of hypospadias repairs. Many efforts to prevent the formation of urethrocutaneous fistulas have been developed and tried with various degrees of success. Among these efforts have been overlapping suture lines, two-stage repairs with the penis being buried in the scrotum,[2] rotating skin flaps, denuding epithelium and overlapping the denuded subcutaneous tissue,[3] and moving dartos tissue beneath the foreskin to cover the urethral repair.[4] In 1985, a random pedicle flap of tunica vaginalis was developed and used as vascularized tissue in hopes of covering the new urethra like a blanket to prevent the formation of urethrocutaneous fistulas.[5] This tunica vaginalis blanket wrap has proved to be very successful in lowering the fistula rate resulting from all varieties of hypospadias repairs.[5]

TECHNIQUE

Tunica vaginalis may be easily obtained during almost any type of hypospadias repair without risk to the newly created urethra. As with all hypospadias surgery, the chordee is generally corrected and the urethroplasty performed according to the surgeon's preference. If the surgeon has chosen a pedicle-type hypospadias repair in which the pedicle wraps around one side of the phallus, the testicle opposite the pedicle wrap is chosen. This way, if either the neourethra pedicle or the tunica vaginalis pedicle exerts any pulling forces on the penis, they oppose and thereby neutralize each other. If the hypospadias procedure does not include a pedicle, the surgeon may chose either testicle to begin the tunica vaginalis procurement. At the base of the penis, where the penis has been degloved, two small retractors are placed. The assistant gently elevates the testicle into view at the penoscrotal junction between the retractors. The scrotal attachments to the tunica vaginalis and testicle are separated, and the testicle and tunica vaginalis can be easily delivered into the wound (Fig. 21–1). Dissection of the filmy attachments along the spermatic cord is completed to the extent that is visible. The tunica vaginalis is opened distally over the testicle near the junction of the tunica vaginalis and epididymis, and the testicle is brought forth. Traction sutures are placed on the lateral edges of the tunica vaginalis, and incisions are made a few millimeters from the edge of the epididymis on either side. Proximal to the testicle, a transverse incision through the

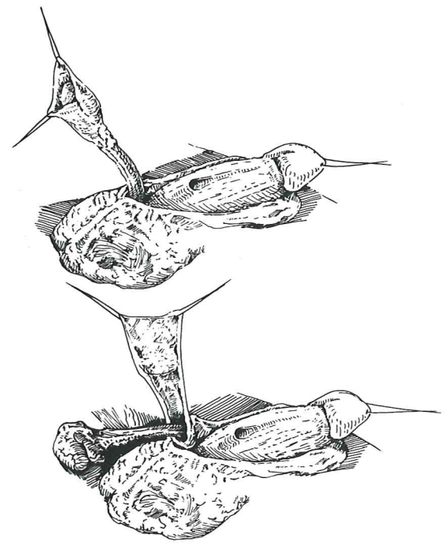


Figure 21–1
The testicle is delivered from the scrotum, and the tunica vaginalis is separated from the spermatic cord. (From Snow BW: Use of tunica vaginalis to prevent fistulas in hypospadias surgery. J Urol 136:861–862, 1986.)

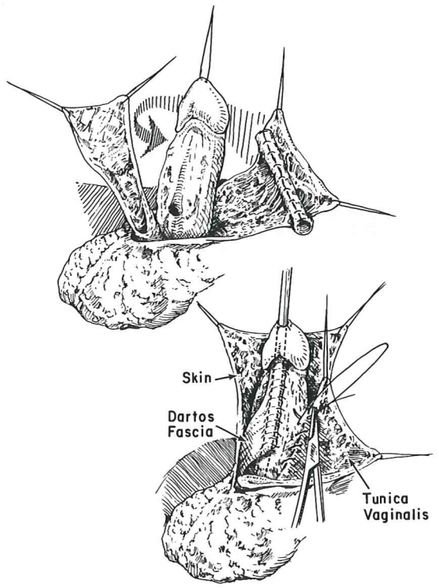


Figure 21–2
The neourethra is made, in this case illustrated by a transverse preputial island urethroplasty. The tunica vaginalis is then sutured laterally adjacent to the neurovascular bundle. (From Snow BW: Use of tunica vaginalis to prevent fistulas in hypospadias surgery. J Urol 136:861–862, 1986.)

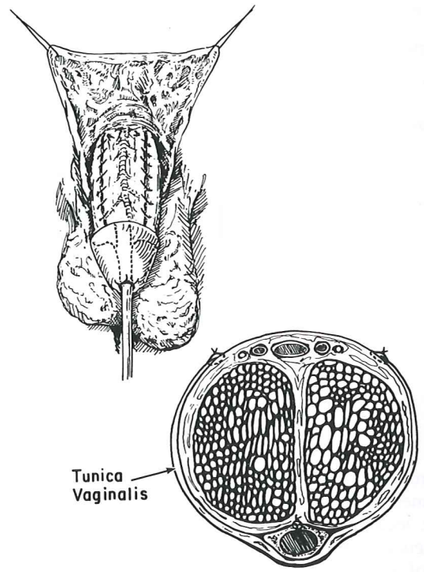


Figure 21–3
The dorsal picture shows the tunica vaginalis sutures along either side of the dorsal neurovascular bundle. The cross-sectional view shows the tunica vaginalis covering approximately three quarters of the penis. (From Snow BW: Use of tunica vaginalis to prevent fistulas in hypospadias surgery. J Urol 136:861–862, 1986.)

tunica vaginalis only is then made. This is similar to the dissection of the process vaginalis from the spermatic cord during an orchiopexy at the proximal end of the spermatic cord. In some cases, the tunica vaginalis is generous and easily covers the penis without separating additional tunica vaginalis from the spermatic cord. In this situation, incisions parallel to the spermatic cord suffice. In the usual circumstance, with the proximal transverse tunica vaginalis incision made, careful dissection elevates the tunica vaginalis from the spermatic cord. This dissection is carried out parallel to the spermatic cord toward the superficial inguinal ring as far as vision and retraction allow, taking care to leave all of the surrounding tissue and cremaster fibers with the pedicle to ensure its rich blood supply (see Fig. 21–1). Length of the pedicle is seldom a problem, and extensive dissection is not regularly needed. As elevation of the tunica vaginalis takes place, the spermatic cord often seems to emanate from a sleeve of this pedicle. To allow the testicle to be replaced in the scrotum, the lateral margin of this sleeve may need a longitudinal incision to allow the tunica vaginalis to move medially and the testicle and spermatic cord to fall laterally. The incision is made laterally to preserve as much blood supply to the pedicle of the tunica vaginalis as possible. Once the dissection is completed, hemostasis is obtained with the electrocautery and the testicle is replaced into the scrotum in its natural position.

With the neourethra in place, the penis is ready to be covered with the tunica vaginalis like a blanket. It has not



Figure 21–4
A ventral view of a hypospadias procedure after the tunica vaginalis is in place to cover the entire neourethra. The shiny tissue is tunica vaginalis.

Table 21–1
Hypospadias Procedures With and Without Tunica Vaginalis Blanket Wrap

Procedures	Loupes + TVBW	Loupes Without TVBW	Microscope Repairs	Microscope Repairs + TVBW
Transverse preputial island pedicle flap[7]	43	15	13	8
Transverse preputial island onlay[8]	23	8	10	5
Mathieu[9]	5	20	14	0
Mustarde[10]	2	5	0	0
Hinderer (ventral island flap)[11]	3		5	3
Other		12	2	
Total	76	65	42	13

TVBW, tunica vaginalis blanket wrap.

made a difference which side of the tunica vaginalis is placed toward the neourethra, and we prefer to place the shiny visceral surface toward the neourethra. Fine absorbable sutures (we currently use 7-0 Vicryl) are used longitudinally to suture the tunica vaginalis parallel and lateral to the dorsal neurovascular bundle (Fig. 21–2). The flap, now sutured into place on the lateral aspect of the penis, is drawn across the ventral aspect of the penis to the other side, and a matching longitudinal closure is accomplished (Figs. 21–3 and 21–4). This blankets the neourethra. If a glans-tunneling technique was used during the hypospadias repair, the tunica vaginalis may be passed distally through the glans channel with the neourethra or it may be tacked as far into the glans channel as possible, because coronal margin fistulas are among the most common that develop. If the neourethra has a pedicle, care should be taken not to confine the pedicle too tightly. It is seldom a problem, and a compartment-type problem has not been seen. When this step is completed, the penis is covered on two thirds to three fourths of its circumference with a blanket of tunica vaginalis from one dorsal neurovascular bundle margin to the other and to the tip of the neourethra ventrally (Figs. 21–3 and 21–5). The skin closure of the surgeon's preference can then be accomplished



Figure 21–5
A lateral view after tunica vaginalis has been placed around a neourethra. The suture line is adjacent to the neurovascular bundle, and the pedicle of this neourethra can be seen coming from the base of the penis to the ventral neourethra.

with ease. There are no special dressing requirements for the penis or scrotum in regard to the tunica vaginalis use. The familiar dressing and postoperative care that the surgeon customarily uses will suffice.

Tunica vaginalis blanket wrap has for many years been effectively used to prevent fistula formation. We reviewed 8 years of our own experience to put into perspective the complication rates, especially regarding fistulas, using many different types of hypospadias repairs.[6] We compared and contrasted optical loupe magnification and the operating microscope with and without tunica vaginalis blanket wraps to augment hypospadias repairs.[5] This review was retrospective over 8 years from 1985 through 1992, including all consecutive non–meatoplasty and glansplasty (MAGPI) hypospadias procedures by one surgeon. Many different types of hypospadias procedures and modifications were used and placed into broad categories for simplicity's sake. Table 21–1 lists the procedures, the type of magnification used, and the numbers of patients who had tunica vaginalis blanket wrap. Tunica vaginalis blanket wrap was at the discretion of the surgeon and generally was used when the case was thought to be difficult or at particular risk for fistula formation. Tunica vaginalis occasionally was not used owing to prior groin surgery such as herniorrhaphy, hydrocelectomy, or orchiopexy. It should be noted that during the first 6 years of this study period, 76 patients underwent tunica vaginalis blanket wrap and 65 patients had hypospadias repairs without use of tunica vaginalis. During the last 2 years that were reviewed, the operating microscope was used and 55 non-MAGPI hypospadias repairs were performed. Patients' ages ranged from 3 to 145 months, with an average age of 28 months. One 46-year-old adult was included. Follow-up ranged from 9 to 105 months, with an average of 60 months. The success of the tunica vaginalis blanket wrap is reported in Table 21–2.

Table 21–2
Fistula Complications

	Fistula Patients	Fistula Rate
Tunica vaginalis blanket wrap (TVBW)	6/76	8%
Without TVBW	13/65	20%
Microscope repairs alone	5/42	12%
Microscope repairs with TVBW	0/13	0%

The data listed in Table 21–2 for tunica vaginalis blanket wrap differ from the reported data because one patient returned since the manuscript preparation for fistula repair and no fistula was found.[5] Five of the six fistulas were noted soon after surgery, but one was discovered only after 5 months. Three fistulas developed after transverse preputial island onlay procedures, two after transverse tubularized preputial island flap procedures, and one after Mustarde urethroplasty.

If transverse preputial island pedicle flap urethroplasties are examined specifically, 2 of 53 patients with tunica vaginalis developed fistulas whereas 7 of 23 patients without tunica vaginalis developed fistulas.

During the final 2 years of the study, the operating microscope was used exclusively. Five fistulas developed during these 2 years, all occurring during the first year, when microscope use was less familiar. Three of the fistulas developed in patients who had undergone prior hypospadias operations.

All hypospadias complications in patients who underwent tunica vaginalis procedures were reviewed in detail. Thirty-three of 89 patients had complications including the six fistulas already mentioned. Table 21–3 lists these complications excluding fistulas. Several patients experienced more than one complication. Sixteen of these patients required corrective surgery, for a reoperative rate of 21%. Six had repair of urethrocutaneous fistulas, four had meatotomies, three had urethral diverticulectomies, one underwent a MAGPI correction of a receded meatus, and two had repair of abnormal scarring of shaft skin. The patient with the 2-cm scrotal hematoma required no treatment and had spontaneous resolution of the hematoma.

The patient with the scrotal abscess underwent drainage and recovered with no adverse effect on the neourethra. None of the 89 patients experienced other testicle complications, and all of the testicles are in a normal location in the scrotum and are normal in size. It is interesting to note that eight patients developed skin separations that exposed the tunica vaginalis, but its presence allowed reepithelialization without fistula formation.

Tunica vaginalis blanket wrap has been a useful adjunct to hypospadias repair for those who do not operate with the operating microscope. The rates of fistula repair with the application of the tunica vaginalis blanket wrap are similar to those achieved with the operating microscope, allowing hypospadias surgeons to minimize the risk of fistula formation without seeking greater optical magnification. It certainly should be considered for procedures deemed to be at risk but is no substitute for proficient surgical technique and delicate tissue handling. When compared with other series of equivalent hypospadias repairs, tunica vaginalis blanket wrap yields a very low fistula rate. This procedure should be considered a valuable tool for hypospadias surgeons who wish to avoid the most common hypospadias postoperative complication, urethrocutaneous fistula.

Table 21–3
Nonfistula Complications

Complications	Number of Patients
Meatal stenosis	10
Skin separation	8
Asymmetric shaft skin	6
Urethral diverticulum	3
Urethral stricture	1
Redundant meatus tissue	1
Scrotal abscess	1
Scrotal hematoma	1
Total	31

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COMPLEX HYPOSPADIAS

CHAPTER

22

Two-Stage Hypospadias Repair

ANTHONY ATALA
ALAN B. RETIK

Opinions about the best operative options for patients with hypospadias have varied, evolving with time.[1] In the 1950s, the accepted methods for surgical management of hypospadias involved a two-stage approach. Horton and Devine,[2] as well as Broadbent and colleagues,[3] were instrumental in popularizing the one-stage approach for the correction of hypospadias in the 1950s and 1960s. Work by Standoli[4] and Duckett,[5] in which the preputial skin was used in a vascularized fashion for correction, further expanded the use of one-stage repairs. By 1988, it was being suggested that all primary hypospadias should be repaired with a single-stage approach.[6]

As in other areas of surgical correction, however, a unified approach for all patients is not always possible. Surgical treatment, in order to be most effective, usually needs to be individualized. Approximately 20% of patients who are born with hypospadias have a proximal defect. Of these, most can be treated with a one-stage repair. For a subset of patients with scrotal or perineal hypospadias, a small phallus, and severe chordee, a two-stage repair may be preferable. This subset of patients, if treated with a one-stage repair, usually need a composite graft. We were not uniformly satisfied with the operative results in this group of patients who were managed with a one-stage repair.[7] Other centers have reported a similar experience and advocate the use of a two-stage repair in this specific patient population.[8, 9]

The current goals of hypospadias surgery are (1) creating a straight penis, (2) positioning of the meatus on the penile tip, (3) normalization of erections and voiding, (4) creating a urethra of adequate and uniform caliber, and (5) symmetry in appearance of the glans and shaft. Although various techniques have been described in the literature for a two-stage repair, the most popular was that of Thiersch and Duplay,[10, 11] which has been well described and modified by Byars.[12] This technique has been further modified by numerous surgeons; however, the surgical concept has remained unchanged. The first-stage procedure includes correction of the chordee and advancement of preputial flaps ventrally and distally to the superior aspect of the glans. After 6 to 12 months, the second-stage procedure is performed using the previously transferred preputial skin to reconstruct the glans and urethra. Careful preoperative evaluation, precise surgical technique, and appropriate postoperative care are required in order to achieve the desired objectives.

PREOPERATIVE EVALUATION

A complete history and physical examination are performed on all patients. Anesthetic and surgical risks are assessed. The physical examination determines the severity of the hypospadias and is also aimed at identifying any associated anomalies. These include meatal stenosis, penile torsion, chordee, and penoscrotal transposition. The entire course of the urethra should be inspected. If a bulge is felt or if urethral compression produces dribbling, a diverticulum is suspected.

Approximately one fourth of patients with hypospadias and undescended testes have an intersex anomaly.[13] Therefore, these patients should be evaluated for intersexuality. A work-up should include a determination of karyotype and serum analysis for follicle-stimulating hormone, luteinizing hormone, testosterone, and urinary 17-ketosteroids and 17-hydroxycorticosteroids.

If a phallus is small, its size may be enlarged preoperatively by the use of testosterone or dihydrotestosterone cream or parenteral testosterone. Patients with a small phallus despite testosterone treatment, with a severe proximal hypospadias and chordee, are best served with a two-stage hypospadias repair.

SURGICAL TREATMENT

Several general principles are important. Skin incisions are made using a fine knife blade such as the Weck microsurgical knife (Edward Weck and Co., Research Triangle Park, NC). Gentle handling of tissues is mandatory using tiny

skin hooks and fine traction sutures. The tissue should be kept moist at all times. Cautery for hemostasis should be precise, brief, and applied with the pinpoint technique.

Perioperative bleeding can be minimized during dissection by intermittent use of an elastic tourniquet for periods of up to 30 minutes. After release, cauterization ensures hemostasis. Glanular and subcutaneous injection of epinephrine (1:200,000) has also been useful in maintaining hemostasis without causing tissue ischemia. The anesthesiologist should be informed when epinephrine is used because halothane, a common inhalation anesthetic, sensitizes the heart to catecholamines, and ventricular arrhythmia may result.

First Stage

In the first stage, a circumferential incision is made proximal to the coronal sulcus, the chordee is excised, and the penile shaft is degloved (Fig. 22–1*A* and *B*). Failure to create a straight phallus is one of the avoidable complications of hypospadias surgery. Penile straightening and removal of full chordee must be confirmed by the use of the artificial erection test.[14] After securely placing an elastic at the base of the penis or using perineal compression, normal saline is injected with a 25-gauge butterfly needle placed in one corporeal body to fill the entire organ. This identifies any restraining fibrous bands that remain. Several tests may be necessary to ensure complete excision. If the penis remains bent despite resection of all chordee, an alternative approach may be needed, such as insertion of a dermal or tunica vaginalis graft into the shaft, or dorsal plication.

When it is ascertained that the penis is straight, the glans is prepared. The glans is either divided deeply in the midline to the tip, or if the mucosal groove is deep, this is preserved, and incisions are made just lateral to the groove on each side (Fig. 22–1*C*). The dorsal foreskin is unfolded carefully and divided in the midline (Fig. 22–1*D*). The most distal portion of the foreskin is rotated into the glanular cleft and sutured to the mucosa of the glans with interrupted sutures of 6-0 chromic catgut. A midline closure is performed, and the midline sutures catch a small portion of Buck's fascia. This eliminates dead space and helps to create a groove in preparation for the second stage (Fig. 22–1*E*). The bladder is drained with an 8 French Silastic Foley catheter for approximately 5 to 7 days.

Second Stage

The second stage of the procedure is carried out 6 to 12 months later, when the tissues have usually softened sufficiently and healing is complete. The previously transferred preputial skin is used to reconstruct the glans and urethra. A 15-mm-diameter strip is measured, extending to the tip of the glans (Fig. 22–1*F*). The strip is tubularized with a running subcuticular stitch of 6-0 Vicryl all the way to the tip of the glans (Fig. 22–1*G*). Suture line tension is reduced before closing this layer by generous mobilization and undermining of adjacent tissues. A urine-tight anastomosis is made and inverted toward the lumen whenever possible. Eversion of suture lines increases periurethral reaction, which contributes to both urine leakage and potential fistula or diverticulum formation.[15] The new urethra must be wide enough to avoid strictures. The lateral skin edges are mobilized, and the remaining tissue is closed over the repair in at least two layers. The subcutaneous and subcuticular tissues are closed with running pull-out stitches of 4-0 nylon tied to themselves (Fig. 22–1*H*). The skin closure is meticulously performed without strangulation to allow for the expected postoperative swelling. Penoscrotal transposition, if present, is usually repaired during this stage. A penile nerve block is used routinely.

POSTOPERATIVE CARE

Postoperative management of hypospadias surgery, like other surgeries, has been markedly altered in recent years as attempts to reduce hospital stays in the interest of cost-effectiveness are weighed against the minimization of complications. Outpatient surgery is used for most patients. If surgery is extensive or performed late in the afternoon, patients occasionally stay overnight.

Attention to detail in postoperative care should rival that of the operation itself. We usually select a transparent biomembrane (Tegaderm) as a surgical dressing. This is applied to the penile shaft and the glans in a circumferential fashion without tension. If excessive bleeding is present during the procedure, a circumferential gauze dressing is applied over the Tegaderm for compression. The circumferential gauze is removed 12 to 24 hours after surgery, leaving the Tegaderm dressing in place.

Premature voiding is not desirable and may lead to the formation of a fistula. A round 7 French soft silicone drain can be positioned in the bladder, and the urine can drain freely into protective diapers. In older children, urinary diversion is usually maintained with a suprapubic catheter. Urinary diversion is continued for 7 to 10 days. One end of each nylon stitch is cut before the patient is discharged from the hospital, and the remaining suture material gradually works out within a few days.

The incidence of late complications of hypospadias is directly related to the complexity of the repair.[16, 17] Hypospadias repair is associated with a number of complications including urethrocutaneous fistula, stricture, diverticula, and persistent chordee. A surgeon's experience with this repair has an equally important role: Nowhere does a learning curve come into play in urology as significantly as it does with hypospadias surgery. The basis of many complications is a deviation from the principles discussed earlier. Management usually entails reassessment and reapplication of those same principles.

We recently reviewed our experience with the two-stage hypospadias repair.[7] From 1986 to 1993, we treated 1437 children with hypospadias. Of these, 58 patients (4%) had scrotal or perineal hypospadias with severe chordee and a small phallus, often resistant to testosterone therapy, which was administered preoperatively as an ointment or parenterally. These patients underwent a two-stage surgical repair. The use of added subcutaneous tissue or tunica vaginalis over the neourethra in several instances achieved the goal of nonoverlapping suture lines and may have offered

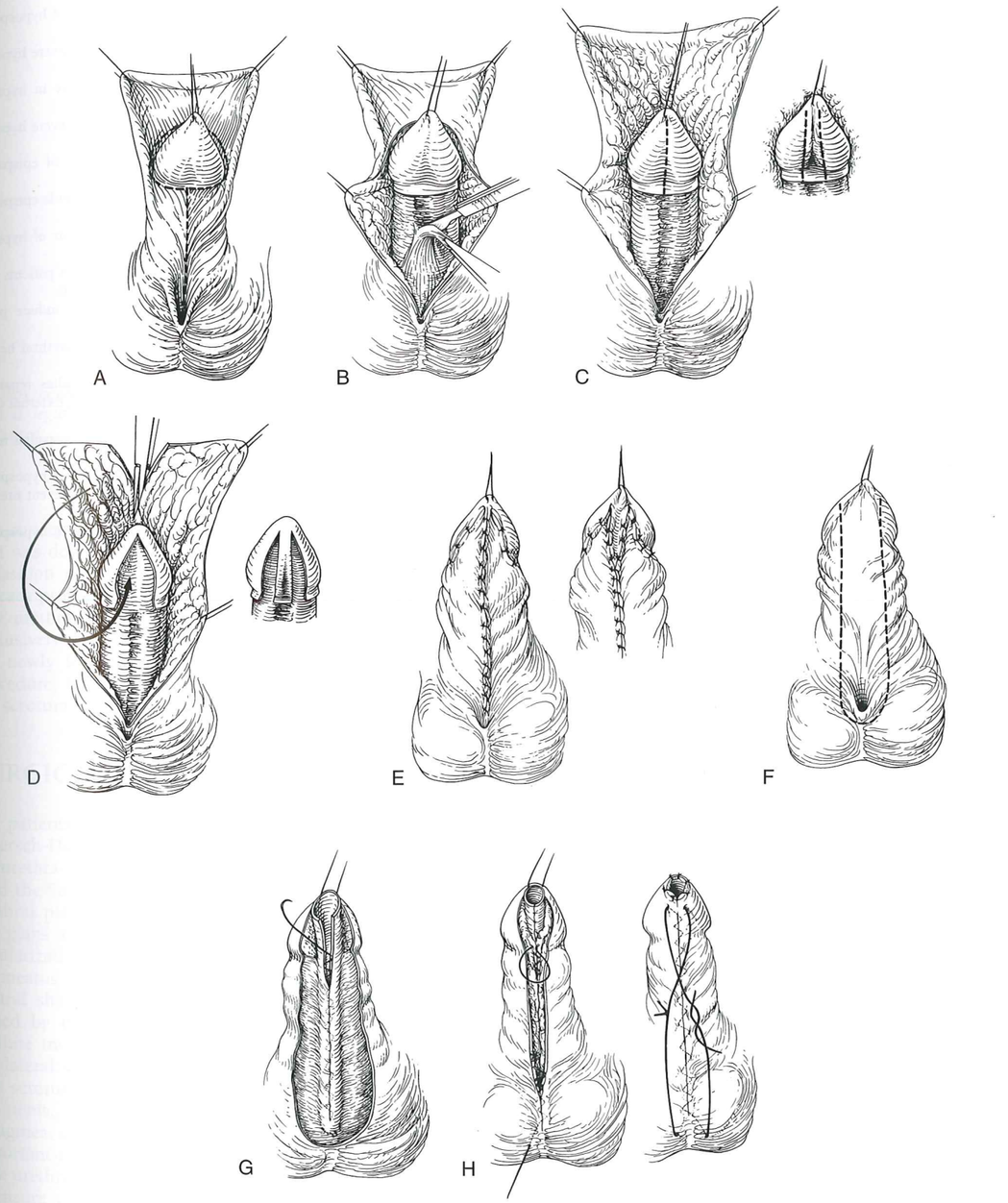


Figure 22–1
Two-stage hypospadias repair. *A:* Skin incisions are outlined. *B:* The penile shaft is degloved, and the chordee excised. *C:* The glans is divided. *D:* The dorsal foreskin is unfolded and divided. *E:* The distal portion of the foreskin is rotated into the glanular cleft with suture closure. *F:* A 15-mm diameter strip is measured, extending to the tip of the glans. *G:* The strip is tubularized. *H:* The glans is approximated over the neourethra, and the skin is closed.

increased vascularity.[7, 18, 19] The penile nerve block and transparent biomembrane dressing allowed for early postoperative mobilization. Excellent functional and cosmetic results were achieved. Only three children developed a urethrocutaneous fistula. Although hard to define, the final cosmetic appearance in these patients, we believe, was far superior to that in those who underwent a one-stage repair for less severe defects. Other groups have had a similar experience.[8, 9]

In conclusion, a subset of patients with severe proximal hypospadias, chordee, and a small phallus may benefit best from a two-stage procedure. In these children, a two-stage repair allows for a better cosmetic appearance and a lower complication rate than a one-stage repair with a free, vascularized, or composite graft.

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CHAPTER

23

Application of the Cecil-Culp Operation

STEPHEN A. KRAMER

If a boy beyond puberty cannot write his name in the snow and have it legible, repair of his hypospadias has left something to be desired.

O. S. CULP, 1966

The concept of burying a tubularized urethra in the scrotum was described by F. B. Bicknell. He used scrotal skin to fashion part of the urethroplasty but experienced significant problems with hair growth and calculi within the new urethra. In 1946, Cecil[1] devised an operation using exclusively penile skin for the urethroplasty and buried the newly formed urethra in the scrotum. In a second procedure, 6 months later, the urethra was released from the scrotum.

SURGICAL TECHNIQUE

For patients with penile or penoscrotal hypospadias, the Thiersch-Duplay technique can be used to tubularize the neourethra out onto the glans penis (Fig. 23–1).[2] I have used the Snodgrass[3] modification of incising the posterior urethral plate distally to advance the urethral meatus to the glans tip. This modification allows complete distal tubularization of the urethra without narrowing of the neomeatus. If there is insufficient penile skin to close the ventral shaft defect primarily, skin coverage can be obtained by burying the penis in the scrotum. A vertical midline incision is extended into the scrotal raphe, and the lateral scrotal edges are undermined (see Fig. 23–1). The scrotum is completely wrapped around the shaft of the penis, with dartos fascia being sewn to the tunica albuginea, covering the corpora cavernosa bilaterally. It is important to wrap the deep scrotal tissue snugly over the new urethra and attach it high on the corpora cavernosa to ensure a long tract in case a fistula develops. A urethral stent is left in place for 7 to 10 days. The scrotal skin is reapproximated to the penile skin with interrupted sutures of 4-0 polyglactin 910 (Vicryl). This procedure effectively buries the neourethra and prevents fistulas, unless the wound is disrupted or becomes infected.

Four to 6 months postoperatively, patients return for second-stage urethroplasty. This involves releasing the penis from the scrotum (Fig. 23–2). The scrotal incisions must be wide so that the scrotum can be brought together in the midline without tension. If the scrotal incisions are too narrow, the result is a skin deficit, particularly at the distal shaft of the penis. Furthermore, it is important that the incision be carried far enough beyond the penile base to prevent penoscrotal tethering and penoscrotal fusion during this second-stage procedure. I have found that the best way to reestablish the penoscrotal angle is to use a Z-plasty at the base of the penis.

In 1966, Culp[4] reviewed his extensive experience with the Cecil urethroplasty and described a modification of the technique for patients whose meatus was on the penile shaft and well removed from the penoscrotal junction. In this operation, only the distal portion of the penis was attached to the scrotum (Fig. 23–3). It is very important to bury at least 1 cm of normal urethra to avoid a possible fistula in the unattached recess at the penile base. Any portion of the pendulous urethra can be attached to the scrotum effectively, provided that some normal urethra is also buried both proximally and distally.

RESULTS

The long-term results of the Cecil-Culp urethroplasty have been excellent in the prevention of urethrocutaneous fistulas. If leakage occurs after removal of the catheter, the long tract usually heals spontaneously. Kelalis and colleagues[5] and Glassman and associates,[6] using a modified two-stage Cecil urethroplasty for 75 patients with hypospadias, found only three temporary fistulas, all of which closed spontaneously. Twenty percent of the patients complained of spraying with urination, and meatal stenosis was noted in 15% of the patients. A small number also complained about unsightly hair on the penis. Culp[4] noted meatal retraction in 11% and meatal strictures in 15% of patients undergoing the first-stage procedure. The abnormal meatus was corrected during the second-stage procedure.

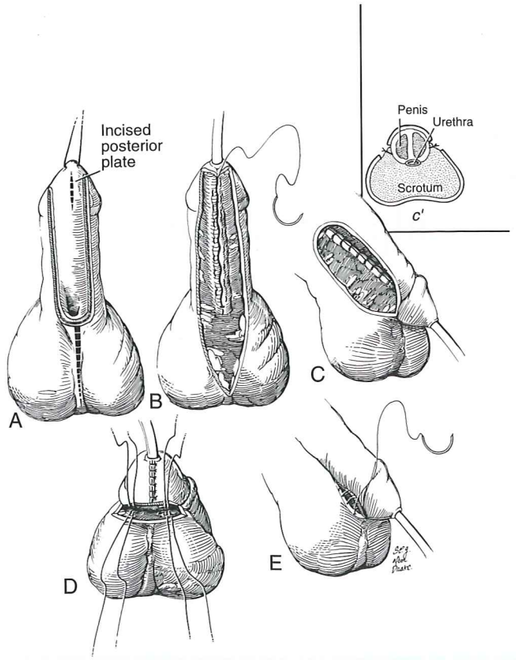


Figure 23–1
First stage of the Cecil urethroplasty. *A:* Location of the incisions to allow tubularization of the ventral penile skin. Note the distal incision in the posterior urethral plate. *B:* New urethra constructed over an indwelling catheter with continuous suture of fine Vicryl. *C:* New urethra buried in the scrotum with interrupted fine Vicryl sutures. *C′ inset:* Sutures are attached high on the lateral aspect of the corpora, and scrotal tissue is wrapped snugly against the new urethra. *D:* Interrupted sutures reinforce approximation of the glans to the scrotum. *E:* Skin closed with subcuticular suture. (From Culp OS: Surgical correction of hypospadias. Trans Am Assoc Genito-Urinary Surg 49:57, 1957; by permission of the American Association of Genito-Urinary Surgeons.)

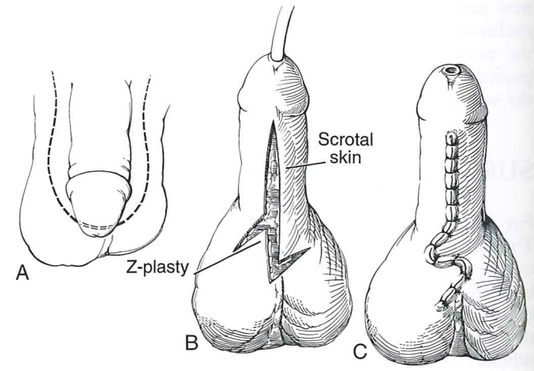


Figure 23–2
Second stage of the Cecil urethroplasty. *A:* Incisions in the scrotum are joined at the new meatus. *B:* With the catheter for orientation, the urethra is freed from the scrotum. A Z-plasty is fashioned at the penoscrotal junction. *C:* Skin closed with fine interrupted chromic sutures. (From Culp OS: Surgical correction of hypospadias. Trans Am Assoc Genito-Urinary Surg 49:57, 1957; by permission of the American Association of Genito-Urinary Surgeons.)

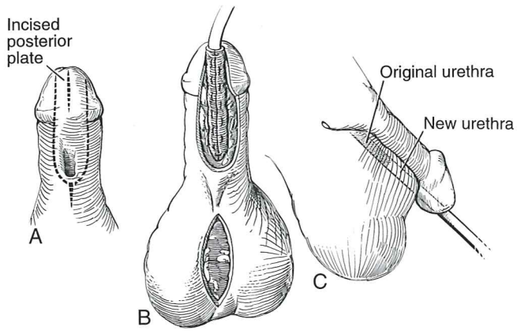


Figure 23–3
Modified Cecil urethroplasty. *A:* New urethra is constructed from the penile meatus out to the glans tip over a catheter *(B),* and a corresponding incision is made in the scrotum. *C:* Some normal as well as reconstructed urethra is buried in the scrotum in the usual manner. The penoscrotal region is left free. (From Culp OS: Surgical correction of hypospadias. Trans Am Assoc Genito-Urinary Surg 49:57, 1957; by permission of the American Association of Genito-Urinary Surgeons.)

CONTRAINDICATIONS

The Cecil-Culp technique should be confined to patients with penile and penoscrotal hypospadias. In patients with scrotal hypospadias, this procedure has resulted in urethrourethral fistulas, presumably because the pendulous urethra is buried in apposition to the new scrotal urethra.[4]

MODIFICATIONS

Marberger and Pauer[7] described a modification of the Cecil-Culp procedure in which urethroplasty and coverage of the penis were accomplished in a one-stage operation. The scrotal skin was mobilized on a thick vascular pedicle and rotated to cover the ventral aspect of the penis. The lateral suture line was offset to prevent overlapping suture lines (Fig. 23–4). I have used this technique for several years with excellent results. One of my initial concerns was potential penile torsion from use of an asymmetrically based scrotal flap. However, I have not found patients to have significant torsion on long-term follow-up.

Marshall and coworkers[8] described a three-stage asymmetric modification of the Cecil-Culp urethroplasty with concurrent scrotoplasty for patients with penoscrotal hypospadias. The investigators observed that in many patients with penoscrotal hypospadias, a portion of the scrotum extended upward and around the penis. They postulated that if this upper scrotum could be rotated caudally, the extra skin obtained by development of the flaps would avoid angulation of the new urethra and tension on the skin's suture line. In the first stage, the chordee was released and a buttonhole technique was used to bring the redundant dorsal skin ventrally. In the second stage, a urethroplasty was performed. The penis was covered with scrotal flaps cut in such a way that they prevented acute angulation from the penis buried into the scrotum. In the third stage, the penis was released from the scrotum. Fistula formation occurred infrequently.

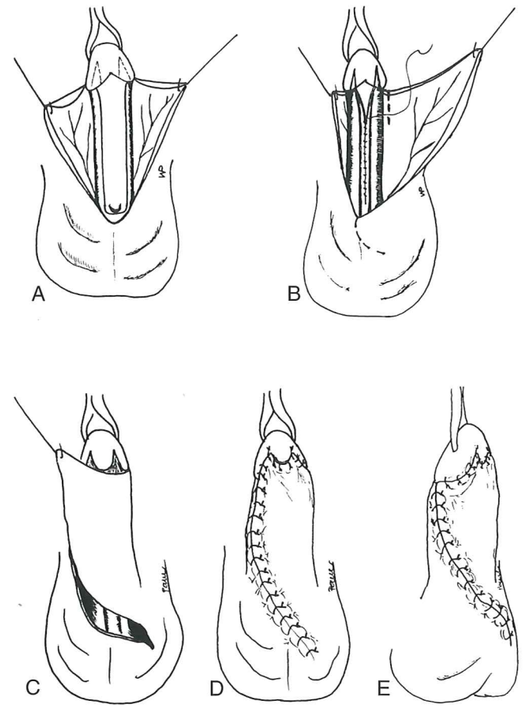


Figure 23–4
Second-stage hypospadias repair: rotated flap and 90-degree rotation of the penoscrotal cylinder. *A:* The diameter of the epithelial strip is twice that of the urethra. A tube is constructed, and the preputial skin is mobilized. An asymmetrical flap, large enough to cover the entire ventral surface, is mobilized. *B:* Dorsal incision and scrotal incision of the expanded penoscrotal skin. *C:* Rotation of the flap. *D* and *E:* Interrupted sutures are placed in the midline, and a neomeatus is constructed. (From Marberger H, Pauer W: Experience in hypospadias repair. Urol Clin North Am 8:403, 1981; by permission of W.B. Saunders.)

SUMMARY

It is interesting how our perspective on hypospadias surgery has changed through the years. In 1966, Culp wrote, "Deliberate termination of the urethra on the base of the glans poses no functional limitations. The urinary stream can be directed normally, . . . [and] several patients in this series are now proud fathers. Extending the urethra to the tip of the glans is fraught with hazards that more than offset any added cosmetic effect. . . . Some of the successful efforts in this region have been only bizarre technical triumphs with no basis for cosmetic or functional pride."[4]

Clearly, our concept of a satisfactory cosmetic and functional result has changed dramatically in the past 30 years. I try to advance the urethral meatus to the glans tip in every patient. Extensive mobilization of the glans wings is necessary to allow a tension-free closure of the glans around the neomeatus. A mucosal collar is used routinely to create a normal appearance of the coronal sulcus.[9]

The Cecil-Culp procedure remains an excellent option for repair of difficult urethrocutaneous fistulas, as well as complex hypospadias, in which there is a shortage of penile skin. The operation is also applicable for coverage of free grafts (i.e., bladder mucosal, buccal mucosal) when ventral skin coverage is inadequate to provide a tension-free closure.

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CHAPTER

24

Buccal Mucosa Graft for Hypospadias

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PHILIP G. RANSLEY

The use of vascularized local penile or preputial skin has been the mainstay of hypospadias repair for a long time.[1, 2] If the reconstruction fails, for whatever reason, these precious commodities are irretrievably lost and further reconstruction necessitates the recruitment of new tissue from elsewhere, generally in the form of a free graft.

A wide variety of options has been explored.[3–5] Extragenital skin from the groin, the inner arm, or the postauricular area has been used with varying success, but a widespread concern is that free graft skin is associated with fibrosis and contracture over many years. The use of bladder mucosa was therefore embraced enthusiastically in the 1980s, particularly in view of its free availability and its compatibility with urine.[6, 7] The complication rate proved to be very high, however, partially because of metaplasia and stenosis when the mucosa was exposed to air at the tip of the penis.[8–10] Such problems were compounded by the thin and relatively weak nature of the mucosa itself, resulting in ballooning of the reconstructed urethra with only the mildest degree of distal obstruction.

It is generally accepted that Humby, a plastic surgeon working at the Hospital for Sick Children in London, first proposed and reported the use of buccal mucosa for hypospadias repair in 1941.[11] Whether owing to lack of suitable antibiotic prophylaxis or technical factors, the technique did not gain acceptance or widespread use at that time. However, current enthusiasm for the technique was promoted by Duckett (1986),[12, 13] Dessanti and colleagues (1992),[14] and Burger and associates (1992).[15] In the past few years, reports have described successful use of buccal mucosa graft, from both the lip and the cheek, in the repair of previously failed hypospadias surgery or in true hypospadias cripples who have been subjected to numerous earlier attempts at correction.[16–19] The technique clearly has a definitive role for complex urethral reconstruction, and indeed, the short-term success is so encouraging that the threshold for its use diminishes all the time to the point where primary buccal graft surgery may be appropriate in some circumstances when skin resources are limited, allowing their preservation for good vascularized coverage of the penile shaft.

SURGICAL TECHNIQUE

Like all free graft material, buccal mucosa may be used as an onlay patch, as a complete mucosal tube, or in various ways combined with other free graft tissue (bladder mucosa) or vascularized skin.

Buccal mucosa may be harvested from the inner surface of the cheek or the inner surface of the upper or lower lip (Fig. 24–1). For a single strip of buccal mucosa for use as an onlay patch, the adult cheek provides up to 6 cm and the lip 4 cm at 12 to 15 mm of width. Although it is technically possible to continue the strip through the angle of the mouth to combine both cheek and lip segments in continuity for 10 cm, it is not easily recommended. In the experience of one of the authors (PGR), the only buccal mucosa donor graft site complicated by a significant contracture was at the angles of the mouth after such a bilateral maneuver.

The strips of buccal mucosa obtained cannot be tubularized lengthwise to create 6-cm or 4-cm tubes, because the width is insufficient. They can be folded lengthwise to provide shorter tubes of up to 3 cm and 2 cm, respectively, or a second graft of similar dimensions, can be applied to

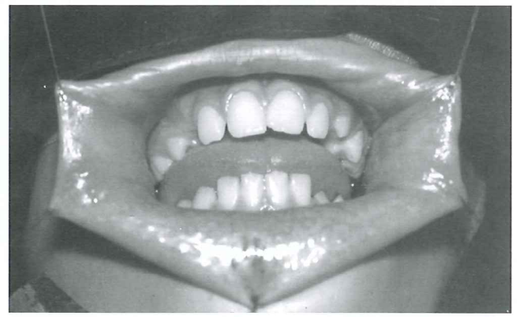


Figure 24–1
The inner aspects of the cheeks or lips can provide an abundance of free graft tissue for urethral reconstruction.

create a full-length cylinder of adequate diameter. When some vascularized preputial skin is available but is insufficient for tubularization, a strip may be usefully combined with buccal mucosa to form a compound neourethra. In very long urethral reconstructions, bladder mucosa may be used successfully for the proximal urethra, reserving buccal mucosa for the distal element and meatus.

Anesthesia

Although a nasal endotracheal tube might at first sight seem appropriate, it often projects inconveniently, and an oral tube that exits from the right corner of the mouth with a short right-angled connector is generally more convenient. A caudal anesthetic is routinely used, and a throat pack is essential.

Antibiotic Coverage

As in all free graft techniques, it is appropriate to protect against anaerobic organisms as well as the normal skin, mouth, and enteric pathogens. We use a combination of gentamicin (2 mg/kg), metronidazole (7.5 mg/kg), and ampicillin (10 mg/kg) intraoperatively and three times daily and continued for 3 days postoperatively. However, any combination covering the appropriate bacterial spectrum would be satisfactory.

Buccal Mucosa Harvest

For a right-handed surgeon standing on the right side of the patient, the lower lip and the left cheek are the most convenient donor sites. If the requirements for the buccal tissue are clear beforehand, the buccal mucosa may be obtained before commencing penile dissection to allow an elegant, uninterrupted repair that benefits the penile tissue. Otherwise, the previous repair must be dismantled, the need for buccal mucosa assessed, and the graft obtained in midprocedure.

If a single strip of mucosa is required, the current preference is to use the left cheek as the mucosal layer because this site is thicker and more robust than the mucosa of the lip, and the donor site may be sutured. However, in terms of outcome, there is probably little difference between cheek and lip.

For cheek harvest, a suitable mouth retractor, such as the Boyle-Davis, with various sizes of tongue depressor blades, is very convenient. Additional stay sutures are placed on the mucocutaneous junction at the angle of the mouth (Fig. 24–2). The parotid duct usually is easy to identify opposite the upper molars, and it may be cannulated with a short length of 3-0 nylon to make sure that it remains visible throughout dissection and closure. The graft is outlined with a waterproof pen, and the submucosa infiltrated with 1% lignocaine containing 1:2000 epinephrine. After waiting for some minutes (7 is recommended—patience!) the parallel upper and lower borders of the graft are incised. These incisions are then sharply angled to meet at the external limit near the angle of the mouth.

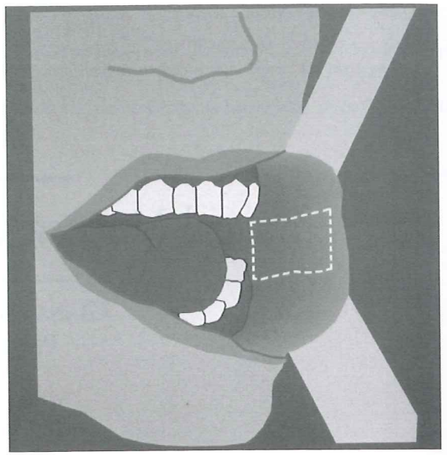


Figure 24–2
Cheek donor site.

One or two stay sutures are then placed to lift the graft toward the mouth cavity, and the mucosa is dissected away by sharp dissection. Buccinator muscle inserts directly into the mucosa, and careful dissection with a knife or sharp-pointed scissors is necessary to free the mucosa. Finally, the internal limit is incised and the graft is free. Diathermy usually is not needed, and the defect is closed with an absorbable 5-0 suture such as chromic catgut. No further local treatment is usually necessary, and patients may eat at once.

Lip harvest is simpler. A series of stay sutures is used to evert the lower lip and to protect the mucocutaneous junction (Fig. 24–3). After epinephrine infiltration and the appropriate delay, the parallel incisions are made transversely, leaving the graft attached at either end. The mucosa (which is a little more delicate than the cheek and prone to tear) is elevated using fine tapered scissors in a manner similar to that used when creating a submucosal

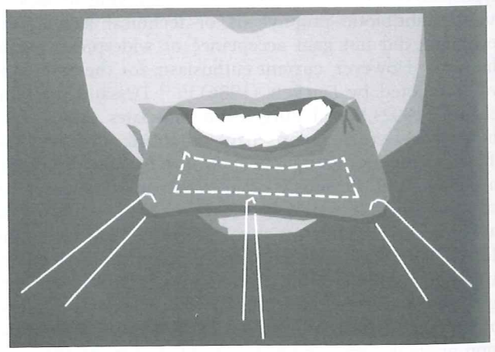


Figure 24–3
Lower lip donor site.

tunnel. Finally, the graft is released at either end and removed (Fig. 24–4). The bare area is not sutured but may be packed with a temporary swab soaked in epinephrine until the end of the procedure. Healing is rapid and complete, and the scar is virtually invisible within 2 to 3 weeks (Fig. 24–5).

The graft tissue is placed in a pot of normal saline for temporary storage while surgery in the mouth is completed. It is then pinned out, face down on a cork or Silastic block for preparation. Excess submucosal tissue and salivary glands are removed by sharp dissection. After a change of gloves, the graft may be deployed in various ways (Fig. 24–6).

Onlay Patch

The urethral plate or previously reconstructed urethra is retained as a midline strip extending forward from the normal native urethra to the glans. This strip varies in width from a few millimeters to 1 cm. The native urethra is incised for at least 1 cm proximally to create a spatulated junction. The graft is trimmed to an appropriate length and width and anastomosed to the margins of the urethral strip using 6-0 or 7-0 polyglycolic acid sutures. Glans wings are wrapped around to provide a terminal meatus (Fig. 24–7). A two-layer closure of well-vascularized penile skin is advised.

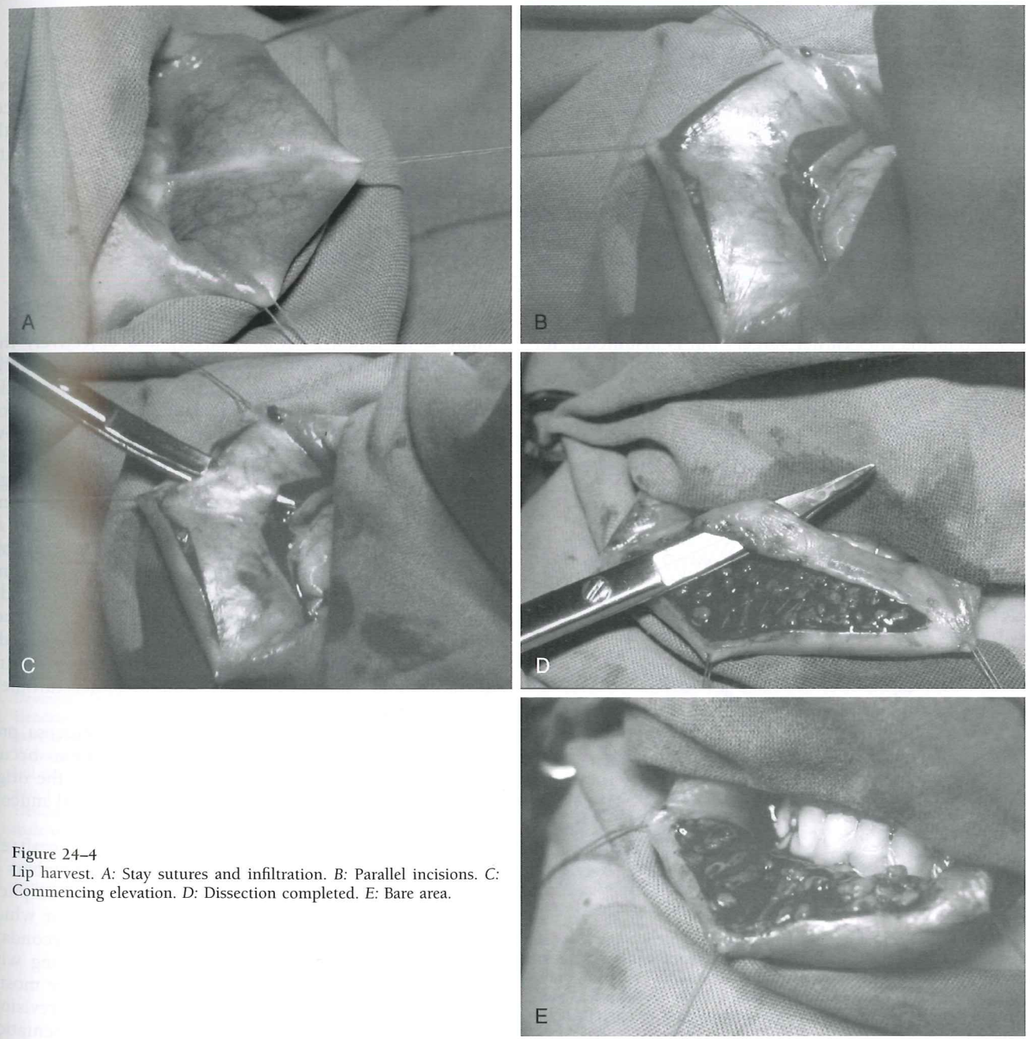


Figure 24–4
Lip harvest. *A:* Stay sutures and infiltration. *B:* Parallel incisions. *C:* Commencing elevation. *D:* Dissection completed. *E:* Bare area.

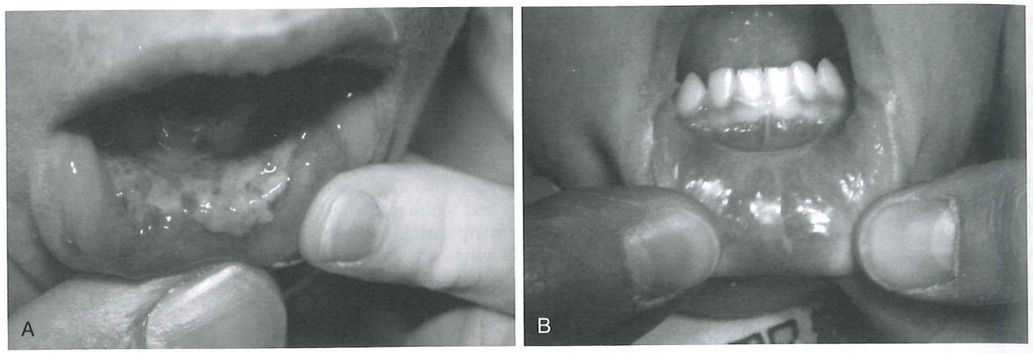


Figure 24–5
Lip healing. *A:* At 1 week. *B:* At 3 weeks.

Tube Urethroplasty

Using either a folded graft or two segments of buccal mucosa as previously discussed, a mucosal tube is created of sufficient length to bridge the urethral defect. The proximal anastomosis is well spatulated, and glans wings are preferable to a tunnel for creation of the terminal meatus. Two-layer skin closure follows.

Compound Tube

A compound tube technique is valuable when some preputial skin remains after earlier surgery but is insufficient for tube urethroplasty on its own. The preputial skin strip is mobilized on its own vascular pedicle, and the buccal graft anastomosed to create the compound tube. This is placed in position on the ventral surface of the penis, with the vascularized skin lying against the corporal surface and the buccal mucosa lying superficially to be covered by a two-layer closure of penile skin.

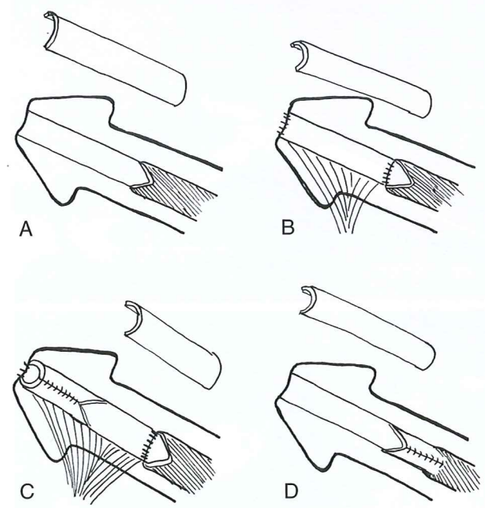


Figure 24–6
Some methods for urethral reconstruction using buccal mucosa. *A:* As an onlay patch. *B:* As a compound tube with a pedicled strip of preputial skin applied to the surface of the corpora cavernosa. *C:* Compound tube variant with partially tubularized preputial skin. *D:* Onlay patch combined with a proximal Duplay tube urethroplasty may be appropriate in primary surgery.

CLINICAL EXPERIENCE AND RESULTS

There is no doubt both subjectively and objectively that buccal mucosa is proving very satisfactory as a material for urethral reconstruction, particularly in hypospadias cripples who have undergone multiple previous procedures. It must be recognized that only short-term follow-up has been reported, although Duckett and colleagues now have 10 years' follow-up on one case[13] and a larger number of cases have had 5 years' follow-up.[19] Two points are particularly worthy of attention. The first is that although some problems still occur at the meatus, necessitating a subsequent meatoplasty, the frequency of such events is a whole order of magnitude less than with bladder mucosa, which produces so many difficult problems when exposed to air at the tip of the penis. In addition, the increased resilience of the buccal mucosa reduces urethral dilatation and ballooning as a result of either turbulent flow or a minor degree of distal obstruction.

It may be that growth factors within the mucosa promote rapid healing and that revascularization occurs quickly because of the thin lamina propria and the originally highly vascular bed from which the buccal mucosa graft was taken.[13]

Our present experience with buccal mucosa graft extends to more than 100 cases, and increasing numbers of reports describe good results with its use. The complication undoubtedly varies with the type of case for which buccal mucosa is deployed, but it seems that a secondary operation rate of approximately 20% is in keeping with most surgeons' experience and that these cases are mostly due to minor fistulas or the need for meatal revision. Radical reoperation with further urethral augmentation with an additional buccal mucosa graft has been necessary on some occasions.

In difficult cases, some preoperative testosterone treatment may improve the vascularity of the penile skin and thereby enhance the chances of success with a free graft technique.

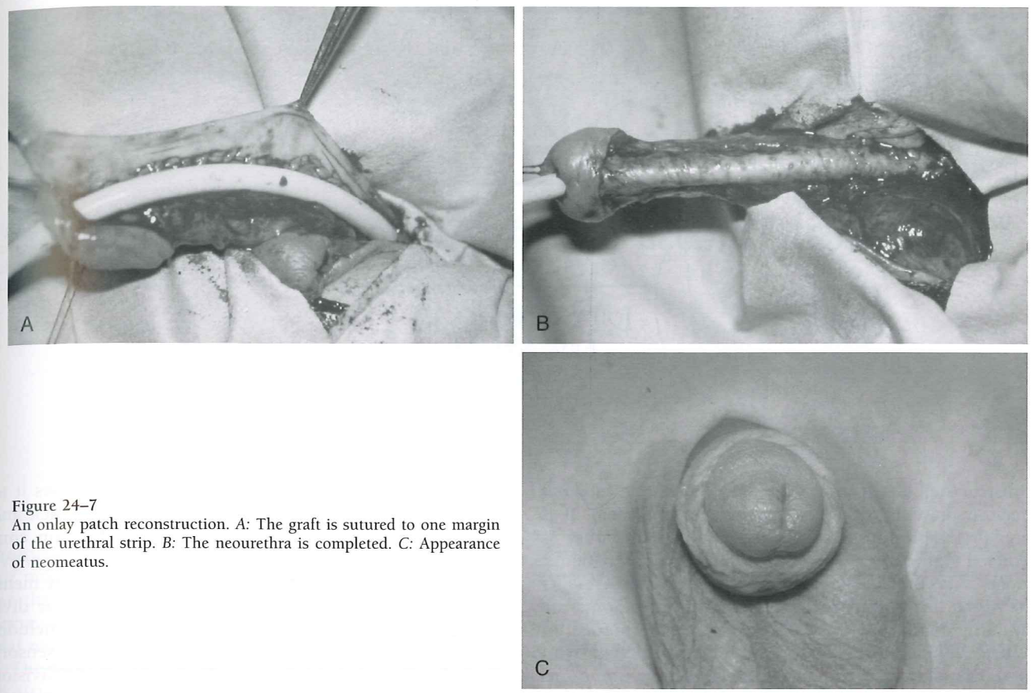


Figure 24–7
An onlay patch reconstruction. *A:* The graft is sutured to one margin of the urethral strip. *B:* The neourethra is completed. *C:* Appearance of neomeatus.

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CHAPTER

25

Buccal Mucosa Reconstruction of Urethra

JOHN W. BROCK III
ERIC NELSON

Reconstruction of the urethra after a failed hypospadias correction presents a difficult management problem. It is always preferable to use available preputial skin either as a pedicled graft or free graft. Unfortunately, many patients, because of several failed procedures, are left with inadequate tissue for reconstruction of the urethra. Some are profoundly compromised by fistula, recurrent chordee, or stricture. Others have had urethral reconstruction with hair-bearing skin and are affected by infection, stone formation, and stricture. For these patients, a superb extragenital tissue source for reconstruction is needed. Many different harvest sites have been used, including non–hair-bearing full-thickness skin,[1] tunica vaginalis,[2] ureter,[3] bladder mucosa,[4–6] and meshed skin.[7] Buccal mucosa, which was described for use by Humby in 1941, has become increasingly popular.[8] The characteristics of the tissue and the ease of its harvest and use have thrust it into the forefront as the preferred free graft for urethral reconstruction in patients with continued problems and a paucity of preputial skin.[9]

The uniqueness of buccal mucosa and its histologic and antibacterial properties make it the superior tissue for reconstruction.[10, 11] The buccal mucosa is actually a lining mucosa and is the mucous membrane of the cheek with the tissue of the oral cavity, consisting of three types: masticatory mucosa, specialized mucosa, and lining mucosa.[12, 13]

The location of the buccal mucosa is limited to the outer vestibule of the oral cavity, which is the space and structure from the teeth to the cheek inside the mouth (Fig. 25–1). A thin strip of masticatory mucosa exists on the maxilla and mandible of the outer vestibule. It begins at the apical portion of the crown of all the teeth and continues superiorly on the maxilla and inferiorly on the mandible for approximately 5 mm. The tissue is immobile and firmly attached to the alveolar bone. The alveolar mucosa is the tissue between the attached gingiva and buccal mucosa to the base of the vestibule. Where the tissue leaves bone and reflects onto the cheek wall, it is considered buccal mucosa. Both the alveolar and buccal mucosa are freely movable, loose, and compliant, the only difference being location.

The unique structure of the buccal mucosa allows it to be an excellent grafting material. It is 500 μm thick and is a nonkeratinized, stratified squamous epithelium consisting of four layers.[14] The stratum basale, or germinative layer, of the epithelium rests against the basement membrane and provides the progenitor cells for cellular division. The basale is two to three cells thick and includes melanocytes, antigen-presenting Langerhans cells, sensory Merkel cells, and lymphocytes. Its rapid mitotic division provides a fast turnover rate, with only 25 days required for all layers of the buccal mucosa epithelium to be replaced.

The stratum spinosum is the next layer, which provides the intercellular bridges that give the buccal mucosa the prickle look under light microscopy. The outer two layers (stratum intermedium and superficiale) are difficult to delineate from each other. These cells, however, are unique in that they are more firmly attached to each other than are other cells of keratinized tissue, providing excellent barrier protection.

Beneath the basement membrane of the epithelial layer is the lamina propria, where collagen and elastin predominate. Elastin fibers are more numerous in the buccal mucosa than in other tissues, allowing the buccal mucosa to recoil after stretching. The lamina propria further provides long, slender papillary invaginations into the epithelia and loose collagen fibers and loops of capillaries from which the epithelium gets its blood supply. The weblike reticular layer of the lamina propria holds the vasculature and nerves of the buccal mucosa. Collagen, elastin, and ground substance depend on the fibroblasts that also reside in this area.

The line between the submucosa and the lamina propria is difficult to delineate. The submucosa, which is firmly attached to the underlying buccinator muscle, is also rich in collagen and elastin in addition to minor salivary and sebaceous glands. A major salivary gland duct (Stensen's duct) from the parotid gland pierces the buccinator muscle opposite the maxillary second molar bilaterally.

The arterial blood supply to the buccal mucosa originates from the facial artery, the buccal artery, the posterior superior alveolar artery, and the inferior superior alveolar

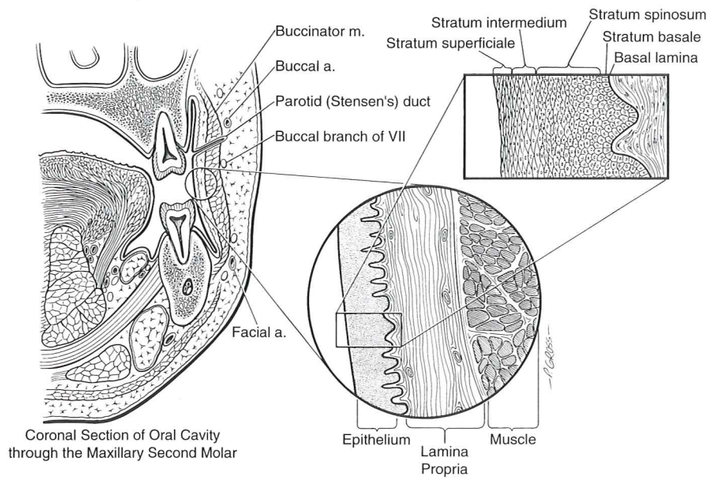


Figure 25–1
Buccal mucosa harvest sites. (From Brock J: Autologous buccal mucosal graft for urethral reconstruction. J Urol 44:753–755, 1994.)

artery off the external carotid. These perforate the buccinator muscle and supply the buccal mucosa. Sensory input for the buccal mucosa is carried through the trigeminal nerve, and buccinator motor function is supplied by cranial nerve VII.

The function of the buccal mucosa is a direct result of its structure. A tight spinosum layer and pump-functioning cells of the superficial layer provide protection from the foreign substances placed in the oral cavity. Elastin and collagen without bony attachment give the buccal mucosa flexibility and the ability to distend and compress. A rapid turnover rate and highly vascularized lamina propria ensure quick healing after injury. The immune response is quickly aided by a lamina propria laden with lymphocytes and macrophages.

The buccal mucosa is a suitable substitution for the urethra not only because of its histologic properties but also because of its ease of harvest and its compatibility with the urinary system. The process of harvest is undertaken at the time of urethral reconstruction after the desired length of tissue has been determined. The harvest sites have included the lower lip and insides of both cheeks (Fig. 25–2), where one or more strips are marked for removal. The fact that buccal mucosa does not stretch and can be harvested one-to-one for urethral size is a distinct advantage. After the site or sites are marked, the area beneath the mucosa is infiltrated with 1% xylocaine with 1:200,000 epinephrine. This is allowed to fix for approximately 10 minutes. At this point, the graft is harvested with the scalpel in a way that removes the full thickness of the mucosa. Portions of underlying muscle are often harvested with the graft and are subsequently removed. Great care is taken not to injure the superficial branches of the facial nerve. Hemostasis is meticulously established with pinpoint electrocautery, and the graft site is then elevated and closed if from the cheek or left open if from the lower lip. The reality is that the vast majority of donor sites are too large to close without creating lip or cheek deconfiguration. Buccal mucosa has a regenerative time of 25 days and has afforded surgeons the option of leaving the harvest site open for epithelialization.[15] We prefer this technique of management. Close follow-up has revealed complete healing in approximately 3 weeks, with the typical granulation tissue present in the interim. No complications have been referable to the donor site in any patient in our series, although one patient did experience transient numbness in the lower lip.

After completion of the harvest, the graft can be reconfigured to the needs of the individual patient. Grafts have been used as full-thickness tubes,[16–18] onlays,[19] or patches.[20] Total urethral reconstruction and segmental reconstruction have also been performed. Increased contraction of full-thickness tubes with anastomotic strictures has led some to avoid tube grafts in favor of onlay procedures.[19] We

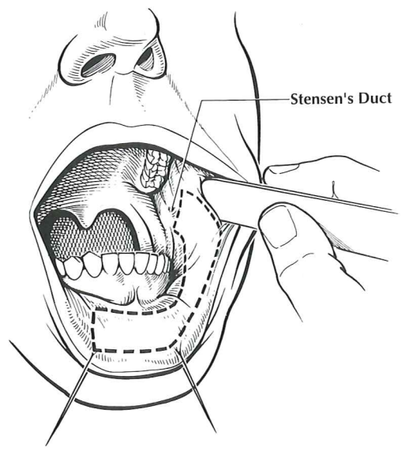


Figure 25–2
Coronal section of the mouth.

have not encountered this problem. Of 18 patients who have had buccal mucosa reconstruction using full-thickness tubes, 4 have developed stricture. However, two of these were adult patients in whom the entire distal urethra was reconstructed at the same time a hair-bearing segment of urethra was removed. The two children who have experienced anastomotic stricture have been treated by dilatation in one and a patch graft of buccal mucosa at the anastomotic site in the other.

Full-thickness tubes are fashioned to the appropriate size and then closed over a Silastic stent with a running subcuticular 7-0 Maxon suture. The suture line is placed against the corporeal body, and great care is taken to spatulate the proximal anastomosis to make it quite patulous. Because of the ease of use and handling of buccal mucosa, we prefer to use several donor sites and to anastomose segments for reconstruction of long defects of the urethra. In our series, two patients have been treated in this fashion for defects of 9 and 11 cm.

Onlay or patch grafts are also an outstanding application of buccal mucosa. Many investigators prefer buccal mucosa as an onlay to prevent strictures; however, their results also include a much higher fistula rate.[16] We have also had experience with this and find it to be quite useful. In most of the cases that have been presented, however, the urethral plate has either been destroyed or is unsuitable for anastomosis. The fact that the plate is a continuous scar has led us away from leaving it as a template because of the worry of suture line healing. Patch graft for urethral stricture may have a place simply because of the short segment involved and the ability to anastomose to healthy tissue on either side of the stricture.

Postoperative management of these cases is vital to success. The importance of immobilization of a free graft to allow imbibition of blood supply cannot be overemphasized. Standards have been to require hospitalization and immobilization of patients for as long as 7 days. Our series has dealt with these patients as we do all those undergoing hypospadias correction: An immobilizing dressing and a drip catheter are used, and surgery is performed on an outpatient basis. The drip catheter is used in children who are not yet toilet trained, and a suprapubic punch cystotomy with a urethral stent has been used in older children or adults for whom this technique has been applied. The drip catheters or suprapubic tubes are left indwelling for 10 to 14 days and are removed on an outpatient basis in the office.

The advantages of buccal mucosa seem to be many and have been borne out by the relatively low complication rate in these complex cases. The meatal problems of excoriation, encrustation, and protuberance, as encountered with bladder mucosa, have not been a problem with buccal mucosa.[5] Certainly, stricture and fistula continue to be worrisome with any free graft, as noted earlier. The relatively high risk of proximal stricture in some series has led surgeons to abandon full tube grafts in favor of onlay flaps. This risk, however, has not been consistent with our experience.

When using a tube graft, caution must be exercised in the use of buccal mucosa in adults who have urethral stricture disease or complications of previous hypospadias surgery. Our reoperative rate has been much higher in this group, and stricture, fistula, diverticulum, and infection present a much more common problem. Whether this is simply a result of the more complicated and difficult nature of these cases remains to be seen.

The structure, function, and ease of working with buccal mucosa make it the ideal extragenital source for reconstruction of the urethra in complex hypospadias. Its graft site retrieval ease and rapid healing process also contribute to its superiority. The only shortcoming at present seems to be related to the limited availability of buccal mucosa as well as the reported increased stricture rate in some series.

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CHAPTER

26

Bladder Mucosal Grafts for Male Urethral Reconstruction

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STEVE WAXMAN

Urethral reconstruction for hypospadias repair or urethral stricture disease may require an extragenital source of tissue when adequate penile skin is lacking. Numerous sources of tissue have been described, including arteries, veins, appendices, hairless skin from various regions of the body, and buccal and bladder mucosa.

Bladder mucosa for the repair of the urethra in hypospadias was first described by Memmelaar in 1947.[1] He discussed the benefits of a one-stage hypospadias repair and the favorable characteristics of bladder mucosa in the reconstruction of the male urethra. Marshall and Spellman in 1955 reported on 39 patients who underwent a two-stage technique using bladder mucosal grafts.[2] Problems with strictures and fistulas when using bladder mucosa led to the abandonment of this type of graft in hypospadias repair. The bladder mucosal graft was reintroduced for use in urethral reconstruction by Coleman and colleagues. They favorably described seven patients who underwent a one-stage repair.[3] Bladder mucosal grafts, however, were being used extensively in China in the late 1970s for one-stage hypospadias repairs.[4] During the past decade, bladder mucosal grafts were used rather extensively in one-stage repair of hypospadias and urethral stricture disease.[3, 5–8] Problems with stricture at the proximal anastomosis, along with fistulas and mucosal glanular protrusion, caused several investigators to devise ways to decrease the complication rate. Duffy and associates used a tube of bladder mucosa combined with penile or preputial skin distally to avoid the mucosal protrusion problem.[9] Other techniques have been described to decrease the incidence of mucosal protrusion and meatal stenosis by cutting the bladder mucosa flush with the glans or even undercutting the glans epithelium and invaginating it into the new meatus.[10, 11] When used as a free tube graft in the posterior or bulbar urethra for urethral stricture disease, bladder mucosa has been shown to work well.[12, 13]

INDICATIONS

Bladder mucosa can be used as a patch or tubularized free graft in a number of complex urethral reconstructive situations. Obviously, it is preferable to use penile or preputial skin for urethral reconstruction whenever it is available. Even in cases of proximal hypospadias with chordee, a tubularized preputial island flap can successfully repair the problem without the need for extragenital tissue in most instances.[14]

Patients who have undergone one or more failed hypospadias repairs and who have inadequate penile or preputial skin for urethral reconstruction constitute the majority of patients in whom extragenital tissue is necessary for a successful repair. As mentioned before, patients who have urethral stricture disease and inadequate penile or preputial skin may also be candidates for bladder mucosal graft. However, other patch or graft alternatives may be more applicable in this situation. Buccal mucosa has received renewed interest by several investigators in the 1990s because of its relative ease of acquisition and low complication rates.[15]

TECHNIQUE

The goals of hypospadias repair have been summarized superbly by Keating and colleagues: resection of chordee, placement of the neomeatus at the tip of the glans, construction of a uniform-caliber hairless urethra, and a cosmetically pleasing external appearance of the glans and shaft.[14] Being a free graft, the bladder mucosa must be able to survive by imbibition for the first 48 hours, followed by inosculation, which occurs on days 2 to 4. For this to be successful, the recipient site must be well vascularized and immobilized in the postoperative period while neovascularization and healing are occurring. In patients who have undergone several prior attempts at repair, a preponderance of scarring may reduce the chances for a viable graft take and increase the possibility of subsequent stricture and fistula formation. The majority of repairs are currently performed as one-stage procedures. The urine is checked preoperatively to make sure it is free of infection. Appropriate broad-spectrum antibiotics are given prophylac-

tically perioperatively. In hypospadias repair, penile dissection including correction of chordee and complete stricture/scar excision is performed before bladder mucosal graft harvest. The glans is prepared by creating a tunnel between the corpora cavernosa and glans and then by excising a generous button of glans tissue at the glans tip where the neomeatus will be positioned. It may be necessary to resect some deep intraglanular tissue to ensure an adequate, noncompressive channel. Alternatively, the glans may be split ventrally, creating glans wings.

Any prior failed tube graft tissue must be excised, and it may be necessary to freshen the proximal edge of the native meatus to reach well-vascularized tissue. Once the bed for the graft has been prepared and checked for good vascularity, the gap is then measured from the native meatus to the tip of the glans tunnel. Attention is then turned to the harvest of the bladder mucosal graft. The bladder is distended with saline so that it is palpable above the symphysis pubis. A Pfannenstiel incision is then performed to expose the underlying bladder. If the patient has had a previous suprapubic cystostomy, this site is avoided because of increased difficulty in obtaining a graft secondary to fibrosis. The detrusor muscle is then incised down to the underlying mucosa with a knife or blunt-tipped scissors. Once dissection reveals the bulging blue mucosa, further blunt dissection allows separation of the detrusor muscle off the mucosa for a distance adequate to harvest the appropriate-sized graft. If the mucosa is inadvertently opened before obtaining an adequate graft, the bladder can be opened and the mucosa dissected off the detrusor. However, this is much more tedious. Once an appropriate-sized area of bladder mucosa is exposed, it is marked with a sterile pencil, stay sutures of 7-0 polyglactin are placed at each corner, and the graft harvested. A suprapubic cystostomy tube is placed, and the bladder is closed in one layer with no attempt to oppose the mucosa.

The bladder mucosal graft is then tubularized over an appropriate-sized catheter using a running, inverting 7-0 polyglactin suture with interrupted sutures on one end to facilitate size trimming of the tube graft without violating the running suture. Long grafts are bolstered with a second layer of interrupted sutures. Tubularization can be facilitated by placing the graft on a polystyrene needle board and immobilizing it at the ends with 30-gauge needles. The graft is kept moist with cool normal saline until reimplantation. A wide, spatulated anastomosis is performed between the tube graft and recipient urethra with 6-0 or 7-0 running polyglactin suture. The graft suture line is placed dorsally against the corpora to avoid overlapping suture lines and thus decrease the chance for fistula formation. The graft can be anchored to the corpora at several points to decrease the risk that shear effect might compromise graft take. The distal end of the graft is then brought through the glans, and the bladder mucosa is cut flush with the glans edge while keeping the graft on stretch to avoid redundancy at the tip. The graft edge is then sutured to the glans with interrupted 6-0 or 7-0 polyglactin sutures. An appropriate urethral catheter or stent is placed for drainage, along with the suprapubic cystostomy tube (Malecot catheter). The graft is covered with at least two layers of well-vascularized tissue such as tunica vaginalis, including skin. Alternatively, bladder mucosa at the tip of the glans may be avoided by either tubularizing the distal skin strip of the glans as described by King or combining the bladder mucosal graft with a strip of penile skin as described by Duffy and associates.[9, 16] The penile or preputial skin may be closed using either Byars flaps or that described by VanderMeulen. The urethral and suprapubic catheters are connected to gravity drainage, and the penis is secured to the anterior abdominal wall with dressing to immobilize it and enhance graft take. In postpubertal patients, diazepam or estrogen can be used to prevent erection in the postoperative period. The urethral catheter is removed on the 12th to 14th postoperative day, and the suprapubic tube capped. Once the voiding trial is deemed successful, the suprapubic catheter can be removed.

RESULTS

In Keating and coworkers' extensive review of the literature related to bladder mucosa grafts, an overall complication rate of 40% was found. Two thirds of these complications were minor, with little or no treatment being deemed necessary. The majority of complications involve protrusion of the graft mucosa at the meatus with or without stricture.[14] This troublesome complication has been dealt with in numerous ways, including cutting the graft flush at the glans tip, avoiding any redundancy. Others have proposed undercutting the glans epithelium and laying the edge into the distal anastomosis. Early and frequent dilations of the neomeatus have also been proposed to help avoid stenosis. The problem with exposed bladder mucosa at the meatus is that it becomes hypertrophic, and metaplastic changes occur. Prevention of mucosal protrusion is the key to management. If mucosal protrusion or stenosis does occur, revision is necessary. Stricture at the proximal anastomosis or fistula can occur with free or vascularized grafts of all types. Urethral diverticulum of the graft tissue can occur if redundant tissue is not excised or distal obstruction is present. Stricture of the proximal or distal end of the graft may be treated with dilation or internal urethrotomy. Although bladder mucosa grafts have had a relatively high incidence of minor complications in the early postoperative period, they have succeeded well in the long run. Bladder mucosa is a good graft tissue for the urethra and has been shown by many investigators to work well.

The recent resurgence of interest in buccal mucosa has been fueled because of its ease of harvest, thickened epithelium, and thin lamina propria when compared with bladder mucosa.[15] Moreover, the fact that the bladder need not be opened makes the morbidity of surgery for buccal mucosal grafts less than that to obtain bladder mucosa.

CONCLUSION

The optimal graft or flap for urethral reconstruction is penile/preputial skin when available. If such skin is lacking, bladder and buccal mucosa have proved to be excellent alternatives for urethral reconstruction. Our current preference is to use buccal mucosa in most instances because of its easy accessibility and reduced morbidity. When a long tube graft is necessary and hence buccal mucosa potentially is insufficient or when the bladder is to be opened coincidentally for other indications, we favor the bladder mucosa graft.

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CHAPTER

27

Fistula Repair

STEPHEN R. SHAPIRO

Hypospadias is one of the more common congenital anomalies in boys. Although significant improvements in surgical technique have been made in recent years, unfortunately, some complications of repair will continue to occur. Urethrocutaneous fistula is the most common complication. The incidence of fistula formation has decreased gradually in the past two decades, and its incidence can be used to judge the success of hypospadias repair.[1] Some procedures are more prone to fistula formation than others. For example, in an extensive review of hypospadias repairs in 1990, Durham Smith[2] noted that the fistula rate for the meatoplasty and glanuloplasty (MAGPI) procedure[3] varied from 0.5% to 10% whereas the fistula rate for flip-flap[4] repairs varied from 2.2% to 35%. Durham Smith found that fistula rates varied from 4% to 33% for island pedicle tubed repairs.[5] Free graft tubed repairs encountered even higher fistula rates of 15% to 50%.[6] Urethral advancement for distal hypospadias repair has a variable incidence of fistulas,[7, 8] from less than 1% to 16.7%. It has not been widely used because of the risk of urethral devascularization with extensive mobilization. For the megameatus variety of hypospadias, the pyramid procedure has a reported fistula rate of less than 5%.[9, 10]

Using a two-stage repair, in more than 500 cases, Durham Smith reduced his incidence of fistula formation to less than 3%.[11] Similarly, Greenfield and colleagues reported a urethral fistula rate of 2.5% with a two-stage modified Belt-Fuqua repair for severe hypospadias with chordee.[12] In 1984, a urethral fistula rate of 6.25% (11 cases) was found in a series of 176 hypospadias repairs including the MAGPI, flip-flap, island pedicle, and free graft techniques.[13] In a more recent review of 112 island pedicle hypospadias repairs in 1993 and 1994, with at least 6 months of follow-up, two fistulas (1.5%) have been identified.

FISTULA PREVENTION

A fistula rate of less than 5% is now to be expected.[14] The numerous factors that have accounted for this lower incidence of fistula formation today are listed in Table 27–1. Better suture materials are available today with greater tensile strength and less reactivity, including 6-0 to 7-0 polydioxanone (PDS) and 6-0 and 7-0 polyglactin (Vicryl) and polyglycolic acid (Dexon). These sutures can be used on the skin (7-0 PDS, 6-0 and 7-0 polyglactin and polyglycolic acid) as well as internally. PDS should not be used in the urethra (subcuticular is satisfactory) because fistula may result. Use of plastic surgical principles such as microvascular instruments and delicate tissue handling are now the norm. Vascularized island pedicle flaps are preferred in the various repairs and their modifications. In addition, the onlay island flap is used as often as possible rather than the tubed repair, which has a higher incidence of complications.[15] The fistula rate can be lowered further by using the island pedicle procedure in a double-faced fashion (i.e., the island of foreskin is used as a patch over the urethral plate but is left attached to the outer skin as much as possible). Deepithelialized flaps were first described by Smith in 1973.[16] The principle was applied by Belman to the island pedicle procedures, with only one fistula in 32 onlay repairs.[17] Hill and colleagues used the deepithelialized flap to improve results of the pyramid procedure.[18] Hypospadias repair without magnification would be unthinkable today. Either the microscope or 3.5× optical magnification can be used.[19] Either a dorsal subcutaneous flap[20] or a tunica vaginalis wrap[21] can provide a second layer when skin is deficient. Using the dorsal subcutaneous flap, Retik and associates[20] performed 204 meatal-based flap hypospadias repairs without a urethrocutaneous fistula. Snow and coworkers used the tunica vaginalis blanket wrap for five different hypospadias repair procedures in 89 patients.[21] The fistula rate decreased from 20% to 9% when microscope magnification was combined with the tunica vaginalis blanket wrap.

Table 27–1
Factors Related to a Lower Incidence of Urethral Fistula Formation

Better suture materials
Microvascular instruments
Vascularized island flaps[5]
Onlay island flaps[15]
Double-faced island flap
Deepithelialized flaps[16–18]
Use of magnification (3.5× loupes or the microscope)[19]
Dorsal subcutaneous flap[20]
Tunica vaginalis wrap[21]
Silicone stents or catheters
Reliable postoperative dressings[22, 23]

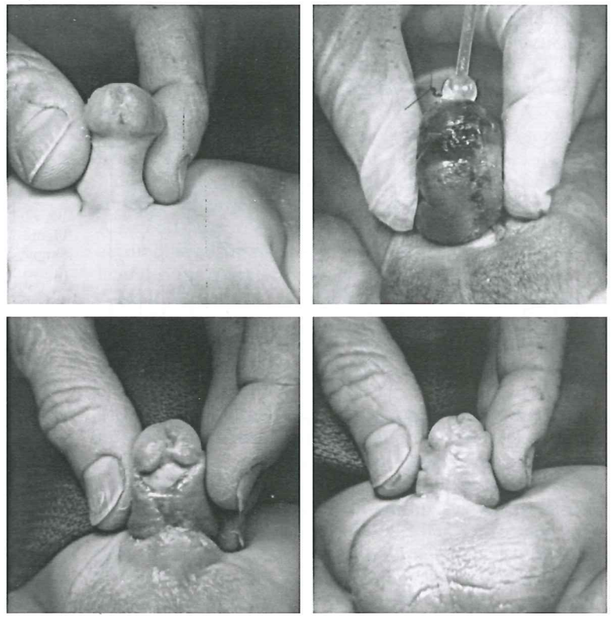


Figure 27–1
Impending fistula never occurred despite spontaneous voiding after the island pedicle onlay repair. *Upper left:* Preoperative appearance. *Upper right:* Appearance 5 days after surgery. *Lower left:* Appearance 5 days after removal of urethral stent. Although there was significant skin separation and skin loss externally, intact deep tissue prevented fistula formation. *Lower right:* Final appearance after healing by second intention. A urethral fistula never occurred.

An additional technique in fistula prevention is use of nonreactive silicone stents or catheters. Nonreactive silicone stents such as the Firlit-Kluge urethral stent (Cook Urological, 1100 West Morgan St., P.O. Box 227, Spencer, IN 47460) and the 8 and 10 French Dover (Sherwood Medical, St. Louis, MO 63103) Foley urethral catheter have permitted excellent urethral drainage and have obviated suprapubic or perineal diversion in almost all cases. A stent or catheter one size smaller than the urethra should be selected to permit voiding around the tube should it become plugged or should bladder spasms occur. Modern hypospadias dressings with materials such as Duoderm (ConvaTec, a Bristol-Myers Squibb Co.) or silicone foam have also aided results.[22, 23] I currently use Telfa gauze (Kendall Healthcare Products Co., Mansfield, MA 02048) covered with Duoderm and then with Tegaderm (3M Medical-Surgical Division, St. Paul, MN 55144). This is left on overnight and removed the next day in order to prevent compression of the blood supply of the elevated flap. Thereafter, a simple dressing of Telfa gauze is applied loosely. Although the fistula rate does not necessarily depend on catheter or stent drainage postoperatively for some types of distal repair, for security, I continue to leave a Firlit-Kluge urethral stent or silicone Foley catheter indwelling for up to 5 days for most hypospadias repairs. Grafting procedures, however, require a longer period of postoperative urinary drainage.

MANAGEMENT OF FISTULAS

Poor vascularization of the external skin with impending fistula formation is occasionally identified before removal of the urinary diversion. If this is the case, the urinary diversion may be left indwelling for an additional 7 to 10 days. On occasion, a fistula may close with this type of management. If the diversion has already been removed, as is the usual situation, one has the option either to allow spontaneous voiding (Fig. 27–1) or to insert a silicone Foley urethral catheter for an additional 10 to 14 days. With either management, if voiding is unrestricted and there is no distal urethral stricture or meatal stenosis, it is still possible for a small fistula to close spontaneously. If the fistula persists, it is advisable to wait for at least 6 months to allow for complete healing before consideration for secondary closure of the fistula. On occasion, a fistula closes spontaneously even at this time.[24]

The same principles that apply to hypospadias repair apply to fistula closure. Delicate instruments are required. Healthy tissue should be incorporated in the repair at all times. Magnification is mandatory. The type of repair depends on the size and location of the fistula. It is important to recognize the presence of a urethral diverticulum or distal urethral stricture because it leads to recurrence of the fistula. Accordingly, the distal urethra must be examined for evidence of obstruction with either cystoscopy, a retrograde urethrogram, or urethral calibration. A lacrimal duct probe can be inserted into the fistulous tract to identify the epithelial lining. For a small fistula, simple closure is often possible (Fig. 27–2). The dissection is

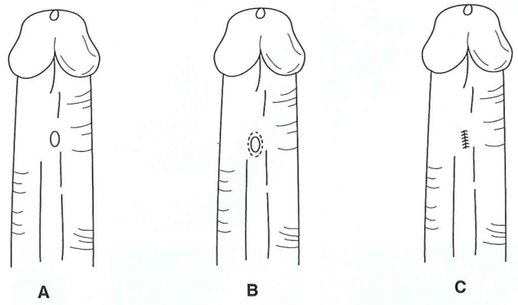


Figure 27–2
Simple closure. *A:* Distal shaft fistula. *B:* Fistula circumscribed and closed in two layers. *C:* Skin closure.

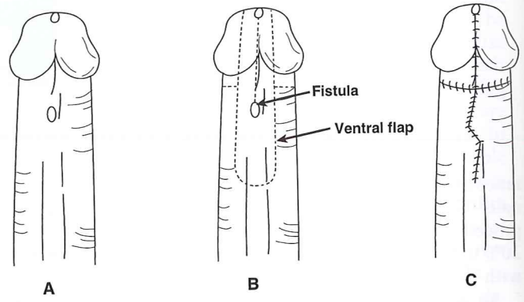


Figure 27–3
Flip-flap repair of fistula near the glans. *A:* Subglanular or coronal fistula. *B:* Ventral flap outlined as in the flip-flap operation. The fistula connected with the meatus on the glans. *C:* Z-plasty closure of skin.

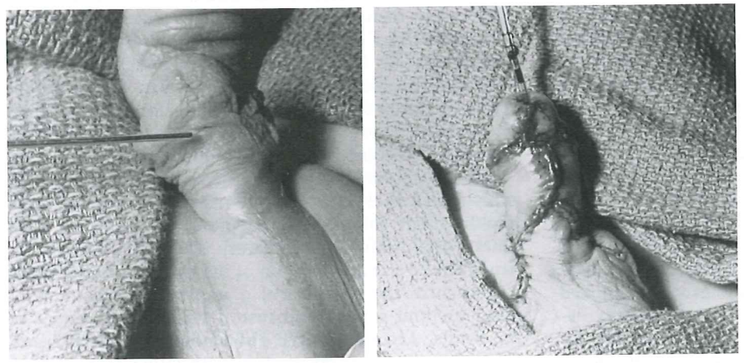


Figure 27–4
Flip-flap closure of coronal fistula. *Left:* Urethral fistula near the coronal sulcus in a circumcised boy. *Right:* The fistula has been closed using the flip-flap technique. A scrotal flap is used to relieve tension on the ventral skin after closure. Dorsal relaxing incision relieves tension distally.

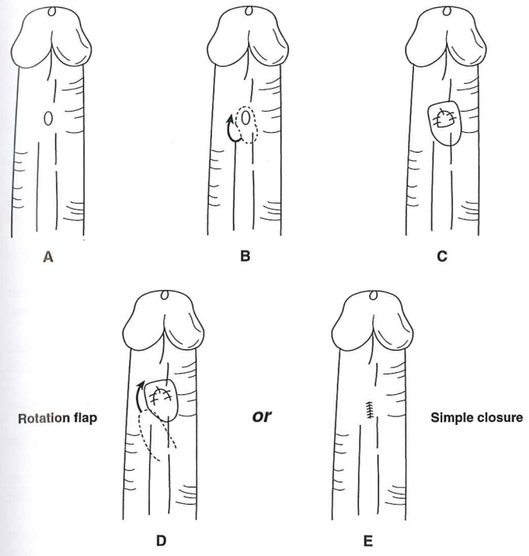


Figure 27–5
Local flap closure of a large urethral fistula. *A:* Fistula location. *B:* The flap to cover the fistula is outlined. *C:* Closure of flap. *D:* Rotation flap of skin for coverage. *E:* Alternatively, simple skin closure.

carried down to the urethra, and a running subcuticular suture of 7-0 PDS is used to close the urethral edges using an inverting technique. Irrigating the urethra with proximal compression helps to ensure a watertight closure. Closure of a second layer of subcutaneous tissue over the fistula is essential. The skin is closed in the usual fashion. Although some favor closure without a urinary diversion,[24] I prefer to use a Firlit-Kluge stent for several days after the procedure. Using this technique, Duckett and colleagues closed 32 fistulas with three recurrences.[25]

A fistula near the glans with thin skin distally can be repaired by connecting the skin between the meatus and the fistula. The defect then is closed using the flip-flap technique to cover over the now subglanular meatus (Figs. 27–3 and 27–4). In this technique, either a ventral or an oblique or lateral strip of skin can be used to cover over the meatus in the classic Mathieu procedure. The flap can be either meatal based or based on an island pedicle of skin. The skin closure is then accomplished using a Z-plasty or transfer of some excess skin from the dorsal surface, which is often present in hypospadias repairs.[26, 27] As with the flip-flap or island pedicle repairs, a second layer of subcutaneous tissue is necessary to cover the edges of the flap or onlay patch.

If the skin surrounding a large fistula is well vascularized and not badly scarred, it is possible to use a local flap of skin to cover the fistula (Fig. 27–5). In this technique, a broad-based flap of skin is outlined and then mobilized. The flap should be large enough so that clean edges can be used for the closure. Two layers are again necessary. The skin defect can be covered with either simple closure (Fig. 27–5*E*) or a rotation flap (Fig. 27–5*D*), particularly with a fistula that has recurred.

Another variant is use of the onlay island patch of skin to close the fistula (Fig. 27–6). The fistula is circumscribed, and a healthy island of skin is outlined somewhat near the fistula. The island of skin is mobilized on its blood supply and then anastomosed to the fistula using a running subcuticular suture of 7-0 PDS and magnification. A second layer of running 6-0 PDS is used. Skin cover is accomplished by means of a rotation flap from either the lateral skin or the scrotum.

Multiple fistulas can be dealt with in a two-stage procedure. The fistulas are converted into one large fistula using the Johanson procedure.[28] In a second stage, the one large fistula can be closed by mobilizing the edges and then closing the urethra in two layers. Skin closure can be accomplished either by rotating a midline scrotal flap or by rotating a lateral flap of penile or scrotal skin. Grafts such as buccal mucosa, bladder mucosa, or extragenital skin are generally reserved for repair of strictures.[29, 30] However, the free graft onlay urethroplasty can be successfully performed for fistula closure,[31] but meticulous attention to layered closure is essential and the risk of fistula re-formation is substantially higher than when local well-vascularized skin is used. With all of these repairs, tension on suture lines must be avoided and narrowing of the urethral lumen must be prevented.

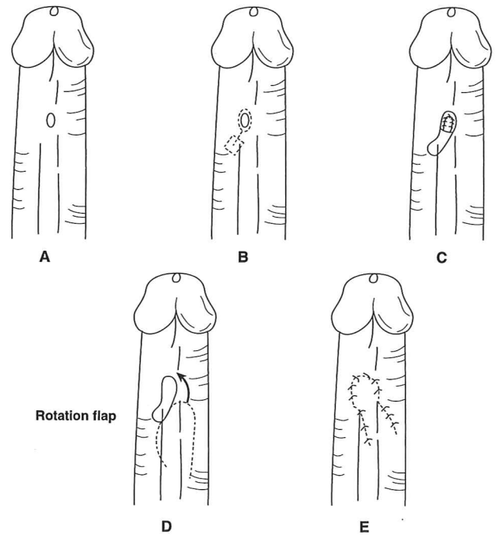


Figure 27–6
Onlay island patch to close a fistula. *A:* Fistula location. *B:* A healthy island of skin is outlined somewhat near the fistula. *C:* Anastomosis of the skin to cover the fistula. *D:* Rotation flap of skin for coverage. *E:* Closure of the skin.

CONCLUSIONS

Most fistulas occur because of errors in technique. Contributing factors include inadequate layers of closure, ischemic tissue, and overlapping suture lines.[2] Infection, tension such as is created by edema or hemorrhage, pressure of dressings, occlusion of catheters with urinary extravasation or early voiding, and blockage of catheters all contribute to fistula formation. The difficulty of fistula closure should not be underestimated. Nevertheless, most fistulas can be repaired on an outpatient basis.[32] Careful attention to detail and technique results in ultimate closure of nearly all fistulas.

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CHAPTER

28

Megalourethra and Urethral Diverticula

JOEL GELMAN

MEGALOURETHRA

Megalourethra is defined as a diffuse enlargement of the anterior urethra. Reports also describe an acquired form of megalourethra or megaurethra. This is a potential complication of pedicle flap urethroplasty in which distal obstruction leads to proximal dilation of the reconstructed urethra.[1] However, the term *megalourethra* generally refers to a congenital anomaly of the anterior urethra that was first described by Nesbitt in 1955.[2] This disorder is characterized by a nonobstructive urethral dilitation associated with deficiency of corpus spongiosum erectile tissue.

In 1963, Dorairajan classified megalourethra into a scaphoid type and a fusiform variety.[3] The scaphoid variant is more common (Fig. 28–1). The corpora cavernosa are intact, and children with scaphoid megalourethra are generally able to achieve erections, although a dorsal penile curvature is often noted. Characteristic ballooning of the ventral urethra occurs with micturition. Retained urine within the dilated urethra may lead to postvoid incontinence. Fusiform megalourethra is characterized by absence of both the corpus spongiosum and the corpora cavernosa. The penis is elongated and saclike, and erections are not possible (Fig. 28–2). In 1986, Appel and colleagues reviewed several cases of megalourethra with histologic evaluation and observed that atresia of the corpora cavernosa was variable.[4] It was concluded that the classification of megalourethra into scaphoid and fusiform subtypes was arbitrary, and megalourethra is currently recognized as a disorder with a spectrum of presentations.

Although the etiology of megalourethra is controversial, mesodermal dysplasia is a potential cause. This view is supported by the observation that megalourethra is often associated with other congenital anomalies, particularly diffuse mesenchymal disorders. As many as 50% of patients with scaphoid megalourethra also have the prune belly syndrome.[5] However, most patients with prune belly syndrome have a normal anterior urethra. Other associated anomalies may include posterior urethral valves, hypospadias, renal dysplasia-hypoplasia, vesicoureteral reflux, imperforate anus, rectovesical fistula, vertebral anomalies, and cardiac anomalies.[6] Fusiform megalourethra is generally associated with nonurologic anomalies and azotemia due to severe renal dysplasia. The prognosis is often poor.

The diagnosis of megalourethra is made by physical examination of the external genitalia. Imaging studies such as a retrograde urethrogram or voiding cystourethrogram demonstrate the urethral dilitation and diagnose any associated lower tract anomalies.[7] Upper tract imaging is mandatory. When instrumentation is performed, prophylactic antibiotics are indicated to prevent sepsis.

The initial management of megalourethra includes the initiation of suppressive antibiotics, particularly when upper

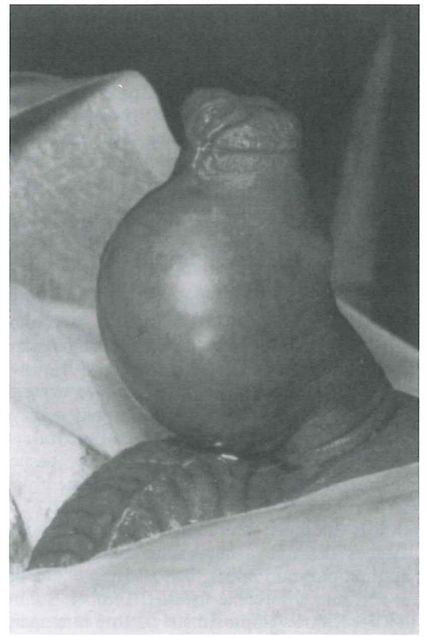


Figure 28–1
A scaphoid megaloureter during voiding. (From Gillenwater JY, Grayhack JT, Howards SS, Duckett JW: Adult and Pediatric Urology, 3rd ed. St. Louis, CV Mosby, 1996, p 2434.)



Figure 28–2
A fusiform megalourethra. (From Belman AB: Hypospadias and other urethral abnormalities. In Kelasis PP, King LR, Belman AB [eds]: Clinical Pediatric Urology, 3rd ed. Philadelphia, WB Saunders, 1992.)

tract anomalies coexist.[8] When the overall prognosis is good, corrective surgical intervention should be considered. With fusiform megalourethra, the absence of corporeal tissue compromises reconstructive repair, and gender reassignment surgery is generally considered to be the procedure of choice. The redundant penile skin is excised, gonadal tissue is removed, and labia are developed from the scrotal skin.[9] A promising alternative to gender reassignment may be phallic construction using a forearm free flap. With this technique, a phallus of adequate size and acceptable appearance can be constructed. The patient can void while standing, achieve erections after placement of a prosthesis, and experience erogenous sensibility.[10]

Patients with scaphoid megalourethra do not always require surgery. When hypospadias is absent, asymptomatic patients can be observed. When minimal postvoid dribbling is the only symptom, this can be managed with massage of the urethra after urination to drain the retained urine. Surgical repair of scaphoid megalourethra is usually achieved by mobilization of the penile shaft skin, ventral vertical incision of the urethra, excision of redundant urethral tissue, and suture reapproximation of the urethra over a stent as originally described by Nesbitt.[1, 9, 11] Although excision of redundant urethra is the most commonly reported repair, Heaton and colleagues describe a successful technique using infolding urethral plication rather than excision.[12] The penis is degloved, and fine absorbable inverted Lembert sutures are placed in a vertical row approximately 2 to 3 mm apart (Fig. 28–3). If necessary, hypospadias repair can be simultaneously performed. Potential advantages of plication include improved preservation of the urethral blood supply and a reduced incidence of urethrocutaneous fistula.

URETHRAL DIVERTICULA

Urethral diverticula can be congenital but are usually acquired.[13] Acquired anterior urethral diverticula are often iatrogenic, and causes include instrumentation with creation of a false passage, inflammation due to infection or chronic catheterization, and prior hypospadias repair complicated by distal obstruction. A posterior urethral diverticulum can also develop as a consequence of prior instrumentation. Posterior diverticula have also been caused by urethral trauma during rectal surgery, and a giant acquired posterior diverticulum after radical retropubic prostatectomy has been reported.[14]

Congenital ventral anterior diverticula are often called *anterior urethral valves*. They may result from a congenital deficiency in the development of adjacent corpus spongiosum. These valves may be obstructive and associated with difficulty in catheterization. A congenital diverticulum of the distal dorsal urethra is also called a lacuna magna or valve of Guérin. The diverticulum is partially separated from the dorsal glandular urethra by a septum.

Urethral diverticula in males are often asymptomatic and discovered only as an incidental finding. Symptoms of diverticula may include postvoid dribbling or urinary tract infection. Stasis of urine occurs within small-mouthed diverticula in particular, and this can lead to stone formation. A lacuna magna may present with postmicturition bleeding or dysuria, and diverticula secondary to distal obstruction are often associated with obstructive voiding symptoms. The diagnosis of a urethral diverticulum is usually made by voiding cystourethrography, and this imaging study offers the advantage of providing visualization of the entire urethra. A retrograde urethrogram outlines the anterior urethra but does not always adequately image the posterior urethra. A urinalysis and urine culture are also standard mandatory diagnostic tests. Endoluminal ultrasound has been reported to be a potentially useful imaging modality.[15] However, the majority of patients evaluated were female, and further studies are needed before ultrasound can be considered a valuable adjunct to or replacement for cystourethrography.

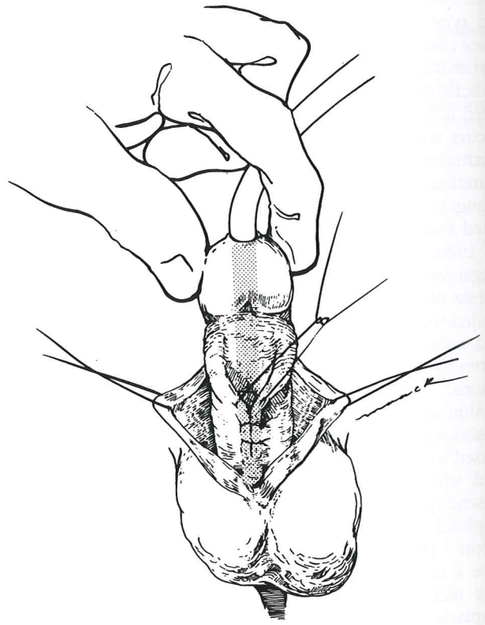


Figure 28–3
This drawing demonstrates the infolding of the redundant urethral tissue during urethral plication. (From Heaton BW, Snow BW, Cartwright PC: Repair of urethral diverticulum by plication. Urology 44:751, 1994.)

The majority of the urethral diverticula in males are asymptomatic and require no treatment. When treatment is indicated for anterior diverticula, options include open excision or plication as described earlier for the treatment of megalourethra. When symptoms are due to stasis in association with a small-mouthed diverticulum, open marsupialization or endoscopic incision should be considered.[16] Posterior diverticula refractory to endoscopic treatment can be approached perineally but are best treated with transabdominal repair. Excellent exposure can be achieved by opening the bladder at the base of the trigone.[13] Overall, open repair of urethral diverticula is usually successful.

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CHAPTER

29

Urethral Strictures Following Hypospadias Repair

GEORGE W. KAPLAN

The study of urethral strictures that occur after hypospadias repair in many ways is a short course in almost all aspects of basic urology. Unfortunately, relatively little research has focused on the fundamentals of urethral wound healing and the permutations that inhibit effective healing without stricture or fistula. Slightly more data concerning the frequency of stricture and fistula following hypospadias repair are available, and some information is also available about the results of different forms of management of strictures once they form. Much of this latter information is extrapolated from adult experiences.

No precise figures quoting the incidence of stricture disease in children are available. It is presumed that strictures have been present since medical history was first recorded, because it is known that lithotomy (which was practiced in children as early as the time of Susruta, approximately 500 B.C.E.) sometimes resulted in strictures. One might assume that such strictures were rare, because only eight cases of strictures in children had been reported before 1961.[1] This appears to be a result of underreporting, however, rather than a reflection of the true incidence of pediatric stricture disease before 1961.

Campbell classified strictures in children into three etiologic groups: congenital, infectious, and traumatic.[2] Brock and I then subdivided traumatic strictures into iatrogenic and noniatrogenic.[3] Although it is true that strictures following hypospadias repair are usually iatrogenic, some can be exacerbations of preexisting congenital strictures and others in actuality are infectious strictures resulting from urethritis secondary to the catheter. For example, a stricture that develops proximal to a hypospadias repair most likely occurs either because a congenital stricture was present before the repair and its presence became manifested some time after the repair or because urethritis produced by the presence of an indwelling catheter produced a stricture in an area of the urethra away from the primary area of repair. Obviously, the mechanism producing these types of strictures is different from that directly related in some way to the repair.

The overall incidence of stricture following hypospadias repair is difficult to determine. Reviews of hypospadias surgery sometimes do not even comment on the incidence of stricture. However, some series have reported stricture rates of 1% to 18%.[4–12] Whether the incidence of stricture varies depending on the form of hypospadias repair is also unclear.[13] Many series are continued for insufficient time to determine whether a stricture has developed, because it is clear that lengthy follow-up is necessary to know with certainty the true incidence of stricture disease.[14] Certainly, strictures have been noted to appear as late as 11 to 15 years postoperatively.[14–15] Nevertheless, comparing short-term results, it would appear that there is no difference between the incidence of stricture disease in procedures that use grafts of prepuce versus those that use pedicled tubes of prepuce.[13] Additionally, there are insufficient data to state whether the incidence of stricture disease will be increased or decreased over the incidence using prepuce or penile skin when bladder epithelium[16] or buccal mucosa[17] is used for grafts for urethral replacement.

In one series of patients who had hypospadias and were treated with a staged approach and who presented with strictures after repair, 55% of the strictures had resulted from a Dennis-Brown technique, 10% from an Ombrédanne technique, and only 5% from a McIndoe technique.[18] In a series of Blair-Wehrbein operations, the incidence of stricture was 1.6%.[19] In yet another series of hypospadias repairs, the incidence of stricture was 4%.[20] The incidence of stricture in single-stage repairs has been reported to be between 1% and 42%.[7, 10–13] These reports might suggest that the incidence of stricture formation is lower in multistage repairs than in single-stage repairs, although I strongly suspect that more accurate reporting of the results of newer (single-stage) repairs is the reason. Even if multistage repairs resulted in fewer strictures than single-stage repairs, the number of operations per patient is always higher in multistage repairs than in single-stage repairs because the total number of operations required in any series of single-stage repairs is always less than two per patient.

The presenting symptoms of patients with strictures following hypospadias are no different from those of patients seen in adult practice or those produced by other causes. In our own series,[21] 73% of patients with urethral strictures following hypospadias repair presented with decreased force of stream detected either by direct observation of the voided stream, uroflometry, or history. In addi-

tion, 46% presented with a urethrocutaneous fistula. Only 13% complained of dysuria. Other presenting problems included urinary retention, splaying of the urinary stream, recurrent urinary tract infection, or incontinence.

Imaging studies can be used to confirm the presence of a stricture. Retrograde urethrography and voiding cystourethrography are two commonly used techniques. When the diagnosis is indeterminate and one does not wish to instrument the patient, a voiding film taken after intravenous contrast has been injected allows sufficient visualization of the male urethra to detect obstruction (although admittedly this study is suboptimal for complete characterization of a stricture). Cystoscopy certainly leads to definitive diagnosis of strictures but may be unnecessary for diagnosis in some cases.

Why do strictures develop after hypospadias repair? Because relatively little is known about the basic mechanisms of urethral wound healing, this is a difficult question to answer. Our own studies[22] and those by Fairbanks and colleagues[23] using rabbits have shed a small amount of light on normal urethral wound healing and the effect of certain variables on it.

An incision in the penile skin of a rabbit induces an inflammatory response first of granulocytes, followed by lymphocytes, followed in turn by fibrosis. Interestingly, foreign body giant cells are also seen as a regular part of this response. The response extends down to but not into the urethra. Hence, incision and closure alone, as expected, induces an inflammatory response.

Merely placing a polyvinyl stent in the urethra without making any skin or urethral incisions produces an inflammatory response in the urethra; this consists of acute and chronic inflammation, squamous metaplasia, and focal erosion of the urethral lumen. Additionally, the presence of a stent causes an inflammatory response in the overlying skin even though no surgical intervention produced that inflammation. This demonstrates that the presence of a stent produces urethral and penile inflammation, even without an incision.

If the skin and urethra were incised but not closed and no stent was placed, urethral fistulas appeared immediately but often closed in 7 to 21 days. If the urethra and skin were closed (and no stent was placed), fistulas that formed were more likely to persist. Additionally, a greater inflammatory response was noted in those rabbits in which the urethra was closed rather than left open, suggesting that suturing produces a greater inflammatory response than does extravasated urine. No difference was observed in the inflammatory response to chromic catgut versus that to polyglactin. Finally, no difference in the inflammatory response of the overlying skin was noted, regardless of which variable was tested, suggesting that the inflammatory skin response was induced largely by the skin incision and closure and was not influenced by differences in urethral healing.

The effect of urethral closure and diversion on urethral wound healing was also studied. Urethral wound closure produced less of an inflammatory response if the urethra was stented than if the stented urethra was left unclosed. The presence of a stent did not influence the rate of fistula, either positively or negatively. Diverting the urine with a cutaneous vesicostomy after urethrotomy produced less urethral inflammation than an unstented undiverted urethrotomy, but the fistula rate was not altered by diversion. Stenting combined with proximal diversion produced a dramatic increase in urethral inflammation and fibrosis compared with stenting without proximal diversion.

When the urethra was incised, the urethral epithelium was reconstituted in 6 to 7 days. Slight changes in the size of the suture material (7-0 versus 8-0 polyglactin) did not seem to affect wound healing. We noted the presence of epithelial nests in the subepithelial and subcuticular tissues alongside suture material, suggesting that epithelium is dragged into the subcutaneous tissues; this may have some role in fistula formation. This latter finding is supportive of the work of Johnson and colleagues.[24]

Fairbanks and associates[23] performed studies on the healing of bladder mucosal grafts in the rabbit urethra. They found that the graft initially floated on a plasma interface, but by the third day after grafting, spotty vascular ingrowth (inosculation) into the graft was noted. By the 8th day, the bladder epithelium seemed viable, and by the 12th to 14th day, the epithelium had uniform thickness. If a stent was not used for at least 7 days, stricture or fistula resulted.

To summarize the foregoing findings, anything that might decrease inflammation might help prevent stricture formation. Urinary diversion is helpful, but a stent (or catheter) is a double-edged sword in that it produces inflammation. Similarly, sutures produce greater inflammatory response than does urine. The native urethra in rabbits is reepithelialized after incision in 5 to 6 days, but a bladder mucosal graft seems to require 8 days for successful engrafting.

Clinically, a number of factors seem to influence stricture formation. Some urethral strictures arise for reasons only tangentially related, or perhaps unrelated, to the hypospadias repair. For example, an occasional child has a congenital bulbar stricture that had not been of any symptomatic importance. However, after the use of an indwelling stent or catheter, sufficient inflammation developed in the area to produce further narrowing, which then resulted in a symptomatic stricture.

Obviously, poor design of the operative procedure can result in stricture.[25] If meatal stenosis is present in association with hypospadias and is not corrected at the time of the repair, the urethroplasty is narrowed at that point. Additionally, the distal urethra is sometimes dysplastic in patients with hypospadias. If this dysplastic tissue is not excised, poor wound healing may result, producing a stricture or a fistula. Nesbit's studies of the principle by which a buried strip of skin encysts to form a tube appear to support the use of the Dennis-Brown principle.[26] Davis and colleagues,[27] in their studies of the ureter, suggested that only half of the epithelium was necessary to reconstitute an entire ureteral circumference (the Davis principle). It would appear that this is not true for skin, however, and if a strip of skin is rolled into a tube or buried open, the resulting circumference is no bigger than the width of the strip.[26] Hence, too narrow a strip results in a stricture.

Whether there are intrinsic differences in wound healing of tubes and patches is unknown. A slightly higher incidence of stricture is noted in repairs that use tubes, whether they are pedicled or grafted.[12, 13] There certainly

is no question that poor design of either tube or graft types of repair leads to poor wound healing, which may increase the incidence of stricture.[25] Finally, it is unknown whether different graft materials such as skin, bladder mucosa, or buccal mucosa have intrinsic differences. Because thick grafts engraft less well than thin grafts, it would be anticipated that buccal mucosa would prove less desirable as graft material than either prepuce or bladder mucosa. However, experience over time should clarify this issue.

Wound infection, which seemingly is uncommon in hypospadias repair (although admittedly the true incidence is unknown), may (because of fibrosis) lead to stricture.[6] It also may be that mild strictures producing a pseudodiverticulum proximal to them may become aggravated by the presence of infected urine in the pseudodiverticulum. There seems no question that ischemia leads to increased fibrosis. It could be that the incidence of stricture at the junction of a tube with the proximal urethra may relate less to the length of the suture line but more to poor tissue perfusion. The ends of a pedicle certainly are less well perfused than the central portion of the pedicle, and it is to be anticipated that strictures might occur at either the proximal or distal end of a pedicled tube. Ischemia or inflammation of the overlying skin of a repair, whether pedicled or grafted, usually results in fistula but also might result in stricture.[6]

Some evidence shows that suture material may have a role in the development of a stricture. Devine believed that chromic catgut may be a source of inflammation leading to stricture,[6] although our own studies of rabbits did not seem to confirm this.[22] Studies by Disandro and Palmer[28] have suggested that long-lasting suture material such as polydioxanone produces a higher incidence of stricture than either polyglycolic acid or chromic catgut.

Yet another factor that may influence the production of strictures is the catheter itself. The length of time that the catheter is in situ may have some bearing on stricture production. Clinical and experimental studies have shown that urethral inflammation increases in relation to the duration of a catheter in situ.[29] Additionally, the material from which the catheter is made is of some importance. Latex produces far more inflammatory reaction than either polyvinyl or silicone.[30] My colleagues and I attribute our relatively low incidence of strictures to the exclusive use of silicone catheters and stents.

Although prevention of urethral strictures after hypospadias repairs is paramount, it remains a fact that strictures will occasionally develop. Once a stricture has developed, therapy of the stricture is of prime concern. Some surgeons routinely pass a catheter or sound through a hypospadias repair at a relatively early point postoperatively in hopes of preventing fistulas.[31] It may be that some strictures are actually treated at that juncture and never diagnosed. Although many pediatric urologists believe that dilation of a stricture may prevent fistula formation, a survey of the Section on Urology of the American Academy of Pediatrics revealed that approximately 85% of pediatric urologists do not routinely calibrate the urethra postoperatively.[32] In our own studies of posthypospadias strictures,[21] we found that 55% of strictures that presented early (within 3 months of repair) responded to either urethral dilation or internal urethrotomy; however, because our median follow-up was only 6 months, it is possible that the failure rate is actually higher. Although hydraulic self-dilation of the urethra is often recommended after dilation or internal urethrotomy, it seems intuitive, based on studies of urethral wound healing, that this should produce more problems because of the inflammation associated with urinary extravasation. This was borne out in the studies by Pansidoro and Emiliozzi[33] and by Steenkamp and colleagues.[34] Studies by Ziprin and associates[14] have confirmed our own impression that multiple urethrotomies are rarely successful and may be counterproductive—that is, if internal urethrotomy or dilation fails to produce a favorable response, repeat manipulative therapy is unlikely to be successful. Additionally, the inflammation produced by multiple attempts at manipulative therapy is likely to hinder the results of open repair.

Open repair can be performed as a staged or single-stage procedure. Although once the mainstay of urologic therapy, staged repair is now only rarely used. In our own series,[21] five of eight patients who had staged repair required more than two operations before the repair was finally successful. However, staging a repair is at times a good option, in my opinion, when a great deal of acute inflammation surrounds the stricture. An open urethrotomy that allows the tissues to return to relative normalcy before proceeding with attempted closure is often efficacious.

A patient who has a symptomatic stricture that developed from a relatively recent hypospadias repair and that has not responded to a single dilation is best treated, in my opinion, with an open urethrotomy to allow the tissues to return to normal and to allow the patient to void well. It is important that the urethra not be dilated immediately before the urethrotomy because if urethral dilation is performed before an incision, the proximal and distal extents of the inflammation associated with the stricture may be very difficult to identify and the length of the urethrotomy necessary may be underestimated. I prefer to pass a small instrument (sound, filiform, probe) through the stricture if possible (or down to it if not), without dilating the stricture, and then to cut down through the penile skin and the neourethral tissue to identify and open the stricture. Once the urethral lumen has been entered, the urethrotomy is extended both proximally and distally until bougienage establishes that normal-caliber urethra has been reached and visual inspection of the tissues suggests that there is no inflammatory response in the tissues at that point. The neourethral epithelium is then sutured to the skin with interrupted 4-0 chromic catgut sutures and left open until all inflammation has subsided. This usually necessitates a delay of approximately 6 months or longer (Fig. 29–1).

In some infants, an alternate form of management, rather than urethrotomy, might be vesicostomy (Fig. 29–2) to divert the urine completely and thereby allow the inflammation in the stricture area to subside so that a one-stage repair of the stricture could subsequently be used.

If a urethrotomy was performed as a first stage, once the inflammation has subsided, the urethrotomy can be closed. It can sometimes be closed in the same manner as a fistula merely by circumscribing the entire area (ensuring adequate width of the strip that will form the neourethra)

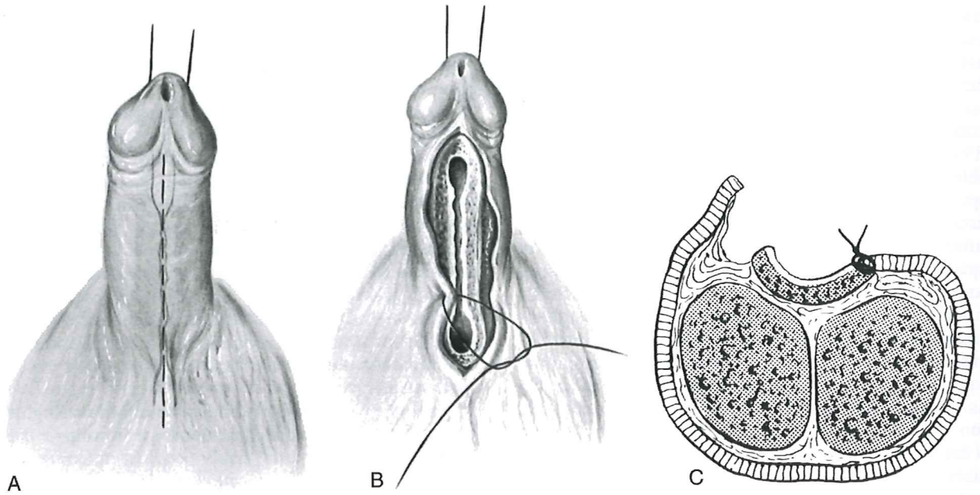


Figure 29–1
First stage of a staged urethroplasty. *A:* An incision is made through the skin and urethra, extending into normal tissue distally and proximally. *B:* The skin is coapted to the urethral mucosa. *C:* Schematic cross section of *B.* (From Eckstein HB, Hohenfellner R, Williams DI: Surgical Pediatric Urology. Philadelphia, WB Saunders, 1977.)

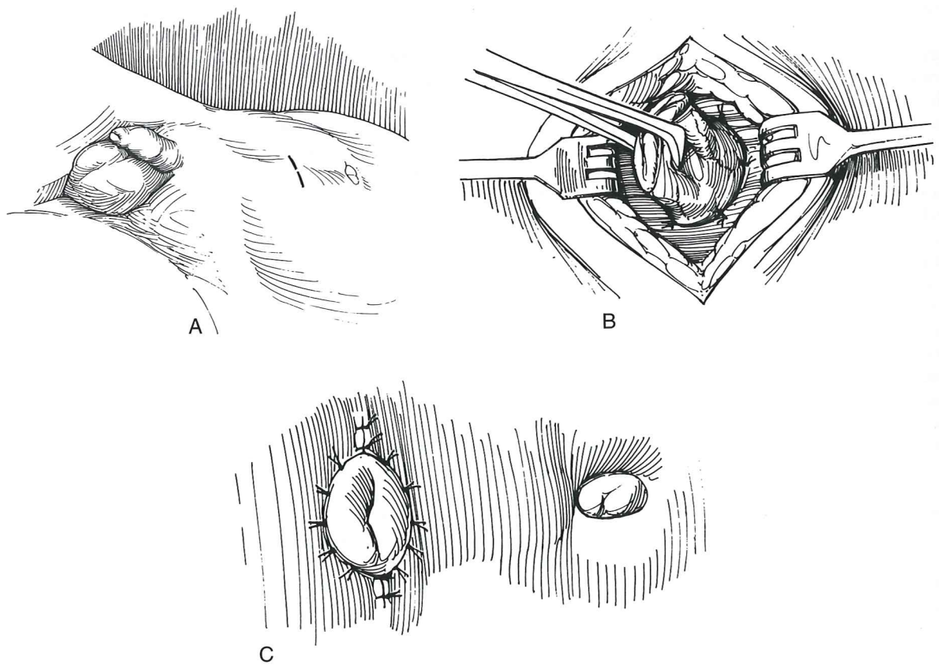


Figure 29–2
Blocksam vesicostomy. *A:* A transverse incision is made caudad to the umbilicus. *B:* The dome of the bladder is sutured to the anterior rectus fascia and opened. *C:* The bladder is sutured to the skin. (From Hinman F: Atlas of Pediatric Urologic Surgery. Philadelphia, WB Saunders, 1994.)

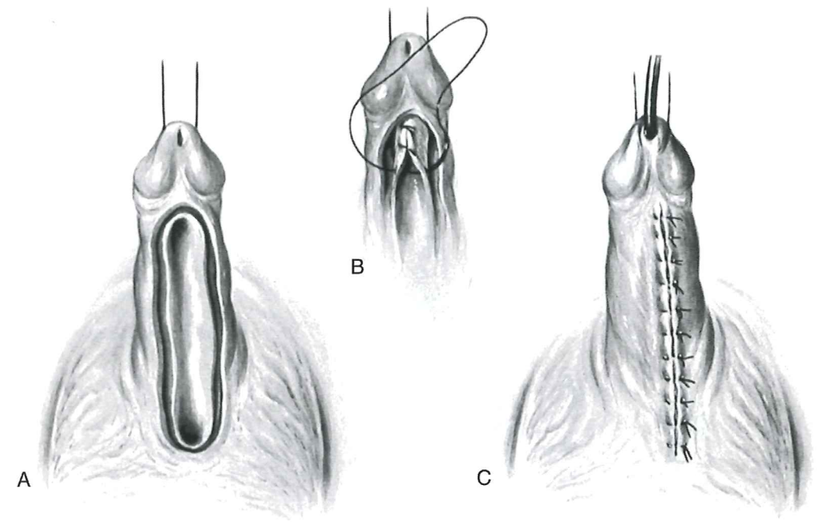


Figure 29–3
Second stage of staged urethroplasty. *A:* An incision outlining the new urethra is made. *B:* The urethra is closed. *C:* The skin is closed over the urethral closure. (From Eckstein HB, Hohenfellner R, Williams DI: Surgical Pediatric Urology. Philadelphia, WB Saunders, 1977.)

(Fig. 29–3). At other times, it is best to plan a vascularized flap of penile skin to be interposed into this closure to provide adequate urethral caliber (Fig. 29–4).

In any stricture repair, design of the repair is extremely important. It is essential in single-stage repairs that there be no inflammation proximally or distally, if at all possible. It is also important that the caliber of the urethra through the stenotic area be repaired such that the caliber of the repair is the same as that of the urethra proximal and distal to the narrowed area. Bougies are used to estimate the caliber of the proximal and distal urethra, and the reconstructed area is planned to be the same circumference as the more normal areas.

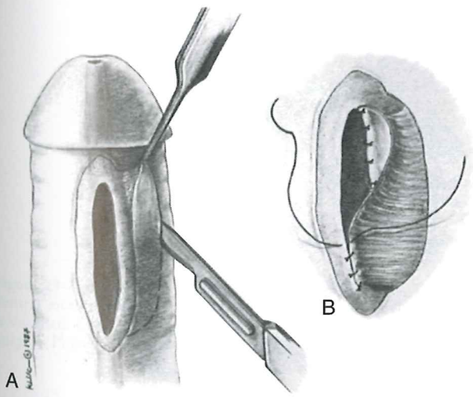


Figure 29–4
Closure of a staged urethroplasty using a pedicled flap of adjacent penile skin. *A:* The flap is raised. *B:* The flap is rotated and sutured in place. (From McDougal WS: Difficult Problems in Urologic Surgery. Chicago, Year Book, 1989.)

One-stage repairs of strictures following hypospadias repair have been successful in my experience. I do not believe that such strictures are conducive to excision and end-to-end repair and hence have not used this technique for them. When grafts were used, the success rate seemed less than when a flap was used.[21] This intuitively would seem correct in that the bed of a stricture is largely scar. For this reason, the vascularity necessary for successful engrafting would be reduced, whereas a flap bringing its own vascularity with it stands a greater chance of viability. The preferred technique, in my experience, has been to use a random pedicled flap of penile skin (see Fig. 29–4).

At times a short stricture is located distal to a fistula, and it is essential that the stricture be repaired at the time the fistula is closed to ensure a successful result. A flap of skin is raised and hinged on the fistula edge, opposite the stricture (Fig. 29–5). The fistula is then dissected from the skin, and the stricture is incised. The skin flap is then rotated into the defect thus created and sutured in place with fine (7-0) Vicryl sutures. Bougienage should establish that the urethra is now of normal caliber. The skin can be closed over this area, preferably in three layers, using a deepithelialized flap of skin to cover the urethrotomy.

Meatal stenosis is a specialized form of stricture following hypospadias repair and can be of some significance. At times, a meatoplasty can be performed by incising the dorsal aspect of the urethra through the stenosis and advancing the urothelium to the edge of the incision, thereby applying the Heineke-Mikulicz principle (Fig. 29–6). At other times, it is necessary to incise the urethra ventrally. If this is done, it leads to a somewhat retrusive meatus. If

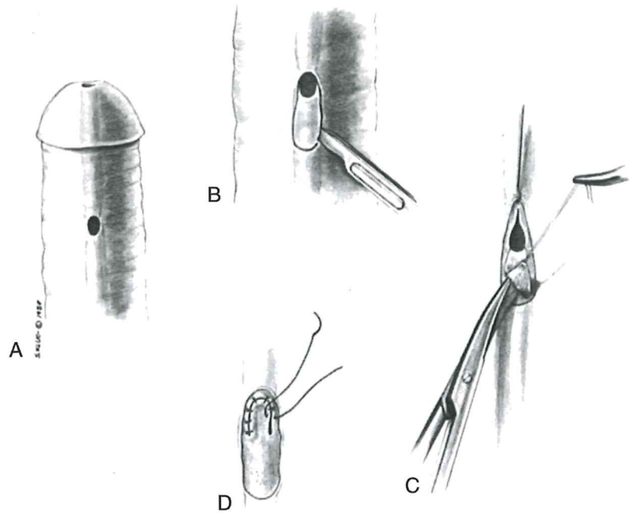


Figure 29–5
Repair of a short stricture associated with a fistula. *A:* The stricture is usually distal to the fistula. *B:* A flap is raised, hinged on the fistula edge opposite the stricture. C: The fistula is dissected from the skin, and the stricture incised. D: The flap is rotated and sutured in place. (From McDougal WS: Difficult Problems in Urologic Surgery. Chicago, Year Book, 1989.)

the meatus can remain glanular, this probably is of no consequence. However, if it is necessary to carry the incision farther proximally, I believe that it is then best to incise through the glans ventrally to raise a pedicle flap of skin from the ventral surface to interpose into the urethra ventrally and then to close the glans over all of this, thereby reconstituting the glanular meatus (Fig. 29–7).

Fortunately, strictures following hypospadias repair are far less common today than they once were. This surely is a consequence of improvements in suture material, cathe-

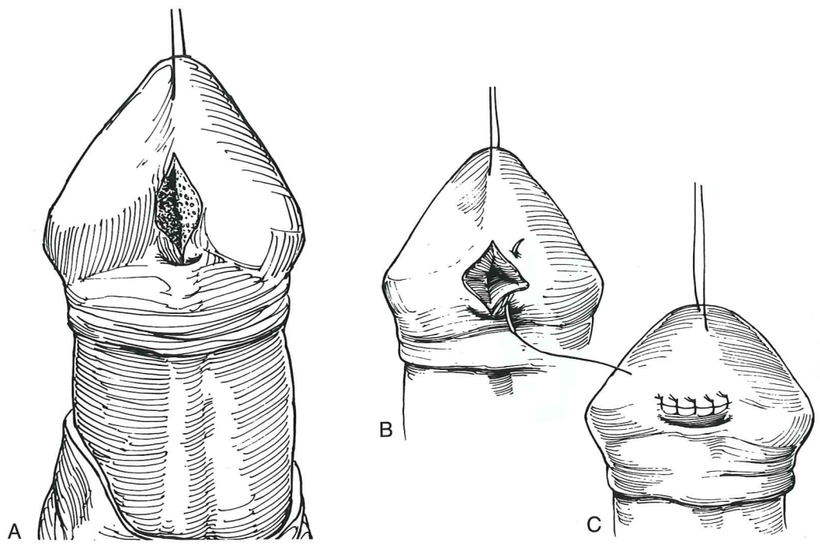
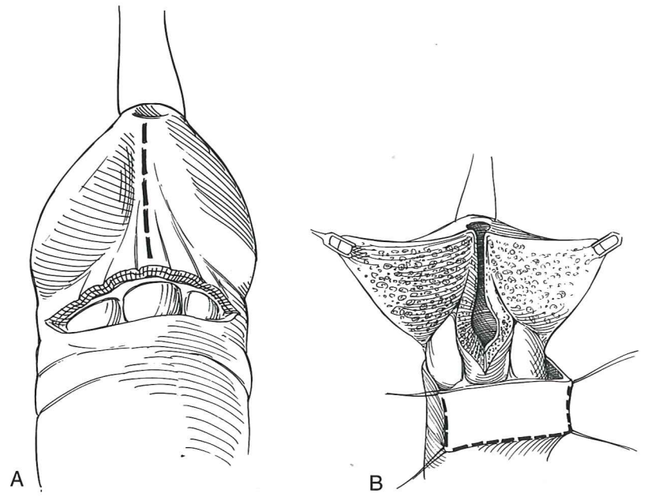


Figure 29–6
Dorsal meatotomy. *A:* A vertical incision is made through the stricture. *B* and *C:* The incision is closed horizontally. (From Hinman F: Atlas of Pediatric Urologic Surgery. Philadelphia, WB Saunders, 1994.)



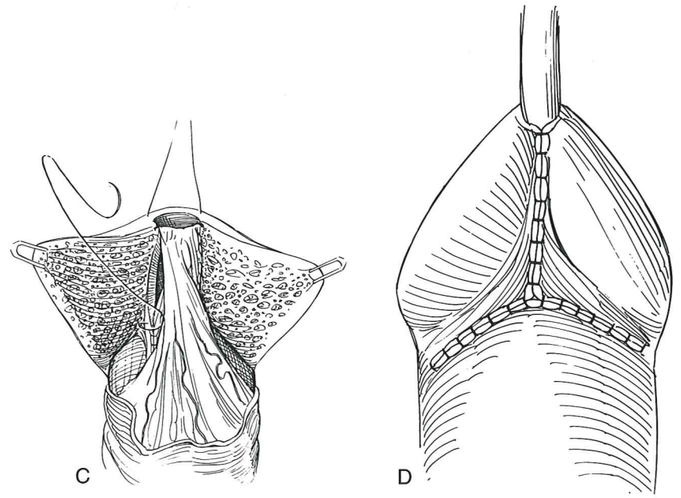


Figure 29–7
Ventral meatoplasty. *A:* A ventral incision is made through the stricture and glans. *B:* The glans wings are developed, and a ventral flap of penile skin is outlined. *C:* The flap is rotated and sutured in place. *D:* The glans is brought over the flap and closed. (From Hinman F: Atlas of Pediatric Urologic Surgery. Philadelphia, WB Saunders, 1994.)

ter material, and, most important, the design of the procedures. Strictures nonetheless continue to plague the hypospadiologist, and a knowledge of urethral reconstructive techniques is essential for their solution.

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CHAPTER

30

Surgical Management of Congenital Anomalies of the Scrotum

JOHN F. REDMAN

Congenital anomalies of the scrotum are infrequent and are more often found in association with other anomalies of the external genitalia. The four most common scrotal anomalies are penoscrotal transposition, scrotal ectopia, bifid scrotum, and penoscrotal fusion.[1] Although they occur as isolated anomalies, penoscrotal transposition, bifid scrotum, and penoscrotal webbing are usually found in association with hypospadias. Scrotal ectopia may be associated with testicular ectopia or undescent.

During the past 20 years, innovative techniques have been described for surgical management of these anomalies. However, a certain degree of innovation, conceptualization, and individualization is still needed in each surgical procedure to produce the best cosmetic and functional result.

PENOSCROTAL TRANSPOSITION

By the simplest definition, penoscrotal transposition is a condition in which any amount of rugal or scrotal skin is positioned cranial to the ventral aspect of the base of the penis. Transposition may further be classified as incomplete or complete.

Incomplete or partial penoscrotal transposition may be more pronounced on one side even though the condition is bilateral (Fig. 30–1). Surgical correction may be accomplished by a simple technique in which the malpositioned cranial portion of rugal skin is excised along with a contiguous portion of the scrotum proper (Fig. 30–2).[2] The procedure is initiated by first outlining the V-shaped portion of rugal skin cranial to the penile base (Fig. 30–2*A*). Although it may appear that the rugal skin is contiguous with the penile skin, it is noted without exception that on retracting the penis medially, several millimeters of smooth skin are present between the penile base and the rugal skin. It is imperative that only rugal skin be excised; therefore, great care should be exercised in the preliminary marking of the skin and in the actual incision. The incision is carried through the dermis only, and careful attention is given to hemostasis. The V-shaped flap is elevated completely (Fig. 30–2*B*). The limbs of the V are then held together with toothed forceps such as Adson forceps, and the resultant dog-ear of contiguous scrotal skin is excised with scissors one limb at a time (Fig. 30–2*C*). The elliptic defect is closed with a few deep sutures of polyglycolic acid and an intracuticular skin closure of 5-0 or 4-0 polyglycolic acid suture.

Correction of complete penoscrotal transposition requires considerable skill, judgment, and imagination, because the anomaly is invariably associated with penoscrotal

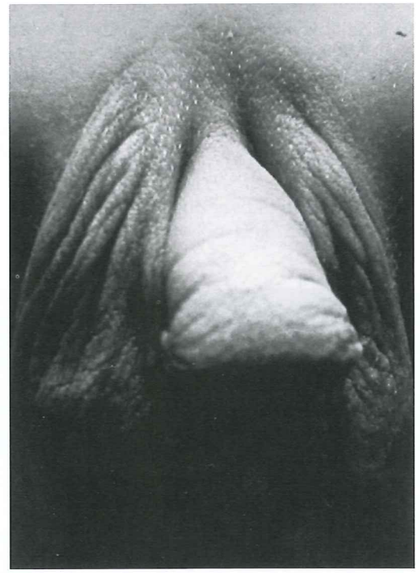


Figure 30–1
Bilateral incomplete scrotal transposition in an 8-year-old boy. (From Redman JF: The surgical correction of incomplete scrotal transposition associated with hypospadias. J Urol 129:115, 1983.)

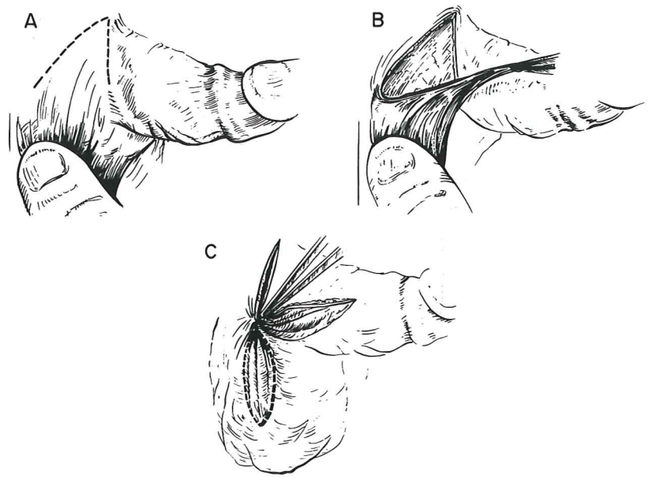


Figure 30–2
Surgical techniques for correction of partial penoscrotal transposition. *A*: Line of initial incision. *B*: Appearance after elevation of a cutaneous flap. *C*: Limbs of incision held together with forceps, producing dog-ear. Dotted lines indicate proposed incision.

or perineal hypospadias and possibly some degree of bifid scrotum (Fig. 30–3).[3, 4] Although it is frequently stated that it is prudent to stage these procedures by performing the scrotal correction as a first stage and the urethroplasty as a second stage or vice versa, I have been well pleased with the results I have obtained performing all of the procedures in one stage.[5]

The operation may be initiated with a suprapubic cystotomy because a long urethroplasty is needed. If a bladder mucosal graft is anticipated, the cystotomy can be delayed until it can be ascertained how much mucosa is needed for the graft. The line of incision is then carefully traced around the rugal skin cranial to the palpable base of the penis (Fig. 30–3*B*). On the lateral aspect, the incision is carried to just cranial to the ventral aspect of the base of the penis. Medially, the line of incision should parallel the shaft of the penis, staying strictly along the rugal margin. At the coronal margin, the incision is carried along the inner leaf of the prepuce dorsally, preserving a wide collar. On the ventral surface of the penis, the incision parallels the urethral plate and is carried around the hypospadiac meatus. At the coronal margin, ventrally, the incision is carried across the urethral plate, thereby dividing it. The penile skin is then completely reflected from the penile shaft, and the rugal tissue flaps are completely freed from their beds and reflected laterally (Fig. 30–3*C*). After the penile orthoplasty, which may be accomplished by the excision of Nesbit ellipses, and creation and placement of the urethral graft, the scrotal wings are rotated caudal to the penile base and are sutured together with interrupted vertical mattress sutures of 5-0 absorbable suture material. The penile shaft is covered with the penile skin, which has been incised to form Byars flaps (Fig. 30–3*D*). No dressing is required. I leave a urethral stent in place for 5 days and a suprapubic diversion for 10 to 14 days.

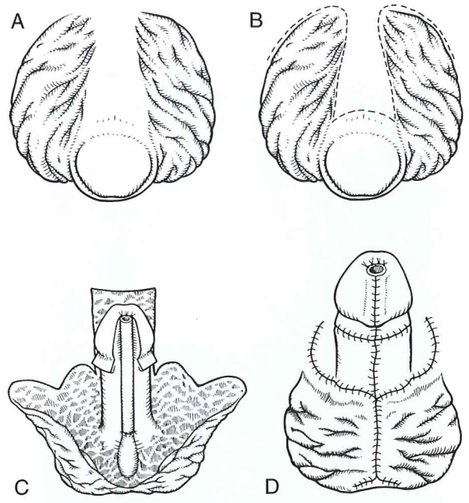


Figure 30–3
A: Initial appearance of penoscrotal transposition with scrotal hypospadias. *B*: Line of initial incision alongside the dorsum of the penis and outlining rugal skin cranial to the base of the penis. *C*: Appearance after lateral reflection of scrotal flaps and completion of free preputial tube graft urethroplasty. *D*: Immediate postoperative appearance. (*C* from Redman JF: The surgical correction of incomplete scrotal transposition associated with hypospadias. J Urol 129:115, 1983.)

BIFID SCROTUM

A bifid scrotum, though usually associated with hypospadias, may occur as an isolated anomaly. If perineal or midscrotal hypospadias is present, scrotal excision to correct the anomaly needs to be more extensive than merely the excision or rolling in of the midline urethral plate.

The simplest technique for correction of a bifid scrotum is excision of a generous ellipse of the midportion of each hemiscrotum. The procedure is initiated by compressing the two sides of the scrotum together until it assumes a normal appearance and then marking a 3-mm-wide midline strip with a marking pen. On releasing the compression, it is immediately noted that an ellipse has been inscribed. The incision of the scrotal skin is carried through the dartos tunic, and the ellipse of scrotum removed. Hemostasis is carefully achieved with electrocautery. The external spermatic fascia of each hemiscrotum is approximated with sutures of 5-0 chromic catgut, and the skin closure is accomplished with interrupted vertical mattress sutures of 5-0 chromic catgut or polyglycolic acid suture material. The incision is not drained.

ECTOPIC SCROTUM

An ectopic or accessory scrotum is also a scrotal transposition (Fig. 30–4).[6] Practically, though, the term is used to describe scrotal tissue that is not contiguous with the scrotum itself. This tissue may consist of only a small tag or may be rather substantial and may frequently house a testicle. The accessory scrotum may be located craniolateral or lateral to the scrotum or may be in a perineal location (Fig. 30–5).[7] Scrotal ectopia to the thigh has also been described.

Each surgical procedure should be individualized. A perineal scrotum, which generally does not contain a testis, may be excised with an elliptic incision. If the scrotal tissue is substantial and contains a testis, a decision must be made about whether to place the testis in the orthotopic hemiscrotum or whether to mobilize the ectopic scrotum and testis and join it to the orthotopic scrotum. The objective is to give the scrotum the most normal appearance. If the ectopic scrotum cannot be mobilized to reach the orthotopic scrotum, the ectopic scrotum is excised and an orchiopexy is performed, placing the ectopic testis alongside the descended testicle.

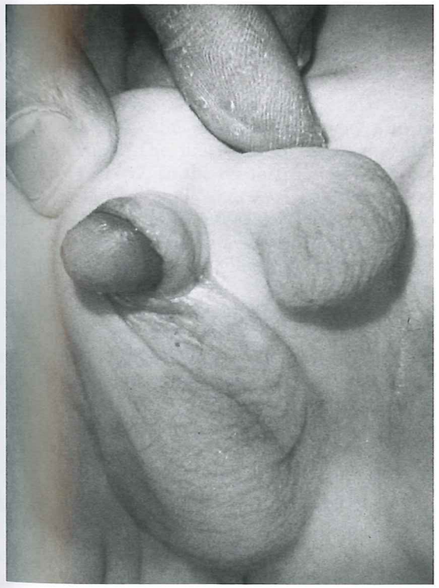


Figure 30–4
Ectopic scrotum containing left testis and associated 120-degree penile torsion.

PENOSCROTAL FUSION

The term *penoscrotal fusion* is used to describe a confluence of the penile and scrotal skin (Fig. 30–6).[8] Other terms

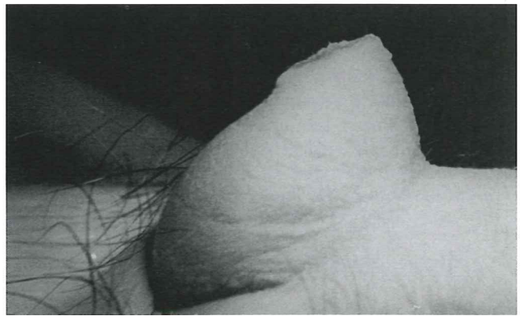


Figure 30–6
Penoscrotal fusion in a 12-year-old boy.

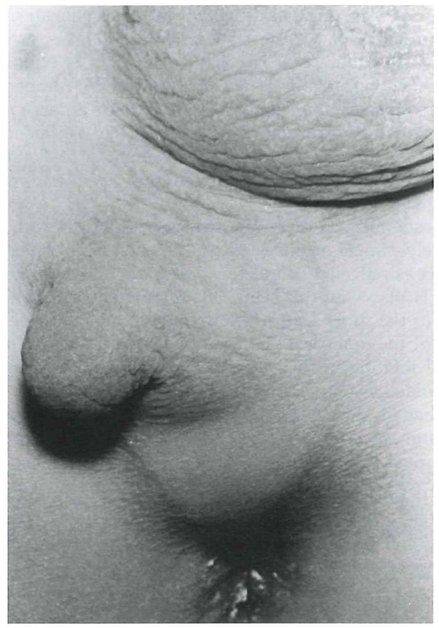


Figure 30–5
Accessory perineal scrotum. (From Redman JF, Morris WD: Accessory perineal scrotum. Urology 22:406, 1983.)

used are *webbed penis, penis palme*, and *penis palmatus*. The basic principle of the most successful techniques used to correct this anomaly is that the ventral shaft is ultimately covered with inner or outer preputial skin. Although a simple transverse incision of the web with a subsequent longitudinal closure may suffice when the confluence is mild, in the more severe cases, the resultant large diamond-shaped defect is difficult to close without severely compromising cosmesis.

Penoscrotal fusion can be managed surgically with two relatively simple techniques. In the first technique, the prepuce is reflected completely and a traction suture of 4-0 silk is placed in the glans. A circumferential incision is made in the inner leaf of the prepuce, leaving a generous collar of the inner leaf. The prepuce is then incised in the ventral midline to the penoscrotal junction. The prepuce is unfolded by separating the inner from the outer leaf. The shaft is then wrapped with the penile and preputial skin, and any distal redundancy is excised. Closure is with interrupted 5-0 catgut.

The second technique is actually a finely tailored circumcision. The outer leaf of the prepuce is incised just proximal to the point at which the skin begins to bevel toward the shaft. The inner leaf is then incised circumferentially, leaving enough of the inner leaf to bridge the space between the corona and the incision in the outer leaf. The redundant prepuce is then excised, and closure is completed as in a standard circumcision.

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CHAPTER

31

Tissue Expansion in Urologic Surgery

RANJIV MATHEWS
UMESH PATIL

Modern techniques in reconstruction of congenital and acquired defects of the urogenital tract allow for better cosmetic and functional results. Skin flaps and free grafts of skin, bladder, and buccal mucosa have to date been the mainstay of these reconstructive procedures. The disadvantages with use of free flaps include differences in pigmentation, the need for depilation, and the potential for graft loss secondary to devascularization. Tissue expansion provides a large supply of local skin with pigmentation and properties similar to those of the surrounding skin for use in reconstruction. With the advent of newer available tissue expanders, tissue expansion can be successfully performed in the pediatric population.

HISTORICAL PERSPECTIVES

Tissue expansion has been used in cultural rituals of certain tribes such as the Kalahari Bushmen, who perform labial expansion. The first clinical use was reported by Neumann,[1] in 1957, in the reconstruction of an ear using expanded temporal skin. Radovan[2] was the first surgeon to gain significant clinical experience with the use of tissue expansion, using a bag with a remote external port for fluid injection. Austad and colleagues,[3, 4] Gibson and Kenedi,[5] and Pasyk and associates[6] demonstrated the histopathologic changes and biomechanical properties of expanded tissue and investigated the electron microscopic features of expanded skin. Sasaki[7] showed the feasibility of rapid tissue expansion as opposed to gradual expansion to close small skin defects.

PHYSICAL PROPERTIES OF SKIN FACILITATING EXPANSION

The physical properties of skin allow for its ability to expand and maintain its fit with various deforming mechanical stimuli. Gibson[8] described three basic properties of skin: tension, extensibility, and viscoelasticity.

Skin Tension. Skin tension occurs in all natural tissue, is a function of the elastic fibers, and varies with the age, location, and species. This property is demonstrated by the contraction of skin edges when an incision is made.

Skin Extensibility. Skin extensibility is the response of the skin to mechanical forces. This property is responsible for the distortion of skin over joints, which returns to normal when the joint relaxes. It may change with age and with repeated mechanical force. Following evaluation of expanded tissue, flap contraction will reduce the amount available for reconstruction. Hence, another caveat concerning increasing the amount of available expanded tissue is to reduce the amount of contraction of the flap after elevation.

Viscoelasticity (Creep and Stress Relaxation). Creep is the extension of the skin with a given force. When skin is stretched to a given distance, the force required gradually decreases. Creep results in maximal stretch from frequent expansion, whereas stress relaxation accounts for the decrease in pressure that permits repeated expansion. Creep or stretch of a given amount of tissue or flap is not possible without thinning of the flap and reorientation of the structures overlying the expander.

EXPERIMENTAL STUDIES

Using experimental models, Pasyk and colleagues[9] were able to show that skin, unlike other artificial membranes, was able to maintain its thickness with expansion. It has become apparent that with expansion, the epidermal tissue undergoes an increase in mitotic activity with a resultant increase in the total cell populations. Manders and associates demonstrated that specialized tissues[10] (i.e., nerve, ureter, bladder, and bowel) also have the capability to be expanded. Sasaki[7] was able to demonstrate the differences in the amount of tissue available when different modes of expansion (gradual versus rapid) were used.

HISTOPATHOLOGY OF EXPANDED TISSUE

Marked thickening of the human epidermis occurs with expansion, as noted on light microscopy (Fig. 31–1). This

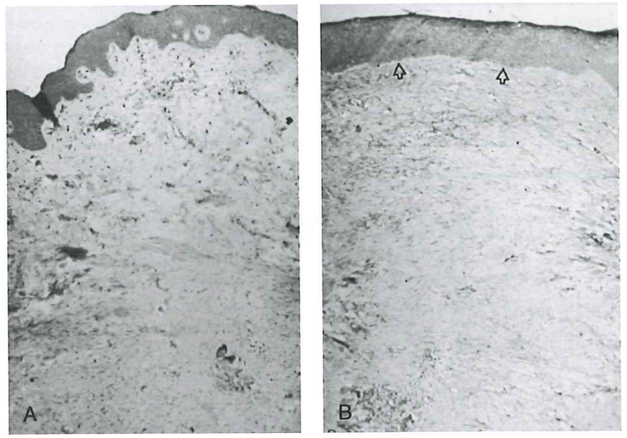


Figure 31–1
A: Normal skin layer before expansion (H&E, ×50). *B:* Seven weeks after expansion, the epidermis is thickened and the rete ridges (arrows) are flattened (H&E, ×50). (From Pasyk KA, Argenta LC, Austad ED: Histopathology of human expanded tissue. Clin Plast Surg 14:436, 1987.)

is secondary to thickening of the stratum spinosum and flattening of the rete ridges. On electron microscopy, the intercellular spaces in all layers of the epidermis are smaller than in nonexpanded skin.

Thickness of the dermis is significantly decreased irrespective of the amount of expansion or the anatomic location of the expanded tissue. The papillary and reticular dermal layers are filled with bundles of collagen showing normal cross-striations. Elastic fibers are thicker and larger and form clusters in some areas.

Sebaceous and sweat glands and hair follicles do not show any changes with expansion. Subcutaneous fat that is undergoing expansion is atrophied (Fig. 31–2). Fibrous tissue appears to surround and sometimes replace fat lobules. Muscle under the expander is pressed and stretched by the expander, forming a depression (Fig. 31–3). Muscle cells undergo atrophy and have increased amounts of collagen.

Implanted tissue expanders become encapsulated in a few weeks. Histologically, four zones (Fig. 31–4) can be identified in this capsule. The *inner zone* (cellular layer) of the capsule is formed of fibrin-like fibers with a second cellular layer containing macrophages. In infected expanders, this layer is thicker and contains polymorphonuclear white blood cells (PMNs). The *central zone* (fibrous layer) contains fibroblasts and myofibroblasts with surrounding collagen. These fibroblasts and myofibroblasts contain intracellular collagen fibers. The *transitional zone* is made up of collagen fibers and some blood vessels. An *outer zone* (vascular layer) of dilated blood vessels and newly formed small vessels and looser collagen is noted in addition to mast cells and thick, elongated elastic fibers.

The role of new cells in expanded tissues was documented by Austad,[11] and the role of the extracellular matrix was initially reported independently by Francis and Marks.[12] Type V collagen in the expanded tissue appears to increase. The importance of the increase in this collagen is not well understood. When comparative histologic analysis of expanded tissue was performed at the time of expansion and at fixed intervals after expansion, it was noted that skin had increased in thickness during expansion. However, at 2 years after removal of the expander, this had returned to normal.

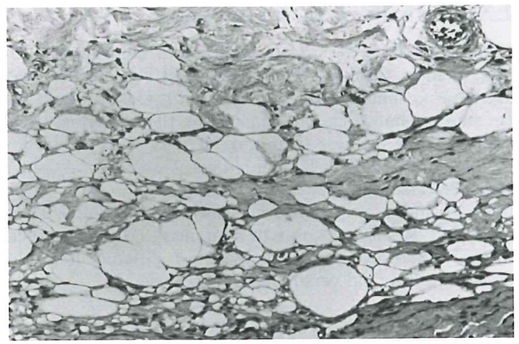


Figure 31–2
Subcutaneous tissue with fat atrophy showing flattened, smaller adipocytes (H&E, ×312). (From Pasyk KA, Argenta LC, Austad ED: Histopathology of human expanded tissue. Clin Past Surg 14:440, 1987.)



Figure 31–3
Muscle under a chest expander undergoing atrophy. Note increased numbers of collagen fibers (Epon–toluidine blue, ×312). (From Pasyk KA, Argenta LC, Austad ED: Histopathology of human expanded tissue. Clin Plast Surg 14:441, 1987.)



Figure 31–4
Section of the capsule of a tissue expander showing the four zones. 1, Thin cellular layer; 2, fibrous layer; 3, transitional layer; 4, vascular layer. (Epon–toluidine blue, ×100). (From Pasyk KA, Argenta LC, Austad ED: Histopathology of human expanded tissue. Clin Plast Surg 14:441, 1987.)

METHODS OF TISSUE EXPANSION

Gradual Expansion

Gradual expansion is the most frequently used method of expansion. After an expander of appropriate size is implanted (Fig. 31–5), expansion is carried out for a period of 6 to 8 weeks. Depending on the size of the expander, 50 to 150 ml of saline is instilled in the expander until maximum expansion has been achieved. The intended reconstruction is then achieved, and the expander is removed at the same operation. Advantages of gradual expansion are better expanded skin quality and better blood supply; however, the deformity caused by having an expander in place for a longer period may not be well tolerated by some patients.

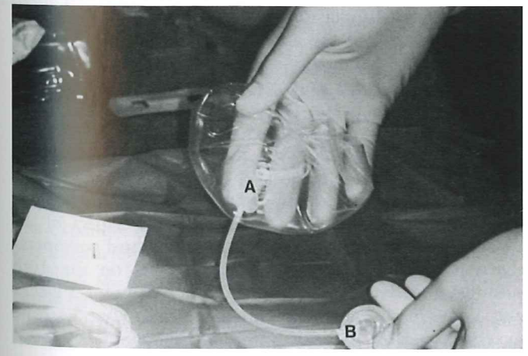


Figure 31–5
Tissue expander (A) and remote injection port (B). (From Patil UB: Role of tissue expanders in genitourinary reconstructive surgery. Urol Annu 8:200, 1994.)

Rapid Expansion

The rate at which tissue expansion should be performed is not well documented. Using rapid expansion, desired expansion is achieved in 7 to 10 days. Tissue is expanded until some degree of hypoxemia is evident. The hypoxemia may promote an increase in the blood flow, but it does compromise leukocyte function, possibly increasing infectious complications. Hence the current recommendations are for rapid expansion to be performed only in selected cases when it is necessary to obtain rapid coverage for large open areas.[13]

Intraoperative Sustained Limited Expansion

A limitation of gradual expansion is the inability to provide immediate skin coverage, which is an attractive prospect when significant visible deformity is being corrected. Intraoperative sustained limited expansion (ISLE) allows skin to be stretched beyond its limits for short periods with the use of temporary tissue expanders. It is useful in the closure of small skin defects and applies the concept of recruitment from the surrounding tissue to cover the defect with minimal tension or distortion. An expander is inserted next to the area of the defect and inflated during the operative procedure. Foley balloons may be used to perform expansion in this circumstance.[14] Despite the risk of ischemia of the flap or its margins, small defects may be closed with very little tension, obtaining an aesthetically pleasing wound.

COMPLICATIONS OF TISSUE EXPANSION

The complication rate with tissue expansion varies with the surgeon, his or her amount of experience, the anatomic site expanded, and the individual patient.[15] Complication rates as great as 40% have been reported.[16] Patient selection is of prime importance in the performance of tissue expansion. Tissue expansion results in temporary disfigurement of the body, which is unacceptable to some patients for psychologic reasons. The period of time that the expander remains in place in an exposed location of the body or on the genital or perigenital skin may have significant impact on a patient's lifestyle.[17] Patients should be educated by means of photographs or other teaching aids about the deformity that the expander will create and should be reassured that it is temporary. A competent and motivated patient or family is a key factor for a successful reconstruction.

Infectious complications can be reduced with the use of perioperative antibiotics. Long-term antibiotics have not been shown to reduce the rate of infection.[15, 18, 20] If infection develops during expansion, an attempt should be

made to treat the patient with antibiotics and drainage.[19] If this is unsuccessful, the implant is removed and replaced once the infection has been controlled.

Exposure or extrusion of the implant is usually secondary to wound dehiscence or erosion of the reservoir through thin overlying skin. An implant placed in a small pocket will abut the suture line, promoting erosion. Exposure of the implant requires antibiotic coverage, but the expansion may be continued carefully.[16, 19] If the implant is extruded, expansion should be terminated. To minimize these complications, creation of a large pocket, use of gradual expansion, and a period of waiting before commencing expansion are important preventive measures.

Implant failure is a rare occurrence and is usually secondary to a technical error.[16, 18, 20] The most common causes are improper connections and breakage or needle perforation of the connecting tube or the implant. Deflation requires the implant to be replaced, and the expansion can be resumed once the incision has matured. At times, implant leakage may be discovered only at the end of a successful expansion. This finding does not necessitate the removal of the expander, and the expanded tissue may still be used.

Flap failure usually represents unfavorable tissue[16, 18, 20] (e.g., postradiation, scarring, disruption of normal vascularity, or too rapid expansion). In some cases, failure of a flap that appeared viable at the time of expansion but was lost during reconstruction has been attributed to the use of epinephrine-containing anesthetics at the time of expander removal.[20]

Striae, resulting from atrophy and dermal collagen rupture, have been seen during skin expansion.[18] This is a rare occurrence that may be significant only in abdominal skin expansions.

Neuropraxia occurs rarely with expansion.[18] Contributing factors may be stretching of a peripheral nerve by rapid expansion or compression of a neural structure by the position of the expander. This is reversible with early removal of the expander.

Hematomas or seromas are treated with the use of rapid drainage and irrigation of the implant cavity.[18] Attention to hemostasis at the time of surgery and judicious use of suction drains may prevent or minimize these complications.

TISSUE EXPANSION IN UROLOGY

Surgical experience gained in the reconstruction of other sites in the body has led surgeons and urologists to use techniques of expansion in reconstruction of the genitourinary tract. Some of the more widely reported uses are described, but the uses of tissue expansion are limited only by the skills and experience of the surgeon.

Vaginoplasty in Adrenogenital Syndrome

Vaginoplasty in females with adrenogenital syndrome (Fig. 31–6) has been performed in infancy and childhood. However, the standard techniques of vaginoplasty have the disadvantage of recurrent vaginal stenosis in as many as 75% to 80% of patients in some series despite frequent dilatation. The use of tissue expansion of the labia provides excellent skin flaps for performance of vaginoplasty[21] and vulvar reconstruction.[22]

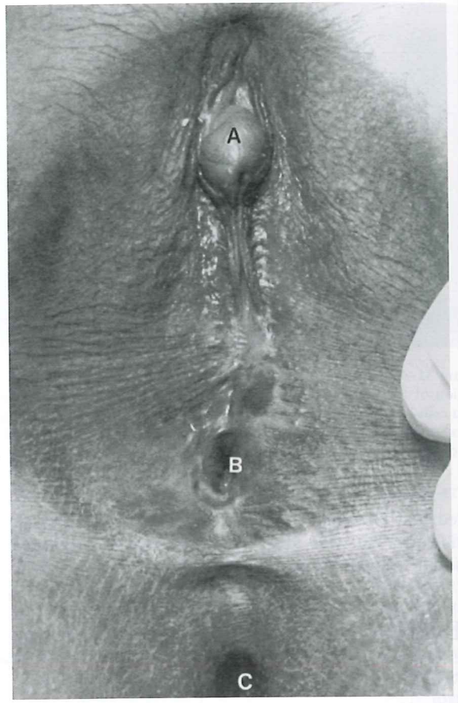


Figure 31–6
Preoperative appearance of the external genitalia of a female with congenital adrenal hyperplasia. A, clitoris; B, stenotic common urethrovaginal ostium; C, anal opening. (From Patil UB: Role of tissue expanders in genitourinary reconstructive surgery. Urol Annu 8:201, 1994.)

Placement of the expander is performed in an outpatient setting through an incision in the inguinal region, approximately 4 cm below the external inguinal ring. A remote port is used for inflation of the expander. The expansion is carried out weekly for a 6-week period (Fig. 31–7). Inflation of the expander is begun 10 days after implantation.

At the time of vaginoplasty, the expanded skin flap is incised and the expander with its remote port is removed. The flap is rotated into position to bridge the defect between the perineum and the vaginal ostium. The U-shaped perineal flap is used to cover the posterior aspect of the repair. The vaginal pack is removed on the third postoperative day. Vaginal dilatation is commenced on the 10th postoperative day and is performed once daily for 3 weeks and then thrice weekly for an additional 3 weeks. The excess skin at the anterior lip of the vagina is refashioned into labia minora 3 months later (Fig. 31–8).

Using this technique, Patil[21] has reported excellent 2-year follow-up results in three patients with no evidence of vaginal stenosis.

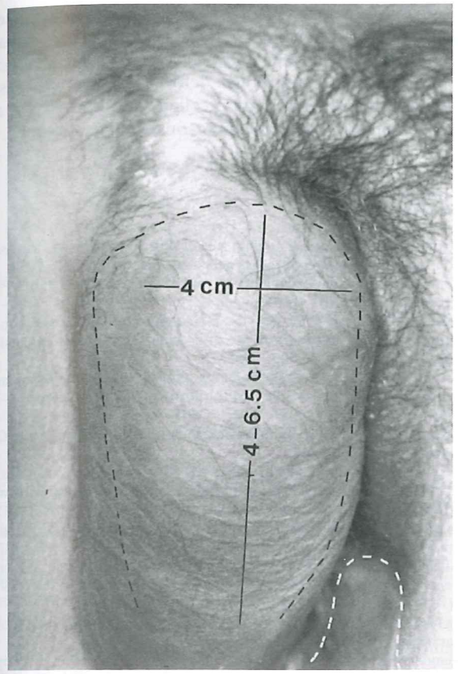


Figure 31–7
Labium with the expander in place, showing the size of the skin flap available for repair. (From Patil UB: Role of tissue expanders in genitourinary reconstructive surgery. Urol Annu 8:205, 1994.)

Urethral and Penile Reconstruction

The use of free grafts in penile and urethral defects has been widely accepted, although occasionally with less than satisfactory outcomes. Free skin grafts for surface coverage result in insensate areas. Penile skin remains the ideal tissue for penile reconstruction and for creation of a neourethra. Hence, the use of a tissue expander allows use of native penile skin for complete reconstruction. Vordermark[23] demonstrated the use of a rectangular tissue expander placed under the penile skin with a remote port in the lower abdomen, in the reconstruction of failed correction of hypospadias. At initial operation, the abnormal urethra is excised and a meatus is left at the site of the proximal aspect of the urethral defect. The ventral surface of the penis is covered by Byars flaps of the penile skin. The expander is placed on the dorsal surface of the penis, and expansion is performed weekly for 4 to 6 weeks. At the time of reconstruction, the excess skin is used for penile coverage.

The obvious benefits of using sensate penile skin and the lack of donor sites make this an attractive alternative in the reconstruction of complex urethral defects and penile malformations. It does require careful follow-up as well as multiple operative procedures for satisfactory reconstruction.

Reconstruction of the Mons Pubis and Lower Abdominal Wall in Bladder Exstrophy

The complex malformation of bladder exstrophy requires a multistaged approach for complete reconstruction. In some patients, this results in abdominal scars and depression of the mons pubis, with a split in the midline devoid of pubic hair that is exaggerated because of widening of the symphysis. Marconi and colleagues[24] have used a two-stage technique with tissue expansion to reconstruct these scarred abdominal walls in six females and two males.

Two 400- to 500-ml tissue expanders are placed through two paramedian incisions. These expanders are inflated weekly for 6 weeks. During the second procedure, the skin expanders are removed and the elliptic area including the depressed median scar is deepithelialized and turned over to form a longitudinal cylinder occupying the medial region of the abdominal wall. The skin expansion allows for the dermoadipose flaps to fill the median scar depression and for skin to cover the cutaneous deficit. In male patients, the excess skin may be used in the closure of epispadias.

Reconstruction of the Scrotum in Transsexualism

Reconstruction of the scrotum in transsexualism or with loss of skin secondary to trauma, burns, or infection is often difficult. The use of tissue expansion can offset the paucity of skin available for reconstruction. Tissue expansion of the labia can be performed in biologic females in whom gender reassignment is being performed.[25] Similar good results have been obtained with the use of expanders in the inguinal area in patients who suffered scrotal skin loss due to trauma.[26]

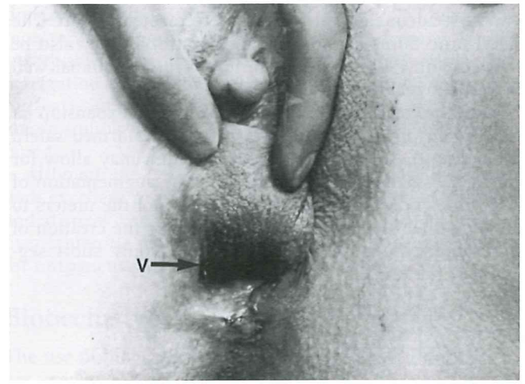


Figure 31–8
Completed vaginoplasty showing capacious vaginal ostium (V). (From Patil UB: Role of tissue expanders in genitourinary reconstructive surgery. Urol Annu 8:207, 1994.)

Reconstruction of Congenital Absence of the Vagina

Congenital absence of the vagina is a rare but devastating entity noted in 1 of 10,000 females. Also known as the Mayer-Rokitansky-Küster-Hauser syndrome, it is characterized by primary amenorrhea, partial or complete absence of the vagina, and 46XX karyotype. The Abbé-McIndoe operation with the use of split-thickness skin grafts, use of colonic or small bowel segments, and use of myocutaneous flaps have been advocated for reconstruction. Serra and colleagues[27] have used a modification of the Abbé-McIndoe procedure using a tissue expander to stretch the neovagina instead of the rigid molds that have been used. They found that patients' discomfort was minimized with gradual expansion and that long-term results were excellent both functionally and cosmetically.

Reconstruction of Genitourinary Trauma

With traumatic injury to the external genitalia and skin loss, reconstruction with ISLE is ideal for the closure of small defects without tension.[7, 14] Loss of scrotal or penile skin may be repaired using skin with similar sensation and hair-bearing properties. Large defects require placement of an expander and gradual expansion. The cosmetic and functional results with expansion in this setting are superior to using free flaps or skin grafts.

Potential Future Applications for Expansion in Genitourinary Surgery

Use of the rapid forms of expansion and sustained intraoperative limited expansion makes skin available for reconstruction with much less delay even at the time of surgery. The possible uses of ISLE may be in the reconstruction of hypospadias in patients who have had prior failure and who lack adequate skin for complete reconstruction. The initial procedures in the closure of exstrophy may also be assisted with ISLE in the expansion of the abdominal wall skin to allow easier closure.

Animal experimentation has shown that expansion of the bladder, ureters, and bowel may be performed safely. Expanding these uses to the clinical realm may allow for the use of smaller bowel segments in the augmentation of short-gut syndromes as well as expansion of the ureters to allow for their use in reconstruction or for the creation of Mitrofanoff-type continent stomas using only short segments of the ureter.

CONCLUSION

Use of tissue expansion is a well-established modality in plastic surgery and lends itself well to use in the reconstruction of complex genitourinary defects. The limitations of potential infection and staged procedures are far outweighed by the benefits of use of local tissue with excellent cosmetic results. Additionally, intraoperative tissue expansion and rapid expansion allow excellent cosmetic reconstruction of complex urologic deformities. Hence, tissue expansion techniques are an excellent addition to the armamentarium of genitourinary reconstructive surgeons.

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HYPOSPADIAS—MISCELLANEOUS

CHAPTER

32

Dressings, Stents, and Tubes

ANDREW L. FREEDMAN

The care of hypospadiac patients has changed dramatically during the past several decades. The development of new techniques including the use of vascularized flaps and extragenital grafts has served to improve results greatly. These improvements in outcomes have led to the widespread acceptance of surgery for even mild forms of hypospadias. This increase in treatment has at the same time led to a demand for outpatient surgery with its promise of less discomfort, shorter convalescence, and reduced cost. Thus, a need for innovative techniques has arisen to provide simple home wound care without compromising surgical results. In response to this need, a large variety of tubes, stents, and dressings has been developed. Despite the wide choice of options available, the ideal dressing remains elusive. This chapter discusses the benefits and drawbacks of many of the commonly used stents and dressings, along with recommendations based on the current practices at the Children's Hospital of Michigan.

DRESSINGS

The goals of postoperative dressings have been long recognized—to prevent hematoma, reduce edema, and immobilize the repair.[1] With the increased use of grafts and flaps, these goals have assumed even greater importance. The ideal dressing should provide wound protection while maintaining patients' comfort, resist dislodgment while allowing easy removal, and maintain cleanliness even in diapered children. The most commonly used materials include cotton gauze, bioocclusive films, and silicone-based foam.

Cotton Gauze

The traditional dressing material most commonly described is cotton gauze.[2] The gauze is snugly wrapped around the penis after application of a liberal coating of mineral oil or antibiotic ointment. In addition, a layer of nonadherent material such as Adaptic (Johnson & Johnson, Arlington, TX) may be applied to prevent adherence of the gauze to the penis. The dressing is then held in place with a sturdy configuration of adhesive tape to secure the dressing and maintain compression.[3,4]

The primary advantage of the gauze dressing is its effective compression and secure attachment to the penis. It provides a platform to which a catheter can be secured as well as a cylinder on which the penis can be suspended, although suspension can also be provided by an inverted coffee cup with the bottom removed.[2,5] Unfortunately, this dressing has several disadvantages. The most significant is its inherent complexity as well as its time-consuming application and difficult removal. Dressing changes are an often painful and exhausting ordeal, frequently requiring sedation. The traditional cocktail of Demerol, Phenergan, and Thorazine has been condemned by the American Academy of Pediatrics,[6] and sedation with the recommended benzodiazepines should be performed only in a monitored setting, greatly increasing the expense. Soaking the dressing with mineral oil may assist in removal. The other major risk is that the dressing, especially if soiled, can become excessively tight, causing glans swelling, blistering, and even ischemic necrosis of the skin flaps.[5] Children frequently require overnight hospital admission to monitor and modify the dressing. The dressing is also susceptible to urine and stool soiling, which may cause maceration of the skin and an intolerable odor necessitating early or repeated changes. One modification to decrease soiling is the use of an outer layer of impermeable tape.[4]

Although the traditional gauze dressings have been used with excellent results in experienced hands, the discomfort and distress caused by dressing changes and the risk of overtightening make this a less desirable choice, especially for outpatient surgery.

Bioocclusive Membrane Dressings

The use of bioocclusive transparent adhesive film dressing has gained increasingly widespread acceptance since its introduction by Vordermark in 1982.[7] Numerous brands with no demonstrable difference in effectiveness are available. Slight modifications in texture and packaging may make one brand seem easier to use or apply. I prefer

Tegaderm (3M Health Care, St. Paul, MN) because its packaging format, with a paper ring, makes it easier to cut to size and to handle when wrapping around the penis. The dressing is wrapped around the glans and penile shaft after the penis is coated with an adhesive substance. It is important to keep the penis dry during application of the membrane to allow complete adhesion. In particular, the presence of dripping urine may prevent a tight seal to the glans and cause the membrane to be later dissected off by urine. The membrane is cut to a size that covers from the tip of the glans to the penoscrotal junction. The penis is then wrapped snugly with two layers. The penis can be wrapped circumferentially or with the two ends of film adhered to each other as a mesentery or "dorsal fin."[8] It is important to include the glans in the dressing to prevent excessive glans swelling (Fig. 32–1). Further fixation of the penis with adhesive tape is unnecessary.

The major benefit of the membrane dressing is its simplicity, allowing early mobilization, minimal home care, few complications, and easy removal. The vast majority of patients with this dressing can be treated as outpatients without hospital admission. The dressing can usually be removed easily by slipping the whole tube upward off the penis. Dressing are typically left in place for 5 to 7 days. The dressing not uncommonly falls off at home but rarely before the third or fourth day, making its replacement unnecessary. Because the dressing is impermeable, the need for routine early dressing changes due to soiling is obviated. The transparent nature of the dressing allows observation during healing. The simplified nature of the dressing may also help to relieve parents' anxiety about taking care of the child at home.

One caution is that if the dressing begins to roll up or down the penis, it may form a tight constricting band, requiring immediate removal. With proper parental counseling and observation, the risk of injury from the dressing's rolling up is minimal. In a chubby infant, the dressing may have a greater tendency to slip off prematurely. Rarely is a replacement necessary, although to prevent concealment of the penis, a gauze wrap may used on occasion.

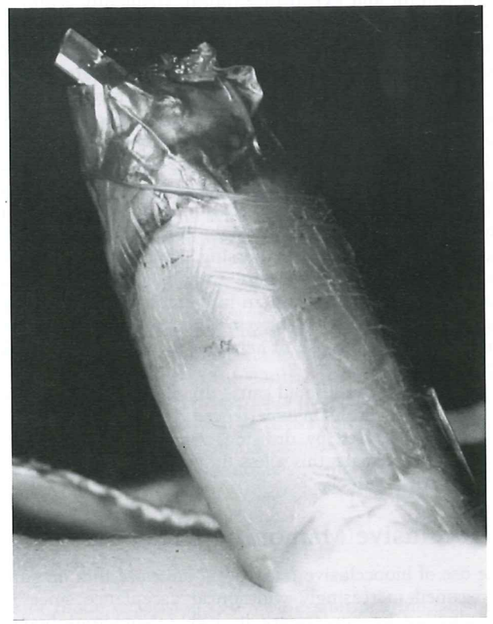


Figure 32–1
Final appearance after application of a double layer of transparent membrane dressing. Note that the dressing covers the entire glans.

Silicone Foam

The use of a silicone foam elastomer compound as a dressing in hypospadias surgery was first reported by De Sy and Oosterlink in 1982 and has since gained wide acceptance.[9,10] The foam base and catalyst are preheated and then mixed in a syringe. The mixture is then injected into a mold placed around the penis, filling upward from the base. The foam sets in approximately 2 minutes, at which time the mold is removed. The cast can then be further anchored at the base with adhesive tape. The cast can be easily separated and removed after scoring its outer surface.

The primary advantage of the foam cast is its secure immobilization of the penis, combined with easy removal with minimal discomfort. It also provides a secure base on which to immobilize an indwelling catheter.

Disadvantages include the need to preheat and properly prepare the mixture, requiring a high degree of familiarity with the procedure. The cast itself is not adherent to the phallus and thus may fall off prematurely despite the use of anchoring adhesive tape.

Other Materials

A number of new materials have become available for various dressing needs and may be adapted for patients with hypospadias. Hydrocolloid dressings typically used for the treatment of pressure sores (e.g., DuoDerm) are tough, thick, and adhesive but still pliable. They provide a greater degree of splinting than a film membrane dressing yet are able to be molded to the penis and removed easily. Also available are gel-based dressings with a tough plastic backing that are adherent, mold to the wound, and provide splinting. The use of such dressings clinically in hypospadias surgery has been minimal and awaits further trial.

Although dressings have come a long way from the traditional cotton gauze, allowing the widespread practice of outpatient surgery, the ideal dressing awaits further creativity and experimentation.

STENTS AND TUBES

Much like dressings, the use of stents and tubes in hypospadias surgery has undergone tremendous evolution. Perineal urethrostomy has been replaced in favor of the simplified diversion provided by percutaneous suprapubic tubes or transurethral catheters.[11] Traditional rubber and latex catheters are being replaced by the more biocompatible silicone, and in young children, bulky drainage systems have given way to simple open dripping stents. This evolution has greatly added to children's comfort, mobility, and convenience of care, making outpatient surgery feasible.

With the exception of the most distal repairs, such as meatoplasty and glanuloplasty (MAGPI), almost all hypospadias surgery requires at least some temporary urinary diversion. Although some have reported excellent results without drainage in the Matheiu repair,[12,13] others have reported an increased rate of complications when a stent was omitted.[14] An informal hand-raising poll at the 1995 AAP Section on Urology meeting suggested that most pediatric urologists stent their distal non-MAGPI repairs. The goal of diversion is to prevent urethral edema from obstructing flow and causing urine to dissect into the freshly healing anastomosis. The ideal drainage system should therefore provide protection of the repair yet should be easy to place and remove, comfortable to wear, and convenient to care for at home. This can be provided for by complete urinary diversion, such as a suprapubic tube or Foley catheter, or by a transurethral stent that allows flow past the anastomosis but prevents distal obstruction. Such stents may in addition allow the drainage of urethral secretions by means of fenestration. The proper choice among the wide variety of systems depends on the age of the child, the complexity of the repair, and the surgeon's preference. No one system is appropriate for all patients, but having a general outline for the use of stents and tubes greatly simplifies demands on operating room personnel and assists in preoperative teaching of the parents.

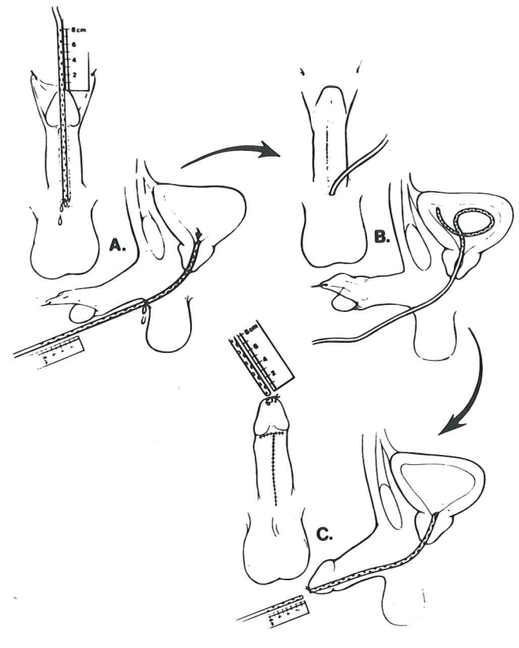


Figure 32–2
A: The catheter is slowly inserted until urine is expressed. The distance is then measured between tip of the penis and most distal perforation. *B*: The catheter is then advanced completely until all perforations are in the bladder in order to maintain a dry field during the repair. *C*: After the dressing is applied, the catheter is withdrawn until the measured length, secured, and trimmed. (Reprinted by permission of the publisher from Gonzalez: "Use of urethral drainage tube and dressings in hypospadias repair," *Urology*, 33:327–328. Copyright 1989 by Excerpta Medica Inc.)

Stents

Stents act as transurethral conduits to allow drainage through the urethra while preventing distal obstruction. They can be placed into the bladder, providing constant drainage, or distal to the sphincter, through which the child can void. Although numerous stents are commonly available, I prefer the 7 French Hemovac drain (Zimmer Inc., Dover, OH). It is a silicone tubing with a nonperforated proximal segment and a distal fenestrated segment. This design allows the use of a fenestrated stent yet keeps the area dry until after placement of the final dressing. During initial placement, the catheter is inserted until reaching the bladder, as confirmed by the expression of urine, or at the urethral bulb, confirmed by palpation. The distance from the tip of the glans to the last fenestration is then measured. The catheter is then inserted until the solid tubing passes into the bladder. The repair can then be completed and the dressing applied in complete dryness. The catheter is then withdrawn to the previously measured distance, secured with a glans suture, and trimmed just above the meatus (Fig. 32–2).[15]

For children who are in diapers, our preferred form of drainage is an intravesically placed stent left open to drip into the diaper.[16] Double diapering has not been routinely used. In rare instances of catheter obstruction by blood or sediment, the 7 French size easily admits passage of a 3.5 French infant feeding tube for bladder drainage or clearance of the obstruction. For continent children, the stent is left extravesically with the anticipation that the child will void through it.[17] Some children, especially older children, may experience discomfort with voiding through a stent; therefore, a suprapubic tube is often also placed to allow drainage in the event the child cannot void comfortably.[18,19]

Tubes

Suprapubic tubes are primarily used in children who are already out of diapers and for whom there is concern that they will not be able to void through the extravesical stent. Suprapubic diversion is usually in the form of a percutaneously placed catheter such as the 10 French Stamey suprapubic tube (Cook Urologicals, Spencer, IN) or 14-gauge Bonnano catheter (Becton-Dickinson, Franklin Lakes, NJ) attached to a pediatric leg bag. Suprapubic tubes are secured with a stitch at the skin level as well as contained in a wide mesentery of 3-inch Elastoplast tape. With the use of this wide umbilical cordlike taping, very few instances of premature dislodgment of the tube have occurred. Although the use of Foley catheters has been

widely reported, disadvantages of their use include severe bladder spasms, decreased mobility, and even reports of disruption of the urethral anastomosis on withdrawal of the deflated balloon.[20]

Children with an intravesical catheter or suprapubic tube are routinely provided oxybutynin chloride (0.1 mg/kg PO b.i.d.) for relief of bladder spasms. All children with catheters are prescribed oral antibiotics. Catheters are generally left indwelling for 5 to 7 days and removed at the first office visit.

CONCLUSION

The increase in outpatient hypospadias surgery has created a demand for dressings and stents that are comfortable, secure, and easy to manage. The use of bioocclusive membrane dressings and soft fenestrated silicone stents should safely meet these challenges for the majority of children without compromising outcomes.[21] Further refinement of materials, along with the creativity and innovation that have long characterized hypospadias surgery, will no doubt continue to improve the comfort and safety of our patients.

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CHAPTER

33

Postoperative Management of Hypospadias

KEVIN A. BURBIGE
JOHN P. CONNOR

Surgical correction of hypospadias has long challenged urologic surgeons. During the past two decades, we have witnessed considerable improvement in the functional and cosmetic results of this type of reconstructive surgery. This progress has been the result of a multitude of factors, including advances in suture and catheter material, refinement of surgical technique, routine use of optical magnification, and a better understanding of wound healing.

The evolution of pediatric urology into a recognized subspecialty has likewise resulted in greater familiarity with hypospadias repair and a heightened awareness of the limitations of each particular procedure, resulting in better patient selection and improved success.

Although the surgical technique of a wide variety of hypospadias repairs commonly performed is well described in the literature and uniformly accepted by surgeons, the postoperative management of hypospadias is controversial.

Historically, most surgeons, regardless of the type of repair used, advocated a bulky gauze, compressive penile dressing, requiring prolonged closed catheter drainage and immobilization of the child in bed. A lengthy hospital stay with the penis concealed in an elaborate dressing was considered the cornerstone of postoperative management. Although it is difficult to picture this, it is necessary to understand the uncertainty of the outcome of hypospadias repair in the past. Surgeons felt compelled to control the postoperative regimen as rigidly as possible in the hope of improving results.

Improved outcome of hypospadias repair and a general trend toward shortening hospitalization have resulted in an ongoing reevaluation of traditional techniques of postoperative management of hypospadias repair. Because hypospadias repair is a surface operation that does not violate a body cavity, it lends itself readily to the outpatient setting. As such, there is no place for a complex postoperative regimen that restricts the child's mobility or interferes with the parents' general care of the child. We currently perform all our hypospadias repairs in the outpatient unit, as do most pediatric urologists.

URINARY DIVERSION

A current general consensus among surgeons is that urethral catheters are no longer universally required postoperatively for distal hypospadias repairs (meatal advancement procedures, meatal-based flaps). Studies have demonstrated no increase in complication rates in catheterless repairs as compared with traditional repairs.[1–3] Postoperative catheter drainage is recommended for more proximal repairs (tube grafts or two-stage repairs).[4, 5] Because the majority of hypospadias repairs are performed in infants, most surgeons use open catheter drainage into a diaper for a period of approximately 5 to 7 days. Various short, small-caliber (6 to 8 French) urethral catheters are commercially available and are suitable for postoperative urinary diversion. One can also use an infant feeding tube, which is readily available in most operating rooms. The feeding tube can be cut short to allow 2 to 3 cm to lie in the bladder for continuous drainage. The flared end of the tube should be left intact to prevent the catheter from being inadvertently drawn into the bladder, should the holding sutures break. Regardless of the type of catheter used, it is held in place by a suture placed through the glans and tied around the catheter. Cutting the suture allows the catheter to be removed in the office postoperatively.

DRESSINGS

Regarding the subject of wound healing, it becomes apparent that the type of dressing used postoperatively is not as crucial as previously thought. The healing of a surgical wound involves a complex series of events at both the surface and deep layers of the wound. At the surface of the wound, the epidermis begins to thicken within 24 hours and reepithelization of opposing skin edges is completed by 48 hours.[6] In the deeper layers of the wound, an inflammatory reaction mediated by leukocytes that remove cellular debris and injured tissue also begins within the

Table 33–1
Techniques Used for Hypospadias Repair

Investigators	Technique	Complications/ Total	%
Rober et al[3]	Free graft	35/81	43
Decter et al[8]	Bladder mucosa	4/13	30.7
Hendren and Reda[4]	Bladder mucosa	6/35	17
Bellman[9]	Mustarde	5/30	16
Burbige[2]	Multiple	18/162	11
Hendren and Horton[10]	Free graft	9/103	8.7
Bellman[11]	Multiple	7/84	8.0
Rabinowitz[1]	Mathieu	3/59	5.0

first 24 hours. As this inflammatory phase subsides by the second to third day, fibroblasts, which synthesize collagen, enter the wound.[7] Simultaneously with the previous process is a rapid capillary proliferation into the injured tissue, as evidenced by an increase in endothelial mitosis and cell migration. Because the important aspects of hypospadias repair involve the healing of epithelial surfaces, it is apparent that most of this healing occurs rapidly within the first few days after surgery. Although occlusive dressings have been shown to facilitate reepithelization of open wounds[8] (avulsion type), they serve little purpose in a surgically approximated incision after 48 hours.

Practical concerns of outpatient management after surgery dictate a simple dressing that does not interfere with the parents' general care of the child or restrict the child's mobility.

We have used a single nonadherent gauze and plastic adhesive wrap dressing to provide postoperative stability to the repair (Telfa and Tegaderm).[9, 10] The majority of these dressings come off spontaneously within 2 to 3 days after surgery. The remainder are easily removed in the office along with the urethral catheter 1 week after surgery. Tedious removal of a complicated dressing from a sedated child is avoided. Hemostasis at the time of surgery must be meticulous because this dressing does not have a compressive effect.

Although double diapering is advocated by a number of researchers, we do not routinely use it. Leaving the repair site wet has not affected the outcome and has proved cumbersome.

Postoperative antibiotics are recommended during the period of open catheter drainage but may be discontinued once the catheter has been removed.

Several large series of patients undergoing hypospadias repair have reported complication rates of 8% to 43%.[9–11] These studies represent a broad range of techniques and management. Our results with a more simplified postoperative management as outlined here compare favorably with previous studies using traditional postoperative techniques (Table 33–1).

CONCLUSION

With improved confidence in the results of hypospadias repair, the traditional aspects of the postoperative management of these patients must be reexamined with the aim of decreasing morbidity and simplifying the at-home treatment of the children. Elaborate penile dressings, immobilization of the child, and extended hospitalization have been relegated to the past.

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CHAPTER

34

Pain Management

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Pain is an adaptive response, warning of present harm, preventing further damage, or causing one to seek remedy for an affliction. Patients with renal disease may present with flank or abdominal pain and usually require a number of potentially painful, invasive, diagnostic, or therapeutic procedures. No role, with respect to medical procedures, has yet been found for pain, either in enhancing procedural efficacy or in improving outcome.[1] Procedures such as venous cannulation, renal biopsy, cystoscopy, circumcision, and surgical reconstruction are themselves painful. Outdated methods of restraint, including strapping a child down in a papoose fashion, without the benefit of sedation, are still being used for many procedures. A great deal of anxiety and psychologic trauma are generated by the pain inflicted with these interventions. The fear brought about by parental separation, unfamiliar surroundings, and being restrained can be overwhelming.[2] It is incumbent on physicians and nurses to be aware of the physiologic and psychologic concerns of pediatric patients and to select therapeutic modalities that alleviate pain and anxiety, thereby lessening their deleterious effects.[3] This chapter elaborates on strategies that are helpful in preventing and treating procedural and perioperative pain.

BEHAVIORAL AND PHYSIOLOGIC PAIN ASSESSMENT

Pain assessment and management in the pediatric population rely on both observed physiologic and behavioral changes that accompany painful stimuli and self-report by the child.[4–6] Pain assessment is the key to adequate treatment. All too often physicians say that a procedure is not painful or causes only minor discomfort without ever having experienced the procedure themselves. The pain perceived by an individual differs owing to diverse factors including genetic and cultural influences. Using pain scales and other assessment tools can assist in the determination of the adequacy of pain treatment by objectifying pain and making patients their own controls. One of the most widely used of these tools is the Children's Hospital of Eastern Ontario Pain Scale (CHEOPS). This scale was derived from children's responses to postoperative pain and pain from venipunctures. It assesses six behavioral components of pain: the patient's cry, facial expression, verbal responses, torso position, attempts to reach for the incision site, and leg movement.[7,8] Although comprehensive, this scoring system is too involved for routine clinical use.

Understanding of how children experience pain has been improved by clinical studies that emphasize consideration of the cognitive and emotional age of children. Children's cognitive developmental age dictates their understanding of pain and thus their level of reactivity to pain.[9] Reactivity, in part, implies the scope of the behavioral repertoire that can be displayed by a child when confronted with an actual or potential painful situation. As learning occurs, the number of stimuli activating the fear response increases. Strategies for coping with pain and fear appear at an early age. As a child matures, the ability to inhibit behavioral response to pain is enhanced.

PREOPERATIVE TEACHING

Preoperative teaching programs have become an effective method of reducing hospital stress. These programs allow patients and parents the opportunity to ask questions about the upcoming events, to meet staff who will be caring for the patient, and possibly to become more acclimated to the hospital environment.[9]

PSYCHOLOGIC TREATMENT OF PAIN

Psychologic methods including physical, behavioral, and cognitive techniques can be used as adjuncts or alternatives to pharmacologic methods of pain management. Story telling, stroking, cooing, swaddling, information enhancement, and distraction all are psychologic interventions. Some psychologic methods, such as relaxation training and cognitive strategies, are highly specialized and used

generally by psychologists or other mental health professionals. A serious limitation to the widespread use of these psychologic techniques of pain control is the high cost of implementing them. This shortcoming can be overcome by the development and validation of minimal therapist contact programs that enable any health professional to deliver these specialized techniques, with a reduced investment of professional time.[10] Psychologic methods pervade all health care and are delivered either deliberately in an effective way or clumsily and ineffectively. All health professionals have a responsibility to learn to apply psychologic methods of pain control.

PAIN TRANSMISSION

A substantial body of knowledge has documented the presence of an intact neuroendocrine capable system and defined neuronal anatomic pathways necessary for the transmission and processing of nociceptive (pain) signals in infants and children.[11] Nociceptors (pain receptors), preferentially sensitive to noxious or potentially noxious stimuli, are located not only on the skin but in joints, tooth pulp, bone, viscera, and muscle. Nociceptors are encapsulated and unencapsulated pain receptors located on sensory neurons. These receptors are specialized units that detect thermal, chemical, and mechanical stimuli and transmit pain signals to the central nervous system (CNS).[12] When tissue manipulation, tissue trauma, or the threat of tissue damage from external sources occurs, a multitude of reactions are set into motion. Released peripherally are endogenous compounds such as serotonin, histamine, potassium ion, hydrogen ion, bradykinin, substance P, and prostaglandins that can modulate the nociceptors (Fig. 34–1). The effect of these substances, when released, is to stimulate the nociceptors. Through stimulation, the activation threshold of the nociceptors is reduced. The result is a lowering of patients' pain threshold, thus making it more likely that they will feel pain.[13]

Signals from peripheral nociceptors are carried to the CNS via several types of fibers: A-β fibers (moderately myelinated, fast conducting) carry impulses from pressure/position sense receptors; A-δ fibers (moderately myelinated, fast conducting) carry impulses from high-threshold mechanoreceptors and polymodal peripheral sensory neurons, which respond to several forms of stimuli, such as cold, pressure, and temperature; and C fibers (unmyelinated, slow conducting) carry impulses from cutaneous and deep, low-threshold mechanoreceptors, chemoreceptors, and thermoreceptors. Both A-δ and C fibers are specialized in alerting the body of tissue damage. Transmission of sharp, spatially distinct pain is attributed to A-δ fibers. C fibers carry dull, diffuse pain signals.[12]

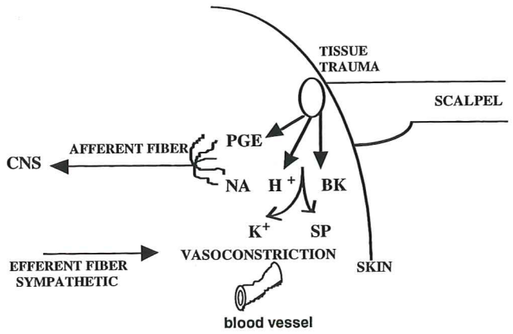


Figure 34–1
Endogenous modulators.

The majority of pain neurons from the periphery have their cell bodies located in the dorsal root ganglion. Some afferent pain input is transmitted through the ventral root, thus explaining why pain is not completely relieved after sectioning of the dorsal roots.[14] As the pain neurons enter the spinal cord gray matter from the periphery through the dorsal root, they separate into bundles of A-δ *and C fibers. Once in the spinal cord, synaptic connections from the peripheral afferent pain fibers are made with several types of secondary cells called* **interneurons**. The interneurons have projections to the spinothalamic, spinoreticular, ipsilateral spinocervical, spinocervicothalamic, and possibly other tracts. The long ascending tracts make monosynaptic or polysynaptic reflex connections with lower motor neurons in the ventral horn of either side and also have projections to higher brain centers. In the brain, the long tracts terminate in several areas including the medulla (medial reticular formation), midbrain, periaqueductal gray matter, thalamus, hypothalamus, and the frontal, parietal, and limbic areas of the cortex. Processing of pain occurs at a number of different levels. Emotional interpretation of pain, the perception of pain, the motivational response, and the cognitive processing of noxious stimuli occur in the higher brain centers.[15]

This system would not be complete without some dynamic mechanism to modulate the afferent pain impulses. Several systems involved with the modulation appear to exist in the nervous system. A number of putative neurotransmitters have been identified. Excitatory amino acids (aspartate and glutamate), somatostatin, endogenous opioids (enkephalins, endorphins, and dynorphins), tachykinins (substance P, neurokinin A, and neuromedin K), serotonergic, noradrenergic, cholinergic, and GABAergic substances (γ-aminobutyric acid) have been isolated in the spinal cord after supraspinal stimulation.[16–20] All of these substances are thought to have a role in the modulation of the pain response as excitatory or inhibitory.[11] The most well studied of these pain-modulating systems involves the endogenous opioids. Information about the endogenous opioid system has improved our knowledge about how the exogenous opioids such as morphine and fentanyl work.

ANALGESICS

Many old and new opioid narcotics are available for use in the postoperative period. A few of the more commonly used pain medications are listed in Table 34–1. A large variety of opioid agonists are available. Morphine, meperidine (Demerol), hydromorphone (Dilaudid), fentanyl, methadone, sufentanil, and alfentanil are the agonists with which one should become familiar. The choice of agent

Table 34–1 Opioid Narcotics (Moderate to Severe Pain)

Medication	Dose	Route	Dosing Interval
Morphine	0.05–0.1 mg/kg	IV/IM	q 2–3 hr
Fentanyl	0.0005–0.001 mg/kg	IV	q 15–20 min
Hydromorphone	0.005–0.015 mg/kg	IV	q 3–4 hr
Meperidine	1–2 mg/kg	IV/IM	q 3–4 hr
Methadone	0.05–0.1 mg/kg	IV	q 4–12 hr
Nalbuphine	0.05–0.1 mg/kg	IV	q 2–3 hr
Codeine	0.5–1 mg/kg	PO	q 4–6 hr

depends on the clinical setting and the treatment objectives. All opioids have a dose-dependent depressive effect on ventilation, apparently affecting this action at the pontine and medullary ventilatory control centers. At equianalgesic doses of drug, all opioids cause similar degrees of respiratory depression. They induce a decrease in tidal volume, respiratory rate, and thus minute ventilation. Opioids lead to a reduced compensatory response to hypoxia and carbon dioxide.[21] Side effects commonly seen with opioids can be effectively eliminated with agonists-antagonists, stimulants, stool softeners, and antipruritics. Other side effects associated with opioids include increased intracranial pressure due to carbon dioxide retention, hypotension from histamine release, and urinary retention. Great interpatient variability is noted in response to opioids. Therefore, the dose should be determined by the patient's response (i.e., administer the amount required to make the patient comfortable).[22] Morphine has been the most commonly used opioid agonist. It remains the gold standard by which the newer agents are measured. Several routes of delivery are available for administering agents (Table 34–2).

Fentanyl is a synthetic opioid that is approximately 100 times more potent than morphine. It has a high lipid solubility and readily crosses the blood-brain barrier. However, because of its increased lipid solubility, when it is given intrathecally it does not have the rostral spread exhibited by morphine, thus limiting its CNS effects at low concentrations. Fentanyl has a very short duration of action. This is a reflection of its rapid redistribution from the blood into other tissue sites such as fat and muscle. Fentanyl suppresses the stress response from acute injury and has been shown to decrease the morbidity of major surgery when given in combination with an inhalation agent versus the inhalation alone.[23] It is very effective for pain relief, especially when given in combination with an anxiolytic agent. One should remember, however, that significant respiratory depression can occur, especially when it is used in conjunction with midazolam.[24] Use of fentanyl in the postoperative period either by the intravenous route or in epidural infusions has been shown to be an effective means of pain relief in children.

Meperidine, hydromorphone, and methadone all have different biochemical characteristics that lend themselves to various clinical settings. Use of meperidine in the pediatric population, especially in situations in which renal function may be impaired, is strongly discouraged. The normeperidine metabolite from meperidine degradation lowers the seizure threshold and causes a moderate amount of dysphoria without adequate pain relief. Hydromorphone is an exceptionally well-tolerated agent. It appears to cause less pruritus and sedation than does morphine. It is important that the nursing staff be instructed in its use, because the names are similar and hydromorphone is five to seven times more potent than morphine. Methadone is an ideal agent for long-term pain treatment because of its prolonged half-life. Methadone has a slow elimination half-life (approximately 19 to 36 hours). Berde and colleagues recommend that administration of methadone begin slowly with the intravenous route, using a loading dose of 0.1 mg/kg over 20 minutes every 2 to 3 hours times three in an awake, opioid-naive patient. After the loading dose, further doses can be titrated on a "reverse-p.r.n." basis every 4 hours. That is, the drug is given unless the patient shows signs of oversedation or respiratory depression. Berde further recommends using the following sliding scale dose administration of methadone after the loading dose has been given: for severe pain, 0.07 to 0.08 mg/kg every 4 to 6 hours; for moderate pain, 0.05 to 0.06 mg/kg every 4 to 6 hours; and for mild pain, 0.03 mg/kg every 4 to 6 hours.[49] Methadone can also be given orally. Because of the bioavailability of methadone, the oral dose is twice that of the intravenous dose.

A number of routes and delivery systems are available for administering pain medications to pediatric patients. One of the most useful and most promising methods is

Table 34–2 Routes of Drug Delivery

Route	Advantage	Disadvantage
Oral	Good absorption	Not viable in NPO/taste offensive
Intramuscular	Convenient/no equipment	Erratic absorption/hurts
Intravenous	Rapid distribution and effect	Requires indwelling catheter
Epidural	Lower drug requirement	Technically difficult/infection
Intrathecal	Lower drug requirement	Technically difficult/infection
Transdermal	Easy administration	Erratic absorption/restricted use

with a patient-controlled analgesia (PCA) pump. PCA offers patients the best opportunity to become active participants in their postoperative pain management. PCA delivery systems provide on-demand administration of analgesic to achieve a steady drug level.[25] The PCA device uses a computer-controlled infusion pump that safely administers preset doses of analgesics when pushbutton activated by the patient. Repeated doses can be administered with repeated pushes of the button. The route of administration is typically intravenous, although many drugs can be given subcutaneously by these devices. Overdosing is avoided through several safety features of the pumps. Delivery of drug after a dose is given is prevented for a specified time called the *lock-out period*. If sedation occurs, the patient is unable to activate the pump; plasma levels of the drug subsequently decrease, the sedation subsides, and the patient becomes more alert. Given the inherent biologic and psychologic variability of the pediatric population, administration of analgesic agents on a fixed time schedule has little utility. Thus, delivery systems such as PCA devices are a more rational approach to pain treatment in pediatric patients. PCA devices have been used safely in children who are as young as 4 years and who have normal cognitive development. With careful monitoring of daily PCA use, better individualization of drug delivery and reduction of side effects can be achieved. Pain management based on good pharmacokinetic principles and safe practices helps to prevent the establishment of terrible pain cycles and leads to greater patient satisfaction.

Nonsteroidal antiinflammatory drugs (NSAIDs) are generally used for mild to moderate pain. These drugs are categorized as nonopiate analgesics and include the salicylates and acetaminophen. NSAIDs act to inhibit the synthesis of prostaglandins and leukotrienes. NSAIDs do not alter ventilation or cause tolerance or physical dependence, unlike other analgesics. They appear to have a ceiling effect similar to that of the mixed agonist-antagonist opiates. In other words, the amount of analgesia produced has a limit. However, because of great patient variability in the dose needed for adequate pain relief, seeking the optimal plasma level for each patient through dose titration yields the best results. Oral preparations of the NSAIDs that specifically target the pediatric population are widely available. These preparations include oral elixirs that have been made more palatable for children. A parenteral NSAIDs preparation, ketorolac, is available. This agent has the benefit of being an excellent analgesic without the troublesome side effects that are associated with opioid analgesics (e.g., respiratory depression or urinary retention). Recommended dosages for some NSAIDs are listed in Table 34–3.

Adverse effects associated with NSAIDs include platelet dysfunction, liver toxicity, hyperkalemia, increased blood pressure, renal dysfunction (in high doses or susceptible patients), and gastric mucosal damage. Prolonged inhibition of prostaglandin synthesis may adversely affect renal blood flow; thus, prolonged courses of NSAIDs are not recommended. When administering NSAIDs, patients' renal function should be evaluated thoroughly.

ANXIOLYTIC AGENTS

Anxiety heightens the level of pain perceived by patients. Limiting this confounding factor is beneficial for patients, parents, and physicians. Midazolam (Versed) is a short-acting water-soluble agent that is extensively metabolized by the liver and excreted in the urine.[26] The time of onset of sedation after intramuscular administration is 15 minutes and after intravenous administration 3 to 5 minutes. Peak sedation occurs at 30 to 60 minutes for intramuscular and in 10 minutes for intravenous midazolam. This drug is useful because it reduces anxiety and in larger quantities is ideal for sedation during medical procedures or as premedication before surgery.[27] It is very short acting, and it renders patients amnestic and cooperative. Midazolam acts synergistically with opioids to produce respiratory depression; therefore, it should be carefully titrated to elicit the desired response. If intravenous access has been established, the drug can be given as a continuous infusion to control and limit variability of the drug in the plasma more precisely.[28] This also decreases recovery time.[29] Good muscle relaxation can be achieved with midazolam; this may be beneficial for many urologic procedures. The various routes through which midazolam can be administered demonstrate its flexibility. Lack of intravenous access does not preclude the use of this drug. Administration can be via the intravenous, intramuscular, oral, nasal, or rectal routes. Rectal administration should be reserved for those children under the cognitive age of 4 years. Parents along with children older than 4 years may attach various complex meanings to rectal administration of medications. This depends on a number of factors, including the child's age and his or her past experiences. Oral and nasal administration of midazolam can be problematic in that the drug is not very palatable and can irritate the nasal mucosa. A number of methods have been devised to camouflage the bitter taste of midazolam, such as mixing it with sweet-tasting syrup or juice.

Table 34–3 Nonsteroidal Antiinflammatory Drugs (NSAIDs) (Moderate Pain)

Medication	Dose	Route	Dosing Interval
Ibuprofen	6–10 mg/kg	Oral	q 6–8 hr
Naprosyn	5–7 mg/kg	Oral	q 8–12 hr
Tolmetin	5–7 mg/kg	Oral	q 6–8 hr
Acetaminophen	10–15 mg/kg	Oral	q 4–6 hr
Acetaminophen	15–20 mg/kg	Rectal	q 4–6 hr
Ketorolac	0.5 mg/kg	Intravenous	q 6–8 hr

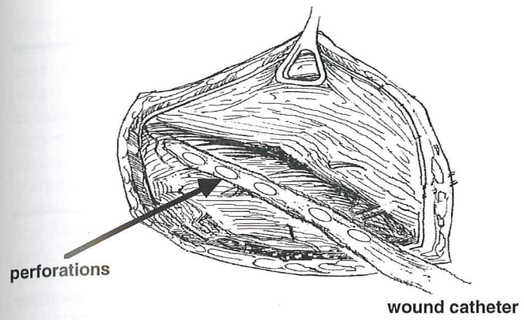


Figure 34–2
Indwelling wound catheter used to supply postoperative analgesia.

REGIONAL ANESTHESIA

Urologic patients lend themselves well to neuroaxial blocking techniques with local anesthetics for several reasons. The genitourinary area is highly innervated and thus quite susceptible to painful stimuli. Second, the approach to blocking nerves innervating this area is rather simple, and thus local nerve blocks and caudal epidural blocks are easily performed. Third, the use of regional anesthesia may have some prolonged benefit.[30] Long-term (>24 hours) postoperative analgesia can be achieved with the use of small indwelling catheters placed directly at the wound site or in the caudal or lumbar space (Figs. 34–2 and 34–3). When used alone or in conjunction with opioids, regional anesthesia can offer patients even more comfort. In addition, Berde and colleagues, in a retrospective study, demonstrated that in pediatric patients undergoing major urologic reconstructive surgery, epidural analgesia actually decreases the time to extubation, shortens intensive care stay, and hastens hospital discharge.[31]

Nerve cell membrane maintains an ionic gradient between the extracellular and intracellular fluids through selective permeability to different ions. The concentration of sodium is high in the extracellular fluid and low in the intracellular fluid, whereas with potassium, its extracellular concentration is low when compared with its intracellular fluid concentration. Local anesthetics block nerve impulse propagation by altering sodium channel function on the nerve cell membrane and interfering with sodium conductance through the sodium ion channels located in the nerve cell membrane.[32]

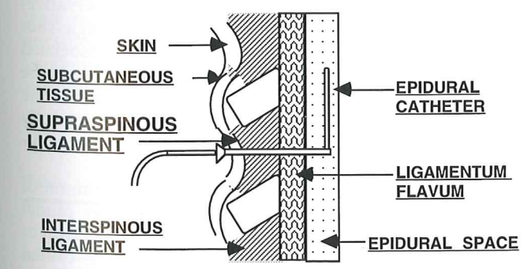


Figure 34–3
Epidural anatomy showing placement of an epidural catheter for postoperative analgesia.

According to their chemical composition, local anesthetics are classified as esters or amides (Table 34–4). Esters are rapidly degraded by plasma pseudocholinesterases. Liver metabolism of esters has only a minor role. The amount of esterase activity in the plasma varies with age, nutritional state, and clinical condition. The amount of esterase activity increases during the first year of life. Esterase activity, however, is reduced by significant hepatocellular disease.[33] The allergic potential of the esters is increased secondary to the formation of para-aminobenzoic acid (PABA) as one of the degradation products. PABA is allergenic in a small number of individuals. The amides undergo biotransformation, *N*-dealkylation and hydroxylation, by hepatic microsomal enzymes. Byproducts of amide metabolism are excreted in the urine. It is important to note that prilocaine degradation products can cause methemoglobinemia in younger children; therefore, its use in this population is limited. Rare reports describe allergic reactions directly attributable to the metabolism of amide agents.

Systemic absorption, tissue deposition, metabolism, and drug excretion are determined by a number of factors.[34] Abundant vascular supply and ample blood flow in the vicinity of deposition lead to greater systemic absorption, short duration of action, and an increased potential for toxic side effects. The order of potential toxicity by site is as follows: intercostal nerve block→ caudal→ epidural space→ brachial plexus→ femoral nerve and sciatic nerve sites → subcutaneous tissue. Addition of vasoconstrictors such as epinephrine to local anesthetics impedes vascular absorption. However, it is important to note that vasoconstricting agents should not be used where end arterioles supply blood, such as in the penis, lips, or fingertips.

Commercially available solutions of local anesthetics are in the form of salt solution. The addition of bicarbonate to solutions of local anesthetics to decrease pain on injection and the time to onset of anesthesia has gained popularity.[35, 36]

The lipid solubility of a local anesthetic directly correlates with its anesthetic potency. Plasma protein binding correlates with drug lipid solubility and limits the availability of active drug. However, membrane proteins binding a drug retard its diffusion away from the membrane and therefore lead to a prolonged duration of action. Albumin is one of the major proteins binding local anesthetics. It has a low affinity for local anesthetics but a high capacity to bind them. Orosomucoid (α_1-glycoprotein) appears to be another major plasma protein that binds local anesthetics. α_1-Glycoprotein has a high affinity but low capacity for local anesthetics. Competitive binding by other protein-bound drugs such as pentothal (phenobarbital), in addition to some biological degradation products like bilirubin, can displace local anesthetic molecules from their binding sites. This can result in toxic levels of local anesthetics in the blood. Neonates have a lower concentration of plasma proteins and thus may be subject to increases of available free drug.[37] In addition, the amount of myelination of the neural fibers could have a role in the duration of blockade.

Table 34–4 Types of Local Anesthetics

Drug	Type	Maximum Dose (No Epinephrine)	Maximum Dose (Epinephrine)	pKa
Chloroprocaine	Ester	7 mg/kg	—	8.7
Procaine	Ester	5 mg/kg	—	8.9
Lidocaine	Amide	5 mg/kg	7.0 mg/kg	7.9
Bupivacaine	Amide	2–2.5 mg/kg	2.5–3 mg/kg	8.1

The higher hepatic blood flow, greater cardiac output, and increased steady-state volume may offset the factors such as an increased terminal elimination half-life and lower plasma protein content that would predispose a child to a higher systemic concentration of agent.

The toxic side effects of local anesthetics mainly affect the cardiovascular system and the CNS.[34] The cardiovascular side effects of toxic levels of local anesthetics include hypotension due to vasodilatation, decreased myocardial contractility, decreased cardiac output, and conduction abnormalities. The CNS side effects are related to the potency of the drug. The greatest side effects occur with bupivacaine and tetracaine, the drugs that are the most potent. A progression from lightheadedness with minor auditory and visual disturbances to convulsions has been reported. The CNS side effects appear to be secondary to the progressive neural blockade of central neural impulse transmission. As with any other class of drugs, careful selection and administration limit the number of untoward events related to their use. Although adults and children differ in the manner in which they process local anesthetics, safe use of these agents for postoperative pain relief is not precluded. Berde has written an excellent review on local anesthetic toxicity in children.[38]

Administration of opioids either alone or in combination with local anesthetics via the caudal, epidural, or spinal route has resulted in striking postoperative analgesia for cardiac, abdominal, urologic, orthopedic, and maxillofacial surgery.[39–43] The close proximity of the opioid receptors in the spinal cord to the subarachnoid space and the epidural space allows for administration of much smaller doses of analgesic drug to achieve their effect. The rate of onset, distribution, and duration of analgesia are dependent on a number of factors, including the lipid solubility of the agent. The advantage of epidural or spinal opioids is that they can produce profound analgesia while preserving motor function, proprioception, and hemodynamic stability.[44] The disadvantages of epidural or intrathecal opioids are the same as in adults. Nausea, decreased gastrointestinal motility, vomiting, urinary retention, respiratory depression, and pruritus all occur. Respiratory depression with intrathecal morphine can occur within the first 6 hours, and depression of the ventilatory response to carbon dioxide can occur for as long as 22 hours after administration of 50 μg/kg of epidural morphine.[45] The major concern with opioids and respiratory depression can be minimized by administration of one of the highly lipophilic opioids, fentanyl and sufentanil, near the spinal cord level(s) through which the nociceptive afferent fibers representing the area of painful stimuli enter. In addition, with proper monitoring and strict prohibition of parenterally administered opioids, respiratory depression can be minimized.

Dosing schedules for epidural morphine vary considerably. Dalens and Chrysostome have used morphine doses of 25 to 50 μg/kg. However, they also recommend that all patients receiving epidural morphine have a continuous infusion of naloxone to prevent delayed respiratory depression.[45] Glenski and colleagues reported that the use of morphine in doses of 70 to 110 μg/kg resulted in excellent pain relief.[46]

Epidural fentanyl, 1.0 to 2.0 μg/kg, has a short onset time (<15 minutes) and lasts for 2 to 4 hours. Because of the short duration of action of these lipophilic agents, continuous infusions are recommended. Fentanyl, 1.0 to 2.0 μg/ml infused at 0.2 to 0.4 ml/kg/hr, provided excellent postoperative pain relief.[47] When used in combination with local anesthetics, effective postoperative analgesia can be attained.[48] A novel approach to epidural analgesia in children has been reported by Caudle and associates.[49] In their study, patients controlled their pain with a PCA pump attached to their epidural catheter. The epidural infusion in this study contained fentanyl only. Patients kept themselves comfortable by activating the PCA. None of their patients had respiratory depression.

The caudal approach to administration of local anesthetics and opioids is very practical. It requires very little training, time, or equipment. It is safe, effective, and reliable. Descriptions of the proper technique for performing this block can be found in several of the listed reviews.[50] The addition of opioids to a caudal block can significantly prolong a neuroaxial block. Krane and coworkers compared single-bolus doses of 100 μg/kg of preservative-free morphine with intravenous morphine and caudal bupivacaine and found patients to be enjoying analgesia for as long as 24 hours after the injection.[51] Current recommendations are that no more than 50 μg/kg of preservative-free morphine be administered as a bolus in a single-shot caudal, because doses greater than 50 μg/kg are associated with more opioid side effects. Also, dosing should be decreased by 50% in patients younger than 6 months. The blood-brain barrier in this group of patients is not fully mature, making these infants more susceptible to respiratory depressive effects of opioids.

Because patients should be observed for a minimum of 24 hours, it would not be prudent to administer caudal epidural opioids to patients who are not staying overnight in the hospital. Studies of outpatients receiving caudal analgesia with the more lipophilic agents, such as fentanyl, may eventually prove it to be safe and effective.

Much debate has occurred over the calculation of local dosages for caudal anesthesia. A very simple but useful method to calculate dosages has been proposed by Armitage (Table 34–5).[52] The spread of the local anesthetic when administered caudally is generally predictable and reliable. Timing of the administration of local anesthetic depends on the duration of the surgical procedure, the amount of time given to performing the block, and the purpose of the block. Rice and colleagues found that the duration of postoperative analgesia was similar whether the block was performed at the beginning or end of surgery.[53] However, performing the caudal block at the beginning of surgery, if time permits, reduces the need for other analgesics or anesthetics and leads to a shorter wake-up time. To extend the period of pain relief and to minimize the dose of either opioid or local anesthetic, a caudal catheter can easily be placed and a continuous infusion of analgesic drug begun. This has been shown to be very useful in patients undergoing major reconstructive urologic procedures such as correction of bladder exstrophy and ureteral reimplantation. Bosenberg and associates have demonstrated the passage of an 18-gauge catheter to the midthoracic area through the caudal epidural space without difficulty in several infants.[54]

A number of advantages of performing regional anesthesia alone or in conjunction with general anesthesia have been documented.[55–57] Benefits include a reduction in the hormonal stress response. The stress response is three to five times greater in neonates than in adults.[3] Other potentially advantageous reasons for performing regional blockade before surgery have now come to light. Bach and colleagues investigated the effects of administering epidural anesthesia on reducing phantom limb pain.[58] They compared two groups of patients who were to undergo amputative procedures: a control group that received no epidurally administered analgesic drugs and an experimental group that was kept pain free with epidural anesthesia. Both groups were hospitalized for 72 hours before surgery. The group treated with epidural blockade had a significant reduction in the frequency of both phantom limb pain and stump pain at 7 days, 6 months, and 1 year after surgery. These results suggest that regional anesthesia has a positive influence on the quantity and quality of postoperative pain. In still another study, Tverskoy and coworkers, in a double-blind randomized manner, compared three groups of patients undergoing inguinal herniorrhaphies: general anesthesia alone, general anesthesia with local infiltration, and spinal anesthesia alone.[59] Postoperative pain scores were significantly reduced in the groups receiving spinal anesthesia and in the group who had general anesthesia combined with local infiltration. Reduction in pain scores was noted up to 10 days after surgery.

Table 34–5 Local Anesthetic Volume

Level of Block	Dose of Local Anesthetic (ml/kg)
Sacral and lower lumbar	0.5
Lower thoracic	1.0
Midthoracic	1.25

Regional Anesthetic Techniques

Infiltration

The use of local anesthetics to infiltrate the skin can provide relief of pain from surgical incisions.[60] Usually performed at the end of surgery, this technique requires little skill or time to perform. Toxicity is not usually a problem if one adheres to the safe limits in the amount of drug infiltrated. Bupivacaine is generally used at our institution because of its long duration (Anderson CTM, Ehrlich R, Jones P: Unpublished data). We recommend using 1 ml/kg of 0.25% bupivacaine or 0.5 ml/kg of 0.5% bupivacaine. The amount of drug administered is based on 3.0 mg/kg of bupivacaine being the upper limit for dosing this drug. The addition of lidocaine, (2 to 3 mg/kg) to the bupivacaine can decrease the onset time of the block. A catheter with multiple exit sites, similar to that used for wound drainage, is placed between tissue layers, and local anesthetic is instilled on a continuous or bolus basis.

Epidural and Caudal Blocks

The epidural space is a potential space just beyond the ligamentum flavum. Insertion of a catheter into this space permits an excellent means through which neural blockade can be achieved. The catheter can be placed anywhere along the vertebral column and fed up or down to a desired level. The difficulties with this technique are having patients cooperate and not move if they are awake and locating the epidural space in a small child. Complications include subarachnoid puncture with possible postdural puncture headache, intravascular injection, and possible spinal cord injury. Use of continuous infusion or intermittent boluses of local anesthetics or opioids depends on the desired endpoint. Caudal or lumbar epidural opiates used include morphine (0.03 to 0.05 mg/kg every 10 to 24 hours), hydromorphone (0.005 mg/kg every 8 to 16 hours), and fentanyl (0.6 to 1 μg/kg every 4 to 6 hours). Fentanyl, with its higher lipid solubility, may be ideal for blocking segmental areas. Respiratory depression is always a consideration; thus, patients should have their respiratory status monitored. Blockade can be substantially prolonged when opioids and local anesthetics are used in combination.

Indications for caudal blockade include herniorrhaphies, urologic procedures, anal and rectal operations, and lower extremity orthopedic procedures. The anatomy of the sacral area is less variable than in adults; thus, the sacral hiatus is easy to identify. The patient is placed prone or in the knee-chest position, and the sacral area prepared with antiseptic solution. A small 22- or 24-gauge needle is inserted through the skin at a 90-degree angle to the skin and advanced until the sacrococcygeal membrane is pierced. The needle is then advanced only slightly and brought to an angle tangential to the skin and advanced 1 to 2 mm. Aspiration with a syringe confirms placement and prevents an intravascular, intraosseous, or cerebrospinal injection. A test dose of epinephrine-containing solution is administered to identify a possible intravascular injection. Personal preference dictates the type of needle

used for this procedure. Bupivacaine 0.25% is very effective, and higher concentrations offer no additional benefit.[61] The complications of caudal bupivacaine are similar to those of epidural administration, with the addition of urinary retention.

Ilioinguinal and Iliohypogastric Nerve Blocks

Ilioinguinal and iliohypogastric nerve blocks are useful in children who have had repair of their inguinal hernia, varicocele, and undescended testicle(s). This block is performed by inserting a 22-gauge needle 1 cm medial and 1 cm inferior to the anterior superior iliac spine above the inguinal ligament. The needle is advanced until loss of resistance is felt as the needle pierces the external oblique aponeurosis. The local anesthetic is deposited in a fan-shaped pattern. Bupivacaine, 0.25 mg/kg up to 2 mg/kg 0.5%, has been suggested.[62]

Penile Blocks

Topical application of local anesthetic, ring blocks, or a dorsal penile block provides postoperative analgesia for circumcisions or hypospadias repair. The dorsal penile nerves are blocked using an approach slightly off midline (10:30 and 1:30 positions), where the dorsal penile nerves lie bilaterally to the dorsal penile vein. A small-gauge, short, beveled needle is inserted perpendicular to the skin and advanced to the symphysis pubis. Then, while withdrawing the needle, the placement is tested by depressing the plunger of the syringe and noting when resistance is lost. This enables one to locate Buck's fascia, where the anesthetic solution is to be deposited. Care should be taken not to penetrate the corpora cavernosa just inferior and to avoid the dorsal penile vein. Doses for the anesthetic range from 1 to 5 ml of 0.25% bupivacaine, with a minimum of 1 ml, depending on the age and weight of the patient. Use of Emla (Astra Pharmaceuticals), a topical local anesthetic cream, placed on the penis provides adequate anesthesia for performing a circumcision.

Table 34–6 Methods of Pain Treatment for Patients Undergoing Urologic Procedures

Method	Advantage	Disadvantage	Procedure
Continuous intravenous	More stable plasma levels No peaks and valleys Appropriate for all ages Less labor intensive	Equipment costs Careful titration required No patient control possible	All except for very short procedures Major reconstruction Nephrectomy
Patient-controlled analgesia	Exquisite patient control Safe Enhances nursing time Good for episodic pain	Pump costs Requires patient cooperation Not useful below age 4 years	All procedures where age is not concern and hospital stay is sufficiently long
Opioid boluses	Good for episodic pain Less costly for short stays Can be used for all ages	Unstable plasma levels if dosing interval is not appropriate Expensive if hospital stay is long	All procedures
Peripheral nerve block (ilioinguinal; iliohypogastric; or dorsal penile n.)	Very effective Inexpensive Requires very little training Preemptive analgesia	Short duration Vascular injection Nerve damage	Circumcision repair Hypospadias repair
Caudal (one shot)	Very effective Inexpensive Requires very little training Preemptive analgesia Lowers anesthetic requirement if done at beginning of surgery	Vascular injection Intraosseous injection Nerve damage Epidural hematoma Bowel or bladder perforation Dural puncture Postdural puncture headache	Good for any procedure below the clavicle Cystoscopy Inguinal hernia Circumcision Hypospadias repair
Epidural (caudal or lumbar)	Constant level of analgesia Safe Enhances nursing time Muscle relaxation with concentrated local anesthetics, or patients can ambulate with dilute epidural solutions	Lumbar approach is technically difficult in children Nerve damage Epidural hematoma Bowel or bladder perforation Dural puncture Postdural puncture headache Vascular injection	Good for any procedure below the clavicle Revascularization Major hypospadias nephrectomy/ureteral vaginoplasty Urethroplasty
Wound infiltration	Constant level of analgesia Safe Enhances nursing time Technically easy Requires very little training Requires no special equipment Very localized effects Fewer attachments, i.e., pumps/poles	Visceral pain is not treated Higher local anesthetic absorption	Procedure where pain is mostly somatic
Topical (EMLA)	Safe Effective Technically easy Requires no special equipment Very localized effects	Vasoconstriction at site Methemoglobinemia in high doses Limited availability in some hospitals	Circumcision* Skin grafting

*As recommended by the manufacturer.

SUMMARY

Urogenital surgery in pediatric patients is associated with considerable pain in the postoperative period. No patient should be denied safe and effective postoperative analgesia. Historically, pain in ill and injured pediatric patients has not been recognized or attended to, because caregivers have often been apprehensive about aggressively intervening to alleviate their pain. Proper treatment of pain in children may be undermined by ineffective use of assessment tools to evaluate pediatric pain, inadequate recognition of pain-vulnerable children, poor understanding of the pharmacology of drugs available to treat pain, and a reluctance to administer more than homeopathic amounts of the proper medication. Fortunately, because of investigations and new techniques in the arena of pediatric pain management, the postoperative comfort of children undergoing surgery has improved significantly. Hospital practice continues to rely on clinical judgment to select the most effective strategies for helping children cope with painful procedures. Until more research addresses this subject, we suggest that individualized intervention begin by carefully assessing children's coping skills and preferences through interviews with both children and their parents. Children can be asked what they have found to be most effective (as well as ineffective) for coping with previous procedures, in addition to what they believe would be helpful for the upcoming procedure. Interventions most consistent with these methods can be selected. However, continual assessment of the effectiveness of these strategies (from the child's perspective, as well as observation) is needed to modify any strategies that appear ineffective or counterproductive to children's own efforts at coping. Various techniques allow a physician to individualize the analgesic therapy based on the nature of the surgery, the patient's underlying medical condition and expectations, and the anesthesiologist's training and experience. Postoperative pain management techniques include opioids, local anesthetics, mechanical devices, antiinflammatory agents, and psychologic interventions. The availability of trained pain management staff members 24 hours a day enables selected patients to receive safe and effective analgesia by means of PCA or epidural catheters. Several regional anesthesia techniques have been proved to be safe and effective for pediatric patients. Both opioid and nonopioid agents may be used as alternatives or supplements to regional anesthesia techniques. The adoption of new technologies such as PCA devices and epidural catheters for continuous regional anesthesia should quickly find their way into the armamentarium of compassionate clinicians. The pain management technique used depends on the site of the surgery, the expected duration of hospitalization, the clinical status of the child, and the technical skill of the available staff. The ultimate goal is to maximize children's well-being and minimize their emotional and physical trauma. A list of various pain management strategies, with their advantages and disadvantages, is found in Table 34–6.

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CHAPTER

35

Suture Material

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The use of suture material in reconstructive surgery permits approximation of tissues while wound healing occurs. The suture used ideally should be as strong as the tissue being approximated, should lose strength and reabsorb in association with wound healing, and should not elicit a tissue inflammatory response. Moreover, it is important that the suture be easy to handle, pass through tissues without causing trauma, and retain a knot without slipping. This chapter reviews the basic concepts of wound healing and describes and compares suture materials commonly used in reconstructive surgery.

WOUND HEALING

Definitions

Stress is defined as the load per unit area and represents the force that opposes tissue approximation. Materials initially respond to stress with a strain, which is deformation per unit length. The initial strain is elastic; the material resumes its initial shape when the stress is removed. As the stress increases, the material generally undergoes permanent deformation, an inability to regain its initial form after the stress is removed. Strength (expressed in newtons per square meter or pounds per square inch) is the stress required for failure. *Tensile strength* is the term most often used in describing wound healing and is defined as the amount of tension a suture or wound can withstand before it breaks or separates. Wound healing is classically described in three phases—the lag phase, the healing phase, and the maturation phase. The loss of suture tensile strength should correlate with the gain in the tensile strength of the wound.[1–3]

The lag phase occurs during the first week after injury and is characterized by an inflammatory response. Immediately after injury, capillaries leak fluid and vasoactive substance such as histamines, kinins, and prostaglandins enter the wound. Neutrophils subsequently accumulate during the next several hours and remain in high concentrations for several days. During the latter half of the lag phase, macrophages migrate into the wound, and these cells promote the clearance of wound debris and release substances that attract fibroblasts, endothelial cells, and other macrophages. During the lag phase, the wound tensile strength is minimal, and wound approximation depends on continued strength of the suture material.

The healing phase of wound healing occurs during the second week and is characterized by fibroblast activation. Collagen is rapidly produced by the fibroblasts, and the wound gains significant tensile strength as intramolecular and intermolecular cross-linking of collagen occurs.

The maturation phase begins after the second week and continues for 4 to 12 months. The rate of maturation decreases in patients with poor nutritional status, infection, and immunodeficiency. Remodeling occurs as the continued cross-linking of collagen causes a further increase in tensile strength. After the maturation phase, the final strength of the wound is tissue dependent but is generally approximately 80% that of unwounded tissue.

Fascia and skin, tissues that are high in collagen and among the strongest tissues in the body, slowly regain their tensile strength. Fascia regains only 40% of its strength at 2 months. In contrast, the bladder and bowel are among the weakest organs of the body. However, they regain almost all of their strength in 2 to 3 weeks. It has been shown that after cystotomy and closure, reepithelialization of the bladder was complete in less than 1 week. These differences indicate that the selection of the proper suture material must be tissue specific and based on wound-healing principles.

SUTURE—GENERAL PROPERTIES

Sutures commonly used in reconstructive urology are listed in Table 35–1. The two basic categories are absorbable and nonabsorbable. The United States Pharmacopeia defines an absorbable suture as a strand derived from healthy mammals or a synthetic polymer. It is capable of being absorbed but may be treated to modify its resistance to absorption.[4] It is unfortunate that some sources define absorbable sutures as those that undergo rapid degradation and lose tensile strength within 60 days, whereas sutures that main-

Table 35–1
Sutures Commonly Used in Reconstructive Urology

Suture Material	Trade Name	Manufacturer	Filament
Absorbable			
Plain surgical gut	Pain gut	Ethicon	Natural fiber
Chromic surgical gut	Chromic gut	Davis & Geck	
Coated polyglactin 910	Vicryl	Ethicon	Synthetic braided
Uncoated polyglycolic acid	Dexon "S"	Davis & Geck	Synthetic braided
Coated polyglycolic acid	Dexon Plus	Davis & Geck	Synthetic braided
Polydioxanone	PDS	Ethicon	Synthetic monofilament
Polyglyconate	Maxon	Davis & Geck	Synthetic monofilament
Poliglecaprone 25	Monocryl	Ethicon	Synthetic monofilament
Nonabsorbable			
Twisted silk	Virgin silk	Ethicon and Davis & Geck	Natural fiber
Monofilament nylon	Ethilon	Ethicon	Synthetic monofilament
	Dermalon	Davis & Geck	
Uncoated polyester	Mersilene	Ethicon	Synthetic braided
	Dacron	Davis & Geck	
Silicone-coated polyester	Ti-Cron	Davis & Geck	Synthetic braided
Polypropylene	Prolene	Ethicon	Synthetic monofilament
	Surgilene	Davis & Geck	

tain their strength for more than 60 days are defined as nonabsorbable. The term *absorbable* should refer to suture materials that are attacked and broken down and eventually taken in by the body. Absorbability and rate of loss of tensile strength are separate and distinct properties of suture material.

The tensile strength of suture changes and generally decreases with time after exposure to tissues. Although absorption and loss of tensile strength often occur simultaneously, there are exceptions. For example, silk is a nonabsorbable suture that eventually loses its tensile strength despite its continued presence in tissues. Inflammatory changes occur in tissues exposed to suture material, because all suture represents a foreign body. Sutures also differ in their ability to elicit a tissue reaction. Another property of suture is resistance to slippage of the knot. The security of a knot is dependent on the type of knot, the suture diameter, the length of the cut ears, and the memory, moisture, and coefficient of friction of the material.[5, 6] Knot integrity can be significantly affected by exposure to tissue, and the presence of a knot generally adversely affects the tensile strength of the suture.

SUTURE COMPARISONS

It is not always clear which suture is the best choice among the many options. It is generally accepted that nonabsorbable suture should be excluded from contact with urine because of the potential for stone formation. Further supporting the use of absorbable sutures in urologic surgery is the fact that genitourinary tissues generally regain their tensile strength rapidly, and the prolonged presence of suture is not needed.

The choices of suture during genital reconstructive surgery are therefore limited to absorbable suture, and the most commonly used materials are catgut, synthetic braided suture such as polyglycolic acid (PGA), or a synthetic monofilament suture such as polydioxanone (PDS) or poliglecaprone-25 (Monocryl). Catgut is absorbed through enzymatic degradation, whereas the synthetic sutures are degraded by acid hydrolysis.[7, 8]

In vitro studies by El-Mahrouky and coworkers compared absorbable sutures and demonstrated that PDS and PGA have approximately twice the breaking strength of catgut before exposure to tissues. After exposure to plasma for a 10-day period, catgut actually gained strength, PDS lost very little strength, and PGA lost half its strength. With exposure to sterile urine, PDS retained most of its strength for 3 days and then rapidly lost its strength. In contrast, PGA demonstrated a more modest loss of strength during the first week. Catgut did not lose significant strength in 10 days. The results were similar when these three sutures were exposed to *Escherichia coli*–infected urine, and catgut again retained most of its strength during 1 week. The contrast between catgut and the two synthetic sutures was even more dramatic when the three sutures were exposed to *Proteus*-infected urine. Catgut retained its strength for 10 days, whereas PDS and PGA lost almost all strength within 2 days.[9] Other investigators have had similar in vitro experimental results.[10, 11] The foregoing findings suggest that the semisynthetic sutures are initially stronger than catgut but may not be an appropriate choice for reconstructive procedures if the suture will be exposed to urine (especially infected urine) and if the suture strength is needed for more than several days. Therefore, urinary diversion remains critical if some semisynthetics are used.

In vivo studies involving the bladder of laboratory animals without infected urine failed to reveal marked differences between the three previously named sutures with regard to a chronic inflammatory response and indicated that the synthetic sutures remained detectable in the bladder to a greater extent than catgut at 6 months.[12–15]

The foregoing in vitro and in vivo comparisons measure specific qualities of suture. Many other factors influence the choice of suture, however, including handling properties, the trauma caused during suture placement, color for ease of identification, and cost. Ultimately, the choice of suture remains a personal preference.

SPECIAL CONSIDERATIONS IN RECONSTRUCTIVE SURGERY

In any surgery, but especially reconstructive genital surgery, it is critical to match the suture choice to the need of the wound. There are many questions to ask each time a suture is chosen. What is the length of time for which maximum tensile strength is needed? What is the minimum suture size that can be used? What is the reliability of the suture when it is exposed to urine? What needle (cutting or taper, size, degree of curvature) is used with the suture? If a subcuticular closure is performed, is the suture clear? If operating in a deep internal space where visualization is compromised, is the suture dyed or clear?

In general, we pick the smallest suture to hold the tissues on the smallest and most gentle needle available to accomplish the purpose. At times, a cutting needle is the most gentle. Our personal preference for urethral and penile reconstruction is usually fine monofilament suture (PDS or Monocryl) because it passes through the tissue very gently with a low drag coefficient. It is critical not to damage a monofilament suture with forceps or a needle holder, especially if it is a running suture. Monofilament sutures are easily weakened by such maneuvers. Monocryl appears to be more pliable than PDS and does not remain in tissues as long as other monofilament sutures before degradation. When using monofilament sutures for urethral reconstruction, urinary diversion is often needed to prevent the potential adverse effects of urine on suture integrity.

Wound approximation in genitourinary reconstruction can now be achieved with laser tissue welding using a protein solder.[16] A thermal control system is likely to improve results.[17] Other investigators have demonstrated that the polyglucosamine chitosan may decrease fibrosis when applied to healing genitourinary tissues.[18] As basic science and clinical experiments continue to reveal the molecular mechanisms of wound healing and new ways to approximate tissues, progress will be made toward achieving the goal of tissue reapproximation with minimal invasiveness and without the complications of urine extravasation, wound breakdown, fistula, and scarring with associated stricture formation.

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CHAPTER

36

Instrumentation for Hypospadias Repair

JOHN F. REDMAN

Although hypospadias repairs are occasionally performed in adolescents and adults, the majority are accomplished in children.[1] The ideal age of repair is from 6 to 12 months.[2] Obviously, the penis of a child younger than 1 year is small, and a child with hypospadias may have a phallus that is abnormally diminutive. In addition to a temperament for tedious fine plastic surgery, surgeons who perform hypospadias repairs must have magnification and miniaturized instrumentation. Just as the best golf clubs do not make a professional of a duffer, neither does specialized equipment ensure good operative results. Better and specialized instruments, however, can greatly enhance a surgeon's ability.

In an attempt to be inclusive, this discussion includes the following general categories: visualization, position, hemostasis, retraction, artificial erection, and surgical instrumentation. When appropriate, my preferences are emphasized. Suture material, splints, and dressings are addressed in other chapters. A discussion of techniques is not intentionally included, but in some instances, instrumentation and technique meld.

VISUALIZATION

Although some surgeons may continue to eschew magnification, most who perform large numbers of repairs advocate some degree of magnification. Magnification may range from optical visors to the operating microscope.[3] I routinely use 3.5× wide-field loupes. To facilitate the use of magnification, bright spot illumination of the operative field is needed and may need to be augmented by the use of a headlamp if an assistant's hands and head intermittently obscure the light.

POSITION

Hypospadias repairs, which require a formal urethral construction particularly coupled with orthoplasty, may necessitate that the surgeon stand or sit in a limited space with the head, neck, and shoulders leaning forward for protracted periods. Operative times are seldom less than 1 hour.[4] Fatigue is reduced if the patient is moved close to the edge of the operative table on the surgeon's side rather than placed in the traditional middle-of-table position. A modern electric operating table, which can be instantly raised, lowered, or canted by the anesthesiologist or circulating nurse at the surgeon's command, reduces the fatigue that results from craning the neck and leaning the body over for a long time.

HEMOSTASIS

Bleeding that occurs in the course of hypospadias repair is from individual vessels encountered in dissection of the skin, dartos tunic, and Buck's fascia and from sinuses when incising the glans, corpus spongiosum, or corpora cavernosa. The vessels that are cut while dissecting the skin and penile tunics are small and numerous and are best dealt with individually to prevent staining of the field. The small vessels require spot coagulation, which may be obtained with either a battery-powered ophthalmic cautery or a narrow electrocautery tip. I prefer a standard flat-bladed cautery tip that I modify by filing so that it retains the blade characteristics as opposed to a needle tip (Fig. 36–1). The width of the modified blade is 1 mm. My cautery setting for coagulation is 5 watts. For the low cautery setting, it is imperative that the vessel be compressed so that no bleeding occurs during the act of coagulation. This compression is best done with a cotton-tipped applicator or a Weck-cel spear. I have seldom needed to ligate vessels in children.

Sinusoid bleeding that occurs in the course of incision of the glans or corpora may be controlled with the injection of epinephrine (usually in solution with lidocaine). I personally have not been pleased with the adequacy of hemostasis obtained in this manner and have long used a rubber band tourniquet placed proximal to the site of anticipated bleeding.[5] I use two sizes of tourniquets, a 0.1 × 1.3 cm rubber band and a 0.1 × 0.6 cm band. The wide band is used generally for surgery of the glans and distal penis when an ample proximal space exists for placement of the tourniquet. I place the tourniquet after injecting the corpora cavernosa with saline, which is facili-

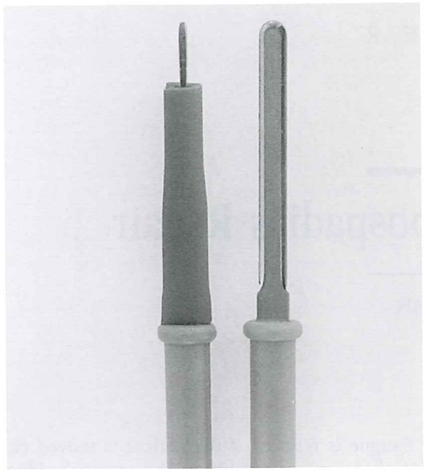


Figure 36–1
Detail of flat-blade cautery tip (right) and modification (left). The tip now measures 1 mm in width.

tated by compression of the corpora against the pubis at the base of the penis. The glans is stretched cranially with traction on the glanular traction suture, and the tourniquet is snugged against the corpora with a hemostat. No bolster is used to cushion the tourniquet. The tourniquet remains in place until the glanular and distal corpora spongiosum closure is accomplished. There is no need to release the tourniquet intermittently. The use of a wide tourniquet distributes the pressure, and a minimal compression defect in the penile tissue is noted on its release.

A narrow tourniquet is used in the excision of Nesbit ellipses or when a wide tourniquet would cover the operative site. In this case, the penis is placed on traction caudally and the tourniquet is snugged on the dorsal aspect of the penis. Hemostasis is absolute with the use of either type of tourniquet.

ARTIFICIAL ERECTION

My preference for producing an artificial erection, after the technique of Gittes, is to use a number 23 butterfly needle that has been bent into a 60-degree angle with the bevel up in relation to the angle.[6] The tubing is 15 cm in length, and only one corpus need be penetrated. The corpora are compressed at their bases against the pubis.

RETRACTION AND TRACTION

Stabilization of tissue and wound edges is a necessity in penile reconstructive surgery. An initial stabilizing maneuver is obtained with traction on the glans penis. Some surgeons use a fine towel clip, which I believe is too cumbersome and risks glans scarring. A more utilitarian method is to place a traction suture in the glans using a round needle and fine suture (5-0). I prefer to place a suture in a transverse manner in the distal aspect of the dorsum of the glans. If the urethral plate is not to be disturbed, some surgeons prefer a vertical placement of the traction suture. There have been concerns that undue scarring results from such a suture, but I have not noted scarring after the use of a small atraumatic needle and suture.

Retraction and stabilization of skin edges may be provided by skin hooks or stay sutures. I prefer 0.5-mm or 0.3-mm Castroveijo forceps. Generally, when possible, only the dermis is grasped, avoiding any crushing or penetration of the skin.

Retraction of the halves of the incised glans is necessary if the urethral plate is to be elevated. This retraction is facilitated by an Agrikola retractor, a small ophthalmic toothed spring retractor, with a thumbscrew to maintain the retraction (Fig. 36–2).

Although not precisely a retractor, a 4 × 8 surgical sponge is used for retraction in two ways. When unfolded so that it is of a single-ply thickness, it is most useful for elevation of the neurovascular bundle from the corpora. Once Buck's fascia has been incised along the neurovascular bundle, the fascia and bundle are grasped in the sponge between the thumb and finger and rolled so that the interface between the bundle and corpora is easily seen. The sponge is also used to compress the dorsum of the glans on either side with thumb and finger to evert the urethral plate when incising the ventral aspect of the glans.

SURGICAL INSTRUMENTS

In addition to the previously described retractors, the four primary groups of instruments used in hypospadias surgery are tissue forceps, scissors, needle holders, and knives. Various instruments designed for ophthalmic surgery, plastic surgery, and microsurgery are available. Many have been used for hypospadias surgery at times but may not be familiar to all hypospadias surgeons.

Table 36–1 is a categorized compilation of various instruments that have been used by a cross section of pediatric urologists known for their interest in hypospadias surgery. In this "tool chest," interested surgeons may well find just the instrument that they have been needing.

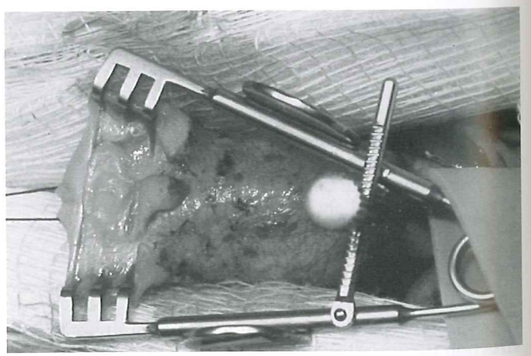


Figure 36–2
Agrikola retractor shown retracting the edges of incised glans penis in a child undergoing a hypospadias repair.

Table 36–1
Instruments for Hypospadias Surgery

- Forceps
  - Adson (smooth and toothed)
  - Bishop-Harman (smooth and toothed)
  - Bonaccolto jeweler's
  - Castroveijo (0.3- and 0.5 mm teeth)
  - Lister conjunctival
  - Micro-Pierce
- Tissue scissors
  - Jamison
  - McPherson-Vannas microiris (curved and straight)
  - Shea
  - Stevens
  - Sullivan (curved)
  - Tenotomy (short and long)
  - Westcott
- Needle holder
  - Castroveijo
  - Crile-Wood
  - Webster
- Knives
  - 15 blade
  - 0064 Beaver blade
  - 0067 Beaver blade

Tissue Forceps

Various fine tissue forceps have been advocated for hypospadias repair. Bonaccolto jeweler's and micro-Pierce forceps have been used for the gentle handling of tissue required in urethroplasty, and Lister conjunctival forceps have been used for picking up skin and subcutaneous tissue.[7] Bishop-Harman forceps have been favored by many surgeons. I have found the Castroveijo 0.3 and 0.5 mm to be the most versatile forceps.[8] The teeth are delicate for atraumatic tissue handling. The length of all the forceps is the same, with the only variation being the size of the tips and the teeth; thus, the feel of the forceps is always the same, and no change in handling is necessary.

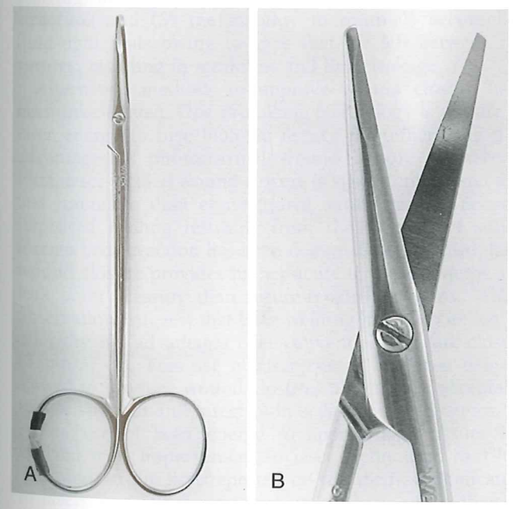


Figure 36–3
A: Shea scissors. *B*: Detail of tips of scissors showing the sharp angle at the tip of the medial cutting edge.

Scissors

Scissors that have been preferred by others include the Castroveijo microcorneal; McPherson-Vannas microiris; and Westcott, Jamison, Stevens, and curved Sullivan scissors.[7] I have primarily used two types of scissors: Shea and tenotomy scissors. Although many surgeons favor sharp-pointed scissors, I have found the Shea scissors to be most utilitarian (Fig. 36–3*A*). The handling characteristics are similar to those of the familiar Metzenbaum scissors, and the blunt tips are atraumatic. The blunt tips facilitate blunt dissection without changing instruments. The medial cutting edge at the tip is sharply angled and can be used to engage even the most delicate tissue plane in the initiation of a dissection (Fig. 36–3*B*). I use tenotomy scissors primarily in undermining skin edges in preparation for fistula closure or for excision of small tissue tags.

Needle Holders

Delicate needle holders that have been used in hypospadias repair include the McPherson microsurgery eye needle holder and the Castroveijo needle holder. I likewise prefer the Castroveijo but have especially used a narrow-tipped driver with diamond dust, which firmly grasps the needle. I also disengage the box-lock mechanism so that the needle is never locked. The surgical technician loads the needle, then inserts the handle of the instrument into an empty foil suture package until time for use so that no time is wasted in loading the needle. For skin closure or for closure of the defects of Nesbitt ellipses, I use a 6-inch Crile-Wood needle holder, which has a narrow tip and diamond jaws.

Knives

Two primary knife systems are used: a standard scalpel handle with a number 15 blade and the knurled Beaver handle with a 0067 or 0064 blade. I prefer the number 15 blade and the 0067 Beaver blade.

CALIBRATION

For calibration of the urethra, bougie à boules and lacrimal probes are invaluable.[8]

Doubtless, instruments designed specifically for pediatric penile reconstructive surgery will emerge in time. Surgeons are encouraged to use the innovative instruments employed by plastic, pediatric, and microsurgeons as well as ophthalmologists, otolaryngologists, and urologists.

Acknowledgments

I wish to acknowledge the pediatric urologists who kindly provided me with a listing of their instrument preferences for hypospadias surgery: Julia Spencer Barthold, M.D.; A. Barry Belman, M.D.; Kenneth I. Glassberg, M.D.; Edmond T. Gonzales, Jr., M.D.; Terry W. Hensle, M.D.; George W. Kaplan, M.D.; Stephen R. Shapiro, M.D.; and Jeffrey J. Wacksman, M.D.

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CHAPTER

37

Laser Tissue Welding: Applications in Genitourinary Reconstructive Surgery

DIX PHILLIP POPPAS

A promising application for the use of laser energy in genitourinary surgery is its use in tissue reapproximation or tissue welding. Although lasers have been primarily used in urology for their ablative properties, increasing evidence suggests their usefulness for wound closure during surgical reconstruction. Current methods for surgical wound closure include the approximation of tissue segments with sutures, clips, or staples. Although these techniques for the most part are successful, a number of limitations are inherent in their use. These include (1) the manual dexterity and visual acuity of the surgeon, which affect the reproducibility and length of time to acquire satisfactory skill; (2) the host's response to foreign materials (sutures or clips), which can lead to impaired healing, infection, lithogenic formation, erosion, ischemia, and scarring, ultimately affecting the function of the repaired structure; and (3) the inability to routinely accomplish fluid-tight seals owing to gaps that are left between the sutures, resulting in weakness and fluid leakage.

Alternative methods to improve wound closure have been investigated. One promising technology is the use of laser energy to fuse biologic tissues photothermally. The advantages of photothermal wound closure are several. First, laser-welded wound closure is significantly faster and less traumatic than conventional suture repair.[1] Second, improved healing resulting from the absence of suture foreign body reaction has been documented.[2, 3] Third, laser wound closure provides higher acute tensile strengths and leak point pressure than suture-repaired wounds.[4] These observations suggest that laser welding has the potential to offer distinct advantages over conventional suture closure (Table 37–1). This use of laser energy has been demonstrated to produce wound closures of clinically acceptable tensile strength and integrity in several model systems.[4–6]

The use of laser energy to approximate tissues has evolved with improvement in laser technology. In 1966, Yahr and Strully first reported on the medical application of lasers for the reapproximation of tissue when they attempted a side-to-side vascular anastomosis without stopping blood flow.[7] After these initial efforts failed, 13 years passed before Jain and Gorisch described the first successful laser seal of 0.3- to 1.0-mm openings in blood vessels using a neodymium:yttrium-aluminum-garnet (Nd:YAG) laser.[8, 9] Subsequent studies using low-power laser energy of several different wavelengths have confirmed the efficacy of laser welding to anastomose small vessels and maintain patency.[10, 11] Early applications of laser welding included its use to repair peripheral nerves with a carbon dioxide (CO_2) laser by welding the epineurium together,[12–14] as well as tissue welding of bowel anastomoses.[15–17]

Although few long-term prospective studies have compared laser tissue welding versus conventional suture controls, these early experiments provided a basis from which to explore the possibilities and advantages of this novel application in urologic surgery.

BIOPHYSICAL PRINCIPLES OF TISSUE WELDING

To date, the mechanisms responsible for laser welding have not been fully elucidated. Existing evidence suggests that the laser light produces thermal remodeling of the intrinsic constituents of the tissues including collagen and other matrix proteins.[18] These thermal effects are dependent on the action of the laser light as it enters the tissue. When

Table 37–1
Laser Tissue Welding

Advantages
Immediate watertight seal
Rapid technique
Relatively atraumatic
Nonlithogenic
Improved healing compared with suturing
Disadvantages
Cost of laser purchase
Training time
Subjective endpoint of laser weld

laser energy interacts with biologic tissues, it is either reflected, transmitted, scattered, or absorbed. Characteristics of the incident laser light as well as the tissue composition affect the extent to which these phenomena occur. Important characteristics of the laser light include its wavelength (which is primarily a function of the medium through which the laser light is generated), the power or watt setting of the laser, the area over which the energy is delivered (the spot size), and the pulse or radiation time used. Relevant tissue characteristics include the tissue water content and the presence of tissue pigments such as melanin in the skin or hemoglobin in the blood. These biologic pigments have absorption curves that affect the absorptive characteristics of laser energy. The laser weld is hypothesized to be primarily a temperature-dependent phenomenon. The tissue is heated as a result of absorption of laser energy by tissue pigments or water. This conversion of light energy to heat energy produces macromolecular structural alterations, which are postulated to be the basis of the tissue weld. Changes primarily occurring in the extracellular matrix proteins such as collagen and fibrinogen are thought to precede alterations in electrostatic and covalent bonding between the structural proteins, which may ultimately be responsible for the formation of a weld.[2] As the tissue is heated to between 60°C and 70°C, protein denaturation occurs, disrupting the secondary and tertiary structures of the collagen fibrils and matrix proteins and resulting in altered cross-linking and the formation of a biologic glue (Figs. 37–1 and 37–2).[19, 20] Noncovalent bonding between denatured collagen strands across the wound defect are thought to cause the coaptation responsible for a successful weld.[21]

Several surgical and technical factors have been demonstrated to significantly affect the success of laser tissue welding. First, it is imperative to maintain close tissue approximation such that the laser energy is evenly distributed along both edges of the weld. Second, the wound defect must be closely approximated and aligned without tension, and ultimately, the characteristics of the incident laser light should closely match those of the tissue so that energy transfer and laser tissue interaction are optimized

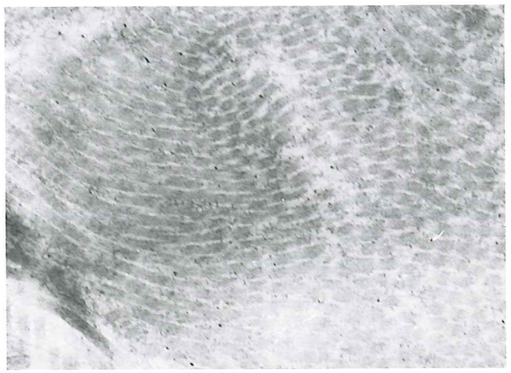


Figure 37-1
Normal collagen fibers in cross section using transmission electron microscopy (× 57,000). Note the round, well-organized pattern.

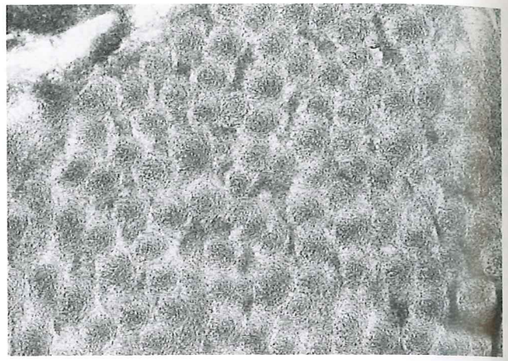


Figure 37-2
Collagen fibers in cross section after laser application with transmission electron microscopy (× 57,000). Note the merging fibers and the disorganized appearance, suggesting fiber coalescence.

while minimizing peripheral tissue destruction. In this regard, several technical advances including the development of tissue solders, the use of light-absorbing dyes (chromophores), and the applicáion of temperature control have improved these variables, thereby facilitating the reliability and reproducibility of laser tissue welding.

TISSUE SOLDERS

The first tissue solder to be used during laser wound closure was introduced in 1986.[22] This solder was composed of albumin and was found to significantly increase the strength and reliability of laser-welded tissue repairs. When the albumin solder was used for the repair of urethral defects, significant improvement in wound healing, reduced fistula rate, and decreased operative time were demonstrated.[22] The protein solder was believed to act as a bonding agent and heat sink, thereby improving weld strength and reducing peripheral thermal tissue damage. It was theorized that the protein solder underwent thermal remodeling via denaturation and became incorporated into the weld site, thereby augmenting welded tissue strength.[23]

Wang and colleagues have hypothesized that laser energy stimulates fibrin polymerization and that this may have a role in improving results of tissue welding.[24] This report led Grubbs and associates to use a heterologous fibrin glue as an adjuvant to laser welding, with improved results during microvascular surgery.[25] Additional protein substances have been evaluated for use as solders, including fibrinogen, fibrin glue, and collagen (my personal observation), with varying results.[10, 25, 26] My laboratory has continued to pursue the development of human albumin protein solder (HAPS) as an adjuvant to improve the laser weld.[26] I have successfully applied HAPS in experimental urethral reconstruction using rat, rabbit, and canine models. I found that repairs using HAPS were routinely superior to laser welding alone or to conventional suture closure.[22, 27, 28] Other groups have also begun to use HAPS as their choice of solder during laser welding.[3] The growing

interest in the use of HAPS as a solder during laser tissue welding is based on several observations. First, it can be prepared inexpensively as a single large-volume stock solution and stored in small aliquots to be used for many procedures. Second, the solder can be stored without refrigeration for as long as 3 years. Third, the risk of bacterial contamination and transmission of the hepatitis virus or human immunodeficiency virus (HIV) has virtually been eliminated using techniques to prepare the commercially available, Food and Drug Administration (FDA)–approved human albumin used for improving intravascular volume.[29–32]

During the past 5 years, additional improvements have been made in HAPS. These include the optimization of solder concentration, the addition of light-absorbing dyes, and the incorporation of biologically active substances such as human recombinant growth factors, thrombin, and heparin (my unpublished data).

Investigations have now demonstrated that changes in protein solder concentration affect the outcome of a laser weld. Wright and Poppas' initial study illustrating this effect compared a diverse group of solder concentrations using HAPS for the repair of ureteral defects. This study demonstrated that a 50% HAPS solution significantly improved the acute weld strength when compared with lower concentrations.[33] Massicotte and coworkers have shown that acute wound closures using 50% HAPS are significantly stronger than those produced by lower concentrations using a full-thickness porcine skin model.[34] Based on these results, a method to prepare 50% HAPS was developed to help improve overall reliability and confidence in the solder to be used in the clinical setting.[35]

It is important to emphasize that human albumin is *not* currently approved by the FDA for the specific indication as a laser tissue solder. Many steps including regulatory approval, clinical trials, and subsequently good manufacturing practices are required before any solder can be marketed for human use.

CHROMOPHORE ENHANCEMENT

The concept of chromophore-enhanced laser tissue welding was initially applied by Oz and colleagues.[36] This involves the addition of a dye (chromophore) that selectively absorbs light at a given wavelength, thereby increasing the absorption of light by the chromophore and in turn lowering the power requirement for a weld and reducing the amount of peripheral thermal injury.[37, 38] Several wavelength chromophore combinations have been studied. For example, indocyanine green (ICG) has a peak absorption at 805 nm that is well matched to a semiconductor diode laser emitting light at 808 nm. Therefore, ICG mixed with a tissue solder enhances absorption of the semiconductor diode laser by the solder. This combination has been successfully used for the repair of rabbit aorta with excellent long-term healing.[38] Other chromophore-laser combinations include the argon and the potassium titanyl phosphate (KTP) 532-nm lasers with fluorescein isothiocyanate (FITC) and the Nd:YAG laser with india ink dye. My laboratory has demonstrated improved success in ureteroureterostomy and hypospadias repair using the KTP-532 laser and HAPS enhanced with fluorescein dye when compared with wounds closed using the laser alone.[39]

Evidence suggests that chromophore-enhanced solder repairs produce a cast type of closure over the approximated wound edges as opposed to a true welding of the tissue edges. This cast forms because the photons of laser light are completely absorbed by the chromophore in the solder. Thus, photon thermal conversion occurs in the solder, allowing only the solder to denature thermally and not the tissue underneath. Although this may limit the degree of thermal injury to the tissue, it also decreases the tensile strength of skin wound repair when compared with wounds closed using solders not containing exogenous dyes.[40]

TEMPERATURE-CONTROLLED WELDING

Widespread use of laser tissue welding has been limited in large part because of the highly subjective visual endpoint practiced during tissue fusion. When performing a laser tissue weld, the surgeon relies on visual clues from the tissue and on prior experience to determine when the weld has been completed. Using visual cues to determine when a successful weld has occurred makes a reproducible laser closure difficult to achieve. This highly subjective, qualitative diagnostic can be minimized by making the laser tissue welding process less operator dependent. Tissue parameters that may provide diagnostic information for welding include the native autofluorescence,[41] the optical birefringence,[42] and the temperature of the tissue.[43] By monitoring the tissue temperature during the welding process, the optimal temperature range (the one that produces the most desirable clinical outcome) for laser welding can be determined.

To provide a means for thermal regulation during laser wound closure, a remote temperature control system has been developed.[43] Using an infrared detector, tissue temperatures are fed back into a computer that controls the output power of a laser. By regulating the power output of the laser, welding temperature can be tightly controlled. In initial experiments by Kliose and associates, rat urethras were incised and repaired using thermally controlled laser welding ranging in surface temperatures from 50°C to 90°C.[43] Results are summarized in Table 37–2. Burst pressures were greatest with a weld temperature of 80°C. However, histologic analysis revealed marked transmural tissue

Table 37–2
Experimental Results with Thermally Controlled Urethral Welding

Temperature (°C)	Number of Incisions Repaired	Bursting Pressure (mm Hg)
50	9	87
60	9	227
70	9	584
80	9	877
90	9	633

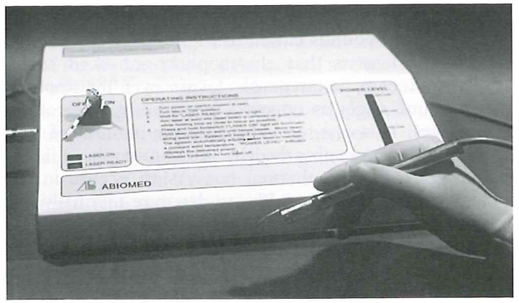


Figure 37-3
The infrared temperature-controlled laser system. (Abiomed R&D, Danvers, MA.)

damage at this temperature, which may ultimately result in poor healing. Welds at 60°C and 70°C, though not as strong, were supraphysiologic and demonstrated significantly less thermal tissue damage, which will likely result in improved long-term healing compared with higher temperatures.

The temperature-controlled laser system has recently been reduced to a working prototype and is being evaluated using in vivo animal models (Figs. 37–3 and 37–4).

GROWTH FACTOR–ENHANCED SOLDERS

Using temperature control technology during laser wound closure, it is now possible to maintain the heat generated during laser delivery below the denaturation threshold of selected heat-stable biologic modifiers. One such group of modifiers that holds promise in effecting improved wound healing after laser wound closure is human recombinant growth factors.

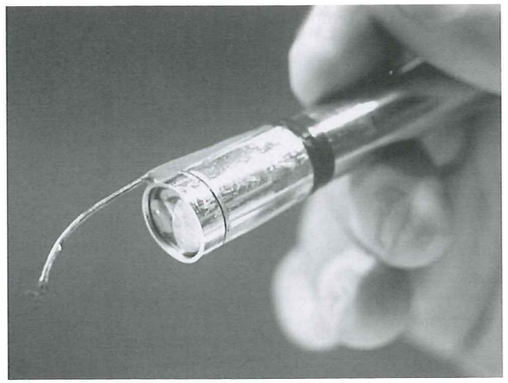


Figure 37-4
Infrared temperature-controlled handpiece. Through this device, laser energy is delivered to the tissue while surface temperature is monitored. (Abiomed R&D, Danvers, MA.)

Growth factors are soluble polypeptides that mediate multiple cellular events, such as cell proliferation and differentiation, by binding to and activating high-affinity cell surface receptors on target cells.[44–46] Specific growth factors are potent mitogens for discrete classes of cells known to migrate into healing wounds, such as keratinocytes, fibroblasts, endothelial cells, and monocyte-derived macrophages.[47] Growth factors also mediate collagen deposition, matrix remodeling, cell turnover, and angiogenesis.[44, 48, 49] Attempts have been made to use recombinant growth factors to facilitate and accelerate wound healing in model systems, with the ultimate goal of improving clinical wound healing.[44] A number of reports have indicated that specific growth factors applied exogenously to acutely excised wounds are indeed bioactive and accelerate healing in model systems.[50, 51] Improvements in growth factor delivery technology are necessary for the effective evaluation of candidate biologic modifiers in diverse clinical settings.

By combining temperature-controlled laser welding with human albumin solder, it may be possible to effect a timed-release delivery vehicle for human recombinant growth factors after photothermal wound closure. This novel application of technologies can provide immediate fluid-tight wound closure while delivering a single application of growth factor(s) in a timed-release manner to accelerate wound healing.

My laboratory has demonstrated the feasibility of using HAPS as a carrier for the delivery of biologically active recombinant growth factors for laser wound repair.[52] Specifically, transforming growth factor (TGF)-β_1, delivered in this manner to incisional wounds, can accelerate healing (compared with conventional suture closure and with photothermal wound closure using HAPS alone). These findings were verified by functional measurements of wound strength that demonstrated the TGF-β_1 solder repairs to be 79% stronger than laser repairs using solder alone.[53] This effect on healing is likely to reflect TGF-β_1's unique effects on extracellular matrix accumulation and its selective retention by the human albumin solder, because several other growth factors at similar concentrations did not affect the rate of healing in this surgical model. This is the first demonstration that incorporation of a biologic response modifier into a protein solder used in laser-mediated tissue repair significantly accelerates wound healing. The benefits of such a technology could translate into improved wound healing, leading to a more successful postsurgical outcome, reduced hospitalization, and an overall decrease in health care costs.

LASER TISSUE WELDING IN UROLOGIC SURGERY

In urology, investigators have examined the use of tissue welding for repair of the vas, ureter, and urethra. Although the ultimate goal is a rapid, sutureless anastomosis, the current state of the art does not allow us to perform laser welding of most large defects without the addition of a minimum number of sutures to align and approximate the edges before welding. We have demonstrated that gut suture offers the greatest margin of error for use during a

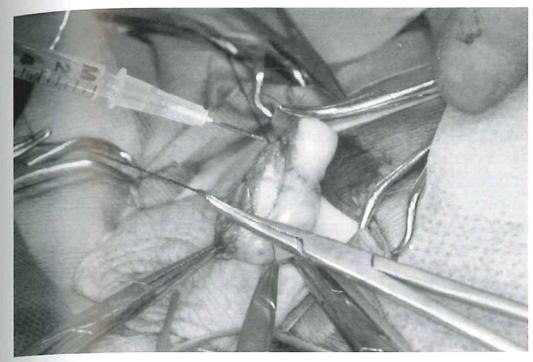


Figure 37-5
Application of 50% human albumin solder to the approximated edges of the neourethra before laser welding. A 10% fluorescein solution (chromophore) has already been applied to the tissue edges.

suture-assisted laser weld with either the KTP-532 or 808-nm diode lasers.[54] Clinically, we continue to use gut suture to align the tissue edges before performing a weld with these laser wavelengths.

Vasovasostomy

Several reports suggest that laser-welded vasectomy reversals are technically feasible and have patency rates that approach those of standard microsurgical repair. Both the Nd:YAG and CO_2 lasers have been used for this application with differing results. The CO_2 laser produces a superficial coagulation limited to the seromuscular layer and achieved a patency rate of 83% to 100% without granuloma formation while maintaining excellent sperm quality,[55] whereas the Nd:YAG laser caused significant scar formation with lower patency rates and a higher incidence of sperm granulomas.[56] These differences can be explained in part by the variation in laser wavelength and the amount of peripheral tissue damage between the two lasers.

Clinically, the use of a CO_2 laser has been reported in 32 patients undergoing vasectomy reversal using 9-0 nylon to reapproximate the tissue edges before circumferentially laser welding the seromuscular layer.[57] In those patients who underwent vasectomy less than 10 years previously, the rate of successful sperm retrieval approached 95% without significant complications such as granuloma formation.[57]

Ureteral Repair

Laser-welded ureteroureterostomies have been successfully performed in animal models and compared with those of a standard spatulated suture repair. In a rabbit model, end-to-end nonspatulated ureteral anastomoses were performed over a small stent, which was removed immediately after welding.[58] Light and electron microscopy findings were comparable in both groups.

Extravesical reimplantation of ureters (Lich-Gregoire technique) has been performed in a canine model using ICG-enhanced fibrinogen solder with an 808-nm-diode laser. Results from this study suggest that laser-welded vesical wound closures appeared equal to suture closures.[59]

These novel applications of tissue welding have the potential to be extended to laparoscopic ureteral surgery including ureteroureterostomy for stricture disease, laparoscopic ureterolithotomies, and pyeloplasties.

Urethral Reconstruction

Laser welding has been well studied in various animal models as a potential method for urethral reconstruction. The CO_2 laser has been shown to be superior to the Nd:YAG laser for urethral welding. Scarring and fistula formation are more common with the Nd:YAG laser, which likely causes more peripheral tissue damage.[60] My laboratory investigated the use of the KTP-532 laser to perform patch graft urethroplasty in 24 adult male dogs using the inner preputial skin as a donor site and demonstrated decreased operative time and significantly elevated intraluminal pressures in the laser-soldered group over the microsurgical controls. No fistula occurred in the laser-welded group.[28]

My group has extended this concept clinically for hypospadias repair using a KTP-532 laser, fluorescein, and HAPS with excellent technical results (IRB-approved protocol, New York Hospital) (Figs. 37–5 and 37–6). Other investigators are also beginning to use similar techniques for hypospadias repair.[6]

Taken together, these studies have demonstrated that laser tissue welding combined with HAPS has the potential to provide a superior repair when compared with conventional suture methods. The current applications being considered for laser welding in urologic surgery are listed in Table 37–3.

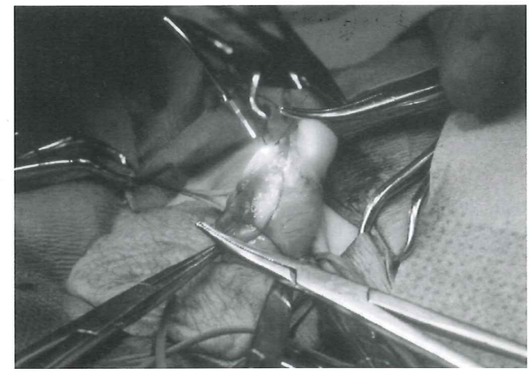


Figure 37-6
The KTP-532 laser light during welding of the neourethra. This defect is 4.9 cm in length and is approximated before welding with three interrupted 7-0 chromic sutures.

Table 37–3
Applications of Laser Tissue Welding to Open Urologic Surgery

Vasovasostomy
Urethral reconstruction
Ureteroneocystostomy
Urethrocystostomy
Pyeloplasty
Augmentation cystoplasty
Continent urinary diversion

LASER TISSUE WELDING IN LAPAROSCOPIC UROLOGIC SURGERY

Today, the combination of low-power laser energy coupled with a protein solder with or without the addition of chromophore appears to offer an exciting alternative to laparoscopic tissue reconstruction and repair. Efforts to perform reconstructive techniques through the laparoscope are still in the early stage. The reason for slow progress on this front is the lack of an adequate means to approximate tissue through laparoscopic access. One study performed ex vivo sutureless ureteroureteral anastomoses in canine ureters using the KTP-532 laser.[23] The researchers contrasted the immediate intraluminal bursting pressure of anastomoses produced by laser alone, versus laser plus a human albumin solder, versus laser plus human albumin solder and fluorescein. The welding technique using solder and chromophore produced an anastomosis with a mean bursting pressure of 281 mm Hg, versus the laser-alone group, which burst at 9 mm Hg. Wolf and Clayman are currently evaluating laser welding to repair in vivo ureteroureterostomies using laparoscopic access in a porcine model (personal communication, 1996).

It is expected that in the future, pyeloplasties, ureteroureterostomies, ureteral reimplants, and other anastomoses may be performed by laser welding, diminishing our dependence on sutures and clips for laparoscopic surgery of the genitourinary tract (Table 37–4).

FUTURE DIRECTIONS IN TISSUE WELDING

Laser welding is an exciting, innovative means of reapproximating tissues with the potential to decrease operative time and limit technical difficulties currently encountered with conventional suturing methods. The goals of current research in the field include identifying the optimal tissue and laser parameters needed for a tissue weld, thereby maximizing laser-tissue interaction while minimizing thermal destruction of the surrounding tissues. Furthermore, laser welding provides a rational alternative to current methods of laparoscopic tissue reapproximation such as suturing and stapling. Studies are currently under way to evaluate its role in laparoscopic genitourinary surgery.

As the mechanisms of tissue welding become better elucidated, a more comprehensive understanding of the physiologic response of the integument to surgery and of wound healing will emerge and the role of laser welding as a tool for reconstructive urologic surgery will become evident.

Table 37–4
Potential Applications for Laparoscopic Laser Tissue Welding

Primary Anastomosis
Ureteroureterostomy
Pyeloplasty
Ureteroneocystostomy
Anastomotic Reinforcement
Bowel
Bladder
Urethrocystotomy
Ureteroenterostomy

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CHAPTER

38

Future Frontiers in Hypospadias

BARTLEY G. CILENTO, JR.
ANTHONY ATALA

HISTORY

Hypospadias has intrigued practitioners of medicine for centuries. Galen was the first to use the word *hypospadias* when he wrote, "Hypospadias is a condition in which the glans penis is curved downwards . . . the glans is shortened and the urethral meatus is concealed beneath it." In the early 600s, Paul of Aegina proposed amputation of the penis distal to the meatus with remodeling of the stump. In the early 1700s, Pierre Dionus used a fine knife to tunnel through the glans in line with the proximal urethra and meatus. The edges of the meatus were incised. A lead cannula was then inserted from the tip of the glans to the meatus and tied in place. The cannula was retained until healing was complete.[1] In 1874, Duplay described his technique for the repair of hypospadias. In his original operation, he configured a longitudinal strip of ventral penile shaft skin into a tube sewn over a catheter. The two lateral skin edges were mobilized and brought together over the neourethra.

More than 150 techniques for the correction of hypospadias are described, thus illustrating the challenge and difficulties in the surgical correction of this anomaly. Considerable advances in the surgical correction of hypospadias have been made during the past 50 years owing to the advances in microsurgical instrumentation, optical magnification, and the development of fine absorbable suture material.[2] The repair of proximal hypospadias is routinely performed today as a one-stage outpatient procedure using vascularized pedicle flaps or free grafts. Two-stage repairs are usually reserved for severe defects.[3] The incidence of urethrocutaneous fistulas and meatal stenosis generally ranges from 8% to 15%. The incidence of complications may be reduced by using additional layers of available tissue over the repair.[4, 5] Total surgical failures are infrequent.

Some of the most challenging reconstructive problems involve those patients with inadequate penile skin, such as patients who have had unsuccessful surgical repairs and circumcised neonates with unrecognized hypospadias. In a review of 5882 circumcisions of newborns, it was reported that 35% of newborn boys with hypospadias were circumcised.[6] Many tissues have been used for urethral reconstruction, including vascularized or free graft skin, bladder, buccal or rectal mucosa, dermal free grafts, and tunica vaginalis. All these tissues have been associated with numerous complications. Because of the problems associated with some of the tissues currently used, several investigators have sought alternative substances for urethral reconstruction.

ALTERNATIVES

Keratinocytes

In 1975, Rheinwald and Green demonstrated that human epidermal keratinocytes could be serially cultivated in vitro to form keratinizing colonies from single cells.[7] In vitro cultured keratinocytes have been used for skin grafts in burn victims and in patients with large skin defects such as chronic leg ulcers or defects caused by surgical removal of large nevi.[8–10] In 1990, Romagnoli reported the use of autologous in vitro cultured keratinocytes for urethral reconstruction.[11] A 2-mm² urethral mucosa biopsy sample was taken just inside the urethral meatus. The keratinocytes were enzymatically treated to produce a cell suspension. Aliquots of cells were seeded onto 9.6-cm² dishes and cultured. After 10 days, the cultures were passaged onto 75-cm² flasks. Confluent sheets of epithelium were available 16 to 18 days after the initial biopsy. Surgically, the graft bed was prepared by making a longitudinal ventral incision from the tip of the glans to the meatus, with dissection to create lateral flaps. The cultured epithelial graft was placed on the graft bed and sewn in place. An occlusive saline-soaked dressing was then applied. The dressing was removed after 10 days, and the new urethra was constructed. The new urethra was formed by tubularization over a stent after dissecting the underlying connective tissue, which was now covered with the newly formed epithelium. The stent was removed 6 months later, when the proximal portion of the neourethra was anastomosed to the hypospadiac meatus. A small fistula occurred in both patients.

Romagnoli subsequently modified his surgical technique by performing his procedure as a two-step urethroplasty.[12] The urethral epithelium biopsy sample is expanded and later placed on the exterior surface of a tubularized polytetrafluoroethylene (Teflon) graft. A subcutaneous tunnel is prepared by gentle dissection from the urethral meatus to the fossa navicularis. The tubularized Teflon graft, seeded with keratinocytes, is placed through the subcutaneous tunnel. The proximal portion of the tubularized graft is anastomosed to the native hypospadiac meatus with 6-0 polydioxanone. A Foley catheter is inserted and left in place for 10 days. One patient developed a fistula 20 days postoperatively at the junction of the graft and native meatus. In all patients, a mild stenosis at the coronal sulcus was observed; it responded to a single urethral dilation in all cases without relapse. This experiment demonstrated that reconstruction of the neourethra could be accomplished with cultivated keratinocytes.

Urothelial Cells

Urothelial cells, rather than keratinocytes, would be ideal for urethral reconstruction.[13] Human urothelial cells have generally been considered difficult to expand reliably in vitro without stromal contamination. We successfully developed a simple method for the harvest of human urothelial cells that could be reproducibly cultivated, passaged, and extensively expanded in a serum-free medium.[14] Independently derived strains of human urothelial cells were routinely expanded from an initial confluent surface of 24 cm² to a total area of 900 cm² within 4 weeks of culture. The growth kinetic demonstrated a doubling time of approximately 40 hours. Strains passaged six times showed no decrease in the rate of cell proliferation. Chromosomal analysis performed at passages three and six showed a normal chromosomal complement. This study demonstrated that homogeneous human bladder uroepithelial cell strains can be developed with high reproducibility, grown and repeatedly passaged, and extensively expanded in culture.[14] This indicated that it could be possible to collect autologous urothelial cells from human patients, expand them in culture, and return them to the human donor in sufficient quantities for reconstructive purposes. Additional studies were able to characterize further the phenotypic and cytogenetic properties of urothelial cells.[15–17]

There is little doubt that the ideal material for urethral replacement would be a homologous urothelial substitute. We have been able to create urothelial tissue grafts using isolated populations of transitional epithelium in concert with a synthetic biodegradable polymer.[18] The synthetic biodegradable polymer is used as a delivery vehicle for the creation of new urothelial structures in vivo from dissociated cells. The biodegradable polymers exist as nonwoven meshes of polyglycolic acid, which is a synthetic polymer of hydroxyacetic acid. The interfiber distance ranges from 0 to 200 μm. The average fiber diameter is 15 μm. These physical characteristics allow for ample surface area for cellular attachment and diffusion of cellular nutrients. To demonstrate the feasibility of this concept, primary cultures of enriched urothelial cells were obtained from New Zealand white rabbits and seeded onto nonwoven polyglycolic acid polymer meshes.[18] These polymer/urothelial constructs were incubated in vitro for 1 to 4 days and then implanted into the mesentery, omentum, or retroperitoneum of athymic mice. The animals were then sacrificed at various times. Ten days after implantation, isolated urothelial cells were seen lining the polymer fibers. At 30 days, the polymer degradation was evident and layers of urothelium one to three cell thicknesses were seen. Polymers implanted without seeded urothelium served as controls showing polymer degradation without urothelial formation. Other experiments demonstrated the feasibility of using biodegradable polymers for the delivery, survival, and expansion of urothelial cells in vivo.[19] Additional studies were able to show adequate functional replacement using the cell polymer technology for ureteral and bladder replacement.[20, 21]

In another set of experiments, polymers seeded with autologous urothelial cells were used as urethral replacements in New Zealand white rabbits.[22] Partial urethrectomies were performed in 10 New Zealand white rabbits through a circumcising incision (Fig. 38–1). A segment of polymer mesh with the appropriate diameter was interposed using continuous 7-0 Vicryl sutures to form the neourethra in each animal (Fig. 38–2). The penile skin was closed over the neourethra with interrupted 5-0 Vicryl sutures (Fig. 38–3). Because of the thick, semisolid consistency of rabbit urine, simultaneous vesicostomies were performed and then closed at 10 days. Retrograde urethrograms showed no evidence of stricture formation. Histologic examination of the neourethras demonstrated complete reepithelialization of the polymer mesh sites by day 14 (Fig. 38–4). These findings were persistent at the 4- and 6-week time points. The polymer fibers were partially degraded by day 14 and almost completely reabsorbed by day 30. These experiments suggested the feasibility of

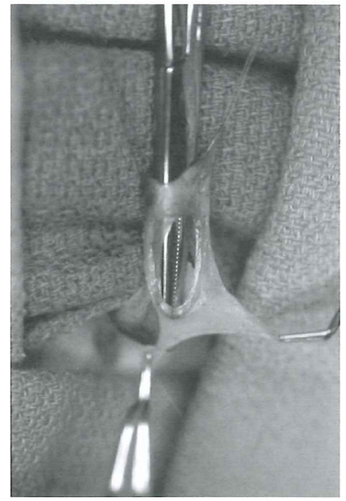


Figure 38-1
Degloved penis with partial urethrectomy.

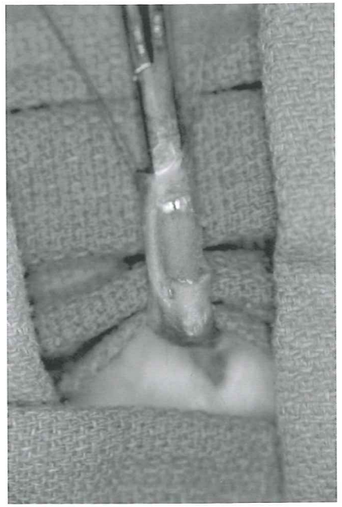


Figure 38-2
Near complete urethroplasty with polymer scaffold.

using this technique in reconstructive procedures involving the urethra.

CONCLUSION

Some of the most challenging surgical reconstructive cases involve patients who have hypospadias and who lack sufficient skin for urethral repair. Fortunately, the situation in which insufficient genital skin is available for surgical reconstruction is uncommon. The use of autologous keratinocytes for urethral reconstruction has been performed with apparent success; however, greater clinical experience, reproducibility of results by other investigators, and long-term follow-up are needed. Tissue culture techniques are now well established and commonplace in university settings. Human urothelial cells have been successfully harvested, cultivated, and extensively expanded in vitro in sufficient quantities for reconstruction. The use of autologous cells has also been proposed for other applications within urology.[23–28] With continued research and clinical application, autologous tissue culture for surgical reconstruction may become a viable surgical option for the reconstruction of complex cases of hypospadias.



Figure 38-3
Completed repair.

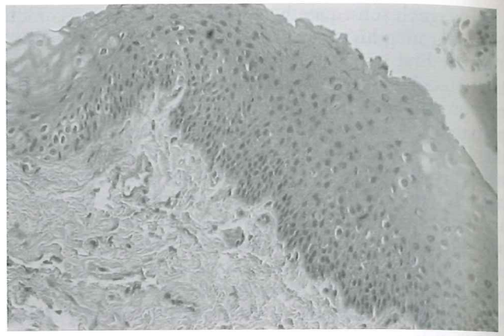


Figure 38-4
H&E-stained histologic section of neourethra showing the urothelium-lined polymer (original magnification, ×400).

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EPISPADIAS

CHAPTER

39

Epispadias

BRUCE L. SLAUGHENHOUPT
JOHN P. GEARHART

TYPES OF EPISPADIAS

In a combined study, Dees[1] reported the incidence of complete epispadias to be 1 in 117,000 males and 1 in 484,000 females. The reported male-to-female ratio of epispadias varies between 1:3[1] and 5:1.[2] Epispadias varies from a glanular defect in a covered penis, to the penopubic type with complete incontinence, to the complete variety associated with classic bladder exstrophy.

Epispadias in males is classified according to the position of the dorsally displaced urethral meatus. The degree of penile deformity and the occurrence of urinary incontinence are related to the extent of the dorsally displaced urethral meatus. The meatus may be located in the glans, penile shaft, or penopubic region. All types of epispadias are associated with various degrees of dorsal chordee. In penopubic or subsymphyseal epispadias, the entire penile urethra is open and the bladder neck may be large enough to admit the examiner's finger. The pubic symphysis is divergent and contributes to the deficiency of the external urinary sphincteric mechanism. The divergence of the pubic symphysis and the shortened urethral plate result in prominent dorsal chordee and a penis that appears short. Research by Silver and colleagues has demonstrated that the corporal bodies in men with epispadias associated with classic bladder exstrophy are actually shorter than in men without exstrophy.[3]

Epispadias in females is characterized by a bifid clitoris, flattening of the mons, and separation of the labia. Three degrees of epispadias occur in females. In the most minimal degree, the urethral orifice merely appears patulous. In intermediate female epispadias, the urethra is split dorsally along most of its length. In the most severe form, the cleft involves the entire length of the urethra and the sphincteric mechanism is incompetent.

SURGICAL MANAGEMENT

The objectives for the repair of epispadias include reconstruction of functional and cosmetically acceptable genitalia. Additionally, in the more severe cases, achievement of urinary continence with preservation of the upper urinary tract is also mandatory.

Kramer and Kalelis[2] reviewed their experience with 82 males with epispadias. Penopubic epispadias occurred in 49 cases, penile epispadias in 21, and glanular in 12. Forty-six of 49 of the patients with penopubic epispadias were incontinent of urine, as were 15 of 21 with penile epispadias. None of the patients with glanular epispadias were incontinent.

Young[4] reported the first surgical cure of incontinence in a male patient with complete epispadias. Since his report, attempts at obtaining continence have progressively improved to a success rate of 82%.[2, 5–8] The majority of these patients underwent bladder neck reconstruction by means of a Young-Dees-Leadbetter bladder neck plasty as well as epispadias repair.

Epispadias repair was formerly performed after bladder neck reconstruction.[2, 5] However, continence results with the small bladder associated with exstrophy[9] and the small bladder associated with epispadias[7] have led us to perform an epispadias repair before bladder neck reconstruction. By proceeding in this manner, we have been able to achieve an average increase in bladder capacity of 95 ml in 18 months in those patients with a small bladder capacity and epispadias.[7] Patients also had an overall continence rate of 87% after undergoing bladder neck reconstruction.[7] In those patients with complete epispadias and adequate bladder capacity, epispadias repair and bladder neck reconstruction can be performed in a single stage.

In patients with epispadias, bladder capacity has been found to be the most significant indicator of eventual continence.[10] Arap and colleagues[5] obtained a 71% rate of continence in children with epispadias and an adequate bladder capacity as opposed to a 20% continence rate in those with inadequate bladder capacity.

Genital reconstruction and urethroplasty in patients with epispadias and exstrophy are quite similar. The following goals must be met: release of dorsal chordee and visualization of suspensory ligaments; dissection of the

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Figure 39-1

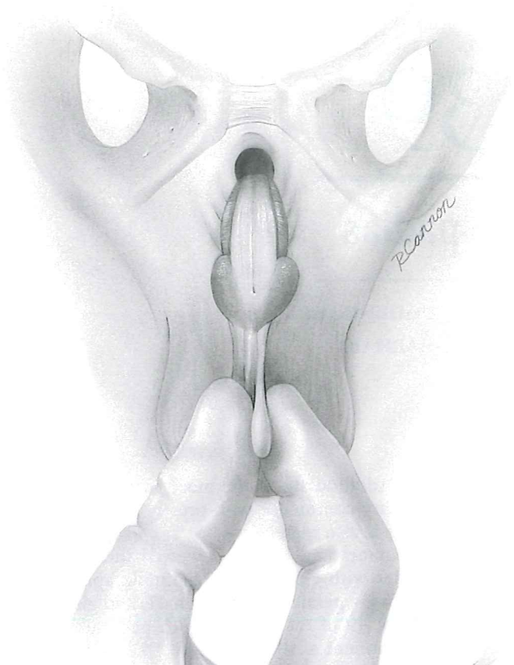


Figure 39-2

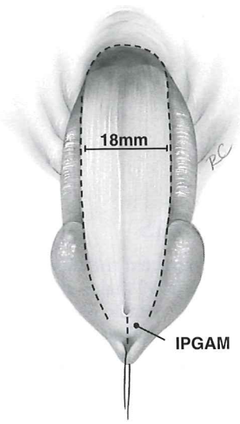


Figure 39-3

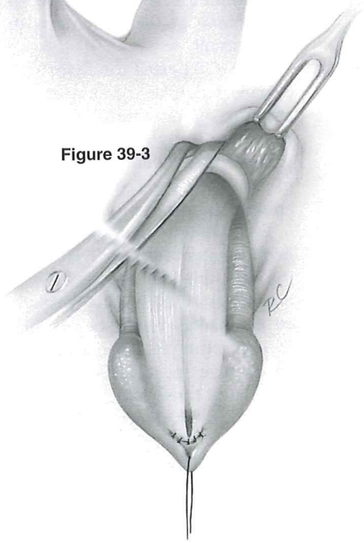
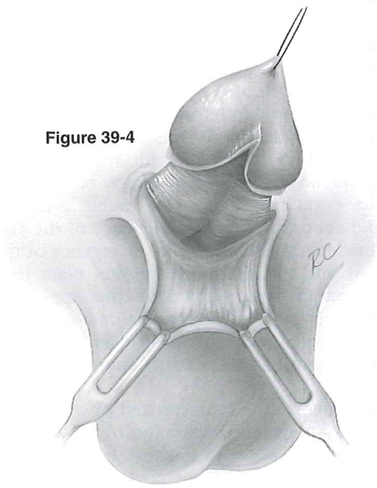


Figure 39-4



corpora from their attachment to the inferior pubic rami; lengthening of the urethral groove; and lengthening of the corpora, if needed, by incision and anastomosis or grafting or by medial rotation of the ventral corpora in a more downward direction.

Many techniques have been described for reconstruction of the urethra in patients with epispadias. Cantwell reconstructed the urethra by mobilizing the dorsal urethral plate completely and transposing the tubularized plate ventrally between the separated corpora.[11] Young attributed the high fistula rates of the Cantwell procedure to excessive mobilization of the urethra. He recommended limiting mobilization of the urethral tube to reduce the incidence of fistula formation.[4] Others have recommended a two-stage repair.[2]

All contemporary means of hypospadias repair have been modified and used to create a neourethra in the treatment of epispadias. These have included the use of preputial skin, bladder mucosa, and skin grafts. The neourethra can then be positioned between and ventral to the corpora.[11–13]

The modified Young repair formerly was the most commonly used technique for urethroplasty in classic bladder exstrophy and epispadias at our institution.[4] However, the resultant neourethra was very tortuous and the fistula rate unacceptably high at 21%.[14] In 1988, we began to use the Cantwell-Ransley repair exclusively for patients with exstrophy or complete epispadias. The surgical technique is similar to that described in a previous communication.[15] However, we have made a few modifications in our technique, and these are highlighted in the following description of repair of the epispadiac male genitalia.

Four concerns must be addressed to ensure a functional and cosmetically acceptable penis: (1) dorsal chordee, (2) urethral reconstruction, (3) glanular reconstruction, and (4) penile skin coverage.

Epispadias is repaired around the age of 2 years. Because the majority of boys with epispadias have a relatively small penis and shortage of available penile skin, most of our patients receive testosterone stimulation before urethroplasty and penile reconstruction.[16] Research by Nijman has confirmed that this practice is not detrimental to the long-term outcome of penile growth.[17]

Just before epispadias repair, cystoscopy and a gravity cystogram are performed to measure bladder capacity. The operation is then begun by placing a Prolene suture through the juncture of the glans and prepuce to provide for traction on the penis (Figs. 39–1 and 39–2). If necessary, a deep vertical incision is made in the urethral plate (IPGAM). This is closed in a transverse fashion with 6-0 polyglycolic acid sutures (Fig. 39–3). This step flattens the distal urethral plate and advances the urethra to the tip of the phallus. This ensures that the meatus will be in an excellent glanular position when the glanular wings are closed over the reconstructed neourethra. Two parallel incisions are then made 18 mm apart on the dorsum of the penis (see Fig. 39–2). These are marked out previously and outline a strip of penile skin that extends from the prostatic urethral meatus to the tip of the glans.

The ventral penile skin is then dissected down to the scrotum. Care is taken to preserve the mesentery to the urethral plate, which arises proximally and extends upward between the corpora to provide blood supply to the urethral plate (Fig. 39–4). To release dorsal chordee and allow for penile elongation, all remnants of the suspensory ligaments and old scar tissue from any previous bladder procedure must be excised. At this time, the corpora cavernosa can be dissected from the inferior pubic rami (Fig. 39–5).

Dissection of the corpora is begun on the ventral aspect

Figure 39-5A

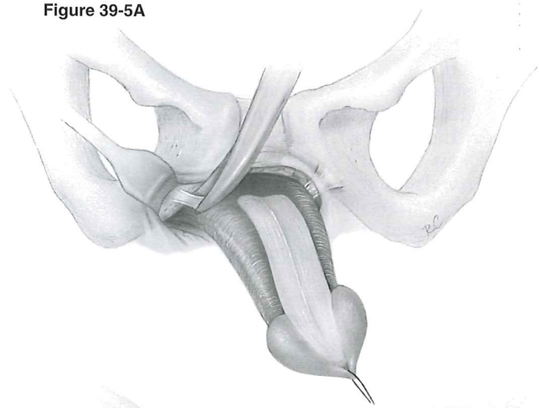


Figure 39-5B

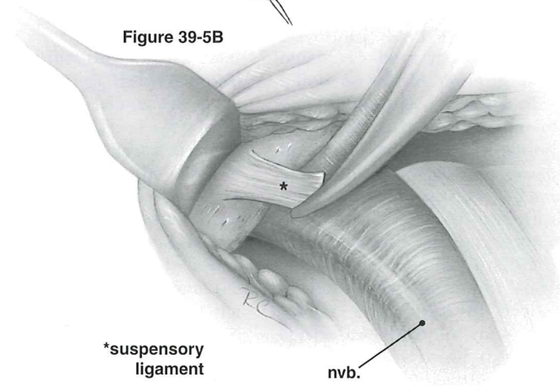




Figure 39-6

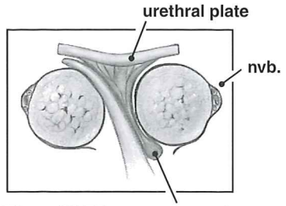


Figure 39-7B

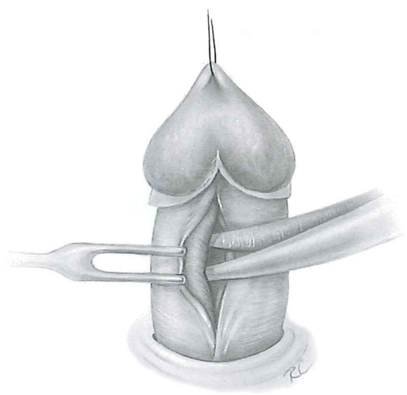


Figure 39-7A

of the phallus on the surface of Buck's fascia (Fig. 39–6). This plane is followed closely until the dissection extends through to the dorsal aspect, between the corpus and the urethral plate. Care is taken to preserve the blood supply to the urethral plate, which lies within the intercorporal septum (Fig. 39–7). This is performed on one corpus and then the other. A vessel loop is placed around each corporal body, and the dissection is extended proximally to free the edges of the urethral plate from the corpora (Fig. 39–8). The vessel loop can be tightened around the corporal body to yield hemostasis during the dissection. After each point of dissection, however, the loops should be loosened and hemostasis achieved with electrocautery. Distal dissection is also performed past the level of the junction of the glans and the corpora by incising along the urethral plate margin and creating glans wings (Fig. 39–9). If an abnormally large amount of blood has been lost during the reconstruction, this step can be postponed until after the neourethra has been tubularized. Unless adequate mobilization is obtained proximally and distally, however, it will be difficult to roll the corporal bodies over the urethra during later steps in the procedure. At this point, glanular flaps are created by excising the uneven mucosal tags, or "knobbly bits," from the medial aspect of the glans wings (Fig. 39–10). The neurovascular bundles lie posterolaterally on the epispadiac corpora. They can be easily identified, and care must be taken to ensure that electrocautery is not applied to either bundle (see Fig. 39–10).

The neourethra is created by tubularizing the urethral strip from the prostatic opening to the glans over a number 8 silicone stent with a running 6-0 polydioxanone acid suture (Fig. 39–11). The edges of the glanular urethra are mobilized, and tubularization of the neourethra is completed and extended to the end of the glans (Fig. 39–12).

The glans wings are closed over the glanular urethra using subcuticular sutures of 5-0 polyglycolic acid. It is important to align the coronal edges at this point to ensure a cosmetically appealing outcome. The glans epithelium is then closed with 6-0 polyglycolic acid sutures (Figs. 39–13 to 39–16).

After the neourethra has been completely tubularized and the chordee divided, the corporal bodies are approximated over the urethra with horizontal mattress sutures of 5-0 polydioxanone acid (Fig. 39–17). This displaces the urethra ventrally and corrects the dorsal angulation of the penis. Care must be taken to ensure that the neurovascular bundles are not entrapped by these stitches. If severe dorsal angulation is encountered, transverse incisions are made on the dorsal side of the corporal bodies. These are placed at the point of maximum curvature. The corpora are then closed over the neourethra by approximating the edges of the diamond-shaped incisions with interrupted sutures of 5-0 polydioxanone acid. In the most severe cases of dorsal angulation, longer corporal incisions are made and dermal grafts are placed over the corporotomies. If these incisions extend far laterally, it is sometimes necessary to elevate the neurovascular bundle from the corpora. Although in the past the bundles were routinely isolated, we now proceed with this maneuver only when corporal incisions or grafts are needed. After the urethra has been transferred to the ventral aspect, a number of interrupted sutures of 5-0 polyglycolic acid are placed between the corpora to bury the urethra further, especially at the level of the junction of the glans and corporal bodies (Fig. 39–18). Adventitial tissue on the dorsum of the base of the penis is sutured to the corpora to reduce the incidence of fistula development (Figs. 39–19 and 39–20).

Penile skin coverage is usually performed using one of two techniques. If shaft skin is abundant, the dorsum of the penis is covered by longitudinally reapproximating the skin with interrupted 5-0 polyglycolic acid suture (Fig. 39–21). The ventral penile shaft skin is then brought up to the ventral edge of the corona. Excess preputial skin is excised and discarded. The preputial skin edge is then reapproximated to the coronal sulcus with interrupted 5-0 and 6-0 polyglycolic acid sutures (Figs. 39–22 to 39–25).

If, however, shaft skin is not plentiful, a different technique is used. A sufficient length of ventral shaft skin is measured from the base of the penis to the coronal sulcus (Fig. 39–26). A vertical incision is then made along the midline of the shaft skin, and reverse Byars flaps are created from the remaining penile skin (Fig. 39–27). The flaps are wrapped around to the dorsum of the penis, and the edges are reapproximated with interrupted 5-0 and 6-0 polyglycolic acid sutures (Figs. 39–28 and 39–29). The silicone stent is secured to the glans and left indwelling in the neourethra to provide bladder drainage (see Fig. 39–16).

RESULTS

Kajbafzadeh and colleagues discussed the results of various reconstructive surgical techniques they have used during the past 15 years. Their most recent modification is similar to that which is described in this text. However, they routinely used corporal incision and creation of cavernocavernostomy in all 75 patients who underwent this type of repair. Thirty-five patients had complete epispadias, and 40 patients had the epispadias/exstrophy complex. Fistula occurred in only 4%, whereas stricture developed in 5.3%. A poor outcome requiring revision occurred in 16% of cases.[18]

We have published our results after reviewing 75 boys who underwent a Cantwell-Ransley epispadias repair between 1988 and 1994. Although most operations were performed as a component to a staged bladder exstrophy repair, 15 boys had complete epispadias. With a mean follow-up of 28 months, all boys had a horizontal or downward-angled penis while standing. A 21% incidence of urethrocutaneous fistula formation was found in the immediate postoperative period, and a 15% incidence after 3 months. Two patients developed an anastomotic stricture, and four patients had minor skin separation of the dorsal penile skin closure. All the patients who have been evaluated with catheterization or cystoscopy demonstrated an easily negotiated urethra.[13] The higher incidence of fistula formation in our series most likely reflects the higher proportion of procedures performed for the epispadias/exstrophy complex rather than simple epispadias. Also, several of these procedures were for patients referred after failed attempts elsewhere.

Finally, we have been able to show that these modifica-

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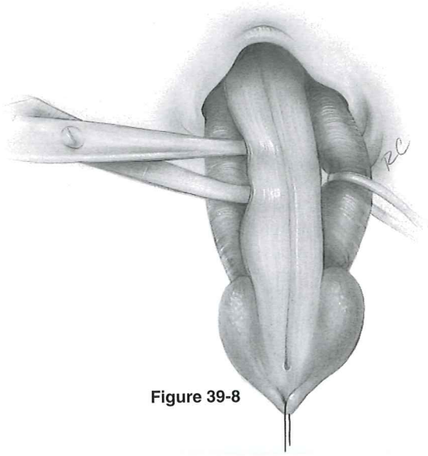


Figure 39-8

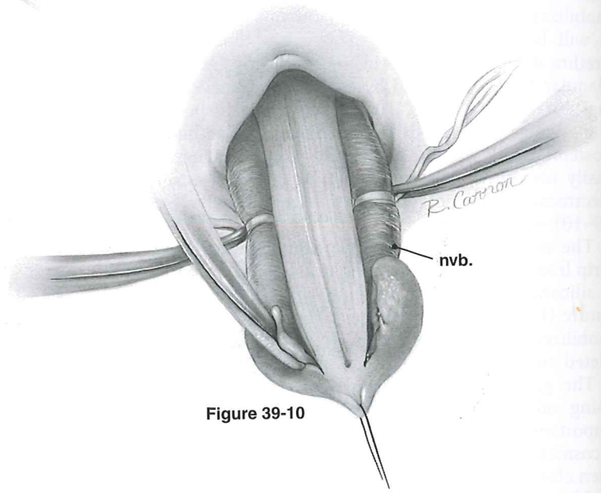


Figure 39-10

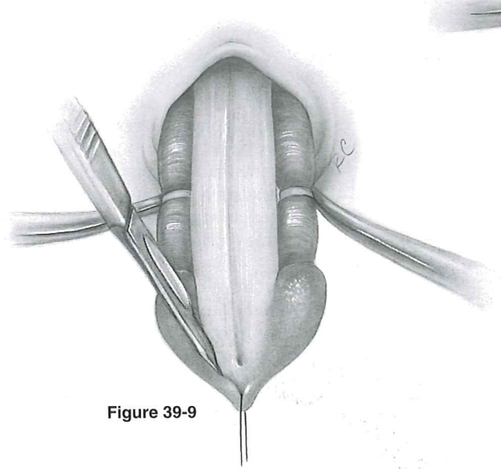


Figure 39-9

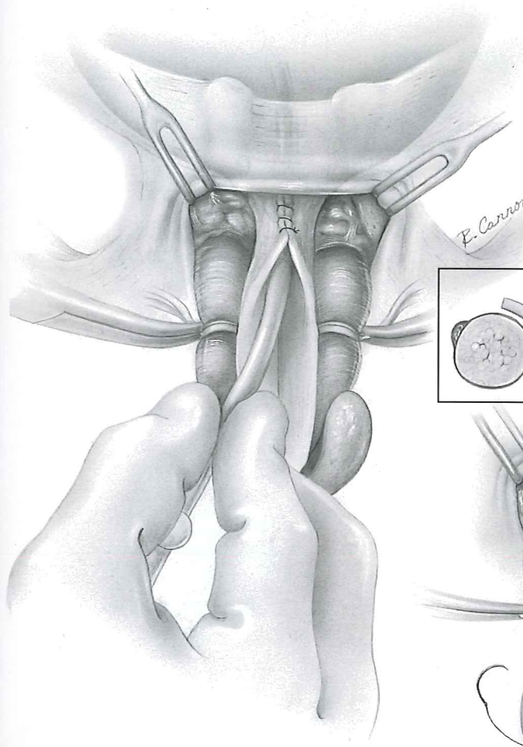


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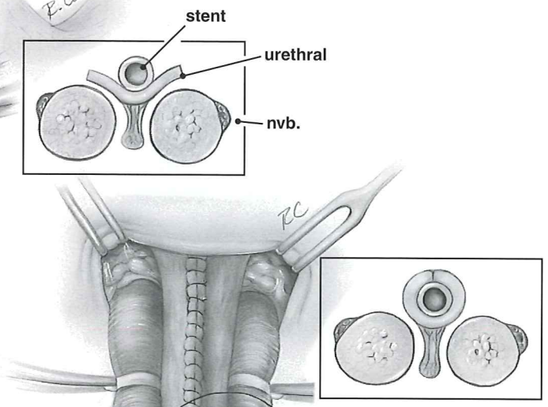


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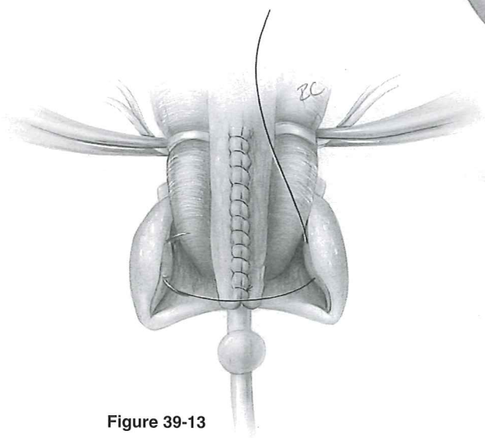


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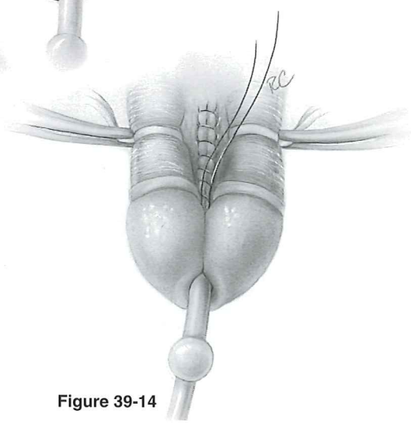


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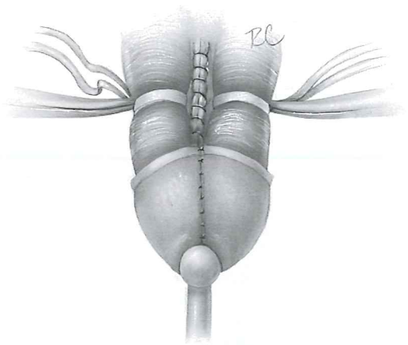


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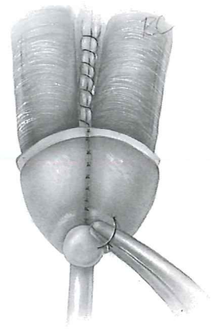


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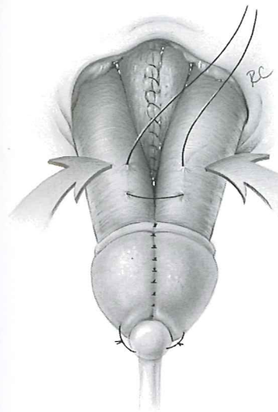


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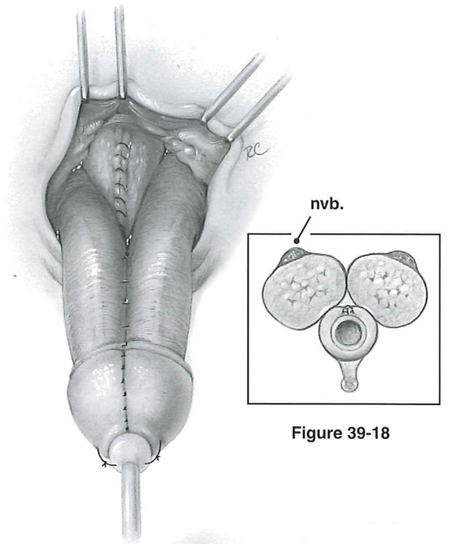


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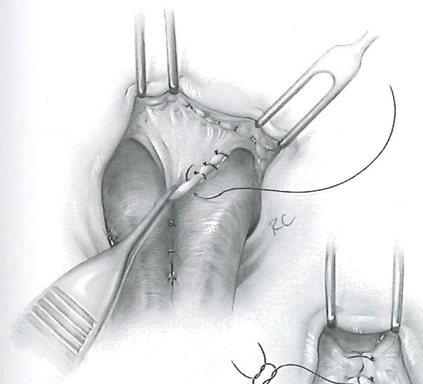


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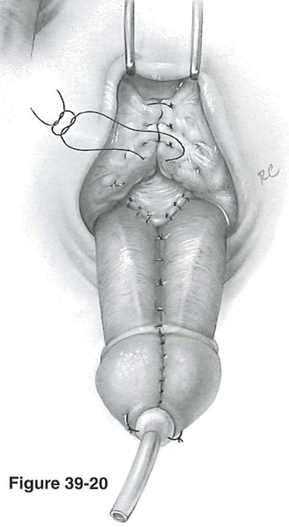


Figure 39-20

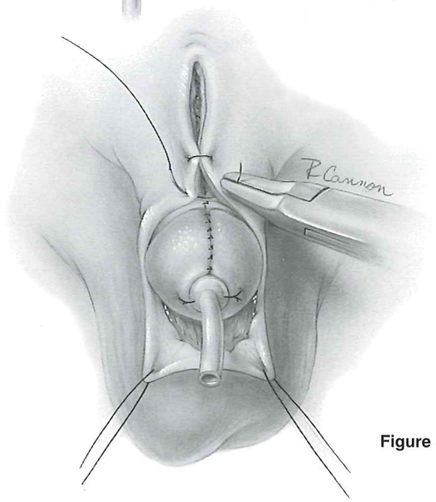


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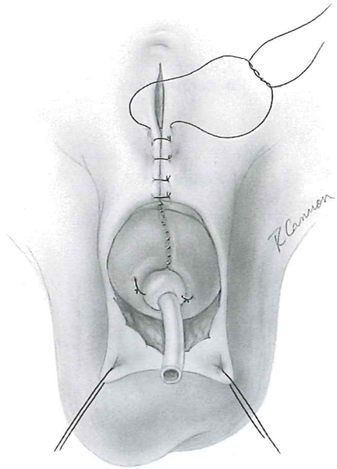


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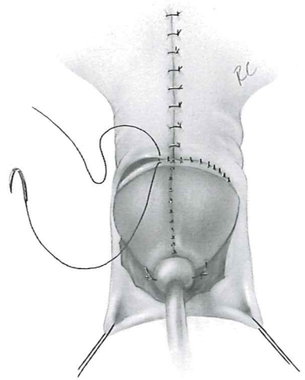


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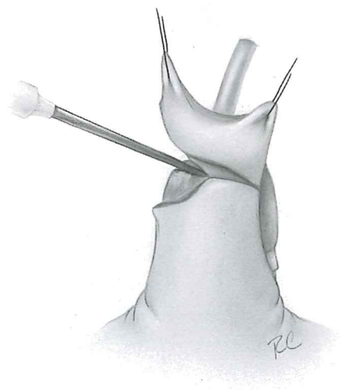


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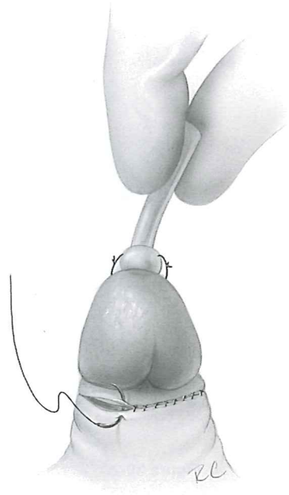


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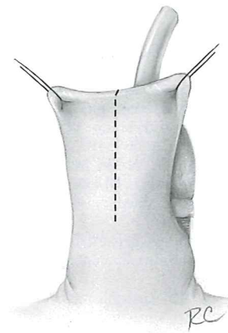


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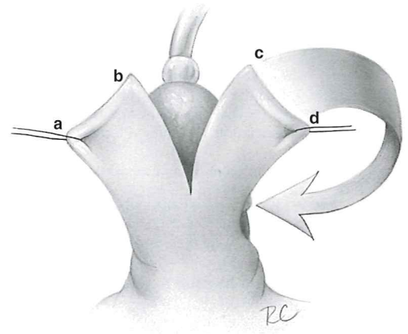


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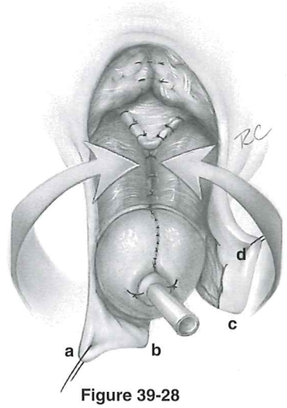


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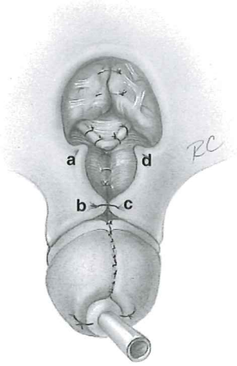


Figure 39-29

tions of the Cantwell-Ransley procedure can lead to a relatively straight penis with a urethra of adequate caliber and minimum morbidity. Although some initial data have been gathered from a few patients in terms of genital function, a more definitive assessment must be deferred until these boys are sexually active.

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CHAPTER

40

Male Epispadias Repair

DAVID A. DIAMOND

In 1895, F.V. Cantwell performed the first true urethroplasty for complete epispadias. In an attempt to restore the epispadiac anatomy to normal, Cantwell completely mobilized the dorsal urethral plate from the corpora cavernosa and transplanted the tubularized urethra below the corpora cavernosa, which were rotated dorsally and approximated in the midline. Although he originally described a successful outcome in two cases, difficulties encountered with the repair were attributed to poor vascular supply of the fully mobilized urethral tube. As a result, alternative approaches were taken to urethral reconstruction in epispadias during the past century. Despite many advances in surgical reconstruction of the epispadiac phallus, the cosmetic results and difficulty with intermittent catheterization left room for improvement.

This chapter describes the contemporary approach to epispadias repair, some of the elements of which are derived from Cantwell's original approach. These include complete mobilization of the urethral plate from the corporeal bodies and ventral transposition of the urethral tube with dorsal rotation of the corpora. The results to date with this approach to epispadias repair have been gratifying, particularly in terms of cosmesis and ease of intermittent catheterization.

PREOPERATIVE PREPARATION

The repair of male epispadias can be facilitated by preoperative administration of testosterone enanthate (TE), which serves to enlarge the phallus and improve the vascularity and suppleness of penile tissue. Our approach is to administer three separate doses of 50 mg of TE intramuscularly at 3, 2, and 1 month before the date of surgery. Urinary tract infection should be ruled out before surgery.

Cystoscopy

It is prudent to perform cystoscopy before epispadias repair, particularly in patients with exstrophy. This enables one to assess the bladder anatomy and to rule out problematic lesions such as acute cystitis or a stone. A cystoscopic aspirate is sent for culture and sensitivity testing.

GLANS RECONSTRUCTION

Glans reconstruction in the modified Cantwell technique of epispadias repair begins with advancement of the distal urethral plate from its dorsal location on the glans to a more distal location where the urethral meatus should ultimately reside (Fig. 40–1). The glanuloplasty is begun by first placing two holding sutures on either lateral aspect of the glans. With lateral traction on each holding suture, a vertical incision approximately 1.5 cm in length is made through the midline of the glans (Fig. 40–2). This divides the dorsal lip of glans epithelium at the terminal portion of the urethral plate. The incision should be deepened to



Figure 40-1
Complete epispadias following exstrophy closure with a dorsally located urethral plate.



Figure 40-2
Midline vertical incision through the distal glans.

divide the tough, white fibrous bands that are recognized subcutaneously. This dissection results in the creation of a small fossa navicularis. The incised surface, when closed transversely, ultimately constitutes the urethral meatus and thus must be 12 to 14 mm in width. The Heineke-Mikulicz procedure is completed with interrupted 6-0 Vicryl sutures used to close the longitudinal incision transversely (Fig. 40–3). This ultimately results in a meatus located in a more normal, ventral location on the glans. It is most important to leave an adequate bridge of glans tissue ventrally and not to extend the glanular incision too far or a hypospadiac urethral orifice may result.



Figure 40-3
Transverse closure of the distal glans to advance the urethral meatus.

URETHRAL MOBILIZATION

A lower midline abdominal incision is made 3 to 4 cm from the bladder neck up onto the abdominal wall. This creates space for the subsequent penile dissection, allows removal of mons fat, and enables one to perform a Z-plasty to create flaps for subsequent skin coverage at the base of the phallus. The incision is carried from the midline into the tissue hollow distal to the bladder neck and is continued laterally along the margins of the urethral plate to the corona of the glans on either lateral aspect (Fig. 40–4). This dorsal incision is linked distally to a ventral transverse incision, 1 cm proximal to the corona. This enables the operator to deglove the phallus of penile skin thoroughly and to expose the entire length of the corporeal bodies bilaterally. In so doing, one is able to visualize the neurovascular bundles that extend laterally along the distal aspect of the penis. The corpora are then mobilized proximally from adjacent soft tissue to the level of the pubic bones bilaterally. The midline bridge of tissue from between the corporeal bodies and the dartos layer of the scrotum on the ventral aspect is preserved in order to

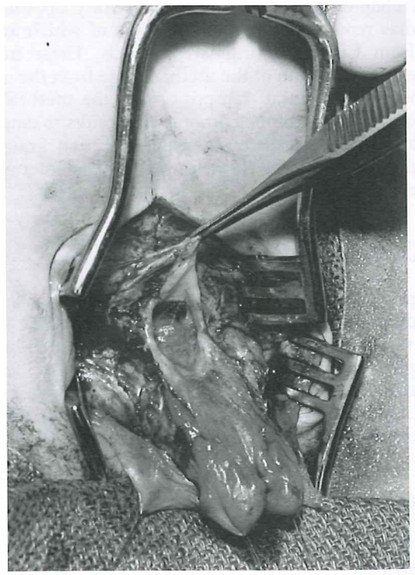


Figure 40-4
Developed initial incision around the bladder neck and along the urethral plate to the glans.

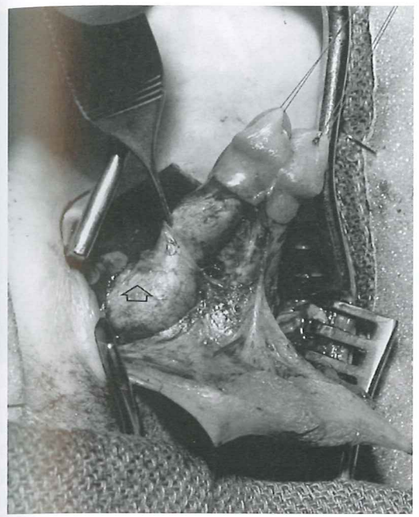


Figure 40-5
Mobilization of the corporeal bodies with preservation of a tissue bridge between the scrotum and urethral plate. Neurovascular bundle indicated by arrow.

maintain this blood supply to the urethral plate (Fig. 40–5). The urethral plate is then separated from the corpora cavernosa on both sides along its entire length. In so doing, the urethra is freed up entirely from the corporeal bodies but retains its attachments to the prostatic urethra proximally and the glans distally. Dissection is begun on the ventral aspect of the corporeal bodies in order to avoid the less well-defined plane between the urethral plate and corpora dorsally. To prevent bleeding from obscuring one's view, it is best to begin the dissection proximally and work distally along the corporeal bodies. The dissection is carried around the corner of the corporeal bodies toward the urethra, remaining close to Buck's fascia. Inadvertent entry into the urethral plate can occur during this dissection, and thus patience is particularly rewarding during this part of the procedure. Once the plane of separation between corpora and urethral plate has been clearly established and defined by a vessel loop, it should be extended proximally and distally along the length of the corporeal body using both dorsal and ventral dissection. In so doing, the urethra is freed from the corpora from the prostate to the glans. At this point, one can readily appreciate the substantial and elastic nature of the urethral plate.

CORPOREAL MOBILIZATION

For the operation to be successful, the corpora must be adequately mobilized. The corporeal bodies are freed inferiorly and laterally in order for them to have the freedom to rotate medially. This dissection in patients with exstrophy is in virgin territory and is straightforward. The more difficult dissection is that of the corpora from the distal aspect of the pubic ramus. Patients with exstrophy tend to have significant scarring as a result of the original freeing of the prostatic urethra from the pubic symphysis. Thus, judicious sharp dissection is necessary to free the corpora, which need not be completely separated from the pubic ramus, as has been historically described, in order to avoid the risk of vascular injury.

Once the corpora have been fully mobilized, attention is directed to the neurovascular bundles. In order to avoid injury to the neurovascular bundles during the corporeal reconstruction, they are freed up laterally by developing the plane between Buck's fascia and the tunica albuginea with sharp dissection begun well away from the bundles themselves. The dissection is best begun with sharp iris scissors to enter the proper plane, and then blunt-tipped scissors are used to develop the plane without injuring the nerves. The neurovascular bundles are freed proximally and distally with their investing layer of Buck's fascia along the length of the corpora. With complete freeing of the neurovascular bundles as well as the corporeal bodies away from the urethral plate, the dismantling portion of the procedure will have been completed (Fig. 40–6).

URETHRAL RECONSTRUCTION

The urethral plate is carefully examined, and any small rents that may have been produced in the course of the prior dissection are repaired using fine absorbable suture. The urethra is then reconstructed from the prostate to the corona of the glans over a 10 French Silastic tube with several side holes placed proximally in the bladder end.



Figure 40-6
Completed dissection before reassembly. A Silastic stent emanates from the bladder neck and overlies the freed urethral plate. Vessel loops around the corporeal bodies are shown by large arrows. Vessel loops around the freed neurovascular bundles are shown by small arrows.

Because the tube can slip during the course of the subsequent reconstruction, it is helpful to position it optimally and to mark with a suture the point at which the tube should exit the urethral meatus. The urethral plate is reapproximated using interrupted 6-0 Maxon sutures or polydioxanone sutures (PDS) to preserve its elasticity. Closure of the glanular urethra is deferred until later in the procedure.

CAVERNOCAVERNOSTOMY AND CORRECTION OF ROTATIONAL DEFORMITY

Before reconstructing the corpora, an artificial erection is obtained with a butterfly needle in each corpus because of the absence of cross-circulation between corporeal bodies. This invariably demonstrates persistent dorsal curvature of the phallus, despite complete freeing of the corporeal bodies from adjacent tethering bands and from the urethral plate. It is important to note the point of maximal corporeal angulation. Correction of the corporeal rotation begins by dropping the urethra into a ventral location relative to the corporeal bodies. This reconstitutes the normal anatomic relationship of the urethra to the corpora. At the point of maximum corporeal curvature, transverse incisions are made on their dorsolateral aspect. At this point, the benefit of dissecting the neurovascular bundles away from the corpora is realized because one can incise the corpora generously (approximately 1.5 cm) and safely. It is interesting to note at this point that the transverse incisions result in diamond-shaped defects as the corpora spring distally approximately 1 to 1.5 cm. The corpora are then rotated dorsomedially over the urethra, and the two diamond-shaped defects, resulting from the transverse incisions in each corporeal body, are approximated in a cavernocavernostomy (Fig. 40–7). A running, double-armed 5-0 Prolene stitch is used with a knot inside the vascular lumen of the corpora. This results in a 90-degree rotation

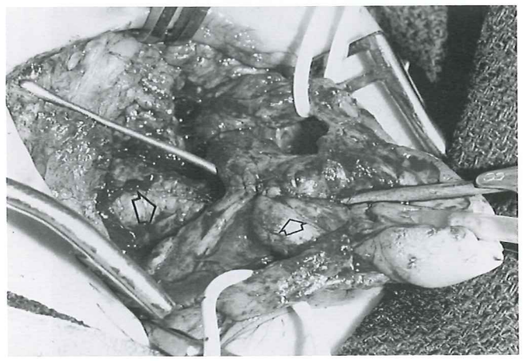


Figure 40-7
Completed cavernocavernostomy overlying the reconstructed urethra. The groove director lies between the urethra below (large arrow) and the cavernocavernostomy above (small arrow). Vessel loops are around the neurovascular bundles.

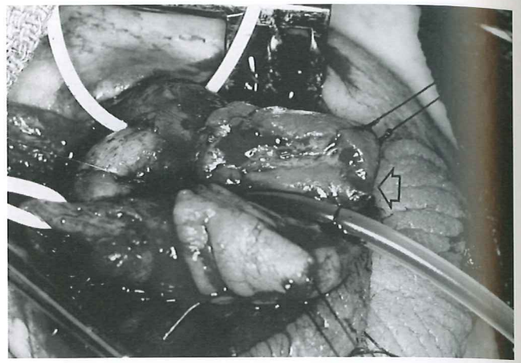


Figure 40-8
Excision of a large triangular area of glans wing (arrow).

of the corpora dorsally and in dorsolateral rotation of the neurovascular bundles, into a more normal anatomic orientation. One can readily recognize at this point that the penis, rather than having dorsal chordee, now is oriented in a more normal, ventral direction.

GLANULOPLASTY

The glans repair is begun by excising a large triangular area of lateral, irregular glans wing tissue bilaterally. The excision should begin at the ends of the transverse closure and extend proximally to the corona of the glans bilaterally (Fig. 40–8). It is important to be aggressive in that inadequate excision of glans wing tissue may result in a midline dorsal groove. Once glans wings are excised, two bared areas of glans epithelium result. A deep, urethral layer of glans tissue is then approximated with a running 6-0 Maxon or PDS stitch beginning at the urethral meatus, which has been produced by approximating the ends of the transverse glans closure dorsally. Before the glans closure is completed, the rotation of the cavernocavernostomy

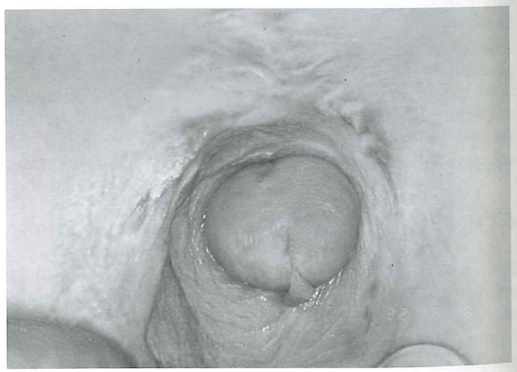


Figure 40-9
Glansplasty at 6-month follow-up.

should be reinforced with two or three interrupted Maxon sutures, approximating the corpora distal to the cavernocavernostomy and just proximal to the corona of the glans. The superficial glans skin is then approximated using a subcuticular 6-0 Maxon stitch. This approach has produced a particularly satisfying cosmetic result with a minimally visible glans scar (Fig. 40–9).

SKIN COVERAGE

Reliable dorsal skin coverage is achieved by rotating a transverse island flap of the inner layer of ventral preputial skin dorsally over the distal penile shaft. Proximal penile skin coverage is achieved by rotating the remaining ventral preputial skin to the dorsum bilaterally and performing a Z-plasty of the distal abdominal wall incision. The Z-plasty results in two triangular flaps that may be approximated at the base of the phallus. This approach provides tissue for proximal penile skin coverage, avoids the hollow that sometimes results at the junction of the pubis and the penile shaft, and avoids a midline scar extending to the base of the phallus, which might be predisposed to contracture.

DRESSING AND POSTOPERATIVE CARE

The penis is encased in a Silastic foam dressing that is secured to the lower abdominal wall with a six-legged Elastoplast wrap. The Silastic stent is allowed to drain into a double diaper postoperatively. Patients are maintained on broad-spectrum oral antibiotics. They may be discharged to home after 1 or 2 days in hospital, when pain control with oral analgesics is effective. Children are seen in the outpatient setting at 1-week intervals until the dressing and stent are removed 2 to 3 weeks postoperatively.

Selected Readings

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CHAPTER

41

Epispadias Repair Using Complete Penile Disassembly

MICHAEL E. MITCHELL

The anatomy of an epispadic penis is unique and *not* analogous to that found in hypospadias. Hypospadias represents fixation at a step in normal development, a true malformation, whereas epispadias represents a deformation of normal development. This concept is probably best appreciated in the epispadias associated with bladder exstrophy. In patients with exstrophy, the pelvis is open and the bladder neck and urethra are thrust anteriorly such that the position of the urethral plate is on the *dorsum* of the corpora cavernosa. The corpora are separated and rotated laterally. Unlike hypospadias, however, in which the distal urethra (spongiosa) is hypoplastic, the urethral plate in epispadias is open *but completely developed*. The deforming process prevents closure of the urethra and causes anterior displacement but does not prevent formation of spongiosa (i.e., all parts are present but are changed in position). The corpora are separated but have normal innervation and blood supply, as does the glans. Therefore, repair of epispadias should focus on specific correction of the deformation, anticipating that all components are present but altered in position and closure. This is the basis of this repair.[1]

These concepts are not new. Dr. F.V. Cantwell of Trenton, New Jersey, in 1895 noted that the urethra could be totally dissected off the corpora to facilitate epispadias repair. It is interesting that his view of the mechanism of formation was also that of deformation, "that it is not one of failure of development, but of traumatism to the fetus."[2]

Cantwell did dissect the urethral plate off of the distal corpora but did not make an effort to separate the corpora totally because he failed to deglove the penis. He made a groove between the corpora and rolled them together over the urethra, which was tubularized. Cantwell reported two cases in his early experience. Subsequent investigators, however, had difficulty with the Cantwell procedure. They were apparently concerned with blood supply of the urethral plate and therefore developed procedures that left the urethral plate adherent to the corpora (one or both corporeal bodies). Unfortunately, this ultimately resulted in dorsal location of the urethral plate. It is now acknowledged that the urethral plate has a unique blood supply from the prostatic urethra and is usually of adequate length to bring to the tip of the penis. It does *not* have significant blood supply from either the corpora or the glans.

Pathologic deformation of the glans results in failure of fusion of the glans halves. The blood supply to each is from the dorsal complex, which is also split, each side located on the *lateral aspect* of the corpora cavernosa. The pathology of the corpora cavernosa is that of *lateral rotation* (the dorsal complex is usually located 90 degrees rotated to the side) and proximal displacement laterally because of fixation to the pubis. Dorsal chordee may occur because of dorsal/ventral corporeal disproportion, but I believe that this is caused by failure to remove the dorsal plate soon enough (i.e., the dorsal disproportion of the corpora is a time-dependent deformation caused by scarring from previous surgery or failure to correct the epispadias *early* enough). A complete penile disassembly (CPD) uses the unique aspect of each of the components of epispadias to facilitate repair. The advantages of CPD are (1) complete ventral positioning of the urethral plate, providing a straight, smooth urethra; (2) freedom of glans rotation and closure, repair not dependent on the urethral plate; and (3) maximal degree of freedom of corpora cavernosa reapproximation.

PROCEDURE

CPD can be performed at the time of bladder closure with bladder exstrophy or independently. One of the important aspects of CPD is that the bladder neck and proximal urethra can be moved posteriorly to facilitate appropriate bladder neck repair and placement in the pelvis, ultimately increasing the potential for continence. Illustrated in Figure 41–1 is the CPD technique in a patient with exstrophy and a failed bladder closure. Figure 41–1 demonstrates the dorsal chordee and the open bladder at the base of the penis. Posterior or anterior osteotomies may be performed before closure and before epispadias repair. Osteotomies are not essential, in general, for epispadias repair but often are essential for bladder closure.

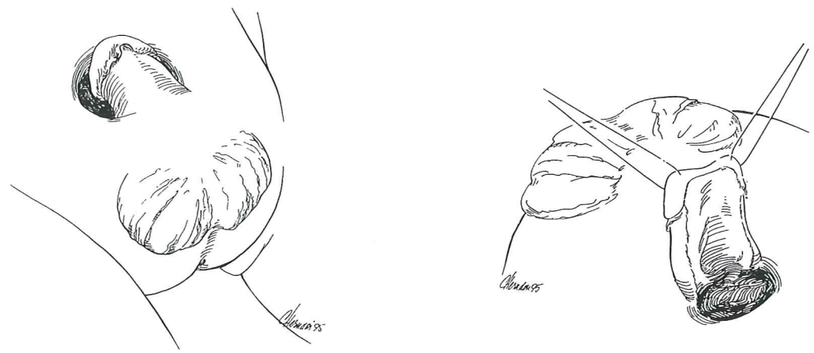


Figure 41-1
A: Penopubic epispadias with dorsal deflection. Bladder hernia is evident at the base of the phallus. *B*: Traction sutures placed transversely at the tip of the epispadias.

The patient is placed in the supine position with the legs in frog-leg position. Traction sutures are placed in the glans horizontally as shown (Fig. 41–1*B*).

The initial dissection is started after outlining the urethral plate. I find it easiest to mark the entire urethral plate to identify all epithelium.

The initial incision outlines the urethral plate and is extended along the ventral aspect of the distal penis at the base of the glans. It is easiest to *perform the ventral dissection first*, because Buck's fascia is easily defined here. Dissection should be carried well back on the base of the penis, as shown in Figure 41–2*A*. The paired dorsal complex can usually be seen through Buck's fascia, extending down the lateral aspect of each of the corporeal bodies.

The urethral plate is then dissected from the corpora. The plane of this *dissection is on the tunica albuginea* of the corpora. This is very different from the plane that was dissected on the ventral aspect of the penis (which was outside of Buck's fascia)(Fig. 41–2*B*). This is a very important point. The urethral plate is dissected in its entirety from the corpora, then distally to its tip, and then peeled back proximally as shown in Figure 41–3*A*. This dissection can be made with great impunity right to the base of the corpora to the point of their separation and beyond. The blood supply to the corpora comes through the central artery. There is little danger of injury to these vessels as long as dissection is along the medial aspect of the corpora (Fig. 41–3*B*).

After the urethral plate is completely dissected off the corpora cavernosa, the *corpora cavernosa should be separated completely.* The *dissection* is carried posterior *well beyond the point of original separation of the corporeal bodies*. This enables the bladder neck and proximal urethra to sink deep into the pelvis. The bladder can be closed and the urethra can be tubularized at this point (Fig. 41–4*A*). Two layers of absorbable sutures are used for this process.

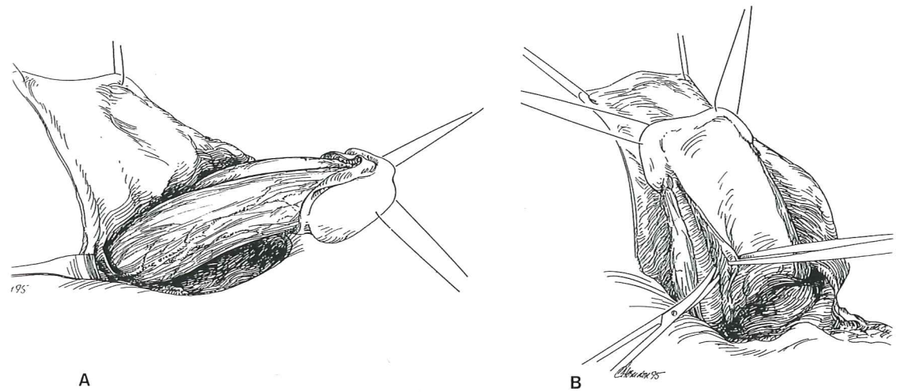


Figure 41-2
A: Initial dissection is on the ventral aspect after circumcision excision. The dissection is along the dartos fascia. The dorsal neurovascular complex can be observed on the lateral aspects of the corpora cavernosa. *B*: Dissection of the urethral plate off the corpora cavernosa is along the tunica albuginea.

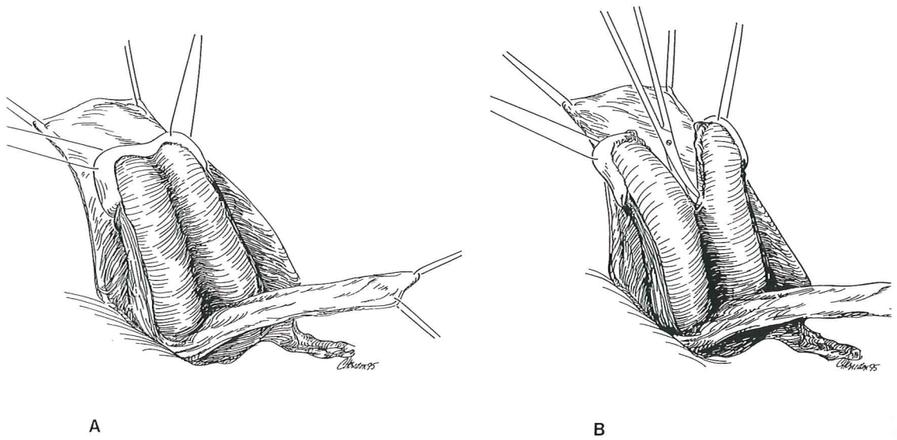


Figure 41-3
A: The urethral plate has been dissected off the corpora cavernosa. *B*: The corpora cavernosa are separated. The tissue that is incised at this point is the ventral aspect of Buck's fascia.

The urethra is closed first with a 7-0 Maxon, followed by a 6-0 polydioxanone suture (PDS) (Fig. 41–4*B*).

Once the urethra is tubularized (the illustrations show two pediatric feeding tubes [5 French], or a single 8 French pediatric feeding tube can be left in the urethra), it is placed between the base of the corpora. The corporeal bodies are then rotated medially, bringing the neurovascular bundles to the dorsum (Fig. 41–5*A*). The edge of the Buck's fascia can usually be approximated, but care must be taken not to injure the dorsal complex with this process. This medial rotation usually results in complete straightening of the penis and correction of the dorsal chordee. If, at this point, the dorsal chordee is not acceptably corrected, erectile measurements can be made by placing vessel loops on the proximal corporeal bodies independently and performing an erection test on *each* body (independently or simultaneously). The deep stitches in the dorsal glans may be placed at this time as well (interrupted 6-0 PDS). It is usually necessary to remove an additional wedge of tissue from each side of the glans on the dorsum to make the dorsal glans repair perfectly smooth.

The urethral plate is then placed in the ventral groove in its normal anatomic position, and the ventral aspect of the glans and meatus are created using interrupted 7-0 Vicryl sutures for the meatus and two layers for the glans closure (inner layer of 6-0 PDS and interrupted Vicryl for

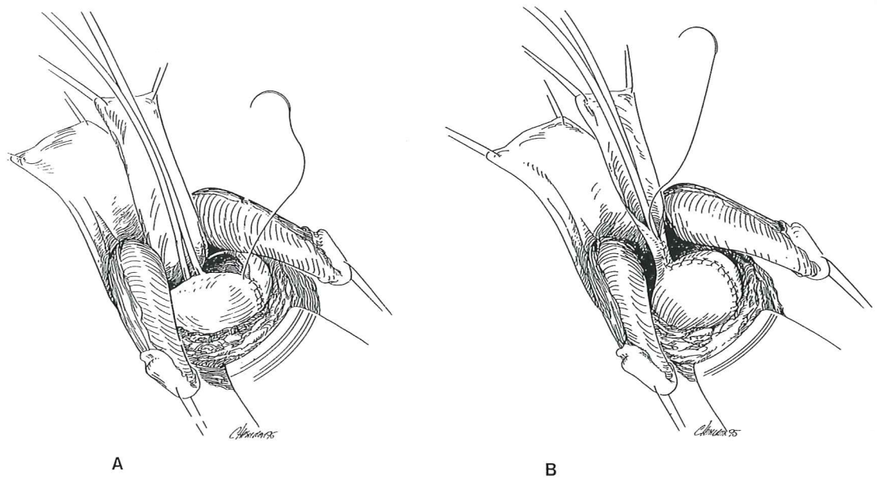


Figure 41-4
A: The bladder is closed in two layers. *B*: The urethra is tubularized. No effort is made to narrow the bladder neck, but dissection on the tunica albuginea of the corpora can be extended posteriorly so that the bladder neck can be placed deep in the pelvis. Note that the bladder, bladder neck, and urethra can be moved en bloc posteriorly after this dissection.

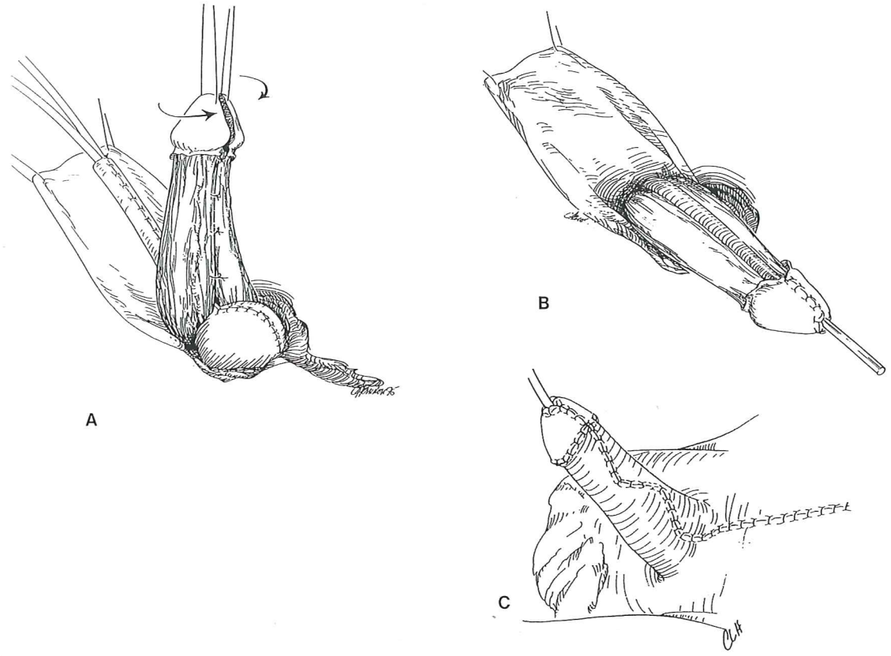


Figure 41-5
A: The tubularized urethra is placed on the ventral surface. The corpora are rotated medially, bringing the neurovascular complex to the dorsum of the penis. *B*: The distal tubularized urethra is brought out the tip of the glans, and the glans has been repaired. This is a view of the ventral aspect of the penis. *C*: The dorsal glans repair is completed, and skin coverage of the penis is completed. Z-plasty is used to prevent contraction of a linear scar along the dorsum of the penis.

the glans). The resultant meatus should be in an orthotopic position (Fig. 41–5*B*). Note that the urethra lies in a ventral groove and adjacent to the tunica albuginea of the medially rotated corpora cavernosa.

The skin closure is then performed by mobilizing skin from the ventral aspect to cover the dorsum of the penis. Ideally, the dorsal suture line is in the form of a Z-plasty to prevent linear contraction (Fig. 41–5*C*). In many patients, it is usually necessary to trim some of the distal prepuce. This is usually true if the urethral plate is long enough to reach the tip of the penis. In patients with a short urethral plate, the redundant prepuce can be used for distal urethroplasty as would be performed in a hypospadias repair. During skin closure on the dorsum of the penis, it is usually helpful to place a deep suture of 5-0 or 4-0 PDS at the base of the penis to prevent the skin from slipping down the corpora and producing a buried penis. This suture also closes the dead space at the dorsal base of the penis, which can be the site of fluid collection and edema that tends to lift the shaft coverage skin, resulting in disruption of the penile coverage.

We apply a standard penile dressing that we use for hypospadias and epispadias repair. This includes a patch of Telfa dressing material over suture lines, a thin DuoDerm dressing applied in a circumferential manner (the penis must be totally dry to permit its adhesion), and Tegaderm applied on an outermost layer to prevent slippage of the dressing. This Tegaderm extends onto the abdominal wall and scrotum to fix the dressing. The bladder is drained with a 5 or 8 French pediatric feeding tube for a period of approximately 1 week. It is possible to perform the epispadias repair as an outpatient procedure; however, it is sometimes beneficial to observe these patients overnight in the hospital.

References

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2. Cantwell F: Operative treatment of epispadias by transplantation of the urethra. Ann Surg 22:689, 1985.

CHAPTER

42

Epispadias Repair in the Adolescent

C. R. J. WOODHOUSE

Epispadias, classic exstrophy and its variations, and cloacal exstrophy form a spectrum of malformations in the development of the cloaca and genitalia.

Although the severity of the abnormalities varies from one end of the spectrum to the other, the basic anatomy is the same in all cases of exstrophy and epispadias with an open pelvic ring. Successful reconstruction of the genitalia depends on an understanding of these anatomic details.

By the time an affected child becomes an adolescent, the anatomy may have been changed (for better or worse) by the early reconstruction. In particular, since the erectile deformities have been defined,[1] the incidence in adolescents has declined.

The increase in the number of patients who have exstrophy and who void through their urethra should decrease the difficulties in adults. It is not easy to keep a dry urethra fully patent.

The better surgical results reported in infancy are welcome. It must be remembered that adolescents have different ideals than children, and later adjustment, particularly of the angle of erection, may be necessary.

MALES

Genital Anatomy

The orientation of the inferior pubic rami and the attachments of the deep parts of the corpora are unlike those of normal males. The findings on cavernosogram, computerized tomography (CT), and surgical exploration are consistent.[2] Not only is the symphysis open, but the pelvis is rotated caudally so that the inferior pubic ramus is parallel to the floor when the patient is standing (Fig. 42–1).

The oblique view of the pelvis gives a true lateral of the inferior pubic ramus. The orientation of the inferior pubic rami is seen in Figure 42–2. Cavernosogram in this projection shows that the deep parts of the corpora are similarly horizontal.

Cavernosograms and CT scans of patients with exstrophy compared with those of normal men show the reason for the shortness of the penis. It is not, as might be thought, that the symphysis is open and that most of the penis is thus buried in the perineum. The corpora are actually deficient in length although of normal caliber. The penis is longer, however, if the divarication of the pubic bones is 3 cm or less, and it is shorter if the divarication is 4 cm or more.[3] In the past, surgical apposition of the pubic bones was said not to lengthen the visible penis.[4] Osteotomies performed in infancy may be more effective.

McLorie and colleagues have tried to establish an experimental model for the penile deformity using an inflatable penile prosthesis attached to a normal adult pelvis. They demonstrated that the visible penis was longer when the pubic ring was closed.[5] It seems unlikely that these findings can be translated to the abnormal penis and pelvis of patients with exstrophy.

The blood supply of the penis in a patient with exstrophy has not been fully investigated. Postmortem examination of an infant who had cloacal exstrophy and who died 72 days after birth has produced some interesting information. The arterial supply to the penis was from pudendal arteries that traveled in the perineum, with the

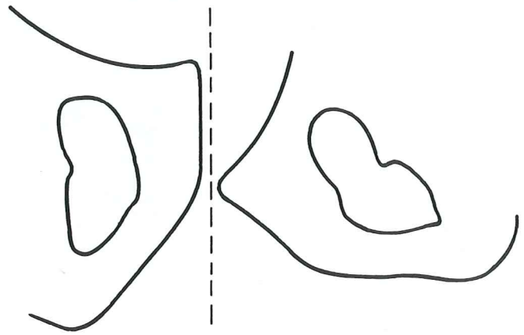


Figure 42–1
Diagram of the pelvic orientation: left, normal, and right, exstrophy. (From Woodhouse CRJ, Kellett MJ: Anatomy of the penis and its deformities in exstrophy and epispadias. J Urol 132:1123, 1984; with permission.)

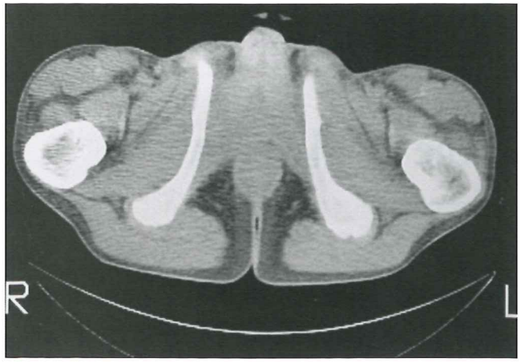


Figure 42–2
Pelvic computed tomography in an epispadiac patient showing the relationship of the corpora to the pubis. Note that the inferior pubic ramus is parallel to the floor.

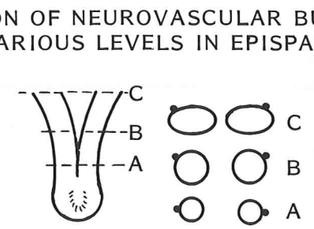


Figure 42–3
Diagrams of the anatomy of the superficial neurovascular bundles in exstrophy. Left, dorsal view of the penis; right, transverse sections at the levels indicated showing the bundles. (From Hurwitz RS, Woodhouse CRJ, Ransley PG: The anatomical course of the neurovascular bundles in epispadias. J Urol 136:70, 1986; with permission.)

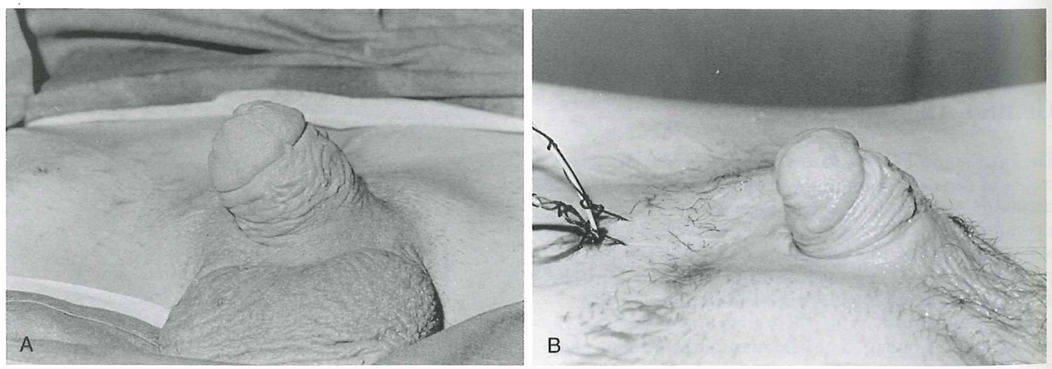


Figure 42–4
Clinical photographs of the adult flaccid exstrophy penis.

somatic nerves, and supplied the corpora. The venous drainage traveled subcutaneously through the inguinal canals and into the external iliacs. The autonomic nerves lay in the midline in front of the sacrum and then split and pierced the pelvic floor on each side medial and posterior to the bladder.[6]

Obviously, it is uncertain how much of this anatomy is applicable to classic exstrophy. The flow of contrast that occurs with cavernosography and the operative findings suggest that the arterial supply of the penis in exstrophy comes from the pudendal vessels that pass through Alcock's canal. The venous drainage is less clear and may be duplicated through Alcock's canal and through the inguinals. No cross-circulation takes place between the corpora.

The position of the superficial neurovascular bundles reflects the lateral rotation, or kippering, of the corpora. They lie in the true lateral position in the distal and middle portions of the corpora and move dorsolaterally as they pass proximally (Fig. 42–3).[7]

The urethral plate is on the dorsum of the penis and is, by definition, open. Surgical dissection in adults suggests that a layer of erectile tissue extends along the proximal two thirds of the ventral aspect and corresponds to the corpus spongiosum.

The fate of the bulbospongiosus muscle is unknown. Logic would suggest that it is present in some form. It might well be too small to identify in neonates and perhaps is destroyed in the primary reconstruction. In adults who have had little dissection in childhood, a thin layer of muscle that can be found at the base of the penis extends from the urethral plate to the pubis on either side. This might represent the bulbospongiosus.

The prostate is present. In the initial dissection in a neonate, it is detached from the penile urethra and remains in its normal relationship to the bladder base. In a series of 13 adult men (4 of whom were continent) assessed by magnetic resonance imaging, the prostate was found to have a mean weight of 21.7 g, which is normal for age. In all cases, the prostate was posterior to the urethra so that it could not provide any outflow resistance. The puborectalis muscles were widely separated.[8] The verumontanum, which is normally positioned, is a useful landmark for surgery in later life.

Appearances in Adults

The adult epispadiac penis is short (Fig. 42–4). It often appears broad because of the separation of the corpora but is, in fact, of normal caliber. The abnormalities may be exaggerated by the recession of the suprapubic area (Fig. 42–5), absence of the mons pubis, and the normal size of the scrotum.

Modern reconstruction attempts a midline closure so that the hair grows as a normal triangular escutcheon. It is not always successful. In the older reconstructions with W skin flaps and in the newer closure with less than perfect results, the pubic hair grows on either side of the pubic area (Fig. 42–6).

The shape of the erect penis depends on the initial reconstruction. In the natural state, the erect epispadiac



Figure 42–5
Clinical photograph showing the recession of the suprapubic scar commonly seen in exstrophy.

penis has a tight dorsal chordee (Fig. 42–7). Cavernosogram in these cases shows that the site of the maximum curvature is at the point where the corpora emerge from the perineum.[1] Increasing awareness of this problem has modified the reconstruction in infancy, and a more normal angle of erection can be produced.[9]

The degree of chordee is variable. In some, the angle is such that sexual intercourse is possible either in the conventional position or in one that brings the female introitus in more direct apposition to the penis.

It might be thought that this deformity was due to the



Figure 42–6
Clinical photograph showing the distribution of pubic hair commonly seen in adults with exstrophy.

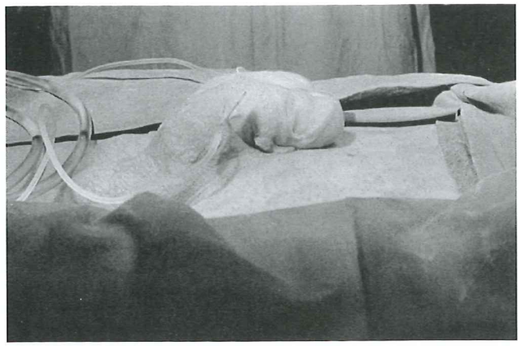


Figure 42–7
Clinical photograph showing an artificial erection with tight dorsal chordee in an exstrophy penis.

scar tissue around the dorsally placed urethra. It has been said that clearance of the scar and detachment of the urethra correct the chordee.[10] I have found this to be so in only 1 of 32 cases postsurgically. Although the original problem may have been a congenitally short urethral plate, by adulthood the basic problem is intrinsic curvature of the corpora.

A more complex deformity occurs when one or both of the corpora are damaged in the initial surgery so that they fail to fill completely. If one corpus fails to fill on erection, it acts as a bowstring on the other and causes lateral deviation in addition to the dorsal chordee.[1]

If both corpora are rudimentary, the visible or exophytic part of the penis is normal except that it is a little higher on the abdomen than usual. On cavernosography, the corpora appear to have no attachment to the pubic rami. Erection is very limited, and the penis unstable. In one of my patients, the whole of one corpus and the exophytic part of the other are missing so that no penis is visible at all.

The evidence suggests that the corpora are normal at birth and are damaged at the primary (and revision) reconstructive surgery.[2, 11] The current incidence of types of erectile deformities in adult patients with exstrophy is shown in Table 42–1.

Awareness of the erectile problems and appropriate reconstruction in infancy may improve the function in adults. Although the techniques reviewed by Snyder[9] have not been in use long enough to allow adult follow-up, results from the Mayo Clinic suggest that modern techniques of reconstruction do lead to just this situation. A short but normal penis with a normal angle of erection was found in 24 of 44 adults.[12]

Table 42–1
Incidence of Erectile Deformities in Exstrophy and Epispadias

Dorsal chordee	77%
Unilateral rudimentary corpus	9%
Bilateral rudimentary corpus	14%

Investigation

An artificial erection, either by intracorporeal injections of prostaglandin E_1 or by infusion, demonstrates the erectile deformity. It does not define the anatomy of the deep portion of the corpora. Unless a patient describes an uncomplicated dorsal chordee and the deep parts of the corpora are palpably normal, a cavernosogram is essential.

The cavernosogram technique is modified from that described by Herzberg and colleagues.[13] The corpora must be infused separately because of the absence of cross-circulation; 120 ml of 65% Urografin in 250 ml of physiologic saline is used. A pressure of 300 mm Hg is generated by Fenwall bags. The corpora are punctured with 19-gauge butterfly needles. No tourniquet should be used because it would obscure the true chordee, which occurs in the deep part of the corpora.[1]

Surgical Reconstruction

Procedures for Lengthening the Penis

The anatomic evidence outlined earlier shows that the corpora are deficient in length. Increase in the length of the visible penis can be achieved only by making the best use of the corpora distal to their attachment to the inferior pubic ramus. Some additional length may be achieved by osteotomy to close the pubic symphysis in the first few days of life. Whatever the situation in infants, pelvic osteotomy does not seem to be a very attractive option for adults.

In some patients, the corpora may have undergone concertina-like contraction and scarring of the urethral plate and pericorporeal tissue. Considerable lengthening can be achieved in children by clearing it all away and cleaning the corpora.[14] This dissection is the first step in chordee correction, but in my experience with adults, it has not allowed any penile lengthening. It may be that by this stage in life, secondary and irreversible changes have occurred in the corpora.

The horizontal plane in which the inferior pubic rami lie prevents lengthening of the penis by partial detachment of the corpora. Some length is gained by dissection from the body of the pubis, but it is useless to continue it posterior to the junction with the inferior ramus. Complete detachment of the corpora from the inferior pubic rami is said to have given good lengthening in 9 of 11 children.[15, 16] Follow-up is lacking, however, and the procedure could damage the blood supply reaching the corpora through Alcock's canal.

Thus, it seems that in adolescents and adults there is no worthwhile procedure for lengthening the penis. Skillful chordee correction gives a little increase in length and allows the best use to be made of the length that is available.

Appreciation of the erectile deformities has improved reconstruction in infants. Maximum possible release of the corpora and correction of the chordee by the Cantwell-Ransley technique (discussed later) can produce a nearly normal penis in childhood. Perovic and colleagues have reported that the penis of infants is similar in length to that of normal boys although slightly different in appearance.[17]

Correction of Erectile Deformities

SELECTION

The penile anomaly should ideally be corrected at the time of the initial reconstruction in infancy. Release of the urethral plate and chordee and partial detachment of the corpora from the pubis are considered essential steps.[9] It is rare for correction to be completed in a single stage, and the mean is 1.6 operations (range 1 to 4).[12]

It is best to achieve complete reconstruction in infancy and to allow a child to grow up looking as much like his peers as possible. The appearance and function of the penis are of paramount importance to adolescents with exstrophy.[18]

I must offer a word of caution, however. The complex erectile deformities that I have seen in some patients are due to rudimentary corpora; it is most likely that they were normal at birth and were damaged by surgery in infancy. Although many techniques are now available for reconstructing a nearly normal bladder from scratch, we so far have no operation to restore the corpora, let alone construct a penis with sexual sensation and function.

The patients who are now adults have some degree of erectile deformity and many require phalloplasty. Careful selection is important. It is preferable to wait until penile growth is complete at the end of puberty and until the boy has developed emotionally so that he understands the purpose of the operation. It is not satisfactory to embark on a program of cosmetic operations if a patient cannot see anything wrong with his existing anatomy. Having an understanding partner and having tried to have intercourse are helpful, but I certainly would not wait until repeated failures have damaged his ego.

RECONSTRUCTION

Several methods of correcting the deformities of the penis of patients with exstrophy have been described. If the deformity is considered as a curve in a parallel-sided cylinder, two basic methods are available for its correction: lengthening of the concave side or shortening of the convex side. The techniques developed for Peyronie's disease are applicable.

Shortening of the convexity is relatively simple by the Nesbit procedure. No dissection on the dorsum is required. The urethra normally lies on the dorsum and thus is not affected by the surgery.

Lengthening of the concavity by implantation of some material in the corpora produces slight lengthening (Fig. 42–8). In Peyronie's disease, many autologous and heterologous materials have been used. In exstrophy, only dermal graft and lyophilized dura mater have been reported.

The results of using dura were good, and so it is disappointing to find that the sterilization procedures may not kill all the viruses in the material. In one case, Creutzfeldt-Jakob disease developed in a 28-year-old woman who had received a dural graft 22 months earlier.[19] Although differ-

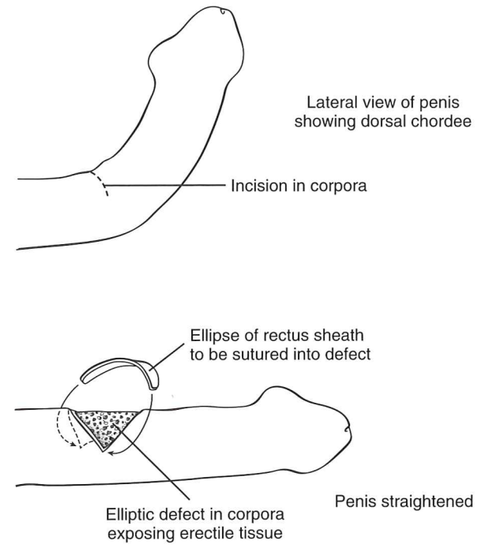


Figure 42–8
Diagram showing the principle of tissue inlay in the dorsum of the penis to correct chordee.

ent sterilization processes are followed by manufacturers in different countries, all preparations may carry a risk of transmitting viral diseases.

When an implant is needed, dermal graft, rectus sheath, or tunica vaginalis may be used instead of dura.[11, 20, 21]

The Koff procedure is an ingenious method of rotating the corpora so that their curvatures cancel out and the resulting angle of erection is satisfactory.[22] The technique has been modified and is commonly known as the Cantwell-Ransley operation (Fig. 42–9). Reports of its use in infants and adolescents show that the short-term results are very good and the complication rate low. Gearhart and associates used it on 26 infants, all of whom have had a good cosmetic result.[23]

An interesting comparison of different techniques for reconstruction in infants has come from Ransley's own unit. He originally used a classic staged repair, later augmented with a dural implant. In the second half of his series, he used corporeal rotation (the Koff technique) and then the cavernocavernostomy (Cantwell-Ransley). The cosmetic result was judged to be acceptable in 40% of the earliest cases, rising to 84% in patients having a Cantwell-Ransley procedure. Similarly, 50% of the early patients required radical revision, usually using the Cantwell-Ransley procedure. The follow-up obviously is very short for the more recent patients (4 years compared with 9 years). Furthermore, all of these patients underwent operation in infancy (3 to 4.8 years), and some deterioration is possible with age. In children, it is difficult to assess the angle of erection and its suitability for intercourse.[24]

The difficulty with the Cantwell-Ransley technique in adults is that the corpora are sometimes too far apart. If the cavernocavernostomy is made at the point of maximum

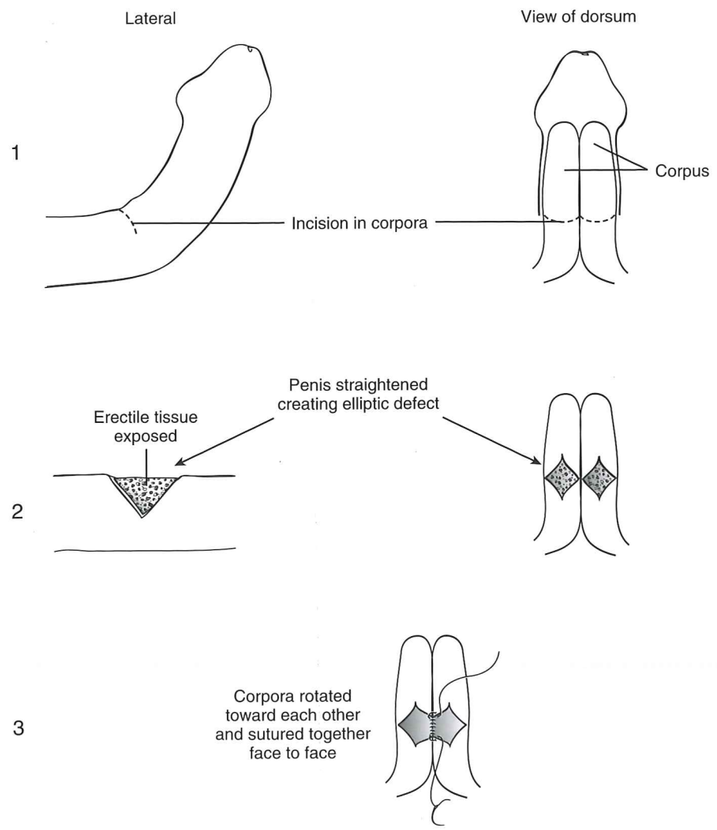


Figure 42–9
The Cantwell-Ransley operation: steps in a rotational phalloplasty. 1. The incision in the corpora seen from the dorsum and laterally. 2. The corpora straightened out. 3. The corpora rotated toward each other and the openings in the corpora sutured together face to face.

curvature, the result may be kinking or an hourglass deformity of the penis. Before deciding on the technique to use, a few trial sutures should be put in to test the effect of the rotation. If the deformity is too great, either an implant on the dorsum or a Nesbit procedure on the ventral aspect will have to be used.

The indications for the various reconstructions are listed in Table 42–2.

The Urethra

The urethral plate in exstrophy is on the dorsum of the penis and is too short. Current techniques of reconstruction use the urethral plate to form the complete urethra. Complete mobilization from the corpora and transfer to the ventral aspect make the reconstruction easier and aid in the chordee correction.[23, 24]

When performing a phalloplasty in an adult, the urethra is nearly always too short; I use the length available to form a urethrostomy at the penoscrotal junction.

At a second stage, if the patient wishes, I perform a urethroplasty by rolling a tube out of ventral skin to bring the meatus to the tip of the glans. I have found the complication rate to be high. Even when the short-term result is good, a dry urethra is difficult to keep patent; patients frequently develop strictures resulting in absent ejaculation and sometimes painful orgasm.

Seldom is enough skin available to allow urethroplasty at the same time as penile straightening. On two occasions, patients with a urinary diversion have had enough remaining bladder to mobilize a strip of urothelium and detrusor on a pedicle from the bladder neck area. The strip is rolled into a tube and brought to the tip of the glans as a urethra.[24]

Of 13 urethroplasties in patients with urinary diversion, only 6 have achieved a complete urethra without any fistula or stricture. The remainder have been left with at least one small fistula (or worse) and have declined further reconstruction. Such poor results do not encourage patients to undergo secondary urethroplasty.[25]

Table 42–2
Current Concepts for Correction of Erectile Deformity in Epispadias

Deformity	Corrective Procedure
Dorsal chordee	
Mild	Nesbit
Major (minimal separation)	Cantwell-Ransley
Major (wide separation)	Inlay rectus sheath
Single rudimentary corpus	Inlay rectus sheath + Nesbit
Bilateral rudimentary corpus	Leave alone

The Mons Pubis (Both Sexes)

In adult patients with exstrophy, the pubic area is at present nearly always recessed from the uncorrected divarication of the pubic bones. The pubic hair lies on either side of the midline.

It is most important in either infancy or adolescence to rotate hair-bearing flaps of skin and fat to cover the midline defect. The flaps may be based laterally or inferiorly (Fig. 42–10).[26, 27] Although the inferiorly based flaps have been described only for females, they should be equally applicable to males. If too little skin is available, larger flaps can be created by the use of skin expanders.[28]

The scarred and nonhairy skin from the midline (see Fig. 42–5) is excised. In females, this excision may be continuous with that from the anterior end of the labia (discussed later).

Flaps of hair-bearing skin, including all of the subcutaneous fat, are then mobilized and rotated to fill the defect (Fig. 42–11). In females, the defect left by repositioning the flaps can be primarily closed. In males, it is often necessary to bring up some scrotum to fill the defect.

Sexual Function

Orgasm is normal in patients with exstrophy. In an early review of adult patients, all but 2 of 31 patients ejaculated.[29] In another series, 16 of 25 patients had ejaculation but its quality was not recorded.[12] Although poor or absent ejaculation may follow genital reconstruction, absence of ejaculation is rare but the emission that does occur is slow and may continue for several hours after orgasm. Some patients describe a more or less continuous urethral discharge of semen-like fluid.

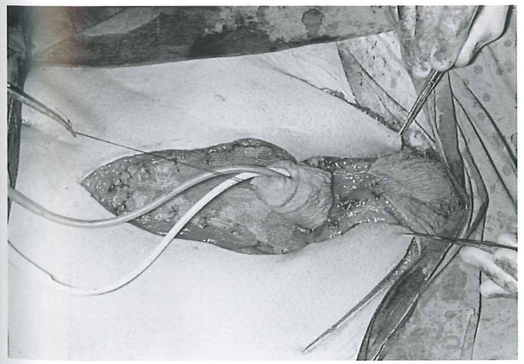


Figure 42–10
Operative photograph showing the laterally based, pubic hair–bearing skin flaps being rotated to the mons veneris. (The patient has also had a midline hernia repaired with plastic mesh, which can be seen in the wound. He also has two urethrae, which have been catheterized.)

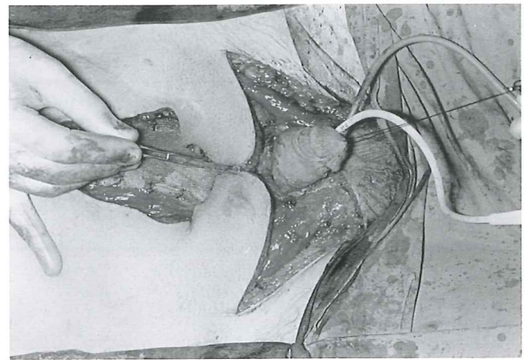


Figure 42–11
Hair-bearing skin flaps have been mobilized and rotated to fill the midline defect.

With or without surgical correction, men appear to have a normal libido. They have few casual sexual partners. They appear to form very stable partnerships with normal women and have a normal family life.

In my own series, 33 of 43 men for whom full information is available have been married or have lived with a partner. Only one patient is known to be homosexual. One patient with epispadias has doubts about his sexual identity: He may eventually seek gender reassignment. The remaining patients of all ages do not admit to any sexual contact, and for many of them the combination of abnormal genitalia and an external urinary diversion seems to be too overwhelming.[26]

Although complete reconstruction in infancy is desirable, later surgery also produces a satisfactory sexual outcome. Using various techniques, Audry and co-workers established normal function in 7 of 14 adolescents or adults.[30] With the Cantwell-Ransley technique, four of seven adolescents have normal intercourse.[17] Obviously, those who were not having intercourse in these series may yet establish sexual relationships.

The effect of exchanging an ileal conduit for an internal continent diversion is striking. I know several young men who lived a celibate existence, apparently because of their abnormal penis. Internal continent diversion gave sufficient self-confidence that they developed relationships with women. For the next generation, a working bladder and counseling of children and parents may further improve sexual function.

A case has been made for early gender reassignment for male infants with a grossly deficient penis and exstrophy, especially cloacal exstrophy.[16] In some cases that have been cited, refusal of such advice by the parents has resulted in poorly adjusted adolescents who commit sexual offenses.[31] In a series of eight males with cloacal exstrophy, only one achieved successful vaginal intercourse. Two were impotent, and three required intensive psychiatric counseling.[32] One of my own patients whose penis is of a reasonable size for exstrophy has served a prison sentence for attempted rape.

Male patients with exstrophy can certainly undergo sur-

Table 42–3
Ejaculation and Seminal Analysis of Patients with Exstrophy or Epispadias

	Reconstruction		Diversion
No ejaculation	6		
Poor ejaculation	23		
Azoospermia	12		16
Poor	6	4*	6
Good	6		17
Paternity	1		7

*Diversion or reconstruction not stated.
Men who claim to have fathered children have not had semen analyses.
Data from references 26, 29, 33, and 34.

gery to become nice-looking little girls.[16] However, male patients with exstrophy reassigned to the female gender have not undergone long-term follow-up, and it is possible that they will be as unhappy as female adolescents as they might have been as males.

Although the genital tract up to the verumontanum is normal, the incidence of poor or absent sperm is high. Of my own patients and of those reported in the literature, about half the men who wish to do so are able to father children (Table 42–3).

The main causes of infertility appear to be early genital reconstruction and repeated prostatic and bladder infections. Thus, ironically, the boys who underwent early urinary diversion have the best record for fertility.[33, 34]

FEMALES

Genital Anatomy

A sagittal section of the pelvic organs is shown in Figure 42–12. It can be seen that the vagina, introitus, and anus all are displaced anteriorly. The vagina is shorter than normal and seldom measures more than 5 or 6 cm but is of normal caliber. The uterus, which is in an almost normal anatomic position, enters superiorly so that the cervix is in the anterior vaginal wall. The ovaries and tubes are normal.

The labia do not meet in the midline anteriorly to form a fourchette. The clitoris is bifid and often quite rudimentary.

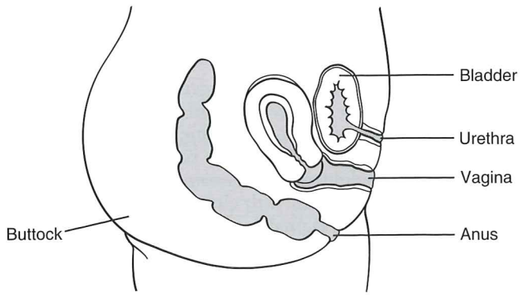


Figure 42–12
Diagram to show a saggital section of the female pelvis in exstrophy.

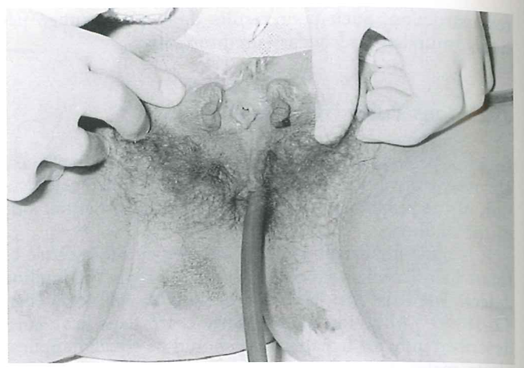


Figure 42–13
Clinical photograph showing the appearance of the vagina in an adult exstrophy patient.

The introitus is very narrow and can be mistaken for a urethra. The narrowing is posterior and is from a more substantial layer than a normal hymen, being in fact the posterior wall of the vagina.

Appearances in Adults

The labia and introitus appear to be structures of the lower anterior abdominal wall (Fig. 42–13). The introitus is narrow (Fig. 42–14), and the anus is in the position of the normal vagina. The bifid and rudimentary labia can be seen. The same abnormality of the pubic hair is seen as in males.

Again, this abnormal appearance is variable, and in some females, the labia are almost in the correct anatomic position. Those with a functioning bladder generally have a more normal appearance; otherwise, the original severity of the epispadias seems irrelevant.

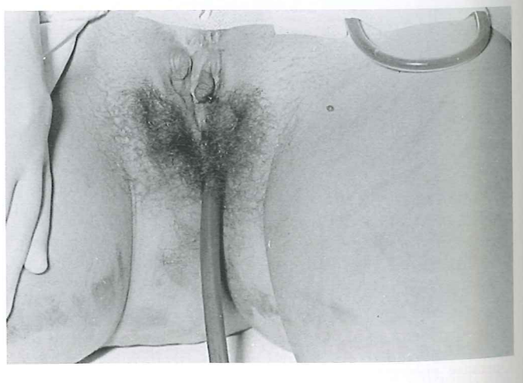


Figure 42–14
Clinical photograph of the female perineum in exstrophy showing the relative positions of the anus and the introitus.

Reconstruction

The Labia

Although the parts of the reconstruction of the female genitalia are described separately, they usually are performed together. They are fusion of the labia anteriorly, opening of the introitus, and reconstruction of the mons pubis.

The object of the labial reconstruction is to unite two halves of the clitoris (assuming that it can be identified) and to fuse anterior ends of the labia to make a fourchette. It is not possible to move the vagina posteriorly to its usual anatomic position, but labial and pubic reconstruction does disguise the abnormality very well.

A diamond-shaped area of skin/mucosa is outlined anterior to the labia and extending down onto the anterior ends of each labium and hemiclitoris (Fig. 42–15). This diamond and the underlying fatty tissue are excised. The defect is then closed longitudinally with fine absorbable sutures such as 5-0 polydioxanone.

The Introitus

Despite the very narrow introitus (see Fig. 42–14), the vagina above is normal. The vagina is opened by performing an episiotomy posteriorly from the introitus until a two-finger opening is created. It is usually possible to close the vaginal mucosa to the perineal skin directly. A flap of mucosa from the medial aspect of the labia is sometimes needed on each side to close the defect. With experience, I have found that the need for formal vaginoplasty for the introitus has decreased from 50% to 25% of cases.

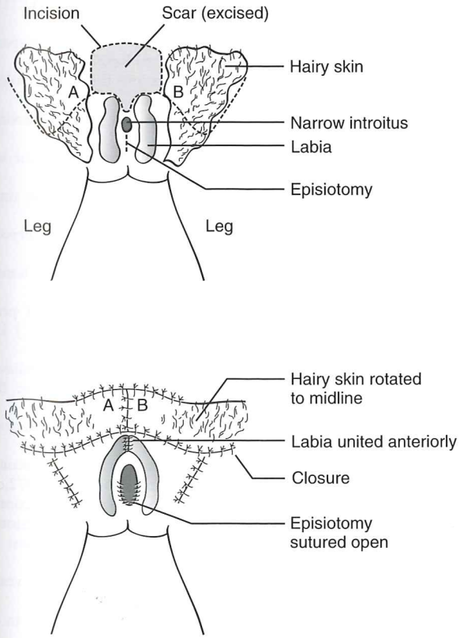


Figure 42–15
Diagram of the reconstruction of the suprapubic area and introitus in a female. The suprapubic scar is excised. The labia are united anteriorly. The hair-bearing flaps are rotated to cover the defect. An episiotomy is made and sutured open.



Figure 42–16
Postoperative clinical photograph.

As with males, a tendency is to reconstruct the genitalia in infancy or childhood. Stein and colleagues suggested opening the introitus and uniting the labia at 3 or 4 years of age.[35] This allows easy drainage of secretions and, later, menstrual flow. The more natural appearance in the school years is welcome.

The Mons

The technique for reconstructing the mons and pubic hair is the same as that described earlier for males. The nonhairy midline scar is excised. The hair-bearing skin flaps are rotated to fill the defect. A postoperative result in a female is shown in Figure 42–16.

Contemporary techniques of primary reconstruction recognize the distribution of hair-bearing skin and position it appropriately. Unfortunately, the benefit of such surgery may be lost if many revision operations cause unsightly midline scars later on. Stein reports excellent results from early reconstruction in 21 of 25 girls reviewed after puberty.[35] Most of these patients had undergone diversion, however, and did not have the sequence of revision operations that is so common after primary reconstruction.

Sexual Function

The vagina extends directly posteriorly so that when the patient is standing her vagina is almost parallel to the floor. It is also rather shorter than usual. These arrangements do not interfere with intercourse: 33 of 47 women in my series have normal intercourse, and none report any difficulties. Orgasm is said to be normal in all patients.[34] All of 19

patients older than 18 years in Stein's series have intercourse, but three consider it unpleasant. The source of unpleasantness is not stated.[35]

Considering the fairly obvious abnormality of the vagina, in both position and appearance, it is surprising that emotional problems are not more common. I am aware of only one patient in my series who has severe problems. Several females note that the rather broad perineum that is a consequence of the outward rotation of the pelvis makes wearing modern narrow-crotched swimsuits impractical.

The cervix enters the superior wall of the vagina and is very close to the introitus. This must contribute to the ease with which these patients become pregnant. It is essential to explain to patients at an early stage that fertility is normal.

The defective pelvic floor and poor uterine supports make prolapse common. It is a considerable problem to correct.[36, 37] Five of my patients have had a total uterine procidentia, and one of these had never had intercourse or a pregnancy. The uterus should not be removed because it is the only solid organ in the pelvis that has any means of holding up the pelvic floor.

For procidentia, the most successful procedure is the Gore-Tex wrap. The sacral promontory is exposed. A strip of Gore-Tex is sutured to the periosteum. The end is passed around the cervix and through the base of the broad ligament and brought back to the sacrum.[38] This procedure has been successful in each of five cases, with follow-up to a maximum of 5 years.

Stein and associates advocate fixation of the uterus to the anterior abdominal wall in childhood. This is said to prevent prolapse but still allow normal pregnancy.[35] Two women were able to have normal pregnancies without prolapse, and one of two women who did not have a fixation had slight prolapse after delivery. This prophylactic surgery may well be helpful. Once prolapse has occurred, however, I have not found an anterior fixation to be an effective repair.

Pregnancy has a poor reputation in women with exstrophy, probably because of the literature review from 1722 to 1958 by Clemston.[39] Only 49 live births resulted from 64 pregnancies, and 2 maternal deaths were reported.

Better obstetric care has improved the results. In a combined series of 22 patients, 32 pregnancies occurred. Two ended in spontaneous abortion and two in therapeutic abortion. One obstetric catastrophe was the intrauterine death of twins. There were 27 live births.[40]

Pregnancy and delivery are usually normal. Elective cesarean should be performed in patients with a functioning bladder or with an artificial urinary sphincter (11 of the 27 deliveries mentioned earlier). The principal problem is subsequent uterine prolapse.

It has been reported from a postal survey of clinics throughout the world that 1 in 70 offspring have exstrophy or epispadias.[41] This figure must represent the worst that can be expected.

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CHAPTER

43

Secondary Repair of Epispadias Deformity

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CHARLES E. HORTON

Management of the bladder exstrophy-epispadias complex represents one of the most formidable challenges confronting genitourinary reconstructive surgeons. Successful management includes preservation of bladder storage capability, achievement of urinary continence, and repair of epispadias, resulting in a functionally normal and aesthetically optimal penis. With modern techniques, almost all exstrophic bladders are salvageable, and urinary diversion has therefore become a rarity. Similarly, contemporary methods of bladder neck reconstruction can consistently achieve continence. New methods of primary epispadias repair are also yielding improved functional and cosmetic results in correction of the penile deformity. However, a large number of older boys and young adults experience significant problems related to earlier epispadias repair.

Patients with epispadias may complain of difficulties related to micturition, poor cosmetic appearance, impaired sexual functioning, or any combination of these. Voiding complaints relate to the presence of a urethrocutaneous fistula, urethral stricture, or meatal stenosis. Cosmetic concerns include an abnormal arrangement of the escutcheon with the pubic hair displaced laterally, unsightly scarring from previous surgery, and the absence of an umbilicus. Sexual problems result from the overall small size of the epispadiac penis, as well as severe persistent dorsal chordee that may make intromission impossible (Fig. 43–1). Each patient presenting for secondary epispadias repair must be individually assessed, and an appropriate plan for reconstruction devised. A simple procedure such as fistula repair or meatoplasty occasionally is all that is required. In our experience, however, most patients require a comprehensive approach that includes release of the penis, correction of chordee, urethroplasty, escutcheon repair, and umbilicoplasty.

RELEASE OF THE PENIS

The genital dissection is performed through a W-shaped incision that elevates a pair of superiorly based groin flaps (Fig. 43–2). The W flap serves several useful purposes. First, elevation of the W flaps provides excellent exposure to the corporeal bodies for mobilization and penile lengthening. Second, if unsightly scars exist in the penopubic and lower abdominal areas, they are excised through this incision. Third, rotation of the W flaps toward the midline transfers the pubic hair from its laterally displaced position to the normal penopubic location. Finally, closure of the W flaps transfers skin toward the dorsum of the penile shaft, where many of these patients have skin deficiency (Fig. 43–3).

One or more of the investing layers of the epispadiac penis, along with tethering of a short urethra, may contribute to overall shortening of the penis and dorsal chordee. These layers include skin and scarring from previous surgery; shortness and abdominal attachment of the deep dartos fascial layer; dysgenetic fibrous tissue bands extending from the penopubic area out onto the shaft; and disproportion of the tunica albuginea, with shortness of its dorsal aspect.[1] Each of these layers needs to be approached in a systematic way to accomplish penile release, which results in a longer straight penis that dangles in a dependent position.



Figure 43–1
Typical appearance of older patient with epispadias, demonstrating a persistent dorsal curvature and lateral displacement of the escutcheon.

After elevation of the skin flaps, dissection is carried down to expose the corporeal bodies (Fig. 43–4). The splayed corporeal bodies are partially detached from the pubic bones, and the corpora are sutured together in the midline. This mobilization accomplishes some penile lengthening.[2, 3] If any dysgenetic spongiosum remains between the corpora, it is excised. At this point, an artificial erection is obtained by injecting saline intravenously into each corpus. If the penis is now straight, the dissection has been sufficient; usually, however, the curvature is persistent and attention should be directed toward the urethra and the tunica.

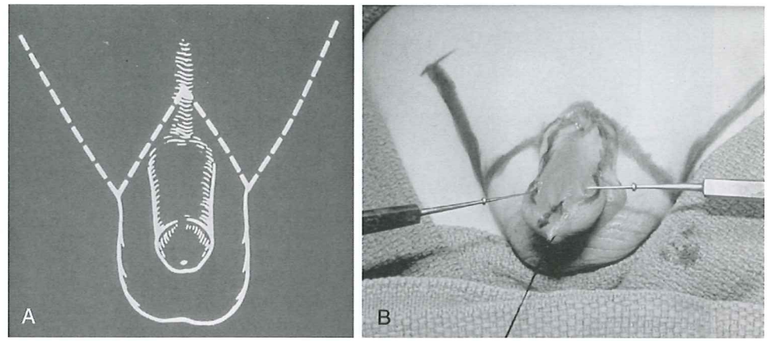


Figure 43–2
A and *B:* Proposed line of incision for groin W flaps.

CORRECTION OF CHORDEE

Initial steps in correction of chordee include resection of any tethering bands of tissue superficial to the tunica albuginea. If artificial erection demonstrates persistent curvature, the previously constructed neourethra is likely to be too short and is acting to tether the penis. The neourethra is divided distally and mobilized off the corpora. Care is taken to identify and preserve the dorsal neurovascular structures, which in epispadias are displaced onto the lateral aspect of each corpus. After mobilization of the urethra, an artificial erection is repeated. If the penis remains bent, the curvature is due to shortness of the dorsal tunica. We prefer to lengthen the dorsal tunica rather than shorten an already modest organ by ventral tunica plication. Dorsal tunica augmentation is accomplished with a dermal graft.[4, 5] The dermis is obtained from an area of hairless skin in the lower abdomen. An ellipse of skin approximately 3 by 2 cm is marked. The epidermis is removed using sharp freehand dissection with a fresh number 10 scalpel blade. The underlying dermis is excised and defatted. A transverse incision is made through the dorsal

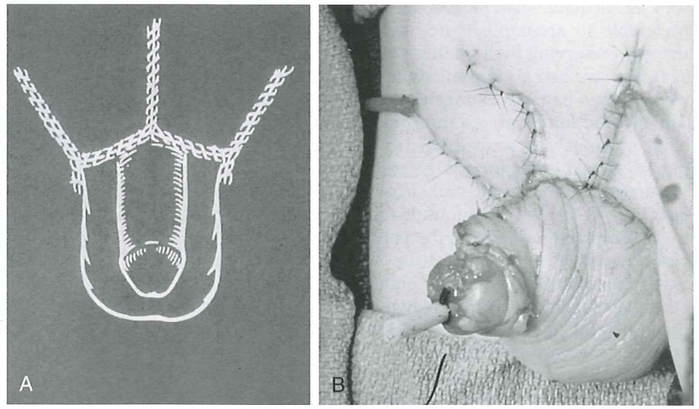


Figure 43–3
A and *B:* W flaps rotated medially and closed.



Figure 43–4
Excellent exposure of the corporal bodies.

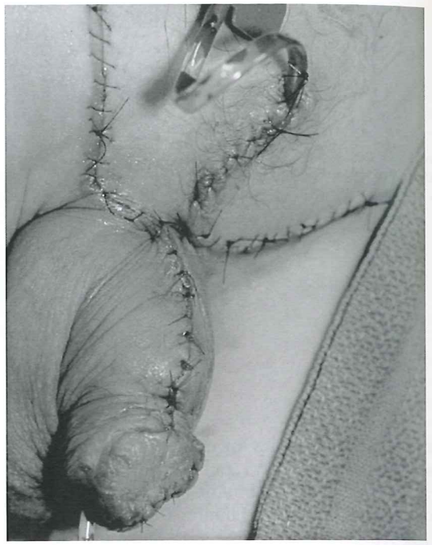


Figure 43–5
Straight, dangling appearance of the penis postoperatively.

tunica albuginea of each corporeal body at the point of maximal curvature. The medial corners of each corporotomy incision are then sutured together, creating one elliptic tunica defect. The dermal graft is contoured to fit the tunica defect and sutured to the tunica edges with absorbable sutures. The artificial erection is repeated. In virtually every case we have encountered, the dermal graft has resulted in a straight, dangling penis (Fig. 43–5).

URETHROPLASTY

If it has been necessary to divide the urethra, urethral reconstruction is required. In secondary epispadias repairs, there is rarely enough local penile skin to allow for both creation of a vascularized skin flap for urethroplasty as well as adequate shaft skin coverage. In our opinion, it is preferable to accomplish urethroplasty with a free graft, thereby preserving high-quality skin for penile shaft coverage. We have had good results with free graft urethroplasty using either hairless extragenital skin or buccal mucosa. The method for creating a free graft tube urethroplasty has been previously described.[6] In those cases that have required dermal grafts for straightening, we attempt to place the urethral graft more distally to avoid graft-on-graft overlap (Fig. 43–6). We have found some overlap of the grafts to be acceptable, as long as the penis is covered with well-vascularized subcutaneous tissue and skin. Good results using simultaneous dermal grafts and free graft urethroplasty have been previously reported.[7] It is also sometimes helpful to reroute the neourethra along the ventral aspect of the corporeal bodies.

Some patients with epispadias have had a urinary diversion and do not use a urethra for micturition. However, all patients require an outlet for seminal emissions. It is difficult to maintain patency of a nonmicturating urethra because the tendency for stricture is great. If a nonmicturating urethra is constructed, patients should perform daily urethral dilation by passing a catheter or sound. Alternatively, a prostatic fistula is fashioned at the penopubic junction. These fistulas are small and inconspicuous and usually well concealed within the pubic hair.



Figure 43–6
Dermal graft to lengthen dorsal, proximal tunica. A tubularized extragenital skin graft is placed distally for urethroplasty.

SKIN COVERAGE

In most cases, the penile shaft can be covered with local skin flaps. The ventral skin is split to form reverse Byars flaps, which are rotated dorsally. Closure of the W flaps also transfers additional skin toward the base of the dorsal shaft. In rare cases with an extreme paucity of skin, urethroplasty is delayed to be performed as a staged procedure 6 to 9 months later, and the penis is covered with a full-thickness skin graft.

UMBILICOPLASTY

After primary exstrophy-epispadias repair, many patients have either an absent or unsightly umbilicus. An excellent umbilicus can be constructed by making a semicircular incision through the midline abdominal skin just above the level of the iliac crests. The underlying subcutaneous fat is removed to expose the rectus fascia. A small full-thickness skin graft (readily taken from any previously excised scar) is then placed into the skin defect and sutured down to the fascia. The graft is covered with a cotton bolster dressing for 1 week.

SUMMARY

The goal of secondary genital surgery in patients with epispadias is to produce a straight, dangling penis of satisfactory length and shape. The penis should also serve as a conduit for urine and sperm. By the time an older patient with exstrophy-epispadias usually presents for revision surgery, the genital defect has often resulted in severe psychologic stress. Therefore, emotional support and sexual counseling are important aspects of treatment. The systematic approach to secondary epispadias repair as described provides an opportunity for successful results, which should greatly minimize the need for additional genital surgery.

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VAGINAL RECONSTRUCTION

CHAPTER

44

Full-Thickness Skin Graft Vaginoplasty

CHARLES E. HORTON, JR.
CHARLES E. HORTON

Construction of a neovagina may be indicated in certain congenital conditions such as Mayer-Rokitansky syndrome, after extirpative pelvic surgery, and in male-to-female transsexuals with gender dysphoria.

Many different techniques for vaginal construction have been described. These include progressive dilation of the vaginal dimple[1]; use of local skin after tissue expansion[2]; peritoneum,[3] amnion,[4] myocutaneous,[5] or fasciocutaneous flaps[6]; split-thickness[7] and full-thickness skin grafts[8]; and use of various bowel segments.[9] We have experience with myocutaneous flaps, ileum and sigmoid colon, and full-thickness skin grafts (FTSG). We have found FTSG vaginoplasty to be a safe and reliable technique that produces neovaginas with excellent functional and cosmetic results, and in most cases this is our method of choice.

Skin grafting to construct a vagina was first reported by Abbé in 1898.[10] In 1938, McIndoe reported the method using a split-thickness skin graft inverted over a stent.[11] The McIndoe technique was widely used thereafter, generally with favorable results.[12] However, the requirement for prolonged postoperative stenting to avoid graft contraction proved to be a significant disadvantage. FTSG vaginal reconstruction is superior (Fig. 44–1). Its advantages include markedly decreased graft contraction, reduced time for postoperative stenting, improved donor site cosmesis, and improved durability during sexual relations.[13, 14]

FULL-THICKNESS SKIN GRAFTS IN VAGINAL AGENESIS

The most common congenital condition requiring vaginoplasty is Mayer-Rokitansky-Küster-Hauser (MRKH) syndrome. Vaginal construction is also indicated in certain intersex conditions such as mixed gonadal dysgenesis or testicular feminization. The typical form of MRKH syndrome represents a developmental deficiency of the Müllerian ductal system consisting of absence of both vagina and uterus. Vaginal agenesis in association with a functional uterus occurs infrequently and may present in adolescence with hematometrocolpos. Therefore, patients with MRKH require preoperative imaging studies to determine whether they have a uterus. If a functional uterus is found, the FTSG neovagina can be anastomosed directly to the uterine outlet.[15] Radiographic evaluation also serves to screen the urinary tract, because patients also have an increased incidence of renal abnormalities.[16] We recommend vaginal construction during the middle teenage years, when the patient can be self-sufficient in providing postoperative care and maintenance of the neovagina.

To construct a vagina of adequate depth, approximately 180 cm^2 of FTSG is necessary. This can be obtained as a single large graft from the lower abdomen or more commonly as two elliptic grafts from the inguinal areas. The donor site is closed primarily with a subcuticular suture, and the resulting scar is inconspicuous. Some patients prefer to have grafts harvested from each gluteal crease. A full mechanical bowel preparation is carried out preoperatively. Before surgery, a vaginal stent of proper size is fashioned from a block of foam rubber and covered with two lubricated condoms.

The patient is placed in low lithotomy position using Allen stirrups. The initial surgical step consists of harvesting the skin grafts, which is done freehand using a number 10 scalpel. The grafts are vigorously defatted down to the dermal layer and sutured together over the vaginal stent with the epidermis facing the lumen, using running 4-0 chromic suture. A percutaneous suprapubic catheter is placed for temporary urinary diversion. The patient's labia are sutured to the lateral thigh skin to expose the introitus. A V-shaped incision is made on the perineum above the anus. This skin flap is later inserted into the new vaginal cavity and sutured to the graft. The flap prevents a circular scar contracture at the vaginal introitus.

The new vaginal pocket is dissected above the rectum and below the bladder up to the peritoneum. The cavity is made with blunt and sharp dissection so that ample vaginal size is established. Care must be taken to avoid injury to the urethra above and the rectum below. A Foley catheter in the urethra and a large Hegar dilator in the rectum

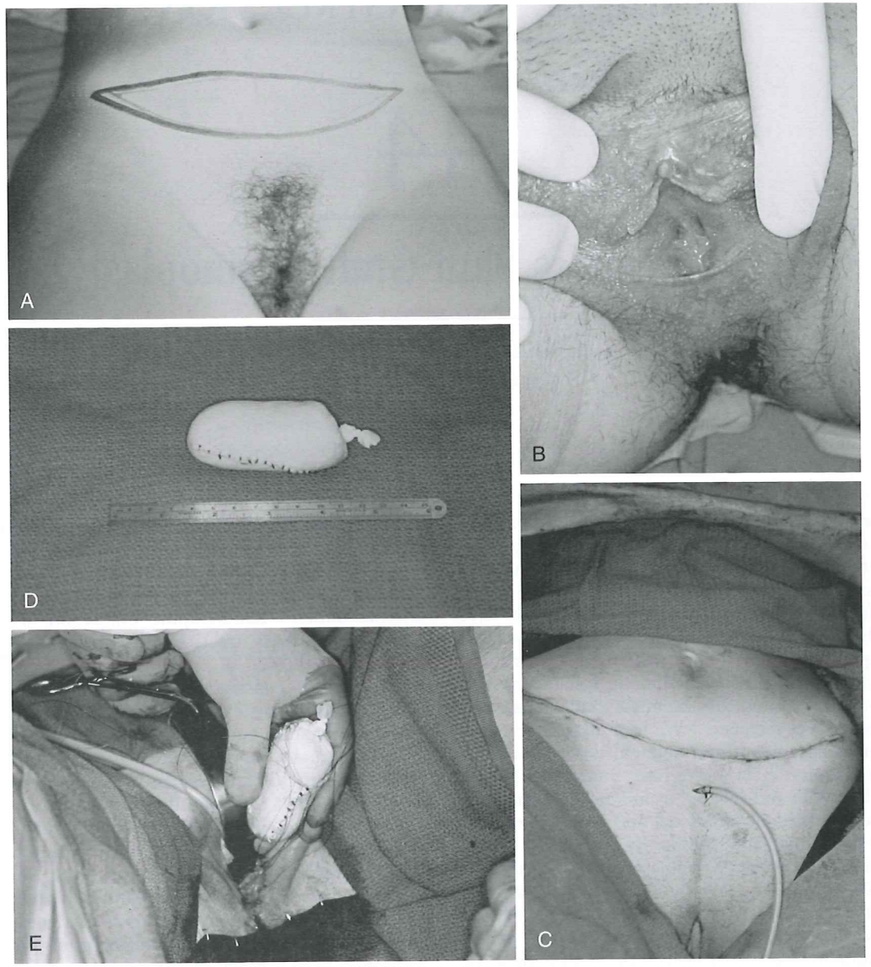


Figure 44–1
A: Donor site for full-thickness skin graft in a patient with Mayer-Rokitansky syndrome. This patient had simultaneous pubofascial sling for urinary incontinence. *B*: Absent vagina. *C*: Donor site closed. Suprapubic catheter placed. *D*: Full-thickness skin graft sutured over vaginal stent. *E*: Full-thickness skin graft with stent being inserted into cavity.

facilitate this dissection. Careful attention to hemostasis is important to avoid hematoma formation. The vaginal stent covered by the FTSG is inserted into the prepared cavity, and the proximal open edge of the skin graft is sutured to the introital mucosa. The V flap is set into the graft inferiorly. The labia majora are sutured together over the stent with large nylon mattress sutures to prevent extrusion of the stent and graft.

FULL-THICKNESS SKIN GRAFTS IN MALE-TO-FEMALE TRANSSEXUALS

Preoperative patient preparation, positioning, harvesting of skin grafts, placement of a suprapubic catheter, and arrangement of the FTSG on the vaginal stent are carried out as previously described (Fig. 44–2). A circumcising incision is made through the distal penile skin just proximal to the coronal sulcus. The median raphe is incised ventrally down the penis, through the scrotum and perineum, to terminate in a V flap oriented just above the anus. The penile shaft is degloved, and bilateral orchiectomies are performed. The corpus spongiosum and urethra are mobilized off of the corporal bodies; the penile urethra is preserved for approximately one third of its length. The dorsal neurovascular bundle is elevated off of the corpora. The corporal bodies are mobilized back underneath the symphysis pubis by dividing the suspensory ligament; the corpora are divided and oversewn with 2-0 polydioxanone suture (PDS). Distally, the glans is reduced to a 1.5-cm

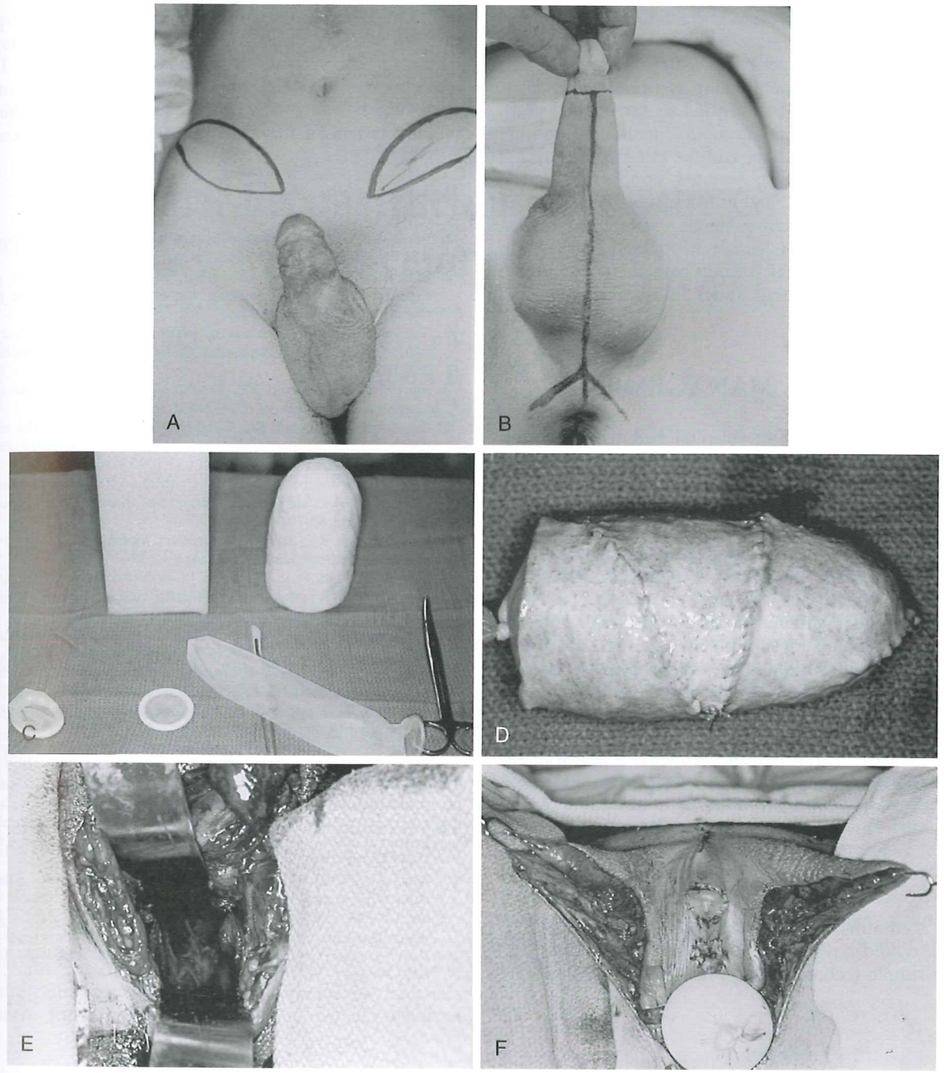


Figure 44–2
A: Donor sites for full-thickness skin graft in a male-to-female transexual. *B*: Proposed incisions. *C*: Vaginal stent fashioned from foam rubber and covered with condoms. *D*: Full-thickness skin graft sutured over a vaginal stent. *E*: Space developed in the perineum for the vaginal cavity. *F*: Stent with full-thickness skin graft inserted into the cavity. Note the clitoris (reduced glans) constructed above. *G*: Completed genitoplasty: labia, clitoris, and stent in the neovagina.

triangular configuration to function as a clitoris. A cavity between the rectum and urethra is created using blunt and sharp dissection, and the stent covered with the FTSG is inserted. Inferiorly, the perineal V flap is set into the vaginal graft. All of the penile skin is preserved and advanced inferiorly, where it is sutured to the vaginal graft; this skin serves as introital mucosa. Small incisions are made in the introital skin flap, and the clitoris and urethra are brought through and positioned appropriately. The scrotal skin flaps are trimmed and advanced inferiorly to serve as labia majora. This tissue is extremely vascular, and adequate hemostasis is essential. At least two suction drains are used. The skin is sutured over the neovagina to ensure that the vaginal stent and FTSG are retained and immobilized.

POSTOPERATIVE MANAGEMENT

Patients are initially kept in hospital bed rest. It is important to minimize motion and shearing of the FTSG during this critical phase of healing. After 2 to 3 days, patients are discharged on a regimen of limited activity. On the fifth postoperative day, patients are returned to the operating room on an outpatient basis, where, using intravenous sedation, the stent is removed, the cavity cleaned and irrigated, and the grafts inspected. The stent is replaced and held stationary with a firm girdle. After the first dressing change, most patients tolerate subsequent changes without anesthesia. The patient is given instructions on stent removal, daily sitz baths, and povidone-iodine douches. After 1 month of this regimen, the patient is given a solid Silastic stent to wear at night for approximately 3 months. A trial period with total removal of the stent is then suggested. After the FTSG has stabilized, stenting is no longer needed.

CONCLUSIONS

We have accumulated an extensive experience with FTSG vaginoplasty and have found it to be a safe, reliable, and relatively simple technique that produces neovaginas with excellent cosmetic and functional characteristics. FTSG vaginoplasty is our method of choice in cases requiring primary reconstruction, in which the recipient site is anticipated to be conducive to a successful skin graft. In secondary cases in which the perineum is scarred or after ablative pelvic surgery, we prefer gracilis or rectus abdominus myocutaneous flaps or use of a sigmoid segment.

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CHAPTER

45

Vaginal Reconstruction Using the Gracilis Myocutaneous Flap

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JOHN B. MCCRAW
ANN MCMELLIN

BACKGROUND

Vaginal reconstruction and the treatment of perineal and pelvic defects were greatly improved with the development of myocutaneous flaps. Many nonhealing wounds were radiation induced and could not be closed with poorly vascularized local flaps or skin grafts. The gracilis myocutaneous flap introduces well-vascularized tissue into the perineal and pelvic defect, creating a neovagina and closing the defect.

Ortichochea reported the use of a gracilis myocutaneous flap as a cross-leg flap to resurface an exposed ankle in 1972.[1] In 1976, McCraw and colleagues described vaginal reconstruction with the gracilis myocutaneous flap.[2]

ANATOMY

The gracilis muscle is a straplike muscle that originates from the pubic tubercle and inferior ramus of the pubis and inserts into the pes anserinus at the medial portion of the knee.[3] The major blood supply to the proximal two thirds derives from a branch of the medial femoral circumflex artery that enters the muscle 8 to 10 cm below the inguinal ligament. Minor branches from the obturator artery also enter the muscle proximally. Two or three more distal minor vessels arise from the superficial femoral artery and are the dominant blood supply of the distal one third of the muscle. In a myocutaneous flap, subcutaneous tissue and skin are attached to the muscle and are supplied by perforating vessels from the muscle surface. The dominant proximal vessel can reliably supply the entire muscle and a skin paddle measuring 8 cm wide by 24 cm long over the proximal two thirds. The skin island must be centered directly over the muscle by precisely identifying its origin and insertion. A skin segment overlying the distal one third of the muscle is not reliable, unless a delay procedure is performed. The motor nerve, an anterior branch of the obturator nerve, enters the muscle near the proximal vascular pedicle.

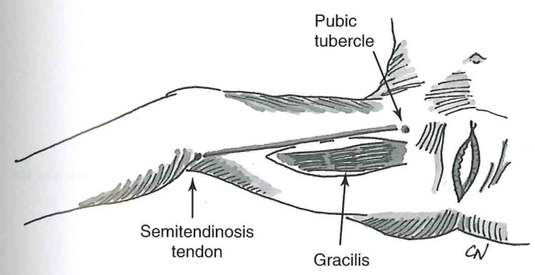


Figure 45–1
The anterior border of the skin paddle is outlined by a line drawn from the pubic tubercle to the distal semitendinosus tendon.

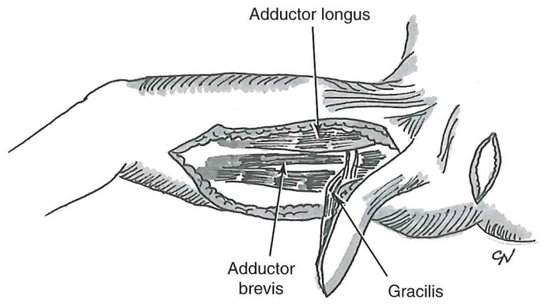


Figure 45–2
The dominant vascular pedicle and motor nerve are exposed as they exit between the adductor longus and brevis muscles.

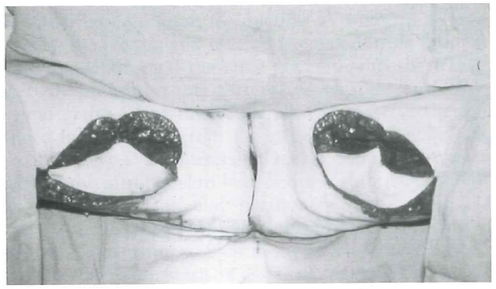


Figure 45–3
Myocutaneous flaps are elevated before transposition. (Courtesy of the Mayo Clinic.)

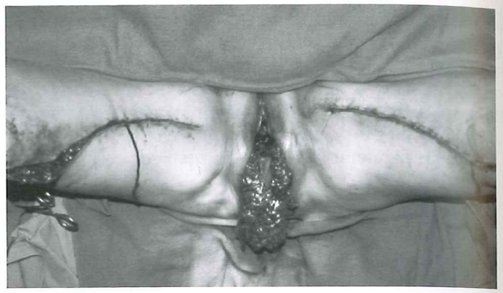


Figure 45–5
Transposition of the flaps with the neovagina formed. (Courtesy of the Mayo Clinic.)

TECHNIQUE

A line drawn from the pubic tubercle to the distal semitendinosus tendon outlines the anterior border of the skin paddle (Fig. 45–1). This line is drawn with the patient in the supine position, because skin laxity or obesity can cause posterior displacement of the skin in the low lithotomy position. The hips are abducted 45 degrees and flexed 15 degrees, whereas the knees are flexed less than 45 degrees. The procedure is often performed at the same time as a pelvic exenteration, and thus two teams are often working simultaneously. A skin paddle width of 9 to 10 cm can usually be closed primarily. The length of the skin paddles to create the neovagina should be at least 12 cm. The flap widths should add together to provide a circumference of at least 15 cm, creating a diameter of at least 5 cm. The distal muscle is located first through a distal incision above the medial femoral condyle. Elevation of the tendon and bow-stringing confirm the gracilis location by palpation over the skin paddle design and direct visualization of the muscle proximally.

After the gracilis tendon is identified, dissection proceeds proximally along the anterior border of the flap. A wide dissection of fascia of the adductor longus and brevis muscles anterior to the adductor magnus muscle is incorporated, and the skin perforators are preserved. The saphenous vein should be preserved anterior to the flap. The distal neurovascular pedicles are cut, and the dominant proximal pedicle is exposed along with the motor nerve as they exit between the adductor longus and brevis muscles (Fig. 45–2). If further mobilization is needed, the pedicle may be dissected proximally to the profundus origin by dividing several branches to the brevis and longus. Posteriorly, the dissection incorporates part of the fascia of the semimembranosus muscle. The rotation point is approximately 7 cm below the pubic tubercle. Once the motor nerve is cut and the pedicle is adequately mobilized, the fascia overlying the gracilis muscle may be divided proximally near the pubic tubercle. The muscle is not divided, and thus a secondary blood supply through proximal branches of the obturator vessels is preserved. The muscle is mobilized and dissected off the adductor longus and adductor magnus muscles (Fig. 45–3).

The myocutaneous flap in the left thigh is rotated clockwise, and the contralateral flap in the right thigh is rotated counterclockwise. Each flap is transposed without tension through a subcutaneous tunnel from the thigh incision to the pelvic defect, taking care not to kink the pedicle or to overly compress the flap. Alternatively, the skin bridge can be divided. Each flap is rotated posteriorly to allow apposition of the posterior edges (Figs. 45–4 and 45–5) with Vicryl sutures. Intravenous administration of fluorescein can be used at this point to assess flap tip viability. The pouch is completed by suturing the anterior margins

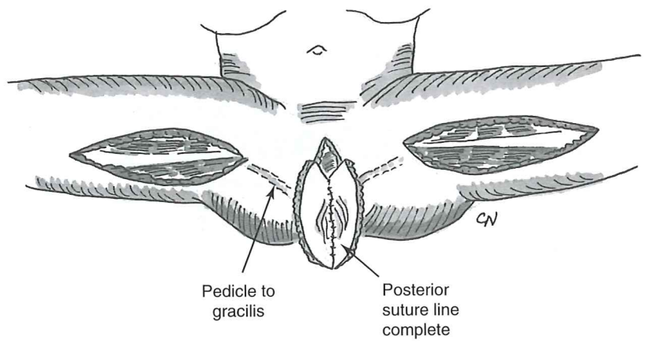


Figure 45–4
Each flap is rotated posteriorly to allow apposition of the posterior edges.

of the flap and is introduced into the pelvic cavity by posterior rotation. Some difficulty transposing the flaps into the pelvis may occur. The neovagina is anchored to the presacral fascia, eliminating dead space in the pelvis. If available, an omental flap could be mobilized and transposed into the defect to obliterate more dead space and restore the pelvic floor. Completion of the introitus is accomplished by suturing the proximal pouch to the perineal skin (Fig. 45–6). A circular closure line is avoided by transposing darts of perineal skin into the defect to lengthen the suture line. To avoid compression of the pedicle, no compressive dressings are used in the neovagina.

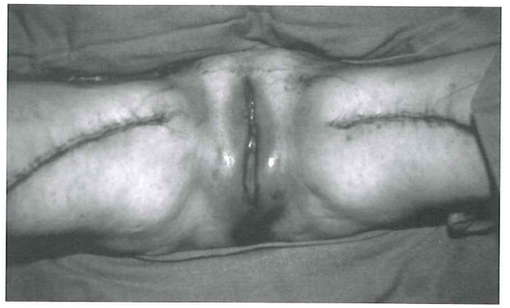


Figure 45–6
Completed neovaginal reconstruction. (Courtesy of the Mayo Clinic.)

CONCLUSION

One advantage of gracilis myocutaneous vaginal reconstruction is its reliability. In our experience, we have lost only one gracilis myocutaneous flap owing to inadvertent tight packing of the cavity after the procedure. Pressure necrosis from the pack, rather than internal derangement of the pedicle, was the cause of flap loss. Functional donor site morbidity is minimal. The medial thigh scars, though prominent, are rarely a significant concern. Whereas the bulk of these flaps is advantageous in reconstruction requiring significant soft tissue fill, this bulk limits the aesthetics of reconstruction involving surface defects only.

Myocutaneous flaps usually allow primary healing because of their vascularity. Primary vaginal reconstruction enables access for examination and assists early diagnosis of tumor recurrences. It restores sexual function and improves patients' self-esteem. Difficulties in flap transposition occur in obese thighs, because the subcutaneous fat is too thick. Torsion or tension on the vascular pedicle at the time of flap inset can cause vascular spasm, destroying blood supply to the flap. Proper design of the skin paddle and careful inset should ensure survival.

The gracilis myocutaneous flap is an excellent choice for vaginal reconstruction in properly selected patients.

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CHAPTER

46

The Short Gracilis Myocutaneous Flap

JOHN T. SOPER

The classic gracilis myocutaneous flap was first described by McCraw and colleagues[1] for neovaginal reconstruction after pelvic exenteration. Their original report described development of a myocutaneous unit composed of the gracilis muscle, fat, and skin of the proximal two thirds of the medial thigh. The primary vascular bundle derived from branches of the profunda femoris artery that enters the medial surface of the gracilis 7 to 8 cm from the pubic tubercle was preserved in constructing the long gracilis flap.[1] This primary vascular pedicle can support a skin island as long as approximately 24 cm and as wide as 12 cm. When the vascular pedicle is mobilized, the flap can be rotated through approximately 180 degrees in both anterior and posterior directions. The long gracilis flap has subsequently been used for various complex pelvic reconstructions, including repairs of large vulvar, vaginal, and inguinal defects.[1–7]

In 1989, both Copeland and associates,[7] from M.D. Anderson, and our group, at Duke,[8] independently reported that a short gracilis flap could be successfully used for pelvic reconstruction. In this modification of the gracilis flap, a smaller skin island is developed and the primary vascular pedicle is deliberately sacrificed. The short gracilis flap receives its blood supply through anastomotic branches of the obturator artery that insert into the proximal gracilis muscle.[7–8] Direct comparison of reconstructions using long and short gracilis flaps has revealed no increase in flap loss or other flap-specific complications among patients receiving the short gracilis flap.[7–9] At our institution, we consider the short gracilis flap as a variation on the gracilis flap technique and frequently use both techniques.

TECHNIQUE

The thin, straplike gracilis muscle is the most medial adductor of the thigh (Fig. 46–1). It normally functions to stabilize the knee but can be sacrificed without loss of function in the lower extremities. It originates from the pubic tubercle and extends posterior to the adductor longus to insert into the medial tibial plateau. Relative sizes of short and long gracilis skin island flaps are detailed in Figure 46–2. The gracilis muscle derives its major blood supply from a vascular perforator from branches of the medial femoral circumflex artery. This supports a large territory of skin extending along the medial thigh and into the distal one third of the thigh posterior to the adductor longus. The dominant vascular pedicle is constant in location, entering the deep gracilis muscle with paired venae comitantes and nerve approximately 6 to 8 cm distal to the pubic tubercle after passing between the adductor longus and adductor brevis muscles (Fig. 46–3). An accessory blood supply, derived from anastomotic terminal branches of the obturator and pudendal arteries, enters within the proximal 1 to 3 cm of the gracilis muscle (see Fig. 46–3). These accessory vessels are not as well defined as the dominant vascular pedicle, but they can support the short gracilis myocutaneous flap for pelvic reconstructions.

The gracilis flap can be rotated either anterior or posterior within a wide arc of rotation, allowing it to be deployed for anterior vulvar or groin reconstructions, neovaginal formation, or repair of posterior vulvar and perineal defects. The arc of rotation of the classic flap is around the mobilized dominant vascular pedicle, whereas the short flap is rotated around the origin of the muscle

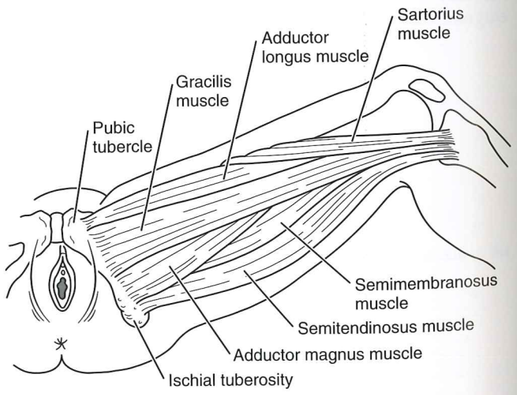


Figure 46–1

from the pubic tubercle. If a classic long gracilis flap is developed, the proximal muscle can be divided to facilitate rotation, but usually there is sufficient mobility such that division of the muscle is not necessary. Furthermore, division of the proximal muscle deprives the flap of its secondary blood supply.

Figures 46–3 to 46–7 illustrate the use of a short gracilis flap for neovaginal formation during pelvic exenteration. The patient is positioned in the modified Whitmore position using Allen stirrups (Edgewater Medical Systems, Inc., Mayfield Heights, OH) with the hips abducted approximately 45 degrees and flexed slightly. The medial thighs are prepared to the knees to allow access to the full skin island if needed. A guideline is drawn on the medial thigh from the pubic tubercle to the medial tibial plateau, along the margin of the adductor longus muscle. The skin island supplied by the gracilis is located posterior to this line. A 10- to 14-cm-long by 5- to 8-cm-wide elliptic skin island centered over the proximal gracilis muscle is used for the short flap, with the proximal margin located at the crural fold (Fig. 46–2).

A full-thickness incision is made along the anterior and distal margin of the skin margin through the fascia (see Fig. 46–3). It is important that the incision be either

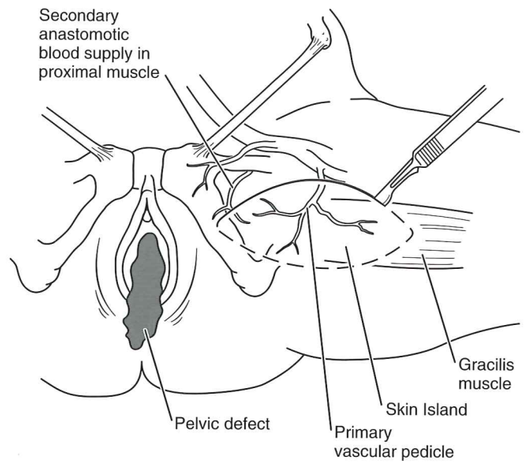


Figure 46–3

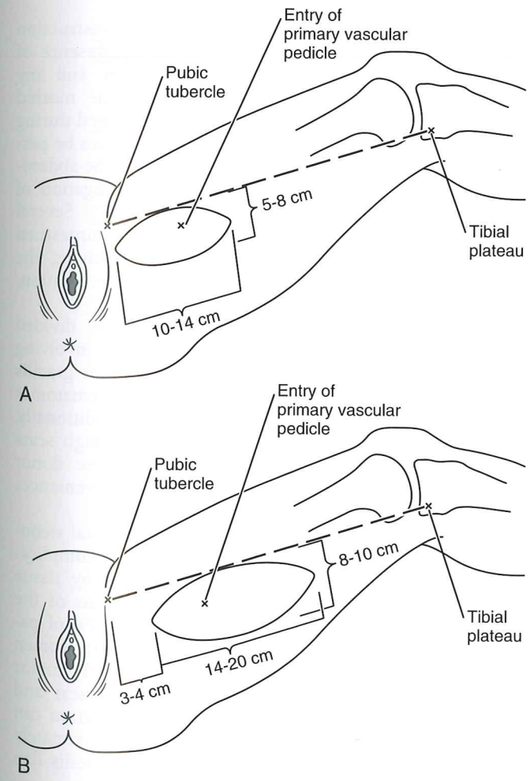


Figure 46–2

straight to the fascia or slightly flared at its base so that the skin is not undermined, which would cause it to lose vascularity. The skin is loosely anchored to the fascia with temporary interrupted sutures to prevent shearing the fat away from the underlying fascia during manipulation of the flap. The belly of the gracilis muscle is identified at the distal margin of the flap, posterior to the adductor longus. It is isolated and divided. The remainder of the full-thickness incision is completed around the margin of the skin island through the fascia.

The gracilis is mobilized from its bed with sharp and blunt dissection. It is important to work from the distal tip of the flap toward the origin so that the dominant vascular pedicle can be identified and preserved if desired (see Fig. 46–4). The dominant vascular pedicle enters the deep anterior belly of the gracilis muscle approximately 6 to 8 cm from the pubic tubercle, emerging from underneath the belly of the adductor longus muscle. With its paired venae comitantes, it is easily distinguished from the loose areolar tissue between the muscles. The nerve usually enters with the dominant vascular pedicle or just proximal to it. If a classic long flap is to be used, the pedicle is mobilized. If a short flap is to be used, the pedicle is cross-clamped, divided, and ligated (see Fig. 46–4). The nerve can usually be spared to provide muscular innervation and sensation to the skin island in the short flap, but it may be sacrificed. The remainder of the gracilis flap is mobilized to its origin. In a short flap, the 2 to 3 cm of the proximal gracilis muscle should not be aggressively skeletonized so that small accessory vessels are not stripped away from the muscle.

For neovaginal construction, a subfascial tunnel is constructed to the vaginal introitus with sharp and blunt dissection. The tunnel should allow passage of the gracilis flap freely without pressure. Bilateral flaps are rotated posteriorly through the tunnels and allowed to hang freely between the patient's legs (see Fig. 46–5). The neovaginal tube is constructed by approximating the skin edges with

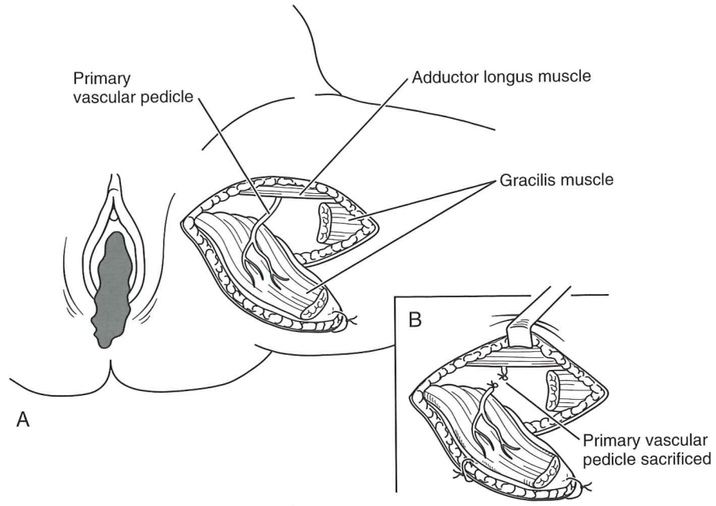


Figure 46–4

interrupted absorbable sutures, beginning at the posterior surface and distal tips of the flaps (see Fig. 46–6). The temporary sutures anchoring the skin to the fascia are removed. The proximal skin margins are left open to form the introitus, sufficient to allow passage of two to three fingers (see Fig. 46–6). The neovaginal tube is then rotated posteriorly into the pelvis and anchored to the levator plate, symphysis, or sacral hollow with interrupted sutures. Redundant skin is trimmed, and the proximal skin of the flap is sutured to the introitus with absorbable sutures (see Fig. 46–7). When unilateral or bilateral flaps are used for vulvar reconstructions, the flaps are rotated either anteriorly or posteriorly, depending on the defect, without use of the subfascial tunnels. The muscle is anchored to the deep tissues of the defect with loose interrupted sutures, and the skin approximated with interrupted absorbable sutures.

The thigh incisions are irrigated and closed in layers over closed suction drains. Patients are allowed to ambulate within 24 to 48 hours of surgery.

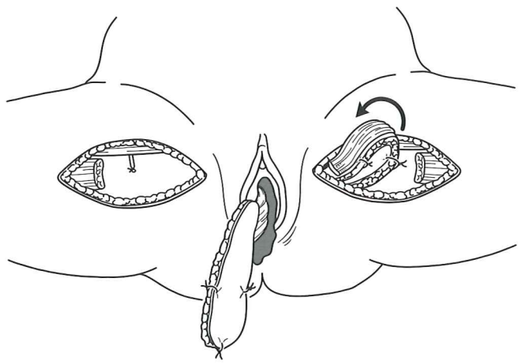


Figure 46–5

COMPLICATIONS OF THE SHORT GRACILIS FLAP

Patients receiving the gracilis flap for pelvic reconstruction have undergone radical surgery, often in the presence of prior irradiation or combined chemoradiation, and any analysis of complications should recognize the morbid nature of these procedures. If gracilis flaps are used during an exenteration, the neovaginal reconstruction can be performed by a second team, without interrupting the abdominal procedure. This results in minimal prolongation of the operative time and no added blood loss.[5–7] Several investigators have reported a decrease in gastrointestinal or urologic complications among patients receiving the gracilis flap neovaginal reconstruction during exenteration, compared with historic controls.[6, 10]

Flap-specific complications can be arbitrarily divided into those related to the donor site and those involving the flap. In our experience, patients with a short gracilis flap tend to have fewer donor site infections or hematomas than those who receive the long gracilis flap.[9] Additionally, patients with short flaps have smaller medial thigh scars than those with the long flaps. However, these donor site complications are usually only minor inconveniences rather than major sources of morbidity.

Complications involving the flap include introital stenosis, neovaginal prolapse, flap loss, and indirect complications of rectovaginal fistula formation caused by tissue pressure on a rectosigmoid anastomosis. Stenosis of the vaginal introitus is observed in approximately 9% of patients, occasionally requiring operative revision in women who desire intercourse, but it is also a relatively minor complication. Avoidance of a circular introital scar and proper planning at the time of neovaginal formation can usually prevent this complication. Overall, approximately 47% of our patients are sexually active after gracilis flap reconstruction.[9]

Neovaginal prolapse was observed more frequently in

patients receiving the classic long gracilis flap than in those who received short gracilis flap neovaginas after exenteration in the series reported by Copeland and colleagues.[7] In our experience, gracilis neovaginal prolapse after exenteration occurs in only 3% of patients.[9] This low incidence of prolapse is probably related to compulsive efforts to fit the neovagina snugly within the pelvic crater and to anchor the neovagina to the sacral hollow, symphysis, or levator plate.

Flap loss of various degrees is observed in approximately 10% to 20% of patients with gracilis flaps, ranging from minor loss of the skin and subcutaneous tissue from the tips or margins of the flaps to complete loss of one or both of the myocutaneous units.[1–9] Flap loss of less than 50% of the flap is usually only a minor inconvenience. Patients in this category are treated with dilute peroxide irrigation until a good base of granulation tissue forms. The muscle usually survives, and a functional neovagina or vulvar reconstruction results after reepithelialization of the muscle.

In contrast, loss of more than 50% of the flap usually

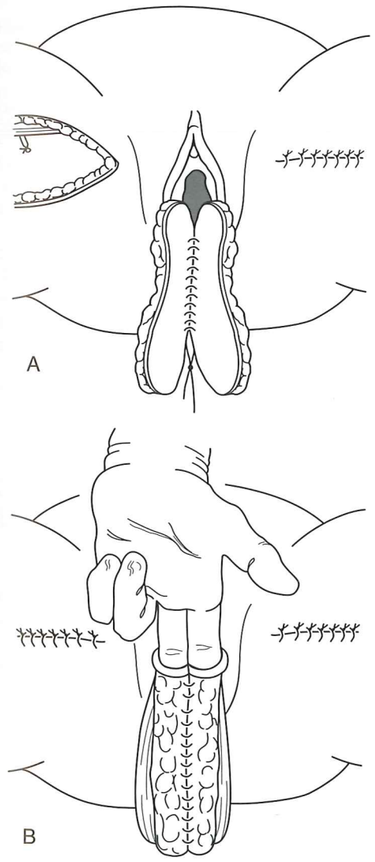


Figure 46–6

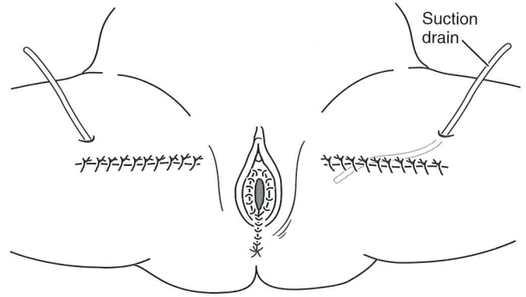


Figure 46–7

requires operative debridement. Total loss of the myocutaneous unit frequently occurs in these patients, often resulting in chronic vaginal stenosis or other pelvic complications. For this reason, we analyzed factors associated with loss of gracilis myocutaneous flaps in 22 women with classic long gracilis flaps and 24 with short flaps used for pelvic reconstructions.[9] The incidence of major flap loss was 14% and 17%, respectively, for long and short flap groups, a nonsignificant difference (Table 46–1).

Among other clinical and operative factors that were analyzed, only construction of a gracilis flap neovagina in conjunction with pelvic exenteration combined with rectosigmoid anastomosis was significantly associated with major flap loss (see Table 46–1), compared with other exenterative procedures or other types of radical pelvic procedures.[9] It is possible that pressure on the myocutaneous unit from surrounding tissue compromises venous return or blood flow into the gracilis flap. Likewise, a myocutaneous flap might jeopardize healing of a rectosigmoid anastomosis. Indeed, Lacey and colleagues reported that two of their three patients who received gracilis flaps

Table 46–1
Factors Associated with Major Loss of Gracilis Flap

Factor (No. of Patients)	Major Flap Loss		
	n	%	*P*
Type of flap			
Long (27)	3	11	NS
Short (24)	4	17	
Prior therapy			
Radiation/chemotherapy (14)	4	29	
Radiation (26)	3	12	NS
Surgery/none (6)	—	—	
Procedure			
Exenteration plus RSA (8)	4	50	
Other exenteration (29)	2	7	<0.05*
Other (9)	1	11	
Pelvic abscess/fistula			
Yes (12)	3	25	NS
No (34)	4	12	

NS, not statistically significant; RSA, rectosigmoid anastomosis.
*Exenteration + RSA versus all other procedures or versus other exenterations.
From Soper JT, Rodriguez G, Berchuck A, et al: Long and short gracilis flaps for vulvovaginal reconstruction after radical pelvic surgery: Comparison of flap-specific complications. Gynecol Oncol 56:271–275, 1995.

in this setting developed major flap loss and rectovaginal fistula.[5] Use of a single gracilis flap, a smaller flap such as the bulbocavernosus myocutaneous flap, or a rectus myocutaneous or myoperitoneal flap might avoid this complication when neovaginal reconstruction is performed in conjunction with a rectosigmoid anastomosis.

The short flap currently is our preference when a gracilis myocutaneous flap is used for neovaginal reconstruction after pelvic exenteration. We are reluctant to use this flap if a patient has had hypogastric or obturator artery ligation or chemoradiation delivered to the groin, situations that would theoretically impair the vascularity of the short flap. However, other series have reported instances of long gracilis flap loss in these circumstances.[1–3]

SUMMARY

In the short gracilis flap modification, the dominant vascular pedicle supplying the gracilis muscle is deliberately sacrificed and a smaller myocutaneous unit is developed from the medial thigh, compared with the classic long gracilis flap. Flap-specific complications occur with similar frequency in patients with long and short gracilis flap reconstructions. Analysis of flap-specific complications indicates that the risk of loss of a gracilis neovagina is increased when this procedure is performed after pelvic exenteration with rectosigmoid anastomosis, compared with total pelvic exenteration or other radical pelvic reconstructions.

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CHAPTER

47

Vaginal Reconstruction Using the Rectus Abdominis Flap

GORDON R. TOBIN

The distally based rectus abdominis muscle-skin flap that carries a neovagina formed by an inversely tubed epigastric skin paddle was developed specifically for vaginal reconstruction in the radical pelvic resection defect,[1] although it can be readily adapted to vaginal reconstruction for a wide variety of other conditions. Many experienced pelvic reconstructive surgeons choose this method for reconstruction after exenteration because it fills the endopelvic defect with well-vascularized tissue while also providing a high-quality and very reliable vaginal replacement. The flap is very well perfused, and thus the defect is revascularized and the incidence of postoperative pelvic wound infections is reduced. In addition, the bulk of the flap and muscle pedicle block bowel migration into the pelvic space postoperatively. With slight modifications, as described in the following portions of this chapter, this flap can be adapted to reconstruct all patterns of vaginal resection in all variations of exenterative pelvic surgery. It can also be used to reconstruct massive defects of the external pelvis, groin, vulva, and perineum.[1–4]

INDICATIONS, ADVANTAGES, AND DISADVANTAGES

Distally based rectus abdominis flaps can be used for virtually all reconstructions performed concurrently with vaginal resection during exenterative pelvic surgery, unless the flap is anatomically unavailable. This flap provides more well-vascularized tissue to exenteration defects, which are frequently irradiated, than any other described techniques of vaginal reconstruction.[5–8] In addition to restoring the capability of sexual function, rectus abdominis flaps also block entry of bowel into the pelvis, revascularize irradiated pelvic cavity walls, and lessen the incidence of pelvic infections, fistulas, and chronically open perineal wounds. Even when intercourse is not likely to be resumed postoperatively, a patient receives the benefits of pelvic filling with well-vascularized tissue to lessen infections and healing complications. The benefits of the bulk and revascularization provided by this flap can be given to male patients having abdominoperineal resections or exenterations by skin paddle deepithelialization to the deep dermal level and placement in the pelvic space without tubing into a neovagina. If skin coverage is required for closure of the perineal wound, an appropriately sized skin paddle is left beyond the deepithelialized portion for inset into the perineal surface defect.

The exceptional versatility of this flap in paddle design and placement conveys additional advantages. In supralevator exenterations, flaps from the thigh or groin[7, 8] must be passed around the retained vaginal segment by a difficult dissection, or the segment must be sacrificed. With this flap, the distal end is simply inset to the proximal cuff of the retained vagina. Some rectal and posterior vaginal wall resections performed for rectal lesions allow retention of the anterior vaginal wall and bladder. In those cases, the paddle is not completely tubed but is designed with dimensions appropriate to the resected vaginal wall and is inset along the margins of the retained anterior vagina. When partial vulvectomy is performed with the vaginectomy, the distal end of the flap is opened in a trumpetlike fashion and spread over the perineal defect, as shown in Figure 47–5*B*.

This flap cannot be used when the muscle and vascular pedicle are transected by previous incision. Ligation of the deep inferior epigastric vessels probably also prevents use of the flap. The most distal of the segmental collateral vessels entering the posterolateral surface of the muscle are usually preserved in transfer, and these vessels provide a blood supply to the flap in the absence of the deep inferior epigastric vessels; however, I am not aware that the reliability of transfer in this circumstance has yet been established. Another reservation in use of this flap is reconstruction of vaginal agenesis (Rokitansky-Küster-Hauser syndrome and related conditions) when the abdomen is unscarred. A less conspicuous donor site scar is preferable to a long midline vertical scar. Design of this flap with a transverse skin paddle placed just below the umbilicus, as in the paddle used for transverse rectus abdominis myocutaneous (TRAM) flap breast reconstruction,[9] pro-

vides a more acceptable donor site scar for this group of patients, if vaginal construction with flap tissue is preferred over skin grafts and stents, as used in the Abbe-McIndoe technique.[10, 11]

ANATOMY

Anatomic features of the rectus abdominis muscle and this flap are shown in Figure 47–1. This rectus abdominis muscle-skin flap is based on either of the paired rectus abdominis muscles spanning the abdominal wall from the pubis to the ventral thoracic cage on either side of the linea alba. Dense rectus sheath fascia surrounds the upper three quarters of the muscle, but the posterior rectus sheet is absent caudal to the linea arcuata.

The upper muscle blood supply is the superior epigastric vessels, which are divided for flap transfer. These pass on the deep surface of the muscle as a continuation of the internal mammary vessels. Cutaneous perforators from the muscle pass through the anterior rectus sheath to supply the overlying epigastric skin. The blood supply of the distal muscle is the deep inferior epigastric vessels, which course on the deep surface of the distal muscle and originate from the external iliac vessels near the inguinal ligament. This portion of the muscle gives cutaneous perforators to the overlying hypogastric abdominal skin, which is also supplied by the superficial inferior epigastric vessels that course in the subcutaneous tissue in a parallel pattern. The deep inferior and superior epigastric vascular systems are joined across a vascular watershed by anastomotic vessels in the midportion of the muscle near the umbilicus. This vascular junction allows perfusion of the entire muscle-skin unit from the vascular supply at either end. For example, blood flow in the vascular supply of this flap is opposite to that of the TRAM flap used for breast reconstruction, in which hypogastric skin is carried on the lower muscle supplied across the watershed from the superior epigastric pedicle.[9] The muscle also receives collateral vascular supply from segmental vessels accompanying the motor nerves that enter the posterolateral border of the muscle. In flap transposition, the uppermost of these are divided to permit transfer, but the most caudal one or two can usually be preserved.

OPERATIVE TECHNIQUE

Steps of the operative technique are shown in Figures 47–1 to 47–5. The full cutaneous territory of this flap extends vertically from costal margin to pubis and horizontally from lines defined by the ipsilateral anterior superior iliac spine and contralateral midinguinal line. Therefore, the cutaneous paddle can be designed in a wide variety of patterns and sizes within this area and can be placed anywhere along the course of the muscle. In vaginal reconstruction, the most frequently used cutaneous paddle design is a wide vertical ellipse centered over the upper half of the muscle. This ellipse extends from just below the costal margin to just below the umbilicus and is approximately 20 to 25 cm long (Fig. 47–1*A* and *B*). The paddle width is related to the intended luminal diameter by the formula πd. Thus, luminal diameter of about 3.5 cm is provided by an 11-cm-wide paddle. If needed, substantially greater paddle widths can be reliably carried, if placed within the vascular territory described earlier.

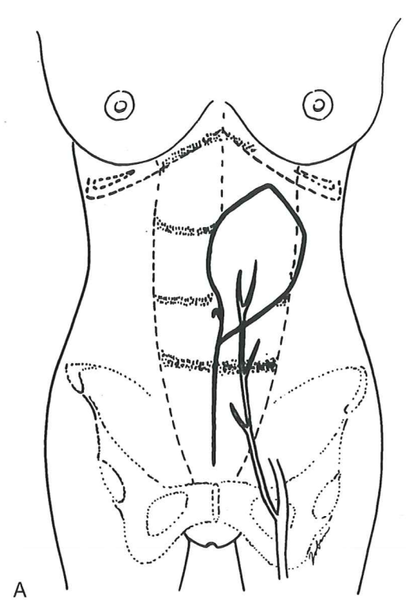
An occasionally useful alternative cutaneous paddle design is a transversely oriented ellipse placed just above or just below the umbilicus (see Fig. 47–1*C*). The half of the ellipse forming the proximal neovagina and cul-de-sac is centered over the muscle, and the half of the ellipse forming the distal neovagina extends beyond the lateral muscle borders, either medially across the midline (see Fig. 47–1*C*) or laterally toward the flank. This gives a much less bulky distal neovagina when the endopelvic passage is narrow and bulk is unwanted, such as in vaginal agenesis or vaginectomies with bladder preservation and colonic pull-through for low rectal anastomosis. Placement of the transverse paddle above the umbilicus better avoids the usual stoma sites, whereas placement of the paddle just below the umbilicus creates a lower scar and can be used if no stomas are made.

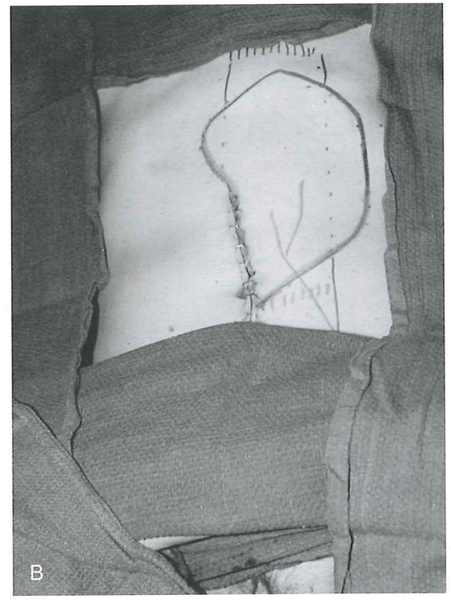
In men, deepithelialized, untubed paddles are used when the benefits of well-vascularized tissue bulk are desired without a vaginal reconstruction. A distal island of intact epithelium can be preserved on the paddle, if needed to close a large perineal defect.

After the skin paddle is incised, a corresponding island of underlying anterior rectus sheath is also incised. This fascial island is usually made somewhat narrower than the skin paddle to leave fascia for direct closure of the remaining anterior rectus sheath. One strip of medial anterior rectus sheath 0.5 to 1 cm wide adjacent to the linea alba and another strip of lateral anterior rectus sheath 3 to 4 cm wide are left in situ (see Fig. 47–2*A*) for direct closure of the anterior fascial layer (see Fig. 47–4*A*). When direct closure cannot be accomplished, the intact posterior rectus sheath forms the abdominal wall layer, and we have seen no hernia or bulges develop in these instances.

The rectus muscle is transected at the cephalic end of the skin paddle, and the superior epigastric vessels are divided. The muscle pedicle and skin paddle are then elevated from the underlying bed of posterior rectus fascia by sequential division of the segmental neurovascular pedicles entering the lateral muscle border. When the flap is sufficiently mobilized to reach the recipient site, no additional segmental pedicles are divided (see Fig. 47–2). Caudal to the skin paddle, the anterior rectus sheath and attached overlying hypogastric skin are left in situ to provide abdominal wall structure after flap transfer (see Fig. 47–4*A*). This is essential caudal to the linea arcuata, where the posterior rectus sheath is absent.

The vaginal pouch is formed by inversely tubing the skin paddle after flap elevation. This is usually done when the flap has been transposed distally onto the drapes over the groin region (see Fig. 47–2), because this allows a second surgical team to construct a urinary conduit and colostomy simultaneously with tubing and inset of the neovagina. The periumbilical apex and lateral margins of the paddle are sutured together to form a closed-end cul-de-sac with the skin on the inside (see Fig. 47–3). The neovagina is then passed into the pelvis through the distal midline peritoneal incision. The open end of the vaginal





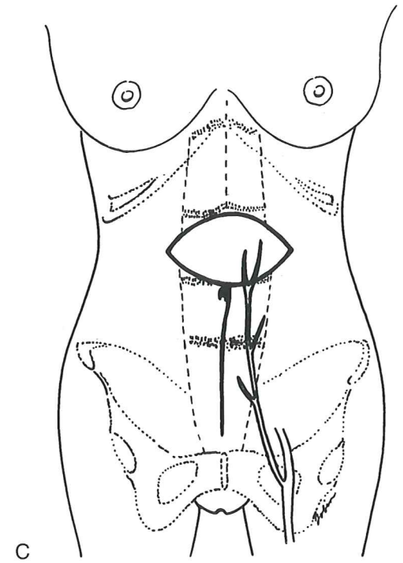


Figure 47–1
The cutaneous paddle designs of the rectus abdominis flap for vaginal reconstruction. The illustrations show relationships of the paddle to the muscle, vascular pedicle, laparotomy incision, and surface landmarks. *A*: The most frequently used design has a vertical paddle axis aligned with that of the muscle. *B*: A vertical paddle is designed on a patient undergoing vaginal reconstruction at the time of pelvic exenteration. *C*: Diagram of a transverse paddle, which can be used to lessen tissue bulk deep in the pelvis. (From Tobin GR, Day TG: Vaginal and pelvic reconstruction with distally based rectus abdominis myocutaneous flaps. Plast Reconstr Surg 81:62, 1988.)

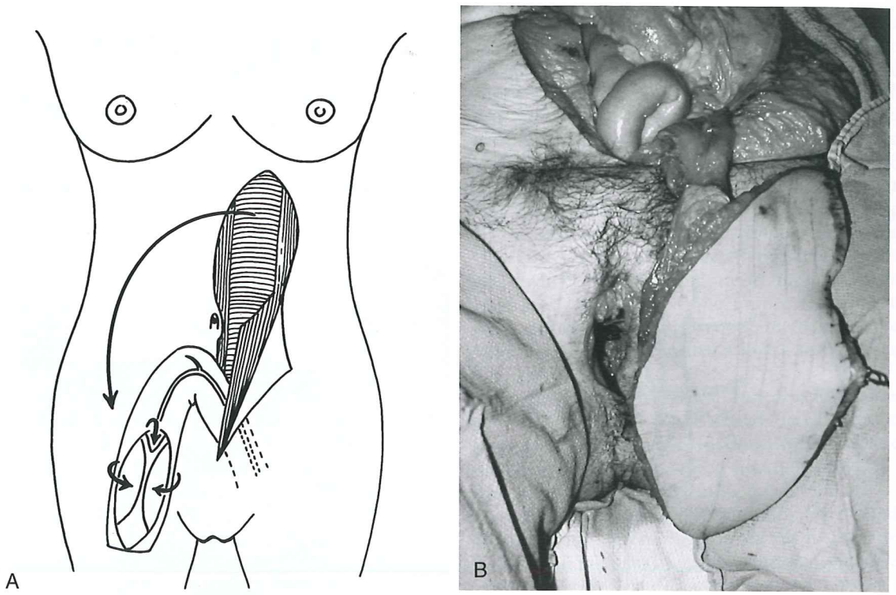


Figure 47–2
A: A flap with a paddle transposed from the abdominal field to the groin region for formation of the vaginal pouch. This allows simultaneous construction of the neovaginal urinary conduit and colostomy. *B*: A transposed flap in a patient shows the size and reach of the flap. *C*: A flap with a transverse paddle transposed for neovaginal pouch construction. (From Tobin GR, Day TG: Vaginal and pelvic reconstruction with distally based rectus abdominis myocutaneous flaps. Plast Reconstr Surg 81:62, 1988.)

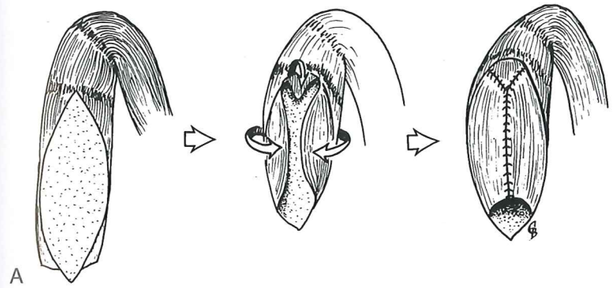






Figure 47–3
Details of inverse tubing of the paddle to create a closed-end neovaginal pouch. *A*: Curved arrows show the infolding pattern. *B*: Alignment of pouch elements before dermal closure. *C*: Pouch completed and ready for perineal inset. (From Tobin GR, Day TG: Vaginal and pelvic reconstruction with distally based rectus abdominis myocutaneous flaps. Plast Reconstr Surg 81:62, 1988.)

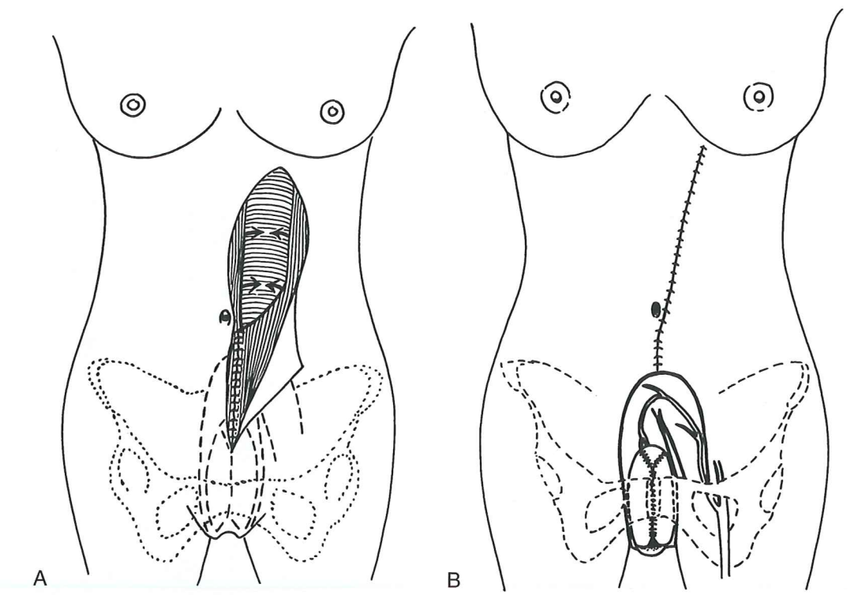
pouch is inset into the vaginal cuff or the perineal defect to form a neointroitus (see Fig. 47–5).

The abdominal donor site and the lower abdomen are closed directly after creation of the colostomy and urinary conduit. The lateral and medial strips of anterior rectus sheath may be sutured together in the paddle donor site to provide a second layer of fascial closure over the intact posterior rectus sheath (see Fig. 47–4*A*). These fascial margins occasionally cannot be approximated without excess tension, and they are then simply inset into the underlying posterior rectus sheath. This method of fascial inset without anterior sheath closure was used routinely in the initial group of patients undergoing reconstruction with this flap,[1] and no hernias or fascial bulges developed in the donor site. The theoretic potential for this, however, led us to attempt closure of the anterior rectus sheath whenever possible.[2–3]

The midline anterior rectus sheath incision distal to the umbilicus is closed directly along the linea alba over the transposed muscle pedicle (see Fig. 47–4*A*). The skin paddle donor site is closed directly in continuity with the laparotomy incision by directly approximating the elliptic margins (see Fig. 47–4*B* and *C*). We use closed suction drains in both donor and recipient sites. Stents or dilation of this neovagina have not been needed postoperatively.

DISCUSSION

This rectus abdominis vaginal reconstruction has been used simultaneously with radical pelvic resections in more than 100 cases since my group and I developed it in 1983.[1–3] Our experience with this reconstruction has been substantially more favorable than with gracilis flaps[7, 12, 13]



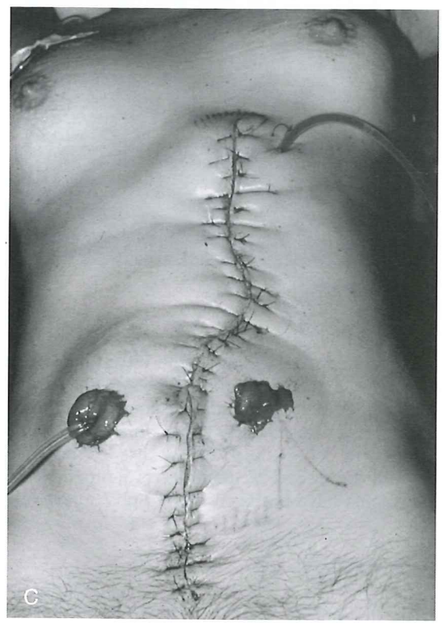


Figure 47–4
Closure of the donor defect after inset of the neovagina and stoma formation. *A*: Direct closure of the anterior rectus fascia donor site above the umbilicus (arrows) and abdominal wall closure below the umbilicus by reclosure of the anterior rectus fascia at the lined alba. Complete fascial reconstruction of the abdominal wall results. *B*: Direct closure of the cutaneous donor site in continuity with the laparotomy incision. *C*: Closure completed in a patient. (From Tobin GR, Day TG: Vaginal and pelvic reconstruction with distally based rectus abdominis myocutaneous flaps. Plast Reconstr Surg 81:62, 1988.)

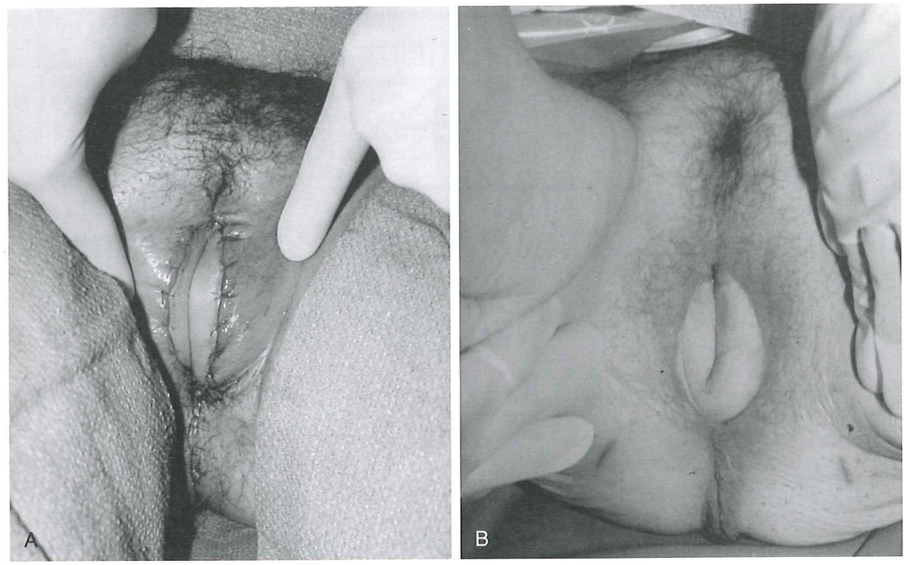


Figure 47–5
A: The reconstructed vaginal pouch is inset into the perineal defect. *B*: A neovagina and vulva reconstructed in a patient who had a simultaneous pelvic exenteration and vulvectomy. (From Tobin GR, Day TG: Vaginal and pelvic reconstruction with distally based rectus abdominis myocutaneous flaps. Plast Reconstr Surg 81:62, 1988.)

or any other method that we used previously. This experience demonstrated many of the advantages of rectus abdominis reconstructions. First, obliteration of residual endopelvic space and exclusion of bowel created by location of the pedicle and bulk of the flap are far superior to that of any other flap. Second, rectus abdominis flaps are far more reliable than gracilis flaps, which have a high incidence of partial paddle loss.[7, 12] Mathes and Nahai found the gracilis flap to have one of the highest incidences of flap loss and the rectus abdominis to have one of the lowest.[14] Third, a single flap restores the vaginal pouch, compared with bilateral flaps that are required of gracilis and other flap reconstructions. Fourth, when a distal vaginal cuff is preserved, as in supralevator exenterations, rectus abdominis reconstructions remain technically straightforward. This contrasts with gracilis and other flaps from the thigh, which are exceptionally difficult to pass around a retained vaginal cuff. Fifth, the rectus abdominis donor site closes in continuity with the laparotomy incision and avoids additional donor site scars on the thighs, which are occasionally sensitive.[13] Sixth, the quality of this vaginal lining is excellent, and stents or dilators are not required to maintain luminal dimensions. Finally, the excellent vascularity provides revascularization of irradiated pelvic wounds of this flap, and the incidence of infection after radical pelvic surgery when this flap is used has declined dramatically from that before its introduction.

In our cases to date, we have had only one complete flap loss, which occurred in a heavy smoker whose iliac artery lumen was severely narrowed and then occluded postoperatively. We experienced only one other significant partial paddle loss, a 30% loss successfully treated by skin grafting the muscle bed. In one case, a partial prolapse occurred. We have not used any prosthetic mesh patches to reinforce the donor site, and no donor site hernias or bulges have been seen to date.

CONCLUSION

In summary, the distally based rectus abdominis muscle-skin flap is a highly reliable, versatile technique for vaginal reconstruction. It also provides reconstruction for massive defects of the pelvic exterior, lower abdomen, groin, or perineum. The accumulated substantial and highly favorable experience with this technique recommends it over other methods of vaginal reconstruction for radical pelvic resections.

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CHAPTER

48

Pudendal Thigh Flap for Vaginal Reconstruction

V.T. JOSEPH

Reconstruction of the vagina is indicated in children with congenital disorders presenting with abnormal genitalia and after ablative surgery for malignant disease in adult patients. The aim is to create a neovagina that is satisfactory both functionally and in appearance[1] using a technique that is simple, reliable, and applicable to most patients. The simplest method of achieving this is to perform a pull-through of the proximally situated vagina in those cases in which this is feasible.[2] However, if existing vaginal tissue is inadequate or vaginal excision has been performed, procedures using tissues from other areas are necessary for satisfactory reconstruction. Earlier techniques used skin grafts[3] or local skin flaps[4] with various degrees of success. For patients in whom more extensive reconstruction is necessary, attempts have been made to increase the flap dimensions by using tissue expanders[5] or by providing vascularized flaps from surrounding regions. The most extensively used is the gracilis myocutaneous flap.[6] An alternative to the use of skin is reconstruction with an isolated segment of intestine,[7] a procedure that has found particular application in the correction of congenital abnormalities.

In 1989, Wee and Joseph[8] described a new technique of vaginoplasty using bilateral pudendal thigh flaps. Similar flaps based on the posterior labial artery were previously used to reconstruct partial defects,[9] but this new procedure was specifically designed for total vaginal reconstruction. The flap is designed with its base horizontal at the level of the posterior margin of the introitus. It is placed just adjacent to the outer border of the labia and extends in conical fashion centered on the inguinal crease toward the femoral triangle. The blood supply comes from the posterior labial branch, which is derived from the perineal artery, itself a continuation of the internal pudendal artery. Through anastomoses with the deep external pudendal, the circumflex femoral, and the anterior branch of the obturator arteries, the area of vascularized flap tissue is increased to include the skin in the groin. Innervation of the flap is provided by the posterior labial branches of the pudendal nerve and twigs from the perineal branch of the posterior cutaneous nerve of the thigh.

PREOPERATIVE EVALUATION

Children with ambiguous genitalia and cloacal abnormalities need to undergo systematic evaluation before vaginoplasty.[10] Gender assignment is carried out at birth, and detailed contrast studies to establish any associated bowel and urinary tract involvement are essential to ensure that the reconstructive surgery does not interfere with the function of these organs.[11] In adult patients, vaginal reconstruction is performed in conjunction with ablative surgery for gynecologic cancer.[12]

SURGICAL TECHNIQUE

Preoperative preparation consists of administration of a simple enema on the night before surgery, supplemented by rectal washout the next morning if necessary. Under general anesthesia, the patient is given caudal bupivacaine to provide analgesia to the perineal area during and after

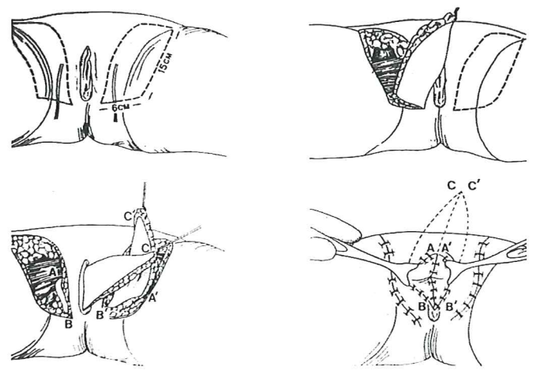


Figure 48–1
Diagrammatic representation of the key steps in pudendal flap vaginoplasty.

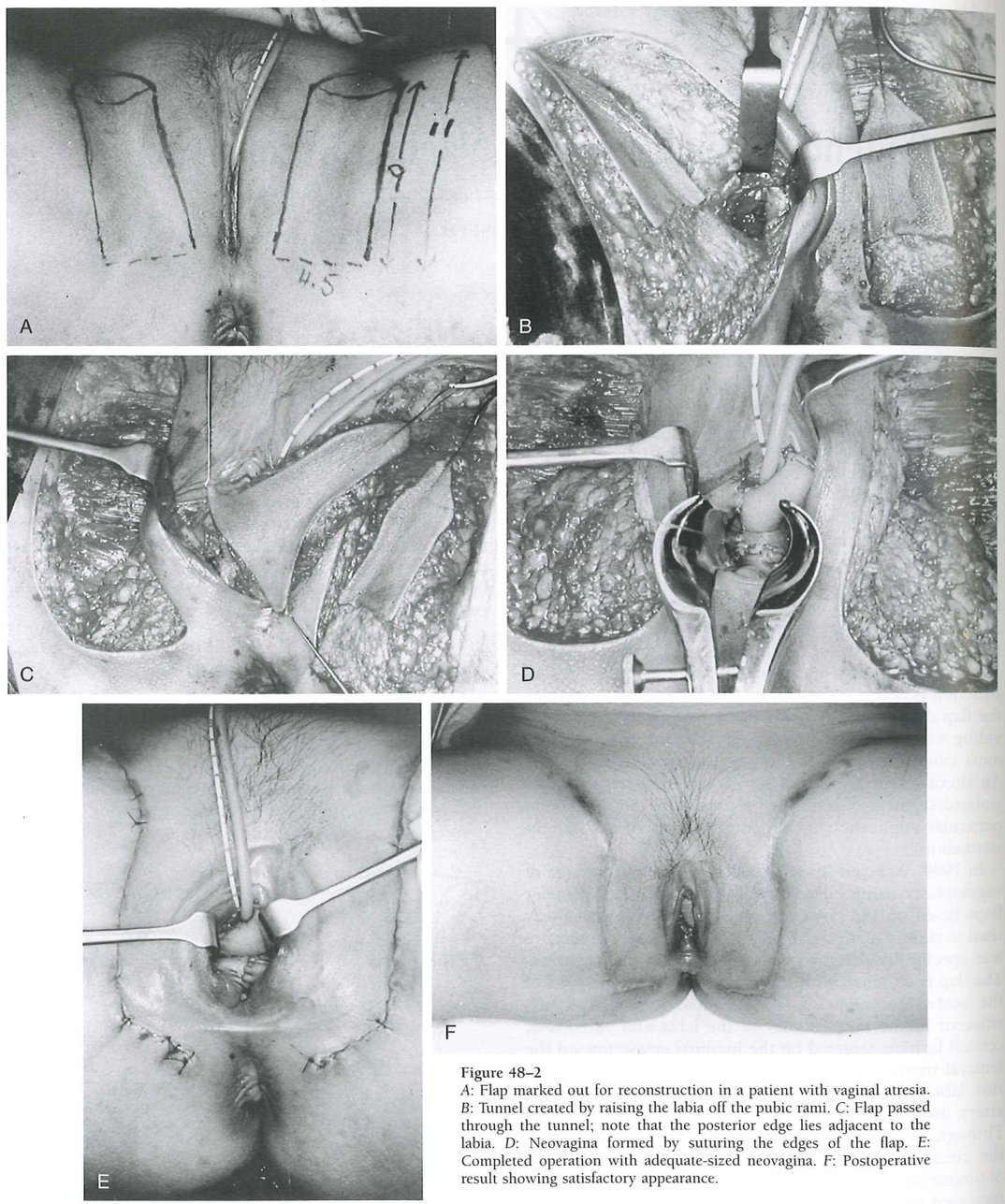


Figure 48–2
A: Flap marked out for reconstruction in a patient with vaginal atresia. *B*: Tunnel created by raising the labia off the pubic rami. *C*: Flap passed through the tunnel; note that the posterior edge lies adjacent to the labia. *D*: Neovagina formed by suturing the edges of the flap. *E*: Completed operation with adequate-sized neovagina. *F*: Postoperative result showing satisfactory appearance.

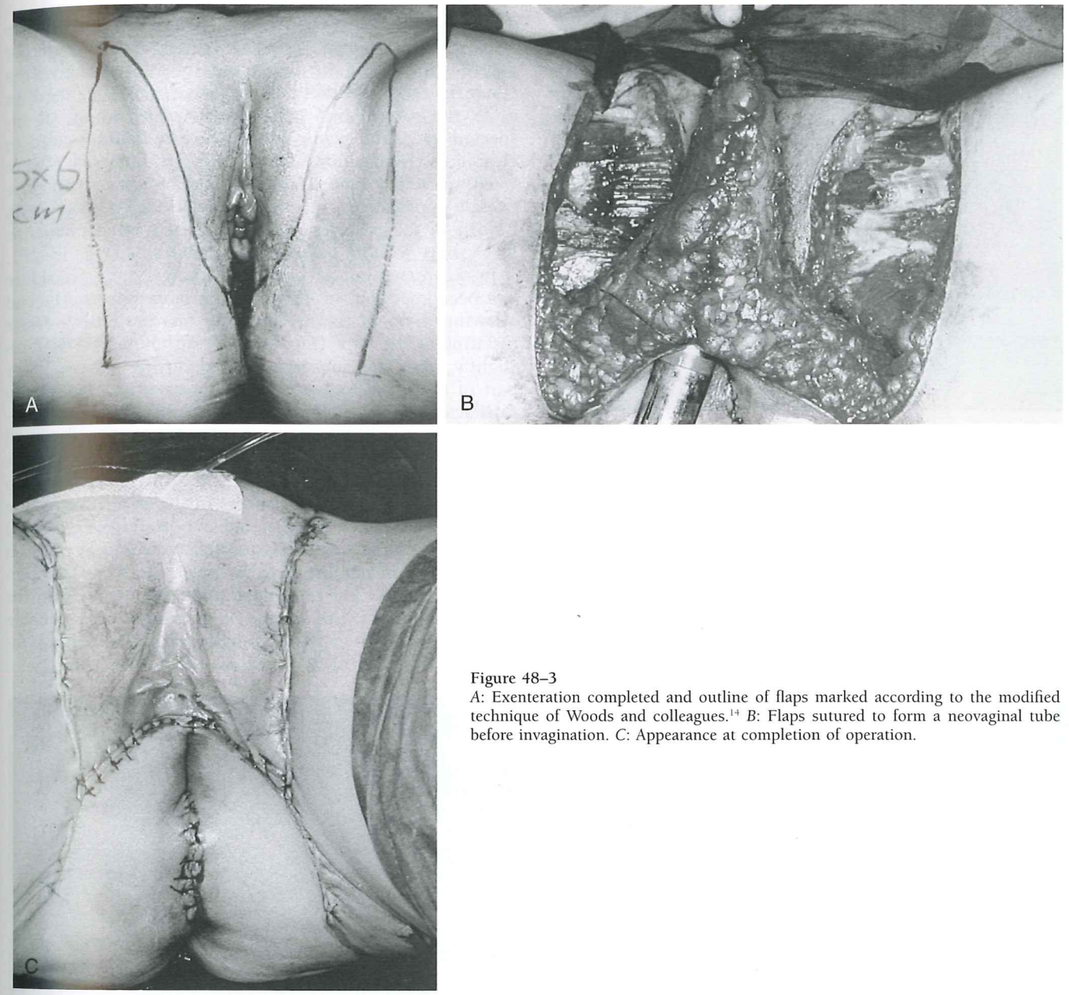


Figure 48–3
A: Exenteration completed and outline of flaps marked according to the modified technique of Woods and colleagues.[14] *B*: Flaps sutured to form a neovaginal tube before invagination. *C*: Appearance at completion of operation.

the operation. Broad-spectrum antibiotics are also given. The positioning of the patient depends on whether an initial abdominal exploration or a posterior sagittal exposure is required[13] to deal with the underlying abnormality. The patient is then placed in the lithotomy position, and a balloon catheter is inserted into the bladder if this has not been done previously. The dimensions of the flap are marked out according to the size of the neovagina that is appropriate for the patient (Figs. 48–1 and 48–2*A*). The first step is to create the space for the neovagina. An incision is made between the urethra and the anal margin, either vertically in the midline or in an inverted-U fashion. The space between the rectum and urethra is developed by blunt dissection, but it may be necessary to sharply divide some fibrous tissue attachments that bind the two structures together, especially at the upper part. Throughout this dissection, a Hegar dilator or a finger is placed in the rectum to help demarcate the rectal wall and avoid accidental injury to the bowel. Elevation of the flaps begins at the apex. The incision is made along the margins except posteriorly and is carried down to include the epimysium of the adductor muscles. Elevation of the flaps is carried out in this plane until the base is reached. The deep fascia is tacked to the edges to prevent shearing. The skin at the base of the flap is incised to the subcutaneous tissue level and is undermined in this plane posteriorly for a short distance. This allows rotation of the flap medially and brings the posterior margin next to the inner edge of the labia, to which it will be sutured. A tunnel is created by elevating the labia off the pubic rami, and each flap is passed through so that both come to lie together in the middle without tension (Fig. 48–2*B* and *C*). The ventral and dorsal margins are sutured together to form a tubular structure, which is then turned in to form the new vagina



Figure 48–4
Chronic ulcer following radiation treated successfully with pudendal thigh flap after several failed attempts using other methods.

(Fig. 48–2*D*). The apex is anastomosed to the proximal vagina if such a structure is present or simply anchored to the tissues at the upper part of the vaginal space (Fig. 48–2*E*). In patients with total pelvic exenteration, the apex is sutured to the periosteum over the sacrum. Suction drains are placed in the vaginal space and in the donor areas, which are then closed in layers with subcuticular sutures to approximate the skin. A simple dressing with a single layer of antibiotic-impregnated gauze is used to cover the suture lines in the vagina. The wound is inspected daily, and gentle irrigation with saline is used to clear any encrustation. The catheter is removed after a week, at which time healing should be satisfactory. The overall appearance is acceptable, with donor site scars hidden in the groin crease, and the neovagina maintains its capacity without any need for dilatations (Fig. 48–2*F*).

In reconstruction after oncologic surgery, the procedure has been modified by dividing the labia posteriorly and allowing them to retract forward, thus permitting easier insetting of the flaps (Fig. 48–3).[14] Although this detracts slightly from the appearance by removing the posterior part of the labial folds, the vagina created is functionally satisfactory. In reconstruction after radical surgery or radiotherapy, particular attention must be paid to the local tissue factors in the area of the flaps because complications may otherwise occur.[15] The pudendal thigh flap has also been used to close chronic ulcers in the perineum, where other methods have failed to achieve healing (Fig. 48–4) and to cover large areas of tissue after radical local excision (Fig. 48–5). It can be used in males for reconstruction of the scrotum. The pudendal thigh flap technique for reconstruction of the vagina is a simple and reliable method that can be applied in both congenital abnormalities of the genitalia and after radical oncologic surgery. The neovagina thus formed maintains its physical attributes without the need for dilatation or other cumbersome procedures. It fulfills the need for an easily performed operation that can be used by any surgeon who needs to carry out reconstructive surgery in this area.

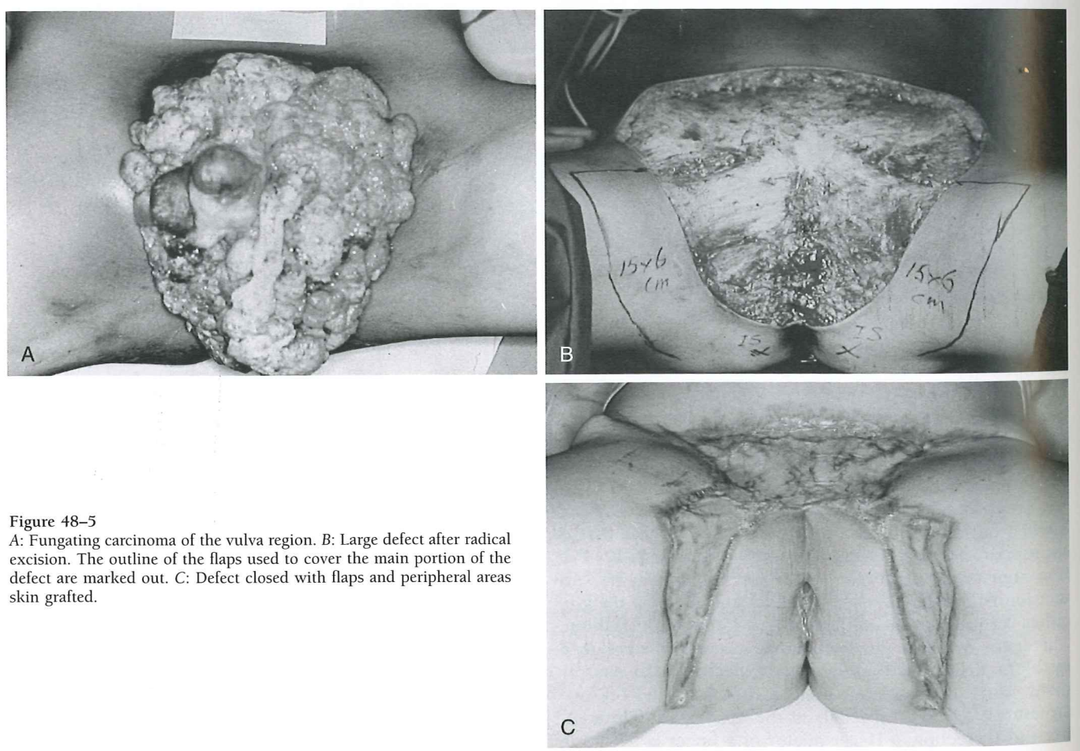


Figure 48–5
A: Fungating carcinoma of the vulva region. *B*: Large defect after radical excision. The outline of the flaps used to cover the main portion of the defect are marked out. *C*: Defect closed with flaps and peripheral areas skin grafted.

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CHAPTER

49

Construction of a "Natural" Vagina Using Rectosigmoid Transplantation

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JUDY VAN MAASDAM

This chapter describes a new technique for vaginal construction resulting in a sensate, natural-feeling, functional vagina associated with a low incidence of surgical morbidity and mortality. This technique has been used to construct a vagina in many circumstances, including vaginal agenesis, congenital urogenital sinus, and gender dysphoria syndrome.

In the past, surgeons described using other portions of the gastrointestinal tract to construct a vagina. In fact, Baldwin described one such technique in 1907.[1] Conway and Stark also described the use of the rectum to reconstruct a vagina; however, they encountered many difficulties due to technical failure at the anastomotic site.[2] Other methods have also been used to construct a vagina, such as split-thickness and full-thickness skin grafts, neurovascular flaps, subcutaneous pedicle flaps, fasciocutaneous flaps, and myocutaneous flaps. Each of these has its own associated advantages and disadvantages.

Our first experience using intestine for vaginal construction began in 1968. We used the sigmoid rather than the rectosigmoid as an island vascular flap to provide fresh tissue for repair of postoperative rectovaginal fistula after vaginal reconstruction in patients with gender dysphoria syndrome. This technique was originally described by Markland.[3] The anastomosis was made above the peritoneal reflection, and the reanastomosis to achieve bowel continuity was hand sewn. Bowel viability was dependent on little more than the marginal artery. This technique was generally successful; however, the circulation to the bowel was not vigorous owing to its tenuous blood supply.

Our current technique of rectosigmoid transplantation uses a 15-cm segment of upper rectum and lower sigmoid colon for transplantation (on a strong neurovascular pedicle) to construct a vagina. The advent of the surgical stapling devices has helped to reduce many of the surgical complications previously encountered during bowel resections, particularly low anterior resection and anastomosis. In the past, the incidence of anastomotic leakage associated with low anterior resection below the peritoneal reflection was unacceptably high, greater than 25%.[4] However, with the use of the end-to-end anastomotic (EEA) stapling device, this has declined to 1% to 3%.[5–7]

Compared with using skin grafts to construct the vagina, rectosigmoid transplantation has a number of advantages:

1. Examination reveals rather normal tactile feeling and visual qualities.
2. Sensibility is retained in the colonic segment.
3. Natural lubrication is present, without excessive mucus production.
4. Vigorous arterial supply is maintained.
5. The malodor associated with skin grafts placed in a body cavity is not present.
6. Long-term use of a stent is not necessary.
7. No skin graft is necessary; therefore, there is no donor site scar.
8. Squamous cell cancer has been reported in seven vaginas; all were constructed with skin grafts, not rectosigmoid transplantation.

TECHNICAL INFORMATION

To optimize the conditions of surgery and thereby minimize the surgical complication rate associated with this procedure, surgery should

- Be performed by a highly experienced and technically expert surgeon
- Be performed on relatively young, healthy patients (i.e., good surgical candidates)

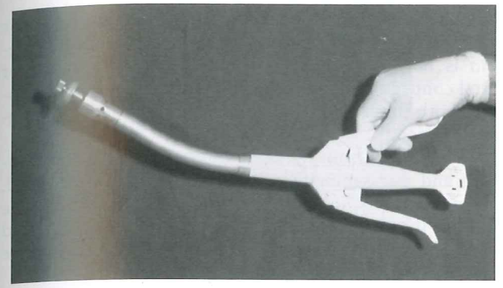


Figure 49–1
End-to-end anastomotic stapling device.

- Use the EEA stapler placed via the anus for colonic anastomosis (Fig. 49–1)[7]

After a complete bowel preparation the night before surgery, the patient is placed on the operating table in a modified lithotomy position. Two surgical teams work simultaneously, reducing the length of the operation. A low transverse abdominal incision is used to isolate the rectosigmoid segment for transplantation and to restore gastrointestinal continuity. A 15-cm segment of rectosigmoid is isolated and moved less than 3 inches to its new position (Fig. 49–2). The blood supply to the pedicle is based on the unpaired superior hemorrhoidal artery system, which is a branch off the inferior mesenteric artery. The colonic mesentery and neurovascular supply of the pedicle are subjected to minimal disturbance. The EEA surgical stapler is then positioned via the anus and is used to reapproximate the distal colon with the rectum (Fig. 49–3). At the same time, the surgeons carrying out the perineal dissection open a passage into the peritoneal cavity from below. The rectosigmoid segment is then positioned as the neovagina and sutured to skin flaps fashioned from the adjacent labia, perineum, groin, or scrotal areas. To decrease the incidence of circumferential contracture, generous darts, Z-plasty, or bias cuts must be used at the skin-mucosa junction (Fig. 49–4).

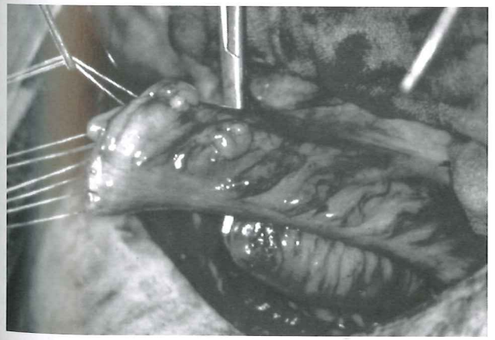


Figure 49–2
Isolated segment of rectosigmoid attached to its mesentery with arterial and neural pedicles intact. Sutures mark the distal end to be sewn to perineal skin flaps.



Figure 49–3
Stapled anastomosis completed with an end-to-end stapling device, restoring continuity of the left descending colon with the rectum.

At the time of surgery, a pneumatic inflatable stent (Mentor Corp., Goleta, CA) is placed and used for 10 days postoperatively. This is then replaced with a silicone foam stent (Precision Ocular Prosthetics, 39 Birch, Redwood City, CA) covered with latex condoms, which is used intermittently twice per day for a period of 6 weeks to 6 months. Douching is not necessary and in fact may cause production of excess mucus.

ANATOMY

The most important clinical aspect of the anatomy is that the colon is transected at the level of the peritoneal reflec-

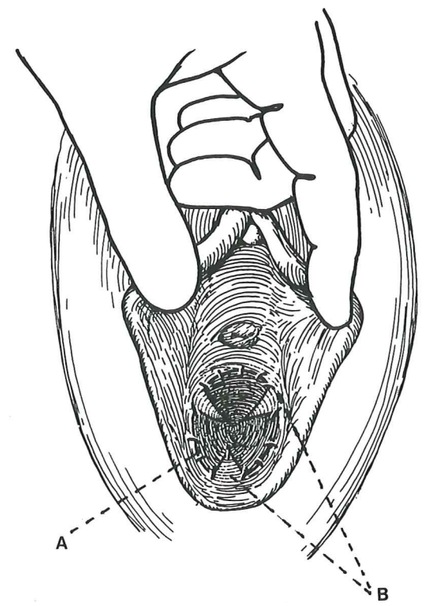


Figure 49–4
The site of anastomosis of the colon (A) to the skin (B). Three large darts are absolutely necessary to prevent pursestring contracture.

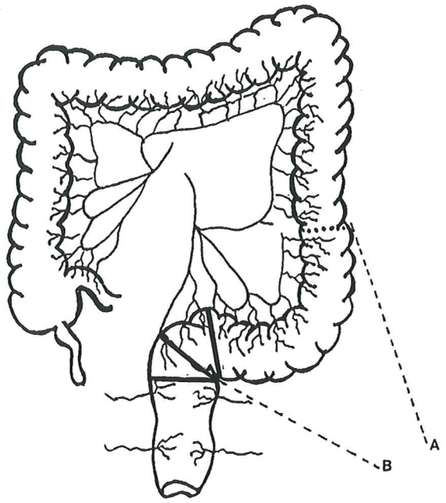


Figure 49–5
The colon and its associated arterial blood supply. A, The point of transection (this becomes proximal end of neovagina); B, the point of transection for the distal end of the rectosigmoid segment. Points A and B are then anastomosed with an end-to-end anastomotic stapler to restore colonic continuity.

tion (or a little below), at a point where the inferior mesenteric artery and vein and their accompanying sympathetic and parasympathetic innervation are merging with another system: that of the middle rectal artery and vein (Figs. 49–5 and 49–6). These vessels are also accompanied by sympathetic and parasympathetic nerves. The arteries, veins, or nerves to either the remaining distal or proximal portions of the intestine suffer no significant interruption

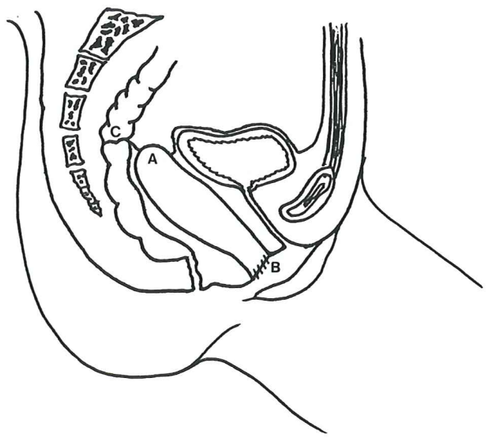


Figure 49–6
Sagittal section illustrating the completed anastomosis. A, Proximal end of neovagina; B, distal end; C, colonic anastomosis.

when this site of disconnection is selected. In a similar fashion, the neovagina formed by the transplanted rectosigmoid is not subjected to interruption of its vascular or neural connections. This maintains an excellent blood supply to both the rectal stump and the transplanted rectosigmoid segment.

Innervation is from the autonomic system, with sympathetic and parasympathetic components. As mentioned, the nerves closely follow the path of the blood supply. The ability of the brain to perceive vibration and pleasure and to be able to distinguish gas from liquid or solid may be facilitated via these nerve pathways.

PHYSIOLOGY

The large intestine receives ileal contents, absorbs water and electrolytes, and acts as a reservoir for feces. The large intestine is insensitive to stimuli that would produce pain if applied to skin; however, it is sensitive to distention. A great difference exists between the colonic and rectal appreciation of this stimulus. In the rectum, detection of small amounts of flatus and differentiation between gas, liquid, and solid feces is possible.[8–10] Indeed, patients relate that they have good appreciation of vibratory stimuli in the neovagina created by rectosigmoid transplantation.

Protective mucus is secreted throughout the bowel by goblet cells in the mucosal lining. The production of mucus appears to be a local phenomenon, linked to irritation of the mucosal lining of the bowel. It is not believed to be controlled by neural or humoral mechanisms. The role of the rectal mucosa in reabsorption of water is unclear. Some have found that the rectum absorbs some water, but less than other portions of the large intestine. Other studies indicate that the rectum is not involved in reabsorption of water at all. In any case, the segment of rectosigmoid used for this procedure does not interrupt colonic physiology in respect to absorption, mucus production, or sensibility. We have encountered no cases of significant postoperative diarrhea or excessive mucus production, and when compared with using other segments of the gastrointestinal tract for vaginal construction, the rectosigmoid has proved to be more desirable.

RESULTS

Our experience using this technique of rectosigmoid transplantation to create a neovagina has evolved significantly since its early stages. The first seven operations used the intestinal tract but not the EEA stapling device and not the low sigmoid/upper rectum. After this, we began using rectosigmoid for the transplanted segment of colon and the EEA surgical stapler. Our present series includes 94 patients, and we have had good results with few complications (Table 49–1). Twenty-one patients in our series developed some degree of vaginal stenosis at the skin-bowel junction. Performing early dilation, perfecting the dissection of viable skin flaps, and enlarging the circumference of the vaginal opening with large darts or Z-plasties or, preferably, using the 3-cm Perović flap of urethral mucosa[11] precluded this problem of stenosis in subsequent cases. One



Figure 49–7
Postoperative appearance of the neovagina.

patient required reoperation for bowel obstruction and was noted to have a closed loop obstruction secondary to a single adhesion. One patient had a superficial wound infection. Of particular importance to note is the lack of technical problems such as anastomotic leak, intraabdominal abcess, or vascular compromise of the transplanted segment of colon.

All patients except one report some sensibility and success with sexual intercourse when attempted. Colonoscopy reveals normal colonic mucosa. External physical examination and digital examination of the transplanted rectosigmoid segment reveal the same characteristic smoothness and lubrication of a natural vagina (Fig. 49–7).

In summary, we have shown that rectosigmoid transplantation for creation of a neovagina results in a good outcome compared to other techniques when the EEA surgical stapling device is used to perform an anastomosis at or below the peritoneal reflection, as described in this chapter. The present series of patients confirms that this technique is feasible to perform, causes minimal surgical morbidity, and results in a normal-appearing vagina with perceptible sensitivity, good lubrication, adequate but not overproduction of mucus, and minimal scar formation. Surgical formation of a natural vagina using rectosigmoid transplantation is invaluable to the patients who seek medical attention for this purpose.

Table 49–1
Complications in 94 Patients After Construction of a Vagina with Rectosigmoid Transplantation

Complication	Number
Wound infection	1
Anastomotic leakage	0
Pelvic abscess	1
Flap failure	0
Bowel obstruction	1
Vaginal perforation	1
Vaginal stricture	21
Neuroma formation	2
Rectovaginal fistula	0
Excess mucus discharge	0
Cramping pain	0
Malodor	0

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FEMINIZING GENITOPLASTY AND VAGINOPLASTY

CHAPTER

50

Clitoroplasty

MARK F. BELLINGER

Surgical reconstruction of ambiguous external genitalia in females (feminizing genitoplasty) may include clitoroplasty, vaginoplasty, and labioplasty. In the presence of idiopathic or isolated clitoromegaly, clitoroplasty alone may suffice. In most situations, however, clitoroplasty, the mainstay of feminizing genitoplasty, must be planned and carried out in concert with labioplasty and simultaneous or delayed vaginoplasty. The surgeon must thus plan, from the onset, in terms of the final goals of surgical reconstruction. Advance planning is particularly important in order to preserve, during the initial surgery, whatever tissue will be needed for later reconstruction when delayed vaginoplasty will be performed.

Historically, until the 1960s, clitoral hypertrophy was dealt with surgically by amputation clitoridectomy.[1] Concern about the functional consequences of ablation of the clitoris led subsequently to several described techniques for recession of the clitoris, shortening and tucking the clitoris back to achieve a cosmetically satisfactory result.[2] These techniques have been abandoned because of long-term functional concerns: painful erections. Contemporary approaches to the enlarged clitoris incorporate resection of the corpora cavernosa to prevent erection while preserving the glans and its neurovascular supply.[3, 4]

The most important aspect of the preoperative evaluation of a patient with clitoromegaly or genital ambiguity is the establishment of a clinical diagnosis. If the etiology of the process that has resulted in clitoromegaly is not determined, inappropriate surgical reconstruction may be carried out with disastrous long-term complications. The most common cause of genital ambiguity is female pseudohermaphroditism secondary to congenital adrenal hyperplasia (CAH, adrenogenital syndrome), caused by an enzyme defect in the normal pathway of steroid biosynthesis. The result is overproduction of androgenic steroids and masculinization of the external structures, which, because they contain 5α-reductase, are readily virilized.[5] Other causes of clitoromegaly include true hermaphroditism, male pseudohermaphroditism, and mixed gonadal dysgenesis (Fig. 50–1).[5]

Evaluation of an infant with genital ambiguity should include the following: (1) historical review of maternal androgen exposure during pregnancy; (2) family history of perinatal deaths, infertility, or genital surgery; (3) physical examination, particularly determining phallic length, corporeal diameter, and the presence or absence of palpable gonads; (4) karyotype; and (5) assessment of serum 17-OH-progesterone or urinary 17-ketosteroid concentrations. In addition, a retrograde (flush) genitogram may be helpful in assessing urethral anatomy and defining both the presence of a vagina and its relationship to the urethra, bladder neck, and perineum, information that may influence the technique and timing of vaginoplasty (Fig. 50–2).

When all of the foregoing information is available, a well-informed decision can be made about sex assignment. It is more appropriate to delay the decision about sex of rearing for several days than to make an erroneous assumption and find it necessary to alter that decision a few days later. The significance of the decision about the appropriate sex of rearing should be conveyed to the parents so that any delay encountered will be tolerated expectantly.

SURGICAL CONSIDERATIONS

Timing of Surgery

Unless a child's health considerations prohibit general anesthesia, feminizing genitoplasty in a neonate with genital ambiguity can be carried out within the first few months of life. By 2 to 3 months of age, a child's general health is established, medical regimens for CAH are well established, and response to medications is documented. Surgery at this age is well tolerated by the child and, even if only clitoroplasty is performed, frees the family from discomfort at viewing the large clitoris with every diaper change, a particularly significant concern with babies in daycare or other situations in which relative strangers may be called on to change diapers.



Figure 50-1
A: Genitalia of an infant with congenital adrenal hyperplasia. *B*: Genitalia of a 14-month-old girl with unrecognized congenital adrenal hyperplasia. *C*: Genitalia of an infant with mixed-gonadal dysgenesis. *D*: Genitalia of a child with idiopathic clitoromegaly. *E*: Genitalia of a boy with hypospadias.

Preparation for Surgery and Anesthesia

In the current climate of medical economics, even infants who have CAH and who are to undergo genital reconstruction are admitted through short-stay surgery units the morning of surgery. It is important that both surgeon and anesthesiologist remain alert to the adverse effects that dehydration and suboptimal steroid replacement may have on infants under the stress of general anesthesia and surgery. In our experience, infants who are offered clear liquids 4 hours before the induction of anesthesia arrive at surgery with an empty stomach and are reasonably well hydrated. Corticosteroid management includes doubling the patient's usual dose the day before surgery. The morning of surgery, the usual oral dose may be given if allowed by the anesthesiologist. Intraoperatively, appropriate fluid replacement is administered together with cortisol supplementation (three times physiologic replacement, or approximately 36 mg/m²/day divided into four doses).[6] Perioperative antibiotics may be administered as usual. After surgery, the child's usual oral dosage of corticosteroids is usually doubled for 1 to 2 days and then returned to the normal regimen. Mineralocorticoid replacement continues as usual.

Anesthetic management may include use of caudal anesthesia in most cases or perhaps a continuous epidural anesthetic in an older child or adolescent undergoing delayed vaginoplasty. For most infants, we find a single-shot caudal injection of bupivacaine (with or without narcotic) both lessens the anesthetic requirement intraoperatively and diminishes postoperative pain for several hours.[7] In many cases, only acetaminophen (10 to 15 mg/kg/dose every 4 hours as needed) is necessary.

Clitoroplasty

The goals of clitoroplasty are feminization, preservation of function and sensation, and cosmesis. To achieve these goals, the surgeon must diminish clitoral length and diameter, decrease the size of the glans clitoris, recess the glans,

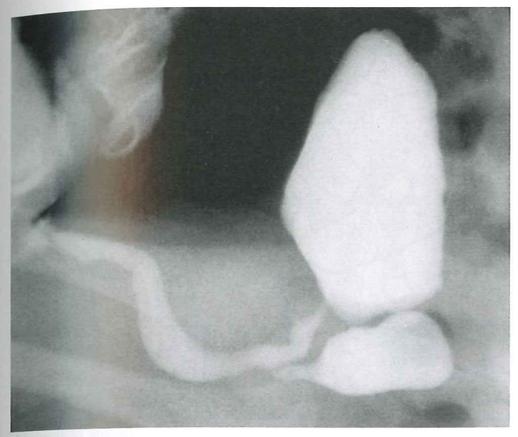


Figure 50-2
Flush genitogram of an infant with congenital adrenal hyperplasia. Contrast fills the bladder (large structure). The vagina (smaller structure below the bladder) can be seen to enter the posterior urethra.

preserve clitoral blood supply and sensation, and coordinate clitoroplasty with simultaneous or delayed vaginal/labial reconstruction (which should be designed to provide adequate vaginal exteriorization and introital diameter).

The procedure is begun with the patient in the dorsal lithotomy position, with all pressure points wellpadded. We have found that most children and infants are wellpositioned and supported using small overhead arm boards (commonly used to support the arms of adult patients in the lateral positioning during renal surgery) as leg supports, rather than the routinely used leg stirrups. After inspection of the introitus and perineum, a small (8 or 10 French) pediatric cystoscope is used to inspect the urethra, bladder, and vagina. When a single perineal orifice is present, it is important to localize the junction of the vagina and urethra accurately. It may be necessary to dilate the vaginal orifice slightly to allow appropriate access for vaginoscopy. In addition, passing a small catheter into the vagina may facilitate its identification if vaginoplasty is to be performed. When simultaneous vaginoplasty is appropriate (low-lying urethrovaginal confluence below the level of the external sphincter), it is carried out before clitoroplasty for two reasons: (1) The posterior extent of the labial flaps needed to complete the anterior and lateral vaginal walls will be better defined after the posterior flap has been defined, and (2) bloody runoff from the clitoroplasty dissection may obscure the field if vaginoplasty is performed secondarily.

Clitoroplasty is begun by placing a small traction suture through the glans. A small volume (0.1 to 0.2 ml) of lidocaine with epinephrine (1:100,000) is injected at the coronal margin of the glans to assist hemostasis. An incision is made around the dorsal margin of the glans close to the corona. It is not carried around the full ventral circumference but is extended inferolaterally into the lateral attachments of the prepuce (usually at approximately 4 o'clock and 7 o'clock on the glans). This leaves the broad midline attachment of the mucosa and corpus spongiosum of the urethral plate to the glans intact (Fig. 50–3). The clitoris is now completely degloved dorsally, preserving the subcutaneous blood supply to the dorsal shaft skin and the dorsal neurovascular bundles on the surface of the corpora cavernosa (Figs. 50–3 and 50–4). This dissection



Figure 50-3
After initial vaginoplasty has been partially completed, the clitoris is degloved, preserving the ventral urethral plate. The catheter is in the urethra.

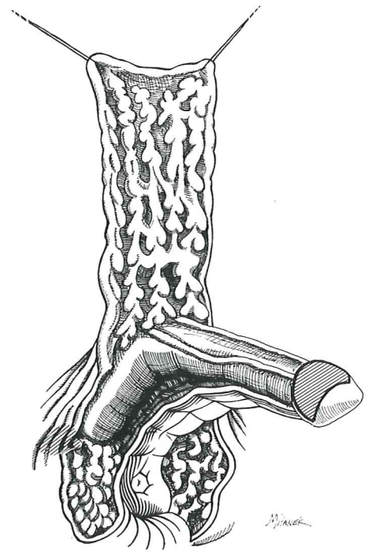


Figure 50-4
The clitoris has been degloved, preserving the dorsal neurovascular bundle and the ventral urethral plate. The shaded area represents the deepithelialized portion of the glans. (From Bellinger MF: Subtotal de-epithelialization and partial concealment of the glans clitoris: A modification to improve the cosmetic results of feminizing genitoplasty. J Urol 150:651, 1993.)

should be extended proximal to the bifurcation of the corpora. Each crus is now isolated lateral to the midline and ligated in situ. With the vascular supply ligated, corporal reduction can be accomplished by one of several techniques. A reliable method is a modification of that described by Kogan and colleagues: subtunical total reduction.[8] A longitudinal incision is made on the lateral aspect of one corporeal body through Buck's fascia and the tunica albuginea (Fig. 50–5). The cavernous tissue is then resected, using sharp dissection or needlepoint cautery. The dissection is usually easily carried transseptally, and both corpora can be removed in one package. Bleeding from the proximal end of the corpora or from the glans may be controlled by suture ligature. This approach ensures protection and preservation of the dorsal neurovascular structures, also leaving intact the tunica albuginea and the ventral urethral plate's mucosa and blood supply (see Fig. 50–4).

Once corporeal reduction is complete, the configuration and size of the glans should be assessed. A normal glans clitoris is small and rather conical, with a small preputial hood. Reconfiguration of the glans is an important part of providing a satisfactory cosmetic result. This is best achieved by a combination of techniques including (1) excision of a small amount of glanular tissue from within the glans (transseptally from the aspect of the attachment of the corpora), (2) excision of a dorsal midline wedge of glans (this reconfigures the glans from globular to conical) (Fig. 50–6), and (3) deepithelialization of the corona and peripheral dorsolateral glans to leave a small central cap of appropriate size epithelialized (see Fig. 50–4).[9] The

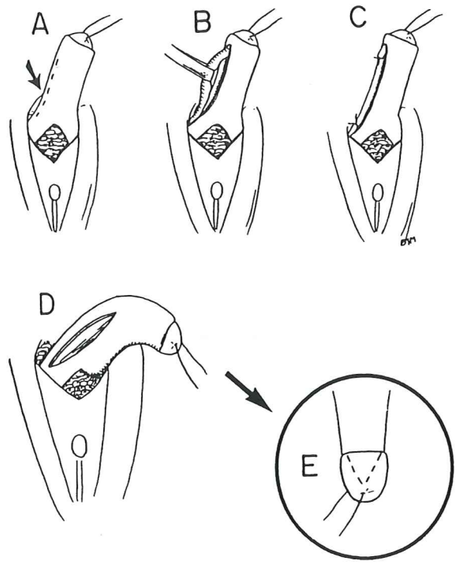


Figure 50-5
Diagrammatic representation of subtunical reduction clitoroplasty. (From Kogan SJ, Smey P, Levitt SB: Subtunical reduction clitoroplasty: A safe modification of existing techniques. J Urol 130:746, 1983.)

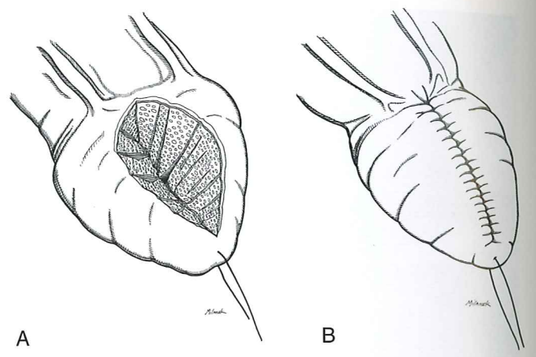


Figure 50-6
A: Excision of a midline wedge of dorsal glans. *B*: Glans closure. (From Bellinger MF: Subtotal de-epithelialization and partial concealment of the glans clitoris: A modification to improve the cosmetic results of feminizing genitoplasty. J Urol 150:651, 1993.)

glans is now tacked to the pubic symphysis using nonabsorbable sutures, folding the attached tunica and neurovascular structures dorsally and laterally so they are not injured. If the length of the urethral plate is excessive and as a consequence the distance from the clitoris to the urethral meatus is abnormally long, a transverse strip of epithelium may be removed from the urethral plate and the gap narrowed by suturing the denuded edges, essentially imbricating the urethral plate in the process.

Labioplasty is next performed using the skin of the prepuce and clitoral shaft. The skin is divided in the midline almost to the level of the penopubic junction. It is now sutured to the circumference of the epithelialized portion of the glans using 7-0 polydioxanone sutures. This technique serves to conceal the peripheral deepithelialized portion of the glans, leaving only a small portion of exposed glans visible (see Fig. 50–6). The two medial folds of the labial flaps may be incised for a short distance and tacked together over the superior aspect of the glans if this maneuver enhances the creation of a clitoral hood.

The dorsal coronal incision, which was initially carried inferolaterally into the lateral preputial attachments (parallel to the preserved midline urethral plate), may be continued posteriorly and slightly laterally toward the ischial tuberosites or toward the lateral edges of the vaginoplasty until enough length of incision is created to equal the length of the labial flap that will be sewn into this incision. The preputial shafts that will now become the labia minora may be tailored slightly to achieve a gradually tapered appearance. They are sewn into the defect (urethral plate medially, labial tissue laterally), using a continuous 6-0 or 7-0 polydioxanone suture (Fig. 50–7). If necessary, the most posterior portion of the flaps may be sewn into the dorsolateral vaginal introitus to enlarge its circumference. Before completing the labioplasty, a single small suction drain is placed or one may be placed under each flap. The drains are brought out through the edge of the mons pubis (Fig. 50–8).

A small urethral catheter is placed into the bladder at the completion of the procedure, and the wound is dressed

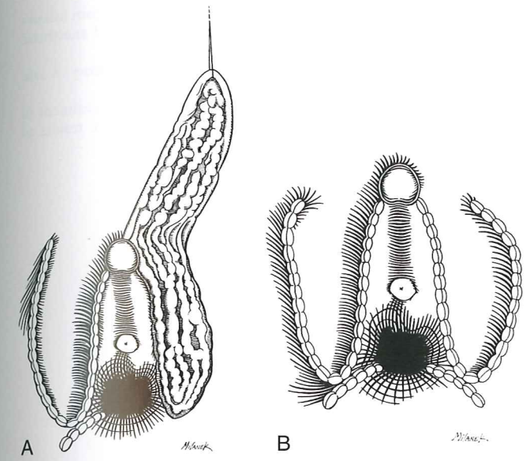


Figure 50-7
Labioplasty. (From Bellinger MF: Subtotal de-epithelialization and partial concealment of the glans clitoris: A modification to improve the cosmetic results of feminizing genitoplasty. J Urol 150:651, 1993.)

with antibacterial ointment. The child is kept at bed rest overnight, with saline gauze used to cleanse the wounds and ointment reapplied as necessary. The morning after surgery, the suction drains and catheter are removed and antibiotic prophylaxis discontinued. Oral prophylactic antibiotics may be continued at the discretion of the surgeon. If the child is afebrile, comfortable, eating well, and tolerating medications orally, she may be discharged from the hospital 1 to 2 days postoperatively. Parents are cautioned to cleanse the wound with warm water and apply A and D ointment to the diaper several times a day for the next 7 to 10 days. After 7 days, the child may be bathed for



Figure 50-8
Immediate postoperative appearance with urethral catheter and suction drain in place.

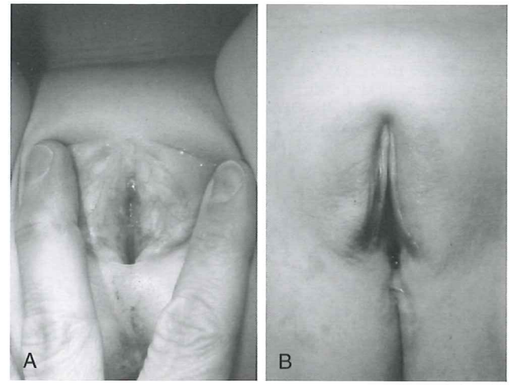


Figure 50-9
Delayed postoperative appearance. Note cosmetically appropriate size of glans clitoris.

short periods daily. Straddle activities are restricted for 3 weeks.

Long-term follow-up after feminizing genitoplasty is important (Fig. 50–9). Vaginal introital stenosis frequently requires dilation or surgical revision, and on occasion, labioplasty revisions are performed to improve genital appearance. Adolescents should be monitored to ensure that dysmenorrhea is not problematic. Adolescents should be counseled about their surgical history, and a pelvic examination should be performed in early adolescence to assess introital caliber before the onset of menstruation and sexual activity. Introitoplasty or instruction in self-dilation may be indicated. It is important to assist each adolescent in finding an appropriate gynecologist who is aware of her past surgical history and, if possible, has experience in managing gynecologic and obstetric problems in women who have previously undergone genital reconstruction. In this relationship, the urologist may continue to act as both a source of information for the gynecologist and a source of support for the patient.

In summary, clitoroplasty, as a focal point of feminizing genitoplasty, should be performed with a complete understanding of the primary endocrine or hormonal problem that has resulted in genital ambiguity. Surgical correction should be planned to provide feminization and cosmesis, ensure proper function, and preserve sensation. Long-term follow-up is necessary to offer surgical revision when appropriate, provide continued support and education at puberty, and ensure adequate and well-informed gynecologic and obstetric care.

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CHAPTER

51

Technical Nuances in Intersex Surgery: Clitoroplasty

STANLEY J. KOGAN

The basic techniques for surgical reconstruction of the clitoris, labia, and vagina in intersex conditions (feminizing genitoplasty) are now well described, and the results of reconstruction are usually satisfactory. Nevertheless, technical subtleties and nuances, when used, can enhance both cosmetic and functional results. This chapter describes techniques I have found useful to maximize results in intersex surgery.

Techniques of clitoroplasty have continually evolved. References to clitoral amputation are made in ancient writings, and this procedure is still performed in African cultures to diminish female sexual libido. Early treatment of clitoral hypertrophy consisted of amputation. Modern-day treatment has evolved from *clitorectomy* to techniques of *recession* and *resection* to reduce clitoral size, each with many variations. Recession techniques involve mobilization of the shaft with relocation under the pubis or in the subcutaneous tissues. Resection may be done by either total or subtotal removal of the corporeal bodies and surrounding tunica albuginea or by subtunical resection of the erectile tissue only. Table 51–1 summarizes chronologically many of these important techniques as well as their indications and variations.

GENERAL CONSIDERATIONS

Goals

The goals of clitoroplasty are to reduce the size of the hypertrophied clitoral shaft and glans while preserving normal glans sensation and creating normal glans appearance. These goals may be accomplished by recession or excisional resection techniques, preserving the glans and dorsal neurovascular bundle in each instance. In most situations, clitoroplasty is a component of reconstruction of the urogenital sinus to separate the vagina and urethra, as well as cosmetic repair of the labia to complete creation of normal-appearing female external genitalia.

Indications

Patients with all intersex diagnoses may require clitoroplasty surgery, although the relative frequency differs according to the underlying intersex condition (Table 51–2). Female pseudohermaphrodites with 21-hydroxylase adrenogenital syndrome constitute the overwhelmingly largest single group of patients undergoing this procedure. The specifics of the underlying condition determine whether other adjunctive surgical procedures may be necessary as well. For example, some intersex patients without palpable gonads may require open or laparoscopic diagnostic evaluation of their internal ductal structures as well as possible gonadectomy. Male pseudohermaphrodites who will be reared as females require orchiectomy. In general, I prefer to complete all diagnostic procedures (i.e., laparoscopy, gonadal biopsy, etc.) during the initial birth hospitalization. Intraabdominal or external gonadectomy can in some instances be performed simultaneously with clitoroplasty.

Single-Stage Versus Staged Procedure

Clitoroplasty was initially performed as a *staged* procedure, followed subsequently by urogenital sinus separation and vaginoplasty. As surgical and anesthetic techniques improved, *simultaneous single-stage repair* became the preferred treatment. Feminizing genitoplasty lends itself, with rare exception (i.e., high urogenital sinus), to a single-stage repair. The incisions can be tailored to accomplish all goals (i.e., clitoral size reduction, separation of the urethra and vagina with vaginoplasty, and labioplasty) in one surgical procedure. Conversely, a staged clitoroplasty leaves scarring that in some instances may make the second procedure more cumbersome. Staging of these surgeries is seldom justified, except in instances of a high confluence of the urethra and vagina (high urogenital sinus).

Timing of Surgery

It was historically suggested that clitoroplasty be performed by 1 year of age; however, this approach puts an

Table 51–1
Chronology of Clitoroplasty Techniques

Investigators	Year	Description of Technique
Lattimer[3]	1961	Bury mobilized shaft in subcutaneous tissues, trim glans
Gross et al[4]	1966	Clitorectomy
Randolph et al[5]	1970	Total shaft recession by wide mobilization, suture corpora to pubis, "buckling" shaft
Spence and Allen[6]	1973	Ventral (or dorsal) total shaft excision, preserve dnvb* and glans
Shaw[7]	1977	Subtotal dorsal shaft resection preserving blood supply through dorsal and lateral skin
Hendren and Donahoe[8]	1980	Single-stage repair with partial resection of shaft and reanastomosis of glans to stump
Barrett and Gonzales[9]	1980	Single-stage repair with subtotal shaft resection, preserve dnvb and glans
Mollard et al[10]	1981	Subtotal shaft resection, preserve dnvb and glans
Glassberg and Laungani[11]	1981	Shaft reduction by multiple plications of tunica albuginea, reduce glans size
Rajfer et al[12]	1982	Ventral approach to clitoris with subtotal shaft resection, preserve dnvb and glans
Kogan et al[1]	1983	Single-stage repair with subtunical erectile tissue resection, preserve dnvb, tunica, reduce glans
Mussinelli et al[13]	1986	Bury intact corpora subcutaneously in labia
Passerini-Glazel[14]	1989	Single-stage shaft resection, reanastomosis of glans to stumps, simultaneous vaginoplasty with inverted phallic skin
Gonzalez and Fernandes[15]	1990	Single-stage repair with subtunical erectile tissue resection, preserve dnvb and glans, then vaginoplasty by pull-through and preputial flap
Sagehashi[16]	1993	Subtunical erectile tissue resection, preserve dnvb and glans
de Jong and Boemers[17]	1995	Single-stage *neonatal* repair by shaft resection, flap vaginoplasty

*dnvb, Dorsal neurovascular bundle.

unfair burden on parents to expect them to live with their child's deformity for an inordinately long time. I personally counsel the parents at birth, emphasizing that their child can undergo complete reconstruction and have a normal genital appearance, which will be done as soon as the child's clinical status is stable. For example, for children with adrenogenital conditions, their electrolytes must be well controlled and their proper maintenance dose of glucocorticoid and mineralocorticoid be established. In practice, most infants with adrenogenital syndrome undergo reconstruction between 6 and 12 weeks of life, allowing parents to have important initial bonding time with their child yet not waiting long enough to allow discomfort about their child's abnormal genitalia to build. Other intersex conditions usually are repaired earlier after a brief time at home for bonding and stability. I have performed clitoroplasty during the initial birth hospitalization when necessary, once the infant is stable and electrolytes are normalized; however, this approach is not advocated except in special circumstances. Clitoroplasty surgery is at times associated with a genuine need for transfusion, and the surgery is technically more demanding at this age because some structures (i.e., the vagina) are less tenacious than later in life and may be more difficult to reconstruct.

Some surgeons claim that the clitoris may significantly regress in size after birth when the infant is removed from the maternal pregnancy hormonal environment and when treatment with glucocorticoids suppresses oversecretion of virilizing androgenic hormones. I personally have not seen this phenomenon and do not support this argument for delaying appropriate surgical reconstruction. Similarly, claims that increased infant pubic and labial fat cause either intraoperative surgical difficulties or worsened results, in my experience, are poorly founded and should not affect decisions about the timing of surgery.

Table 51–2
Frequency of Clitoroplasty in Various Intersex Disorders with Genital Ambiguity

Cause	Phenotype	Virilization	Frequency
Female pseudohermaphrodite	Ambiguous	+/+++	+++
Male pseudohermaphrodite			
Testicular feminization	Normal female	−	−
XY gonadal dysgenesis	Normal female	−	−
	Ambiguous	+	++
		++	−
Micropenis	Small male	−+	+
Testicular regression	Small male	+	+−
	Ambiguous	−+	++
Testis steroid defect	Ambiguous	−+	+−
Other androgen receptor defect	Ambiguous	+	+−
	Normal male	+++	−
Central nervous system	Normal male	+++	−
True hermaphrodite	Ambiguous	++	++
	Male	+++	−
Mixed gonadal dysgenesis	Ambiguous	++	++
	Male	+++	−

Surgical Preparation

Infants with adrenogenital syndrome should demonstrate satisfactory feeding and weight increases as well as electrolyte homeostasis before surgery is scheduled. A genitogram (antegrade and retrograde contrast injection study of the urogenital sinus) should be performed to identify accurately the urethral-vaginal confluence. Blood is cross-matched and reserved, because corpus spongiosum bleeding may sometimes be significant and difficult to control. Maintenance doses of glucocorticoid and mineralocorticoid should be continued, with an additional stress dose of 3 mg/kg body weight hydrocortisone administered 8 hours before surgery, at anesthesia onset, and 6 hours subsequently. Perioperative antibiotic coverage is used and continued for 3 to 5 days postoperatively.

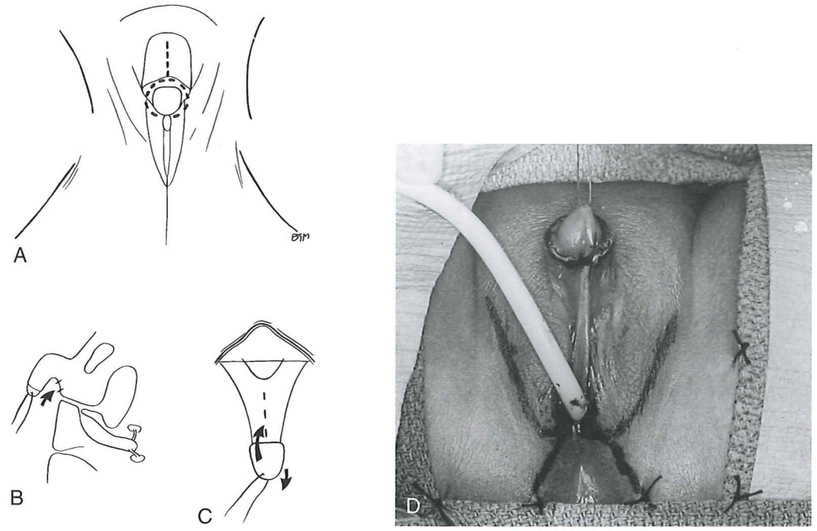


Figure 51–1
Incisions used for clitoroplasty. *A*: Incision circumcising glans, with extension cephalad up dorsal shaft. *B*: Lateral view showing incision through the ventral mucosal plate between the glans and urogenital sinus, preserved in most other clitoroplasty techniques. *C*: Phallus may be moved dorsally or ventrally, facilitating access to the entire shaft. *D*: Gross view of the initial incisions used in an 8-month-old true hermaphrodite undergoing single-stage repair. (From Kogan SJ, Smey P, Levitt SB: Subtunical total reduction clitoroplasty: A safe modification of existing techniques. J Urol 130:746, 1983.)

CLITOROPLASTY TECHNIQUE

My preference for clitoroplasty is to reduce the size of the hypertrophied shaft by subtotal excision of the corporeal bodies from within the surrounding tunica albuginea (*subtunical reduction clitoroplasty*).[1] Minor degrees of enlargement are better treated by conventional subtotal corporeal body resection with preservation of the dorsal neurovascular bundle, because it is sometimes difficult to develop a surgical plane within the tunica when the corporeal bodies are very small. I do not use fold-over recession clitoroplasty because I have had to reoperate on some girls in adolescence who had previously undergone clitoroplasty by this technique and who developed painful erections from congestion and engorgement of the restricted shaft.

Contrasting with other described techniques, when subtunical clitoral reduction is performed, the clitoris is mobilized circumferentially without preservation of the ventral mucosal plate between the urogenital sinus and the ventral glans (Fig. 51–1). The entire shaft is then dissected free of the surrounding cylinder of skin, following the corporeal bodies as they diverge on the descending pubic rami. The skin cylinder is then split in the midline dorsally to be used subsequently to form labia minora. This maneuver aids in exposing the most inferior aspects of the corporeal bodies. The tunical coverings of the hypertrophied clitoris are then incised ventrally or laterally on each side, and the erectile tissue, which forms the bulk of the corporeal bodies, is excised from within the tunica, and the proximal and distal ends are ligated with a 4-0 absorbable suture ligature (Figs. 51–2 and 51–3). The dorsal neurovascular bundle is *undisturbed* in this approach, and the glans blood supply is preserved. The glans may then be reduced in size, if necessary, by either wedge resection of a portion or deepithelialization of the proximal portion with subse-

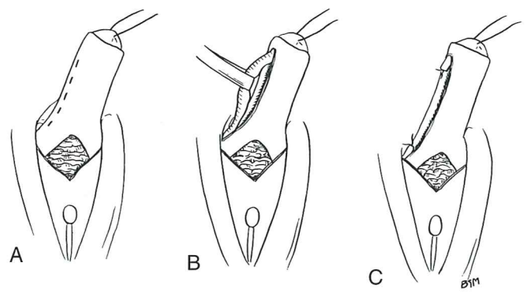


Figure 51–2
Diagrammatic representation of incisions in the shaft. *A*: Lateral incision through the tunica albuginea. *B*: Mobilization of right erectile tissue. *C*: Ligation proximally and distally. (From Kogan SJ, Smey P, Levitt SB: Subtunical total reduction clitoroplasty: A safe modification of existing techniques. J Urol 130:746, 1983.)

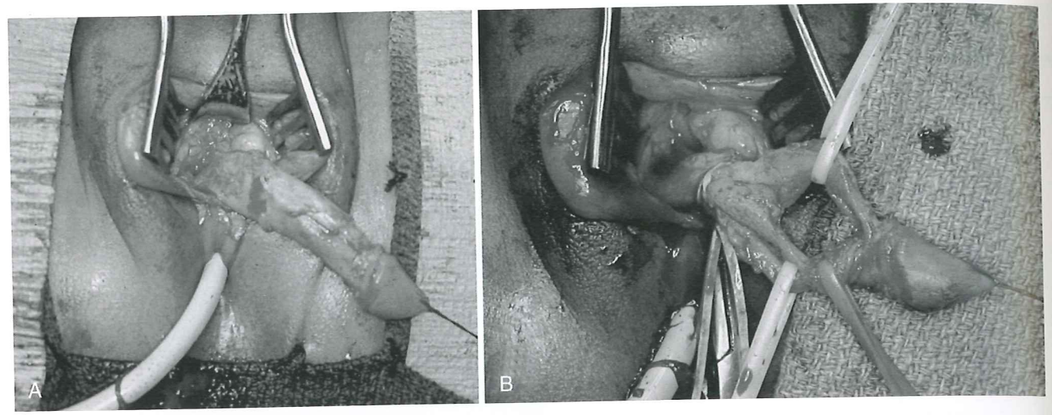


Figure 51–3
Dissection of erectile tissue from within the tunica albuginea. *A*: Shaft completely mobilized, as in Figure 51–2*A*. *B*: Right and left erectile tissue (light vessel retractors) dissected from the remaining tunica albuginea and dorsal neurovascular bundle (dark vessel retractor).

quent burial of all but the epithelialized distal portion. The shaft skin, which had previously been mobilized and split dorsally, is brought around as a clitoral hood, and the glans, which is now suspended by the neurovascular bundle and tunical attachments, is sutured to the skin at an appropriate position (Fig. 51–4). The genitoplasty is then completed by raising an inverted U-shaped flap from the perineum, lifting it off the posterior wall of the urogenital sinus, which is incised until separation of the urethra and vagina is noted. The perineal flap is sewn into it, exteriorizing the vagina. The clitoral skin previously formed into a clitoral hood is advanced inferiorly on either side as labia minora, framing the urethra. The labioscrotal folds are advanced inferiorly into the defect left on either side of the posterior perineal flap as labia majora, framing the newly formed vagina (Fig. 51–5).

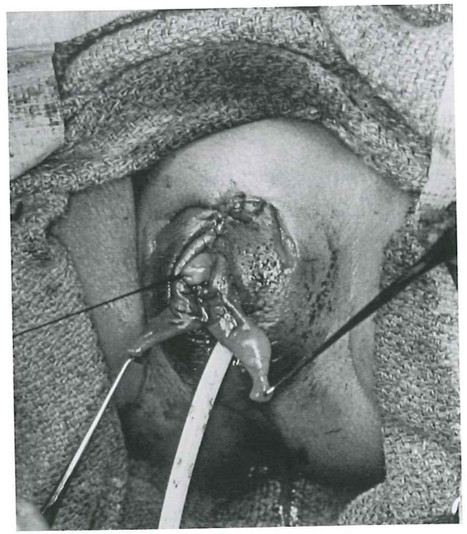


Figure 51–4
Reconstruction of phallic shaft skin around the resected clitoris and glans, forming the clitoral hood and labia minora.

This procedure is especially suited for the rare occurrence when reoperative clitoroplasty is necessary. In some instances (i.e., inadequate corticosteroid adrenal suppression), clitoral regrowth may occur after initial surgical clitoral reduction and may not regress after appropriate subsequent dosing. When a cosmetically inadequate clitoroplasty has previously been performed, reoperation may be necessary to achieve adequate clitoral size or position and skin covering. A previously recessed clitoris may require reoperation because of subsequent restriction and painful clitoral erections during puberty. In all these instances, periclitoral scarring may make it difficult to identify and preserve the dorsal neurovascular bundle and the ventral mucosal attachment that must be salvaged to supply circulation and innervation to the glans in standard clitoroplasty techniques. Because the subtunical route leaves the dorsal neurovascular bundle untouched, these structures are not put at risk in reoperation.

RESULTS OF CLITOROPLASTY

In most instances, after clitoroplasty, especially when combined with single-stage repair of the urogenital sinus and labioplasty, the genitalia are so markedly improved in appearance that parents are universally pleased with the cosmetic appearance. With time, a more critical analysis has led me to alter and refine already successful techniques, maximizing the cosmetic results. Glans location, color, and size are variable after clitoroplasty, and various technical nuances in clitoroplasty techniques can improve the postoperative appearance even further. In assessing my results of clitoroplasty, I have relied heavily on analysis of observations and measurements I have made of *normal female external genitalia* at various ages at the time of cystoscopy (Fig. 51–6).

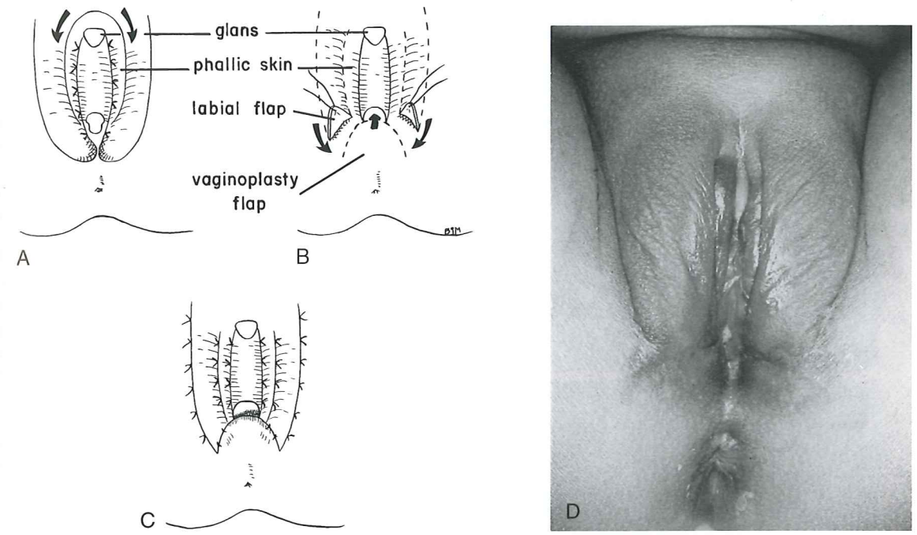


Figure 51–5
Vaginoplasty and formation of the labia majora. *A*: Clitoral skin sutured in place over the clitoris and advanced on either side as the labia minora. *B*: Mobilization of the inferior vaginoplasty flap sutured into the posterior wall of the urogenital sinus and lateral labia majora advancement flaps. *C*: Finished vaginoplasty, labia minoraplasty and majoraplasty. *D*: Patient in Figure 51–1*D*, 1 month postoperatively.

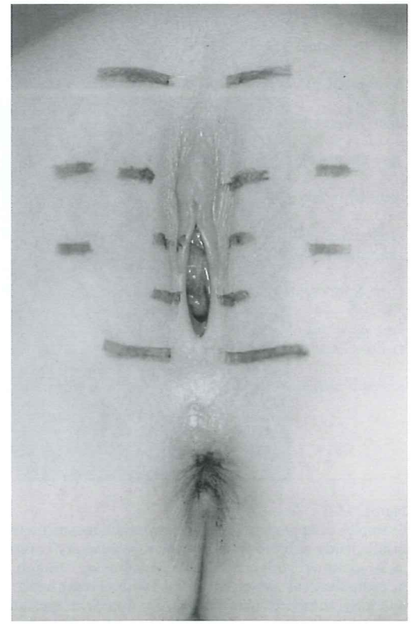


Figure 51–6
Example of child undergoing measurements of normal genital structures at cystoscopy.

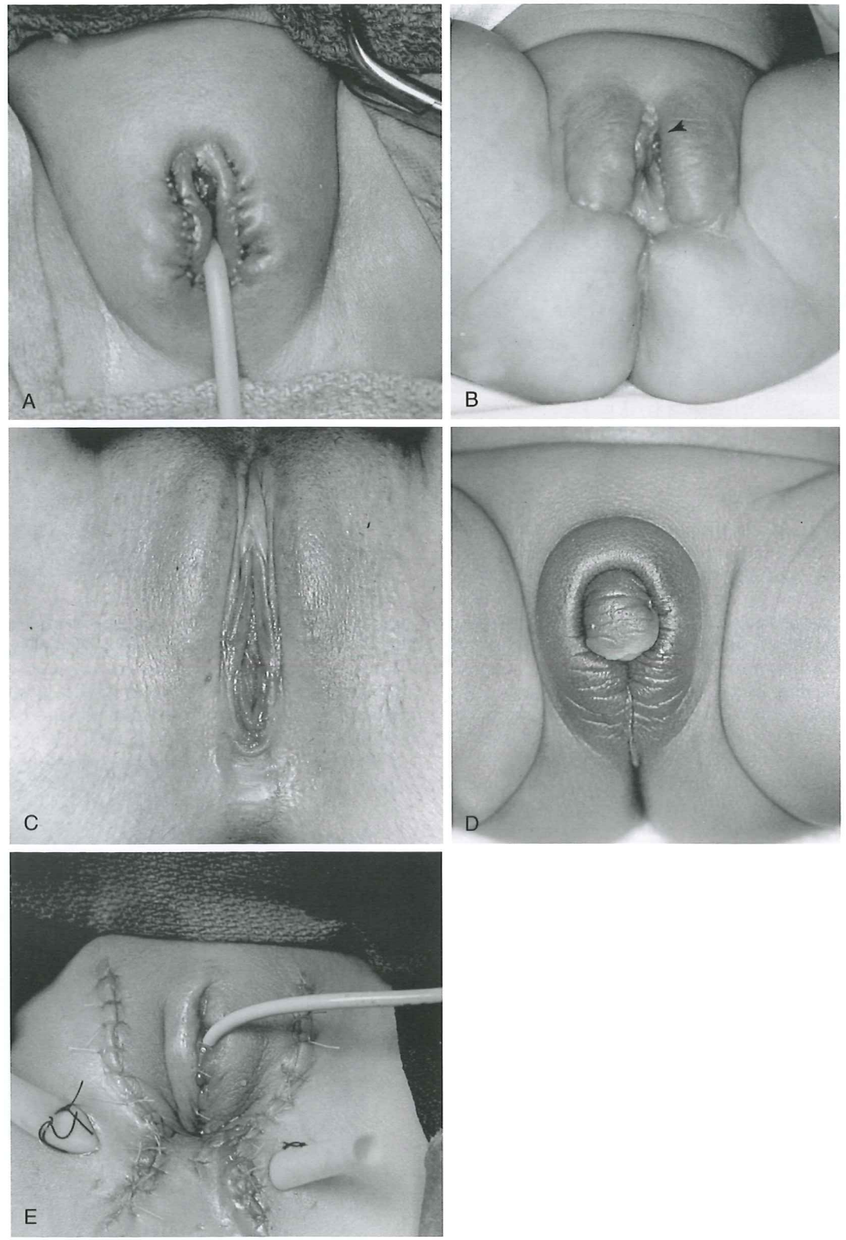


Figure 51–7
Examples of appropriate and inappropriate reconstructive techniques. *A*: Single-stage reconstruction in 21-hydroxylase adrenogenital syndrome. Glans insufficiently reduced in size without satisfactory covering with clitoral hood. Labia minora advanced too far inferiorly. *B*: Single-stage reconstruction in 3-month-old with adrenogenital syndrome, 1 month after surgery. Good positioning of clitoris (arrow) and labia minora. *C*: Results of clitoroplasty in postpubescent adolescent female with clitoral hypertrophy. Vaginoplasty was not required. Excellent formation of clitoral hood and positioning of inferiorly advanced labia minora. *D*: Appearance at birth of female with 3 beta-ol dehydrogenase adrenogenital syndrome with a high vagina and extreme virilization. *E*: Repair at 10 months. The clitoris is appropriately positioned just above the urethra. Advancement labia minora flaps extend down to form the anterior vaginal wall and prevent a normal anatomic cosmetic appearance.

Glans Size

What constitutes normal glans clitoris size? Obviously, no standards exist, and size varies with age. In girls with normal external genitalia, the glans is usually not fully exposed unless the labia minora are spread; a small portion may peek from beneath the clitoral hood, or the glans may be completely hidden. In intersex reconstructions, the glans should similarly be appropriately hidden under a properly constructed clitoral hood to mimic normal anatomy and not simply positioned in place as a prominent button. Adequate deepithelialization or wedge resection should be performed to reduce the size of the glans adequately so it does not protrude abnormally.

In some techniques of clitoral reduction in which the shaft is partially resected or recessed (i.e., by folding over), the remaining shaft may still be too large or may be improperly positioned, contributing to an appearance that the clitoris remains hypertrophied. In the previously described technique of subtunical total shaft resection, little erectile tissue remains to contribute bulk to the shaft; thus, considerations of clitoral size pertain only to the glans.

Glans Color

Glans color should not make the clitoris appear so prominent and different that it appears unsightly and draws attention to it as an outstanding spot within the labia. In most instances, the glans is usually slightly darker than the surrounding labia minora; occasionally it is the same color. Rarely the postoperative glans appears paler or very much darker than the surrounding labia, especially after reoperative repair. In two instances, I have used tattooing of the glans in older children who had a blanched prominent sensate glans that appeared unsightly after reoperative repair.[2]

Glans Position

One of the most important nuances gleaned from critical study of normal female external genital anatomy is that the glans lies just above the urethra, not more superiorly. Virtually all published descriptions of clitoroplasty techniques indicate that a surgically corrected clitoris should be attached to the pubis, well away from the urethra, but in reality, it is not located there. Feminizing genitoplasty can achieve a very cosmetically pleasing appearance but with the clitoris improperly positioned. After reduction in clitoral size, the clitoris should not be sutured to the inferior border of the pubis as previously indicated but rather should be attached to the tissues at the apex of the clitoral hood immediately above the urethra. The extensions of clitoral skin from the hood then extend inferolaterally on either side of the urethra as labia minora. In normal girls, the labia are fused for a distance then diverge on either side, terminating at a level approximately equal to or just below the urethra (see Fig. 51–6). When reconstructing the clitoris in intersex conditions, as much attention should be paid to glans position and covering as to overall clitoral size, because incomplete attention to either detracts from the overall final cosmetic result (Fig. 51–7).

Labia majoraplasty and vaginoplasty follow in my usual single-stage repair. These techniques are diagrammed in Figure 51–5 but described fully in other chapters.

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CHAPTER

52

Vaginoplasty in the Adrenogenital Syndrome and Exstrophy of the Bladder

W. HARDY HENDREN

The most common intersex problem is adrenogenital syndrome in newborn females. In females with this disorder, the internal structures are normal (uterus, tubes, ovaries, and upper vagina) but a variable degree of virilization can be noted externally, depending on the timing and amount of androgen production in the fetus. At the extreme end of the spectrum, a female infant's genitals can look like those of a male with a well-formed phallus with a urethra extending to its tip. I have treated several infants who had been named as males and were circumcised before the true diagnosis was made. At the lesser end of the scale is a female with an enlarged clitoris but an open vaginal introitus. The spectrum is shown in Figure 52–1.

The lower urinary tract and vaginal anatomy also varies in these patients (Fig. 52–2). An infant with minimal or moderate virilization externally usually has a low confluence of the urogenital sinus and vagina distal to the external urethral sphincter. In very masculinized cases, however, the anatomy can be much different. The vagina can communicate with the urogenital sinus between the external urethral sphincter and the bladder neck. Endoscopically, a verumontanum is observed, similar to that seen in males. Insertion of a small ureteral catheter into the prostatic utricle at the summit of the verumontanum reveals that it has depth consistent with the upper two thirds of the vagina. An infant urethroscope can be introduced through this opening, disclosing a normal vagina with a cervix at its apex.

Vaginal reconstruction in females with the adrenogenital syndrome should be guided by the level of confluence of the urogenital sinus and the vagina.

After the baby is metabolically stable following appropriate endocrine management, the anatomy should be studied. Injection of radiographic contrast medium into the urogenital sinus usually shows the relationship of the vagina to the urogenital sinus. In some instances, however, contrast fails to fill the vagina. Endoscopy demonstrates the external urethral sphincter and whether the vaginal opening is located above the sphincter, at a verumontanum, or below the sphincter, where it can be exteriorized with a flap vaginoplasty.

THE CLITORIS

Surgical alteration of the clitoris can be performed in the first few months of life or it can be deferred until the infant is somewhat older, depending on the degree of prominence of the clitoris and the wishes of the parents. Many years ago, the clitoris was simply removed, with the belief that it is not essential for sexual gratification. Most surgeons have modified that view and prefer to save it. Some surgeons preserve the entire shaft and glans, mobilizing and recessing it; however, the clitoris can be quite large. I prefer to resect most of the shaft, preserving the neurovascular bundles that supply the glans and reattaching the glans to the proximal shaft at the pubic symphysis. Skin is removed from the proximal glans to hide it better beneath the mons. Vaginoplasty can be performed either simultaneously with clitoroplasty or later during infancy.

FLAP VAGINOPLASTY

Flap vaginoplasty is illustrated in Figure 52–3. It is the most common procedure used to exteriorize a low vagina that is covered by skin and subcutaneous tissue of the perineum. This operation is not applicable to a high vagina in which flap inlay would transect the external urethral sphincter, resulting in female hypospadias as well as stress incontinence.

PULL-THROUGH VAGINOPLASTY

When the vaginal confluence is at a high level, above the external sphincter as shown by endoscopy or radiography, a much different operation must be performed. The vagina should be separated from the urogenital sinus, which is closed and saved as the urethra. The operation described in 1969 is shown in Figure 52–4.[1] I have used this method for 26 high-placed vaginas in the adrenogenital syndrome,

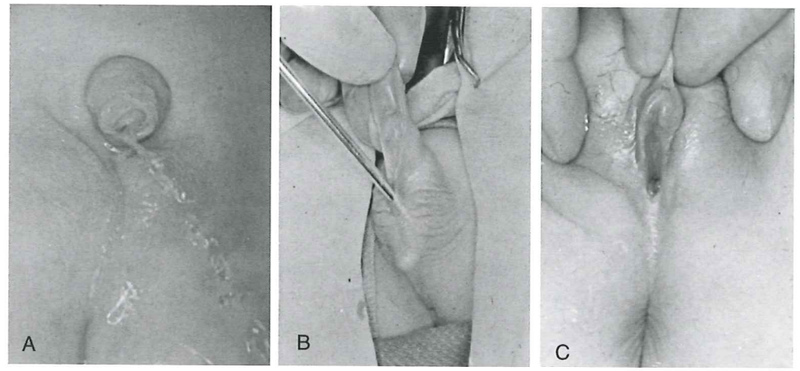


Figure 52–1
Three female patients with adrenogenital syndrome, showing the spectrum of masculinization of the external genitalia. *A:* An entirely male-appearing phallus with the urethra at its tip. This infant was thought at birth to be a male with bilaterally undescended testes. A salt-losing crisis with shock prompted clinical investigation at age 1 week. *B:* Apparent hypospadias with the urethral opening at midshaft. The phallus is an enlarged clitoris. A probe is tenting up the perineum. Endoscopy showed low confluence of the vagina with the urogenital sinus, demonstrating the feasibility of flap vaginoplasty. *C:* Clitoral hypertrophy and an almost normal introitus in a patient with minimal masculinization.

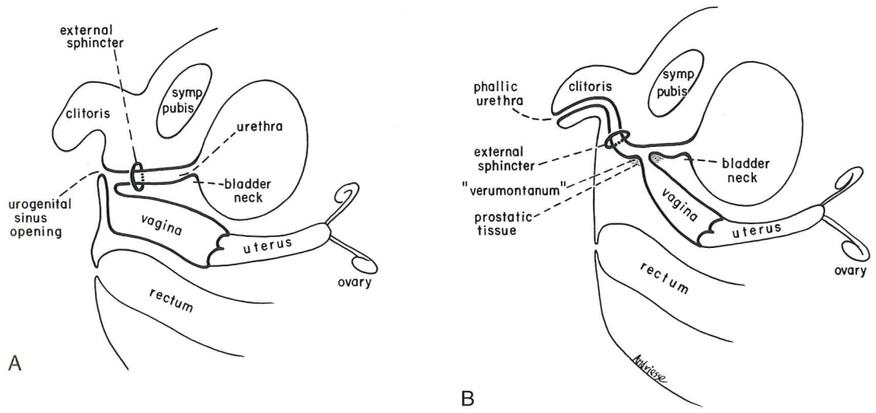


Figure 52–2
Variation of the lower genitourinary anatomy in the adrenogenital syndrome. *A:* Low confluence of the vagina with the urogenital sinus, distal to the external sphincter. The vagina can be exteriorized by flap vaginoplasty or sometimes by a simple vertical cut-back procedure. *B:* Male configuration of anatomy, with high entry of the vagina above the external sphincter and below the bladder neck. Immature prostatic tissue usually surrounds the lower vagina. A pull-through vaginoplasty should be performed for this type of case.

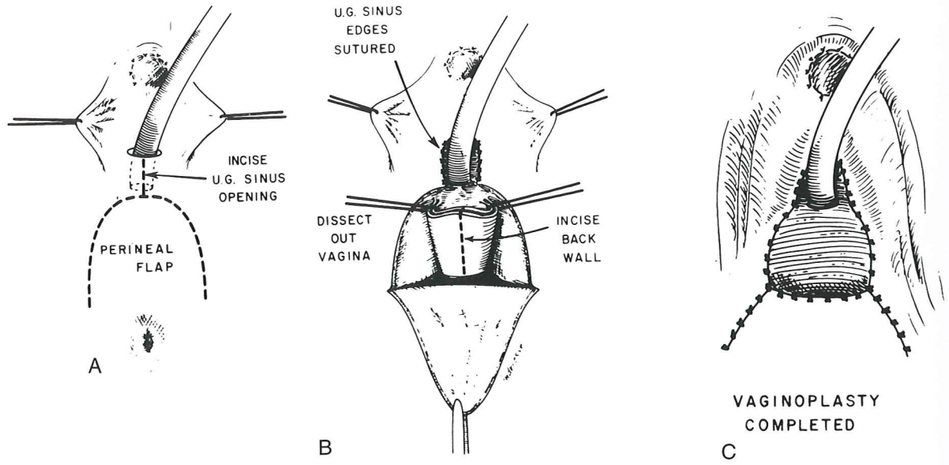


Figure 52–3
Flap vaginoplasty. *A:* The urogenital sinus is incised an appropriate distance if necessary, to gain entry to the vagina, which has been determined to be distal to the external sphincter. An inverted U-shaped flap of perineum is created. Its base should be wide enough to avoid sloughing of the apex of the flap. *B:* The back wall of the vagina is incised upward to prepare for inlay of the flap into its back wall. *C:* Completed vaginoplasty.

with a satisfactory outcome.[2] Passerini has described an alternative method to separate the vagina from the urogenital sinus and to exteriorize it.[3] It has been suggested that total reconstruction should be performed for these infants as early as possible.[4] I believe that the age for performing this procedure, which is not an easy one, should vary with the size of the baby and the experience of the surgeon. The transrectal approach has been used to separate a high vagina;[5] however, it entails colostomy and later closure.

Recessing a large phallus is a desirable goal early in infancy. It can be accomplished without great difficulty. A pull-through vaginoplasty is difficult to perform but is easier between 1 and 2 years of age than in the first few months of life.

If clitoroplasty is combined with a pull-through vaginoplasty, shaft skin can be advanced posteriorly to construct labia minora, as described previously.[6, 7] Labioscrotal tissue in these patients can be advanced posteriorly toward the anus to give normal-appearing labia majora (Fig. 52–5). Reconstruction of an extremely virilized case is shown in Figure 52–6.

If late stenosis of the new vaginal orifice should occur, local perineal flaps can easily be advanced into the orifice to enlarge it. It is not emotionally disturbing for a girl to undergo a minor revision of the vagina on an outpatient basis at an older age. However, undergoing vaginoplasty for the first time when a patient is of adult age is a major psychologic event.

The adrenogenital syndrome is not the only type of case that entails a difficult vaginoplasty operation. Much more common are infants with a cloacal abnormality. The bladder, vagina, and rectum typically converge in the urogenital sinus. The level of this convergence is variable. Many variations have been noted in the vaginal anatomy (Fig. 52–7). Reconstruction requires separating the three organ systems and bringing each to the perineum. Bowel may be needed to extend a short vagina to the perineum. Cloacal malformations and operations used for their repair have been described.[8, 9]

VAGINOPLASTY IN PATIENTS WITH BLADDER EXSTROPHY

Patients with bladder exstrophy often have a thick flap of tissue occluding the vaginal introitus (Fig. 52–8). Flap vaginoplasty solves the problem. In a patient with two side-by-side vaginas, the midline septum should be incised, and the edges are oversewn to create a single vaginal passage.

Prolapse of the uterus is common in these patients when they become adults because the pelvic outlet is open, secondary to separation of the pubic symphysis. Prolapse can be remedied by laparotomy and pexis of the uterus. If the bladder is missing, the pexis sutures can be placed to the anterior abdominal wall. If the bladder is present, the uterus can be affixed to the presacral fascia, moving the rectosigmoid to one side. Patients with bladder exstrophy should not be allowed to deliver a baby vaginally, lest the uterus evert and prolapse. Cesarean section is the safest way for most of these patients to deliver.

Monsplasty can benefit these patients. The pubic hair typically diverges off to each side, and no hair grows in the center of the lower abdomen. As shown in Figure 52–9, this can be improved by creating interdigitating flaps of the lower abdominal tissue to bring all of the hair-bearing tissue together in the midline.

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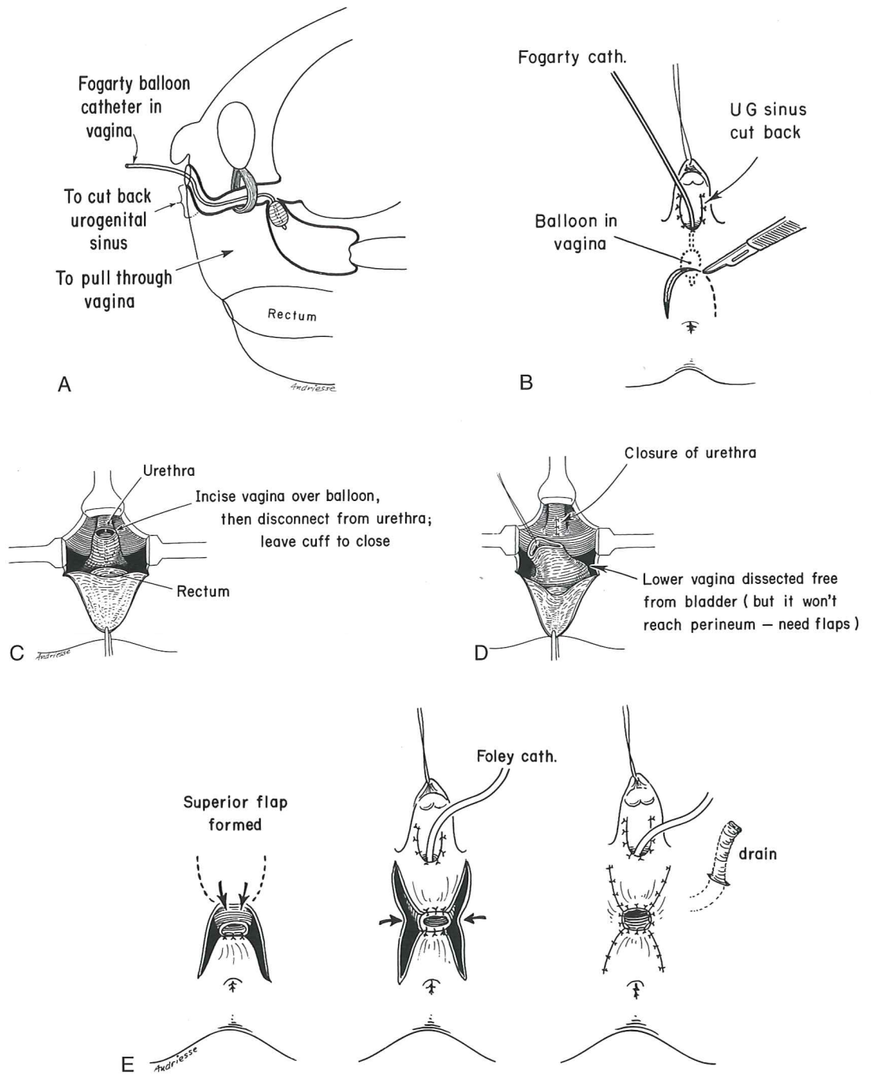


Figure 52–4
Pull-through vaginoplasty. *A:* With the patient in lithotomy position, a Fogarty balloon catheter is placed in the vagina. The balloon is inflated and pulled back gently to the entry of the vagina into the urogenital sinus. The balloon catheter is clamped so that it does not deflate, and the endoscope is removed. The urogenital sinus is cut back a few millimeters but well distal to the external sphincter. The bowel is always prepared preoperatively in these patients to avoid fecal soiling, and a povidone-iodine pack is placed in the rectum as further protection against contamination from the colon. The dissection is facilitated by placing a finger in the rectum, changing gloves before the perineal wound is reentered. *B:* An inverted U flap is created to begin the dissection upward to the junction of the vagina with the urogenital sinus. *C:* The junction of the vagina with the urogenital sinus is identified. This is facilitated by tugging gently on the Fogarty catheter. A transverse incision across the lower vagina discloses the balloon, which is removed. The vagina is dissected free by visualizing its interior to accomplish this without narrowing the urogenital sinus. It is unnecessary to encircle the vagina with a tape. It is best to leave a millimeter or two of vaginal cuff on the urogenital sinus to avoid narrowing it during closure. A urethral catheter is placed in the bladder after closing the urogenital sinus. *D:* The vagina is mobilized upward to the level of the cervix to gain maximum length. The vagina seldom reaches to the perineum, because developmentally it is only the proximal two thirds of the vagina. Perineal flaps are required to join it to the perineum. *E:* Creation of perineal flaps to exteriorize the vagina. Labioscrotal tissue can be incorporated in this closure as shown in Figure 52–5. Alternatively, that can be done at a later time.

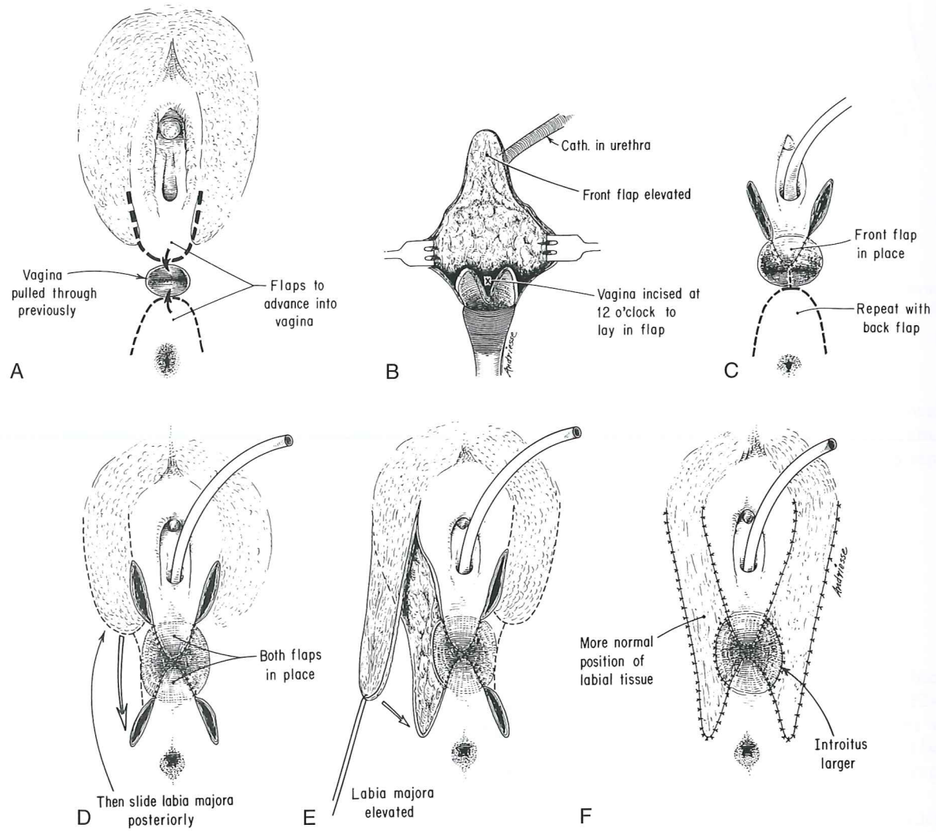


Figure 52–5
Feminizing labioplasty. *A:* Creation of midline flaps to enlarge the vaginal opening. *B:* Opening the vagina to inlay flap. *C:* Suturing the anterior flap. *D:* Mobilization of scrotal tissue to create labia majora and to widen the vaginal opening. *E:* Advancing the tissue posteriorly. *F:* Completed appearance after feminizing labioplasty. This can be performed simultaneously with clitoral reduction and vaginal pull-through in some patients.

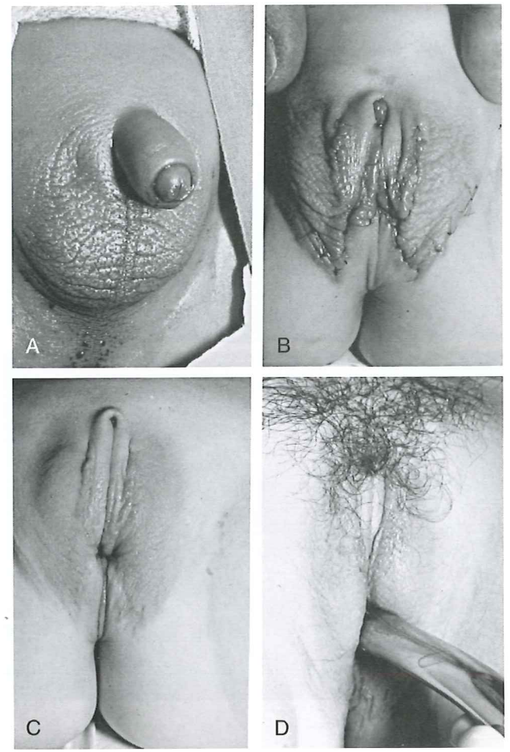


Figure 52–6
Genital reconstruction in a very masculinized female with adrenogenital syndrome. *A:* At age 5 months. The phallus looks like a normal penis. *B:* After phallic reduction and recession, and labioplasty at age 5 months. The skin of the shaft was used to make labia minora. The scrotal tissue was used to make labia majora. *C:* Age 3 years, soon after pull-through vaginoplasty, which was performed as a separate operation. *D:* At age 12 years. Note the very female appearance. A Hegar dilator is inserted in the vagina to demonstrate adequate opening.

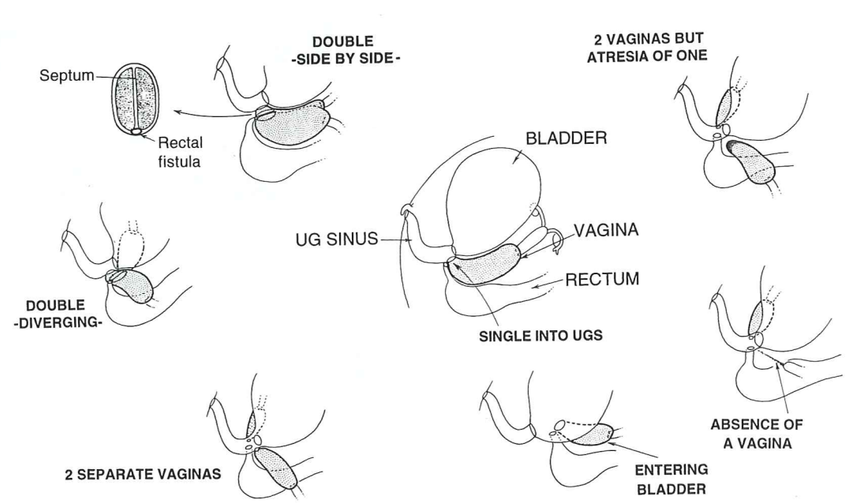


Figure 52–7
Variations in vaginal anatomy in cases of cloacal malformation. In the center is the most common type, with a single vagina close to the bladder neck and a rectal fistula entering the back margin of the vagina. In the author's series of 133 cases of cloacal malformation, 58 patients had one vagina, 54 had 2 vaginas, and 21 had no vagina. Bowel was needed for vaginal reconstruction in 41 of these patients. As shown, a patient can have two vaginas separated by a midline septum, which can be incised with a cutting electrode to make them become a single vagina with two cervices at the apex. Less commonly, a patient can have two separate vaginas. If a patient has a laterally placed vagina, the surgeon should suspect an occult vagina or absence of the contralateral vagina.

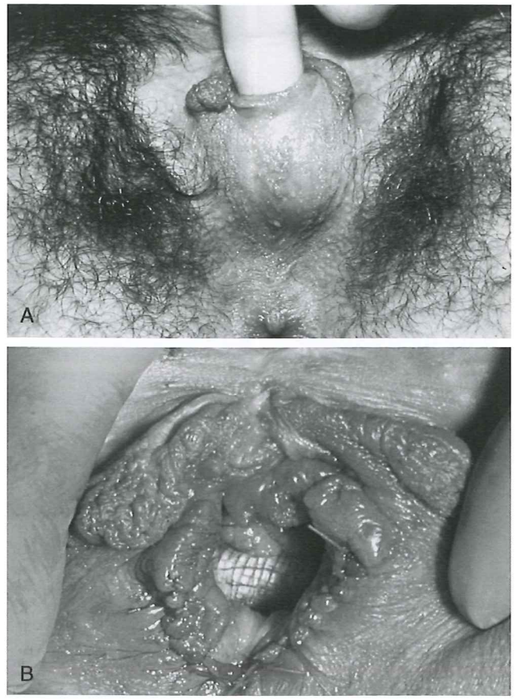


Figure 52–8
View of the perineum in exstrophy of the bladder. *A:* Note the dense membrane covering the vaginal introitus. A finger is tenting up the tissue occluding the vagina. *B:* After Heineke-Mikulicz plasty to exteriorize the introitus. A gauze sponge has been placed in the vaginal lumen as an aid to its visualization.

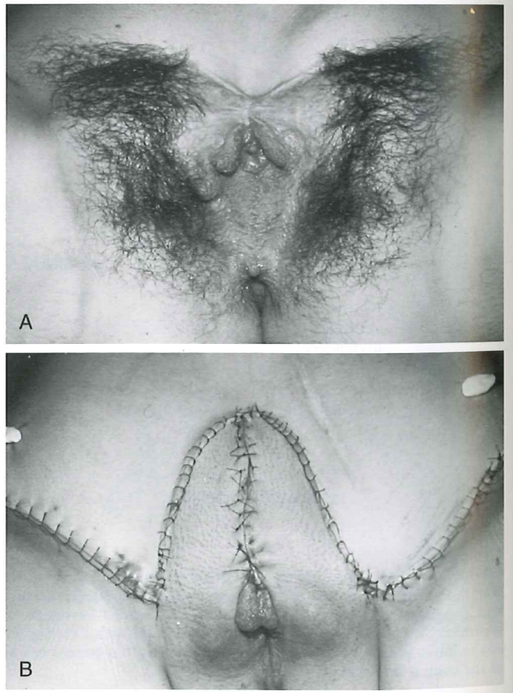


Figure 52–9
The pubic escutcheon in a female with exstrophy of the bladder. *A:* Note the diverging pubic hair on each side. *B:* After transposing hair-bearing flaps to the center of the mons. Note joining also of the labia minora, which were initially divergent. Vaginoplasty was performed for this patient as well. Coitus should be satisfactory for these patients, although vaginal depth is not as great as in normal females. This can cause painful coitus, which can be improved by instructing the patient to maintain the legs in adducted position during coitus to prevent deep penetration by the male.

CONCLUSION

A properly performed vaginoplasty is the key to successful reconstruction of many urogenital sinus malformations. In most patients, coitus should be possible, as well as childbearing when the uterus, tubes, and ovaries are present. Several of my early patients have had babies, most by cesarean section. One patient had a successful vaginal delivery, and I had the privilege of being present during that event.

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CHAPTER

53

Feminizing Genitoplasty

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JOEL GELMAN

Intersex disorders are often associated with partial virilization of the external genitalia. Female pseudohermaphroditism secondary to congenital adrenal hyperplasia is the most common intersex condition.[1] Individuals with this condition are genetically female and fertile but are virilized to a variable extent as a result of a defect in adrenal steroid biosynthesis. Other intersex disorders associated with ambiguous genitalia include mixed gonadal dysgenesis, male pseudohermaphroditism, and true hermaphroditism.[1, 2] Gender assignment is always female in a female pseudohermaphrodite. In males with inadequate virilization, gender reassignment remains one option.

Feminizing genitoplasty is designed to eliminate the signs of virilization—that is, to make the external genitalia appear more female. Other disorders of the penis not associated with intersex issues that are potential indications for feminizing genitoplasty include micropenis and penile amputation during neonatal circumcision.[3] Additionally, the management of male-to-female transsexualism includes feminizing reconstruction.[4]

EVALUATION

Ambiguous genitalia are usually identified at birth, and initial efforts should be directed toward recognition and treatment of any life-threatening fluid and electrolyte abnormalities if present. Subsequent diagnostic tests to identify the specific intersex abnormality include a karyotype, a full laboratory evaluation, ultrasound imaging, and, when appropriate, a genital sinogram. Gender assignment must be made quickly after birth. A detailed discussion of the evaluation for intersex disorders is beyond the scope of this chapter. However, several excellent reviews can be found in the literature.[5, 6]

Once the karyotype is established, specific tests that are performed in preparation for reconstructive surgery are a genital sinogram and cystoscopy. In particular, the anatomy of the genitourinary organs must be imaged and defined, and the location of the vaginal opening must be determined. Arrested development of the urovaginal septum (i.e., maldevelopment of the distal vagina) is the cause of a persistent urogenital sinus, a condition in which the vagina joins the urethra instead of forming the normal perineal vaginal introitus. In a patient with a persistent urogenital sinus, the vagina usually joins the urethra/sinus distal to the external sphincter. This is referred to as a *low vaginal entry.* When the vagina opens proximal to the sphincter, more complex pull-through reconstructions or extensive flap reconstructions may be necessary.[7]

SURGICAL RECONSTRUCTION

Feminizing genitoplasty includes (1) reduction clitoroplasty/penoplasty with preservation of sensation, (2) tailoring of the labial scrotal skin, (3) removal of male gonadal tissue when present, and (4) creation of an introitus and adequate vagina. Reconstruction can be performed within the first 3 to 6 months of life in most cases, and some surgeons perform surgery as early as 2 to 3 weeks of age.[8] When a low vaginal entry can be documented, vaginoplasty can be performed using a perineal flap for a Y-V advancement. If the vagina enters the urogenital sinus at a higher level, repair may be deferred until the child is older.

Initially, a Foley urethral catheter is placed in the urethra. The catheter can be advanced into the bladder but may also be directed into the vagina. In some cases, inflation of the balloon in the vagina facilitates identification of this structure. Incisions used during feminizing genitoplasty include an inverted U-shaped perineal incision (Fig. 53–1*A*) and a degloving incision of the hypertrophied clitoris. It is often advantageous to preserve the strip of tissue on the ventral midline of the clitoris (Fig. 53–2*B*). The incisions raise a flap (Fig. 53–2*B* and *C*). As the flap is dissected toward the base of the penis/clitoris, the suspensory ligament of the clitoris is exposed and can be divided. Virilization tends to be accompanied by anterior displacement of the clitoral attachments. Division of the suspensory ligaments allows the reduced clitoris to be subsequently fixed to the pubis in a lower (gynecoid)

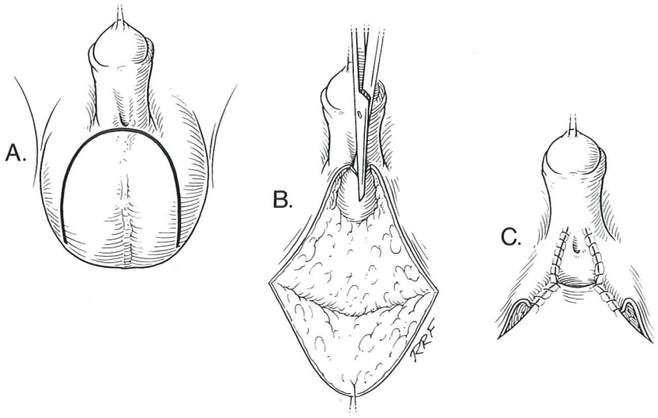


Figure 53–1
Illustration of cutback vaginoplasty in a virilized female child. *A:* A posteriorly based inverted U-shaped flap is marked. Note the flap is carried to the dorsal lip of the urogenital sinus. *B:* The flap is a random flap, developed with the subcutaneous tissue and, if possible, the Colles' fascia to provide the fasciocutaneous blood supply also. The urogenital sinus is divided, and the true urethral meatus is exposed. *C:* The flap is advanced into the vaginal cutback (Y-V advancement) and sutured.

position. A common mistake is to fix the clitoris high at the crest of the pubis (android position).

Amputation of the clitoris was initially advocated for the treatment of clitoromegaly.[9, 10] Clitoroplication was subsequently advocated.[11] These techniques are obsolete, and the current standard of care is to reduce the size of the clitoris by removing corporeal or erectile tissue while preserving the dorsolateral neurovascular bundles responsible for glanular sensation. Excision of the entire corporal bodies reduces the size of the shaft.[12] However, adequate reduction of the shaft with preservation of erogenous sensation provided by the dorsolateral neurovascular bundles can also be achieved by widely incising the tunica lateral to the neurovascular bundles with subtunical excision of the erectile tissue,[13–16] or by excision of the majority of the corporeal bodies with preservation of a dorsolateral strip of tunica along with the adherent neurovascular supply to the glans.[17, 18] We prefer to excise corporal erectile tissue and leave the tunica intact with the adjacent neurovascular bundles and ventral urethral strip (Fig. 53–2*C* to *E*). The glans generally needs to be reduced in size, and this can be achieved with a wedge resection of the glans or subtotal deepithelialization[19] (Fig. 53–2*E* and *F*).

The inverted U flap of skin and subcutaneous tissue is developed with the base of the flap between the ischial tuberosities and the apex just posterior to the opening of the urogenital sinus. During the posterior dissection, we prefer to take down the attachments between the rectum and posterior wall of the sinus laterally and proceed medially, because this helps to avoid a rectal injury. All the incisions described allow ample access to the scrotum in transsexual patients when orchiectomy is required (illustrated later). The urogenital sinus is incised posteriorly (creating the Y), and the incision is carried well into the vagina (Fig. 53–1*B*). The flap is now interdigitated as a Y-V advancement maneuver, creating the posterior introitus (Fig. 53–1*C*).

After completion of the reduction clitoroplasty and the dissection and development of the posterior perineal skin flap, the apex of the flap is sutured to the posterior vaginal wall (see Fig. 53–2*F*). In cases such as micropenis or penile amputation, when a vagina is absent, the urethra is opened ventrally down to the bulbar urethral anatomic location and the apex of the flap is sutured just posterior to the urethra to provide a feminine external appearance.[3] Formal vaginal construction is deferred. However, as experience has accumulated with regard to the nuances of penile inversion vaginoplasty in the transsexual population, it would appear that immediate vaginal construction using a penile inversion type of technique may accomplish much, with little risk.

Labial reconstruction is the final procedure performed during feminizing genitoplasty. The previously elevated preputial skin flap can be divided along the dorsal midline when it is used for subsequent labial reconstruction (see Fig. 53–2*F*). In virilized females, the preserved urethral strip is sutured to the penile skin flaps. We prefer to split the flap to the base of the clitoris and then divide the continuity of the skin while preserving the dartos fascia and its blood supply, which enters on the lateral shaft of the clitoris. Thus, two skin islands are created. This technique subsequently allows the reconstructed labia to be reapproximated cephalad to the clitoris, making the appearance cosmetically more appealing. In a transsexual or male patient with a penis, midline division of the penile skin island is not usually required. The bilateral clitoral or penile skin flaps that were previously created are brought down lateral to the clitoris to create labia minora (Fig. 53–2*G*) and, part and parcel, the lateral aspects of the introitus. It is important to reconstruct the labia minora so that the glans is partially concealed with a hood of skin.

In transsexual patients (Fig. 53–3*A*), we usually have the ultimate effects of virilization, a normal male phenotype. Although many forms of vaginal construction have been advocated, the penile inversion technique has gained in popularity. In this repair, the normal scrotum allows for the development of an exaggerated posterior marked V flap, particularly if the scrotum is relatively nonhirsute. The incisions are then continued up the ventral midline to deglove the deep penile structures (Fig. 53–3*B*). All skin and fascia are dissected, preserving the extended Colles' fascia. Note the wide exposure allowing for reduction penectomy and orchiectomy (Fig. 53–3*C*). In transsexual patients, preservation of the ventral tunica albuginea is not

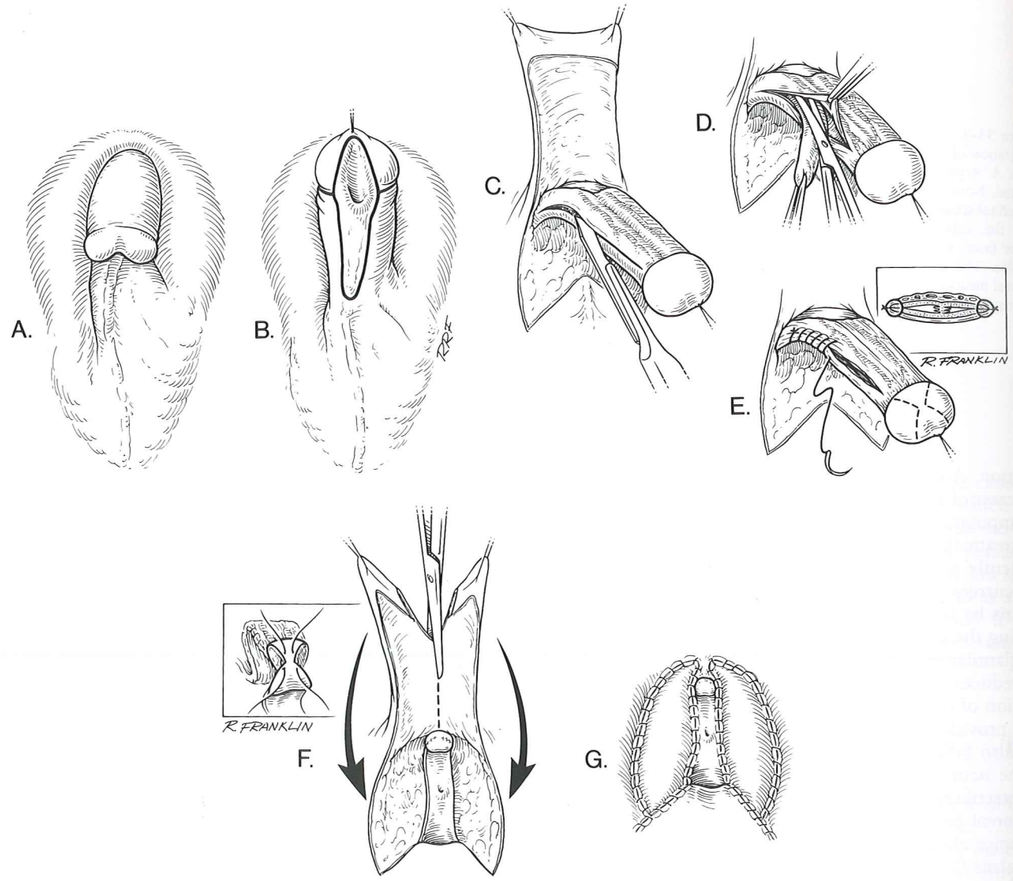


Figure 53–2
A: The usual appearance of a virilized female on physical examination. *B:* Incisions are marked to deglove the clitoris and to preserve the ventral urethral strip. *C:* Degloving is performed, leaving Buck's fascia attached to the clitoral shaft. The lateral Buck's fascia and tunica albuginea of the corporeal bodies are incised. *D:* The spongy erectile tissue is dissected from within the corporeal bodies and is excised. *E:* The Buck's fascia and tunica albuginea are sutured (closed) with generous bites, creating a robust strip that carries and supports the dorsal neurovascular structures and the ventral urethral strip. In most cases, the glans is reduced by removing wedges laterally. *F:* The dorsal preputial and clitoral skin is divided along with the Buck's fascia, although the skin may in some cases not be divided but rather buttonholed at the base. The base continuity can be divided partially (as shown) or completely. *G:* The flaps are transposed posteriorly, sutured to the urethral strip medially, the anterior vagina (in some cases) or the reduced labia majora laterally, and the posterior Y-V dorsally. Dividing the base either completely or partially allows the labia majora to fuse anterior to the clitoris.

necessary, and that layer and the erectile tissue can be excised along with the majority of the corpus spongiosum. The corporal bodies are oversewn at the midcrural level, and the corpus spongiosum is mobilized to the level of the membranous urethra to shorten the midportion of the urethra optimally. The base of the penile skin island is divided, preserving the continuity of the dartos fascia. This allows the skin paddle to be transposed posteriorly, hooding the clitoris and forming the urethral meatus and anterior vaginal wall (Fig. 53–3*D*). The penile skin island and the posterior V flap are sutured to form the vagina. The cavity has been dissected, as already discussed. The vagina is inverted and fixed in the cavity, the scrotum is reduced, and the incisions are closed (Fig. 53–3*E*).

CONCLUSION

Feminizing genitoplasty can effectively eliminate signs of virilization. A functional vagina can be created, clitoral reduction can be achieved with preservation of erogenous sensation, and cosmetically acceptable labia and an introitus can be fashioned. Although the procedures in many cases were developed to treat virilized females, with little modification, these techniques apply to ultimately virilized females, male-to-female transsexual patients. In transsexual patients, however, substitution vaginal construction is the rule. In that population, vaginal construction can be accomplished by penile inversion, by bowel vaginoplasty,

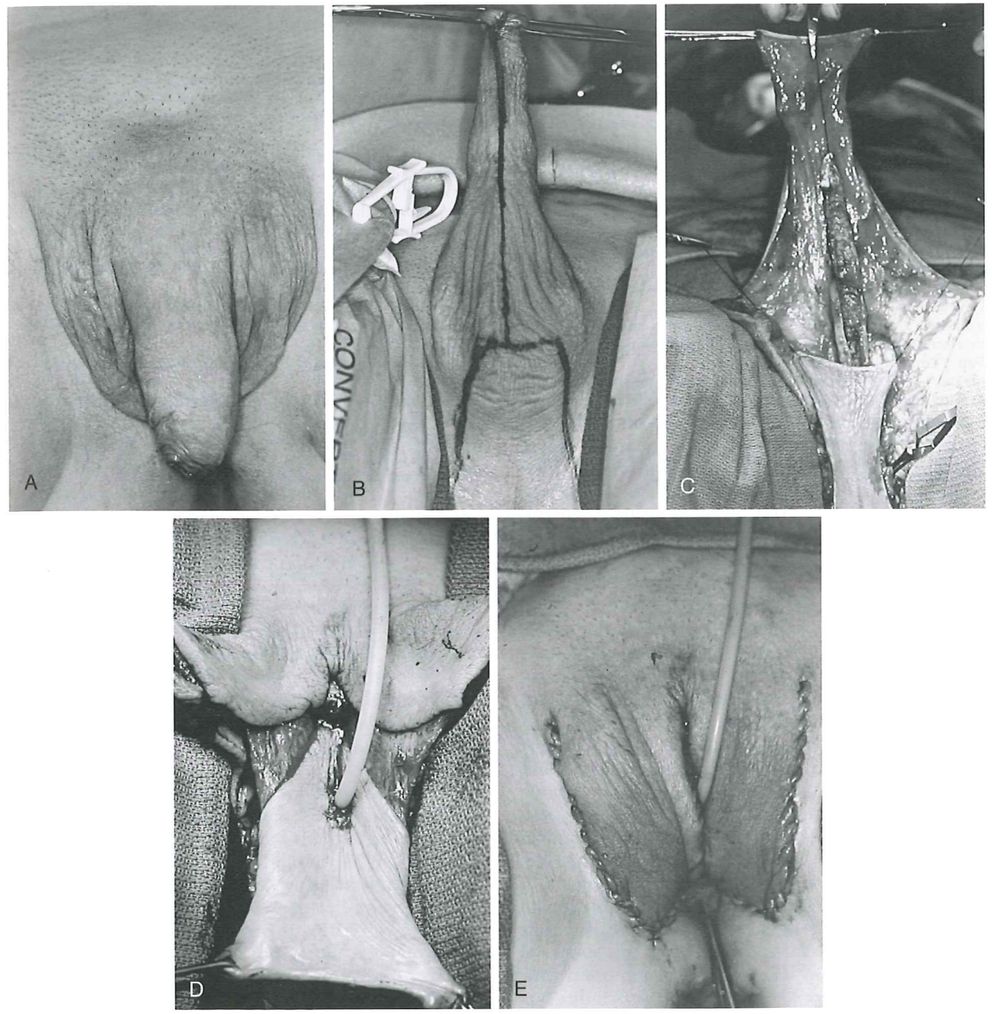


Figure 53–3
A: The appearance of a transsexual patient ready to undergo feminizing genitoplasty. *B:* Incisions are marked to create a posteriorly based inverted U flap. The genital skin is then divided in the midline up to the ventral coronal margin. This patient is uncircumcised. *C:* Notice the broad flap developed from degloving the penis, maintaining the dartos layer. In this projection, the testicles have been removed. Note that the glans has been reduced, and the dorsal neurovascular bundle is carried on a broad strip of the dorsal tunica albuginea. The posteriorly based U flap is being retracted. The foreshortened urethra is not well visualized in this photograph; the bulldog clamp is on the proximal corpus spongiosum for hemostasis. Notice the broad exposure that these incisions create, thus allowing for orchidectomy, reduction penoplasty, and dissection of the vaginal vault to be accomplished. *D:* The dorsal flap has had the continuity of the skin divided. Notice the rich and robust dartos layer, which allows the skin island to be transposed ventral to the reduced glans. Notice that by dividing the continuity of the skin, the labia majora can be sutured in the midline, effectively hooding the glans. The urethral meatus has been created, and the dorsal penile skin flap will be sutured to the posteriorly based U flap, creating the vagina. In this projection, the vaginal cavity has been dissected. *E:* The appearance at closure. Notice the hooding of the glans clitoris and the anatomically correct location of the meatus. The introitus is slightly posteriorly displaced, and a small pack is in place. The remaining scrotal skin has been reduced to form labia minora.

or by the use of extragenital full-thickness skin grafts. We prefer, in many cases, to use the bowel, but select cases are ideally suited for the penile inversion technique. As demonstrated, the reduction penoplasty is very similar to the reduction clitoroplasty described. In transsexuals, partial urethrectomy with excision of the ventral glans is performed. Feminizing genitoplasty techniques can be used very effectively, and almost perfect cosmetic results are achieved.

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MALE-TO-FEMALE GENDER REASSIGMENT

CHAPTER

54

Neocolorrhaphy in the Male-to-Female Transsexual

STANLEY BIBER

This chapter discusses and illustrates the basic technique of vaginoplasty in male-to-female transsexuals. Attention is given to variations that can accomplish a satisfactory end result when insufficient penile skin is available for the more simple penile inversion technique.

A decision must be made before surgery whether the basic inversion technique will suffice or whether a variation is necessary for a good surgical outcome.

The basic penile inversion technique is as follows: Under general, epidural, or spinal anesthesia and after preoperative preparation and draping in the lithotomy position, a longitudinal incision is made in the midline raphe, extending from the base of the penis to approximately 2 to 2.5 cm from the anal orifice. This incision is carried down through the subcutaneous tissue, areolar tissue, and fat, exposing the corpora cavernosa and spongiosum (Fig. 54–1).

The corpora are then lifted out of their bed, and the skin, with much of the dartos fascia, is dissected from the corpora to the penile coronal line at the base of the glans. In essence, the skin is inverted off the underlying corpora. At the level of the coronal sulcus, with the skin inverted, the glans is cored out and allowed to fall away with the inverted penile skin. The crura are dissected down to their origin on the pubic bone, and the corpus spongiosum is freed of the transverse muscle fibers covering this base. Then, with careful dissection, the corpus spongiosum with the included urethra is dissected out of the corporal bed down to the pubic bone level, and the suspensory ligament, at this level, is partially incised to allow the tissue to drop forward. Meanwhile, the urethra has been catheterized with a Foley catheter. The base of the corpora cavernosa are then clamped and cut, and the distal portions of these corpora are removed. Hemostasis is carefully secured with multiple heavy chromic catgut sutures in an oversewing manner.

The lateral areolar tissue and fat are then removed carefully to avoid impeding circulation to the overlying skin. Dissection is carried out to expose the testicles and cord. The spermatic cords are ligated doubly after stretching them through the external oblique ring, and the remainder is allowed to draw back up into the inguinal canal. Further dissection under the lower abdominal flap is carried out, if need be, to the umbilicus to allow more tissue to be pulled down for the inversion. Formation of the vaginal cavity is next approached. With the assistant's finger in the rectum and the Foley catheter in the urethra, the various superficial layers of fascia in the perineal body are incised. The rectal sphincter muscle is exposed, and the central tendon is incised. The bulb of the corpus spongiosum is separated from the underlying rectum and sphincter. The urethra is carefully separated from the rectum, and laterally, a portion of the levator muscles is incised. Dissection is carefully carried back on the periurethral fascia until a usually small prostate is exposed. Careful dissection is carried out to locate the emanation of Denonvillers fascia. The anterior layer is separated from the posterior layer, and this space is easily enlarged with finger dissection. The bladder falls into view anteriorly, as do the seminal vesicles. With finger dissection, a cavity of almost any desired depth can be developed. Hemostasis must be well maintained to make this cavity dry and acceptable to inversion of the penile skin (Fig. 54–2).

Attention is next given to the penile skin. Using a plastic dilator, the assistant extends and stretches this inverted skin over the dilator. The dartos fascia and excessive areolar tissue are removed from the distal third of this skin with sharp dissection. One can readily recognize a dermal and subdermal plexus of blood vessels in this distal skin; these add to the skin viability. The additional distensibility of the skin now allows this skin to be stretched to cover a much larger portion of the cavity than if the areolar tissue were allowed to remain with the inverted skin.

The anterior abdominal skin is pulled down to the perineum with as much stretch as deemed necessary, and a wire retention suture is placed through the skin and over a gauze stent to hold this skin to the pubic bone fascia. This wire is removed on the fourth postoperative day.

With the penile skin stretched taught, a site is chosen for the position of the urethral orifice and a small incision made. This site has to conform to the site of the natural orifice in a genetic female so that the urine can be passed downward in the sitting position. Meanwhile, the bulb of

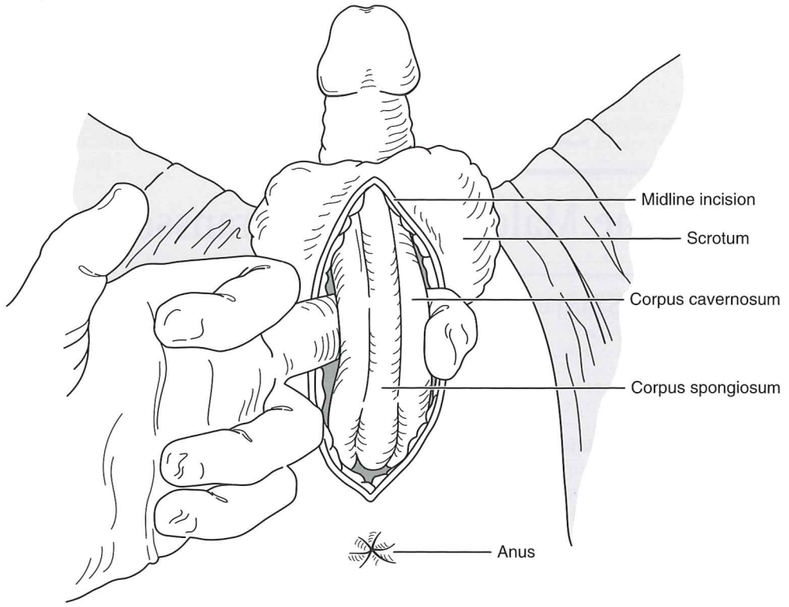


Figure 54–1
Incision.

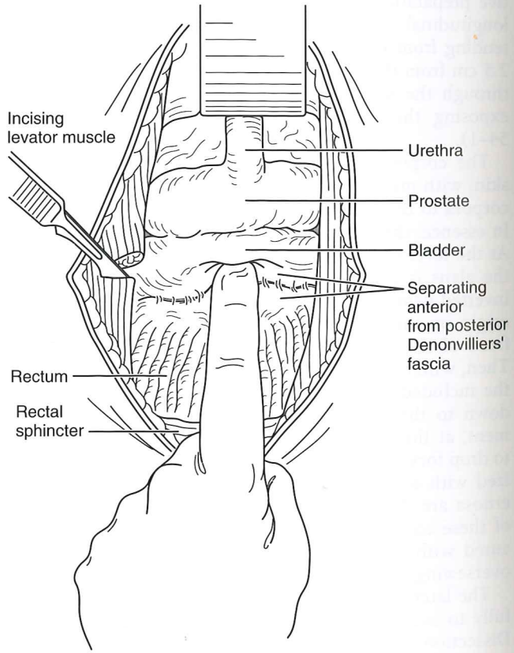
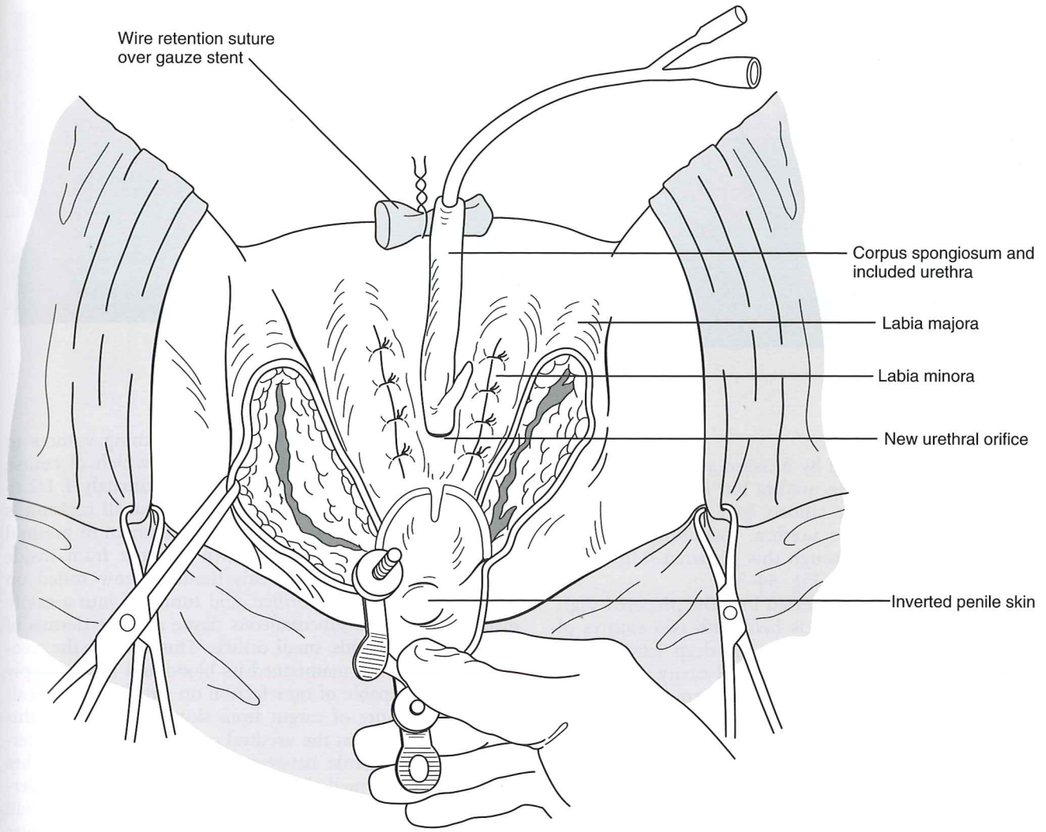


Figure 54–2
Vaginal cavity dissection.



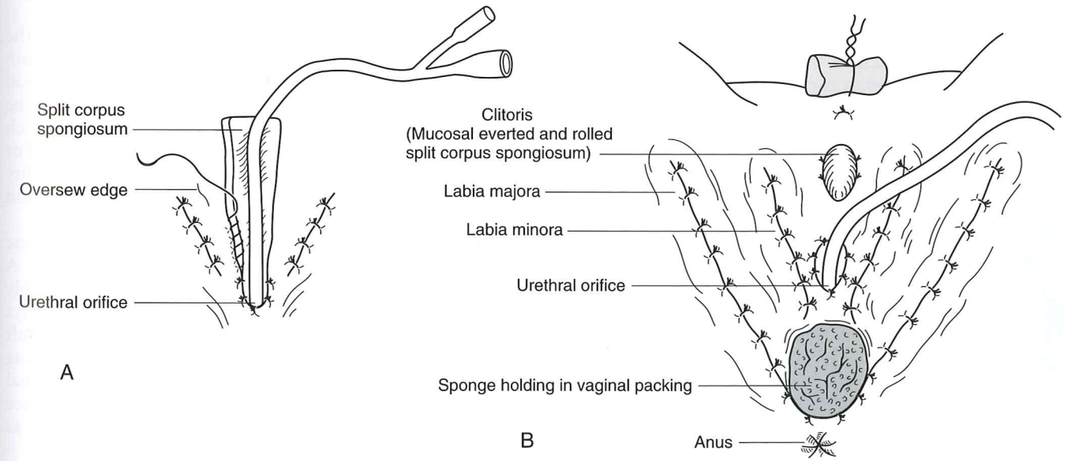


Figure 54–3
Penile skin inversion and beginning reconstruction. *A:* Hemostasis of split corpus spongiosum. *B:* Rolled spongiosum to form clitoris.

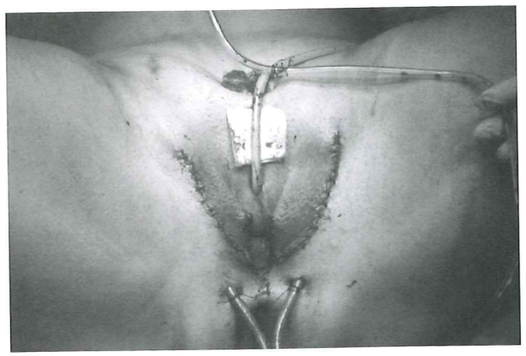


Figure 54–4
Formation of labia.

the spongiosum is prepared by incision and oversewing to reduce its size down to the urethra but keep its posterior portion intact to form the clitoris later. The spongiosum remaining, along with the urethra, including the Foley catheter, is then drawn through this prepared skin orifice and brought to the outside (Fig. 54–3).

The penile skin is then inverted into the prepared vaginal cavity. The inverted skin is held with two sutures of catgut at the distal level sewn to the deep lateral vault tissues within the newly formed vaginal cavity. The external posterior portion is then tailored to form the posterior orifice and sutured into this position. Packing of the inverted skin is accomplished with 2-inch packing powdered with an antibiotic.

Tailoring of the remaining skin entails folding the thinned skin at this point to form an inner labial fold and then removing excessive lateral skin to form the external labial fold (Fig. 54–4).

The urethral orifice is then established. Incision is made into the urethra, which is filleted distally. The proximal portion of this incision is carefully sewn to the skin with fine chromic catgut. Additional sutures are placed laterally. The catheter, of course, protrudes to the outside. The filleted portion of the distal urethra and spongiosum is



Figure 54–5
Double Z labioplasty.



Figure 54–6
Final result.

then laterally oversewn with locking running sutures to obtain hemostasis in this spongy tissue, which of course bleeds continuously (Fig. 54–3*A*). Approximately 1 1/2 to 2 cm above this urethral orifice, another small incision is made through the skin, and the distal remnant of urethral mucosa and spongiosum is drawn through from inside out. With chromic catgut, this tissue is now rolled on itself, sutured into this orifice, and tunneled into a cavity made between the subcutaneous tissue and the dermis of skin, anterior to this small orifice. This then is the neoclitoris, which has maintained its blood and nerve supply and is quite capable of tumefaction on stroking after healing. A fine suture of catgut from skin to mucosa of this described segment at the urethral orifice is used to obliterate any pseudofistula between the orifice of the urethra and the newly formed clitoris. The urethral mucosa underlying the bridges of skin is roughened so that it will accept and heal to the undersurfaces of the skin bridges (Fig. 54–3*B*).

It has been our practice to use suction drains under the labial flaps for a period of 24 hours (see Fig. 54–4). Certain variations in technique may be used to ensure a good outcome with this technique. Some information can be gained in the initial examination before surgery, which helps to determine what variation should be used. For example, if the penis is too small or basilar penile mobility is poor or if the perineal body is elongated, one should contemplate modifying the technique.

If the penis definitely is very small, one would determine that a skin graft is necessary to line the vaginal cavity. A split-thickness graft is taken with a dermatome, preferably from the buttock and posterior thigh, and inverted over a distensible stent. The proximal portion of the sleeve graft is then sutured to the penile skin after, of course, removing the glans. This is then inverted into the formed vaginal cavity, with the original penile skin used for the orifice and the suture lines placed as far in the vaginal cavity as can be allowed.

The distensible stent is then packed into the vaginal cavity and inflated with 100 cc of air. This allows excellent coaptation of the skin to the raw vaginal surface and obliterates open pockets for hematoma formation. This stent is removed on the eighth day, when the graft usually is seen to have taken extremely well.

Another variation can be used if the penile skin is at least borderline sufficient. In combination with undermining abdominal skin and subcutaneous fat to the level of the umbilicus, a posterior triangular flap can be formed to cover the posterior triangle of the newly constructed vagina and allow coverage of the difficult posterior angle at the orifice. This posterior flap must not be too wide at the base or the orifice posteriorly will be widened, gaping, and unsightly.

Another aide to accomplishing the inversion technique in borderline cases is to bring the patient's legs down from the lithotomy position and continue the reconstruction in a level position. One can gain another inch of depth with this maneuver. In my experience, with the aid of the foregoing variations, I am able to accomplish a successful procedure without the use of a skin graft in approximately 90% of cases. Approximately 40% of patients return in 6 months or longer for a labioplasty (Fig. 54–5). This is a single-day procedure in which a double Z-plasty is accomplished to bring the upper lips together to form an anterior fourchette immediately above the neoclitoris.

At the same time, further cosmetic procedures may be performed if a patient so wishes. It is not uncommon to perform a tracheal shave, breast augmentation, or rhinoplasty along with the neocolporrhaphy in the same morning (Fig. 54–6).

CHAPTER

55

Vaginoplasty in Male-to-Female Transsexuals by Inversion of Penile and Scrotal Skin

J. JORIS HAGE

Vaginoplasty by inversion of penile and scrotal skin is the surgical method of choice for male-to-female transsexuals.[1, 2] Using this technique, the male external genital structures are transplanted to become their female counterparts as much as possible (Table 55–1). In experienced hands, this operation leads to favorable results.[3] Penile and scrotal skin inversion has to date been performed in our clinic for more than 300 male-to-female transsexuals. Although minor modifications have been adopted through the years, the basics of surgical technique and perioperative treatment remain the same.

PREOPERATIVE TREATMENT

Patients are admitted to the hospital 2 days preoperatively, and a liquids-only diet is started. Estrogen treatment is interrupted for 3 to 6 weeks before operation in order to prevent venous thrombosis. The day before surgery, only residue-free liquids are permitted, and purgative salt and cleansing soap enemas are administered because of possible rectal injury during surgery.[1–3] Preoperatively, 1500 mg of cefuroxime sodium (Zinacef) and 500 mg of metronidazole are administered intravenously.

Table 55–1
Transplanting Male External Genital Structures to Become Neovaginal Structures

Male Structure	Female Neovaginal Structure
Penile skin	Neovaginal lining
	Minor labia
Glans penis (reduced)	Neoclitoris
Dorsal neurovascular pedicle	Neoclitoral pedicle
Corpora cavernosa (excised)	—
Corpus spongiosum (excised)	—
Testicles and funiculus (resected)	—
Urethra (shortened)	Urethra
	Neovestibular lining
Scrotal skin	Major labia
	Neovaginal lining

OPERATIVE TECHNIQUE

Patients are operated on in the lithotomy position, under general anesthesia. From the penoscrotal juction downward, an incision is made following the raphe scroti. Halfway down the scrotum, the incision divides into two diverging lines ending 3 cm apart and approximately 1 cm ventrally to the anal orifice (Fig. 55–1). Thus, a dorsally based triangular perineoscrotal flap about 10 cm long is created, to be used to widen the neovagina and its introitus. To locate the rectovesical septum, the median fibrous connection between the urogenital diaphragm and the external sphincter ani is cut (Fig. 55–2).[2]

Orchiectomy is performed. For this, the funiculi spermatici are clamped, cut, and ligated as high in the groin as possible (Fig. 55–3). After circumcision, the penile skin tube with most of the fascia is dissected off the erectile corpora, leaving the dorsal neurovascular bundles unharmed. The distal opening of the penile skin tube is closed to form the future neovaginal cul-de-sac (Fig. 55–4). I no longer include the inner surface of the preputium by splitting this from its outer surface, because the extra length of skin thus obtained generally sloughs.

Once the erectile corpora are bared, the two neurovascular bundles are raised from the dorsal aspect of the corpora cavernosa to serve as a pedicle of a small part of the corona glandis (Fig. 55–5).[4–6] This represents a vascularized sensate neoclitoris (Fig. 55–6).[7]

An indwelling catheter is inserted, and the corpora cavernosa, remnant of the glans, and spongious rest are resected (Fig. 55–7).[8] Dorsally to the urogenital diaphragm, the rectovesical septum (Denonvilliers aponeurosis) is opened bluntly to become the rectovaginal cavity, using the indwelling urethral catheter as a guide. Both levator ani muscles usually are partly incised to obtain additional width of this cavity. If the central vascular supply of these

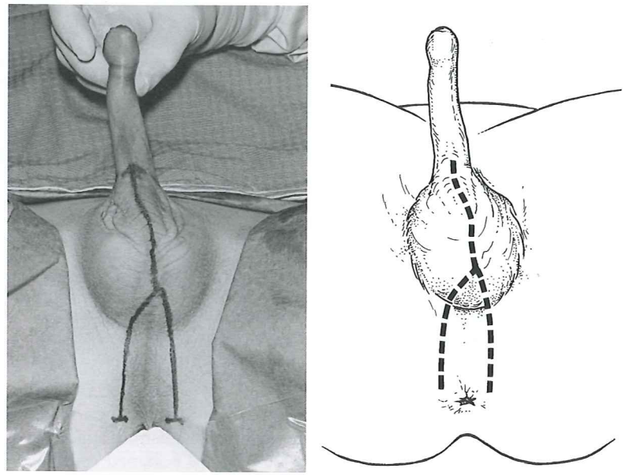


Figure 55–1
The scrotal skin incision ventrally follows the raphe scroti and divides halfway the scrotum into two diverging lines ending 3 cm apart and approximately 1 cm ventrally to the anal orifice. (From Karim RB, Hage JJ, Bouman FG, et al: Refinements of pre-, intra-, and postoperative care to prevent complications of vaginoplasty in male transsexuals. Ann Plast Surg 35:279–284, 1995.)

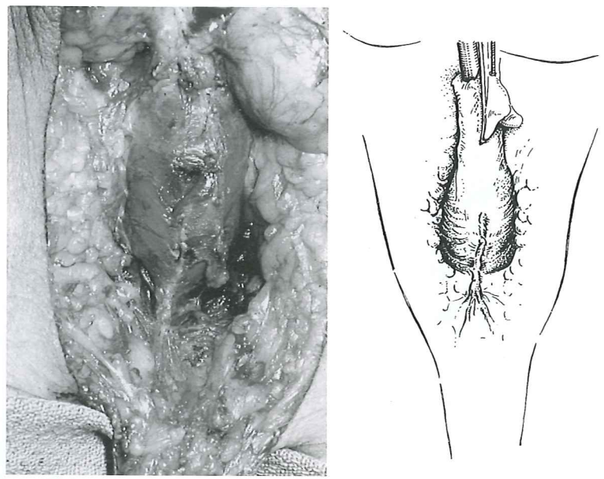


Figure 55–2
To start opening Denonvilliers aponeurosis, the median fibrous connection between the diaphragm and the sphincter ani is cut.



Figure 55–3
The funiculi spermatici are clamped, cut, and ligated as high in the groin as possible.

muscles is observed as maximal depth of this incision, no sphincter weakness resulting in fecal incontinence results postoperatively.

Once the peritoneum is reached, ensuring a neovaginal depth of approximately 12 cm, the penile skin tube is incised longitudinally toward the virtual top of the penis and transposed dorsally. A suture is led through the base of the penile skin tube on both sides of this longitudinal incision. These sutures fix the base of the skin tube to the base of the dorsal triangular perineoscrotal flap. The perineoscrotal flap is sutured to the longitudinal defect in

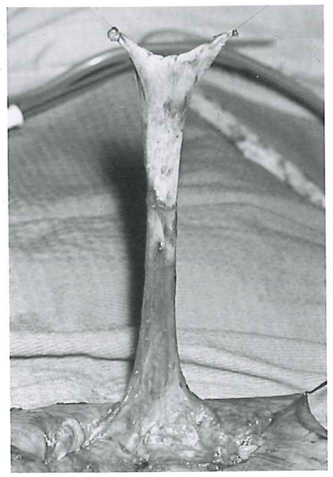


Figure 55–4
The distal opening of the penile skin tube is closed to form the future neovaginal cul-de-sac.

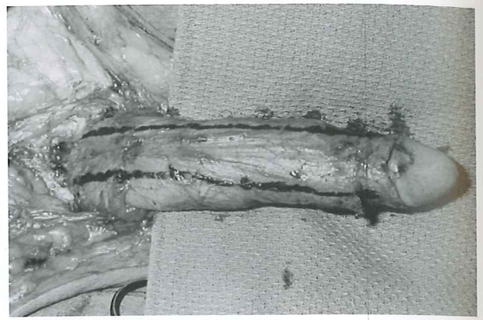


Figure 55–5
The two neurovascular bundles are raised from the dorsal aspect of the corpora cavernosa to serve as a pedicle of a fragment of the corona glandis. (From Hage JJ, Karim RB: Sensate pedicled neoclitoroplasty for male transsexuals: Amsterdam experience in the first 60 patients. Ann Plast Surg 36:621–624, 1996.)

the posterior wall of the skin pouch (Fig. 55–8). The widened pouch is then inverted to line the neovaginal cavity. In its ventral pedicle, the neomeatus urethra is created by a Y-shaped incision.[8] The catheter and urethra, as well as the pedicled neoclitoris, are pulled out through this opening. The neoclitoris is sutured to the ventral triangular flap of this Y-shaped incision. To facilitate suturing the urethra to its new meatal opening and to imitate the minor labia, bilateral sutures have already been passed through the skin at a level just ventral and lateral to the new urethral orifice, fixing the skin tightly to the urogenital diaphragm (Fig. 55–9). The first stitch of the neomeatus fixes the skin of the dorsal end of the Y-shaped incision to the posterior margin of the urogenital diaphragm. Two drains are inserted, one in the neovaginal cavity and the other in the prepubic region. The subcutaneous contents of the major labia are fixed dorsally to prevent uneven filling of the labia. The folds of scrotal skin on both sides are trimmed and sutured to imitate the major labia.

To secure the inverted penile skin pouch in the neovagi-

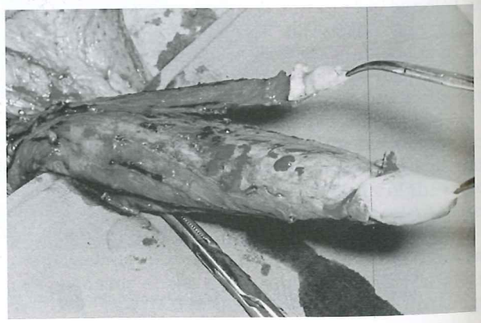


Figure 55–6
The coronal fragment will serve as a vascularized sensate neoclitoris. (From Hage JJ, Karim RB: Sensate pedicled neoclitoroplasty for male transsexuals: Amsterdam experience in the first 60 patients. Ann Plast Surg 36:621–624, 1996.)

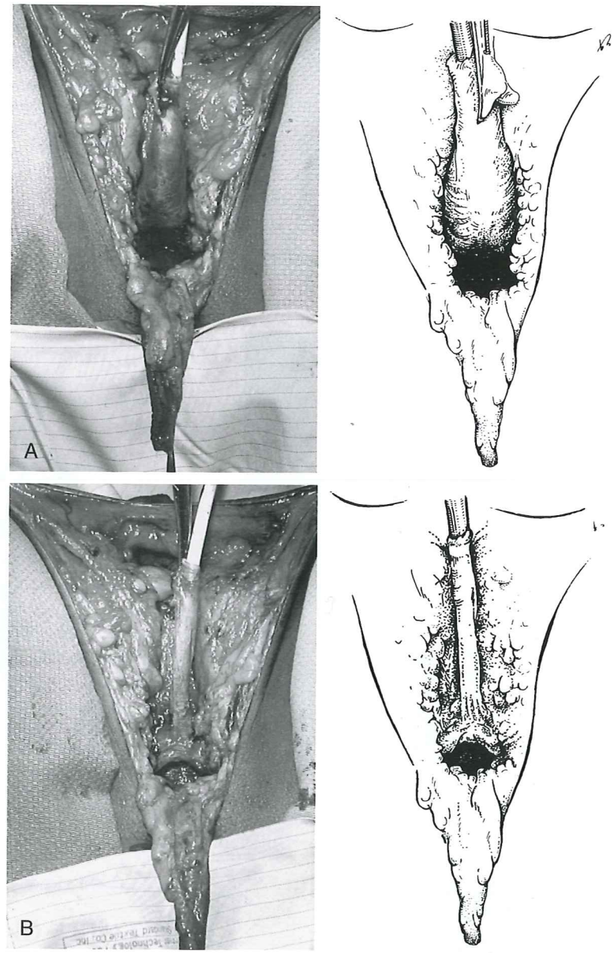


Figure 55–7
After an indwelling catheter is inserted, the spongious remainder is resected. *A*: Urethral and spongious remnants before resection. *B*: After near total resection of the spongious tissue.



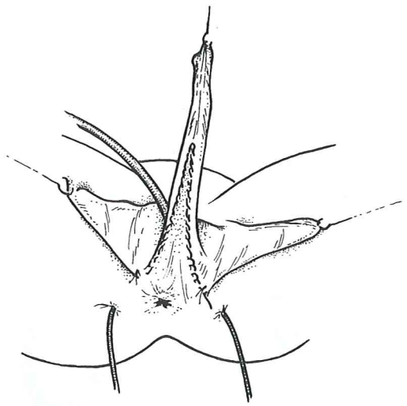


Figure 55–8
Once the penile skin tube is incised longitudinally and transposed dorsally, the perineoscrotal flap is sutured to the longitudinal defect in the posterior wall of the penile skin pouch. (From Karim RB, Hage JJ, Bouman FG, et al: Refinements of pre-, intra-, and postoperative care to prevent complications of vaginoplasty in male transsexuals. Ann Plast Surg 35:279–284, 1995.)

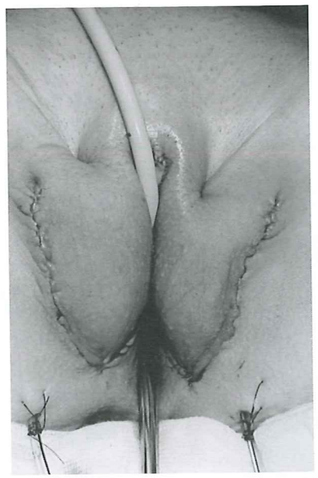
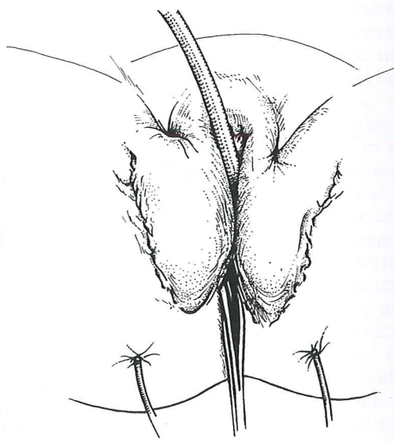
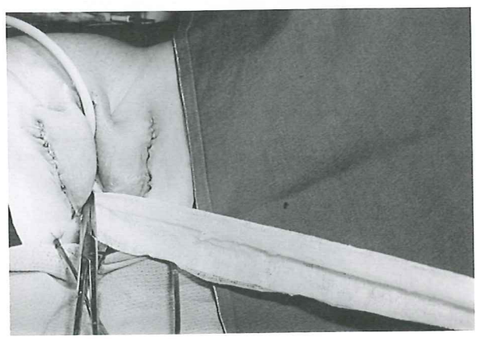


Figure 55–9
To facilitate suturing the urethra to its new meatal opening and to imitate the minor labia, bilateral sutures are passed through the skin at a level just ventrally to the new urethral orifice, fixing the skin tightly to the urogenital diaphragm. (From Karim RB, Hage JJ, Bouman FG, et al: Refinements of pre-, intra-, and postoperative care to prevent complications of vaginoplasty in male transsexuals. Ann Plast Surg 35:279–284, 1995.)





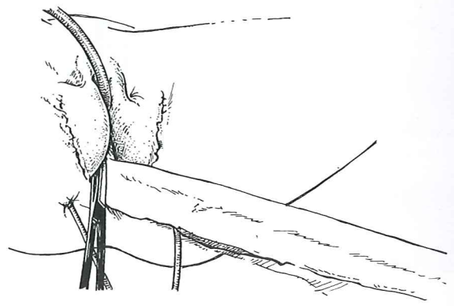
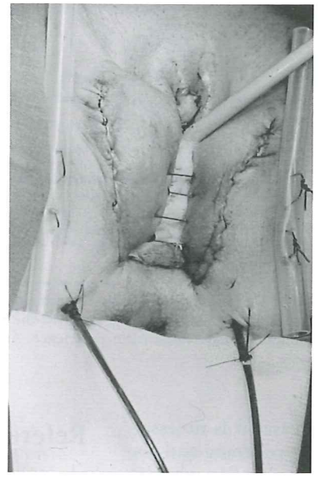


Figure 55–10
To secure the inverted penile skin pouch in the neovaginal cavity a petroleum jelly gauze tampon is used. (From Karim RB, Hage JJ, Bouman FG, et al: Refinements of pre-, intra-, and postoperative care to prevent complications of vaginoplasty in male transsexuals. Ann Plast Surg 35:279–284, 1995.)



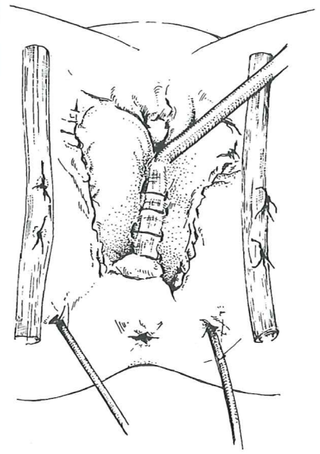


Figure 55–11
The intravaginal tampon is secured by two sutures led over silicone tubes through both major labia. (From Karim RB, Hage JJ, Bouman FG, et al: Refinements of pre-, intra-, and postoperative care to prevent complications of vaginoplasty in male transsexuals. Ann Plast Surg 35:279–284, 1995.)

nal cavity, a petroleum jelly gauze tampon is used (Fig. 55–10). This tampon is fixed by two sutures led over silicone tubes through both major labia (Fig. 55–11). No attempt is made to medialize the ventral aspect of both major labia.[9]

POSTOPERATIVE TREATMENT

Antibiotic prophylaxis is continued for 24 hours. The two drains are withdrawn on the first postoperative day. On the fifth postoperative day, the neovaginal gauze tampon is extracted, as is the catheter. After this, patients are prescribed 960 mg of co-trimoxazole (Bactrim) twice daily for 5 days. Rinsing of the neovagina twice daily also is started. Patients are discharged on the sixth day after surgery; hence, total hospitalization is 8 days. Continuous dilation of the vaginal canal by a firm mold is not advised. After examination at an outpatient clinic, patients are instructed to dilate the vagina as of 21 days postoperatively, applying a 3-cm-wide dildo daily for 15 minutes.[3] This is to be continued for half a year. As an alternative, sexual intercourse is permitted.

PREVENTING AND TREATING COMPLICATIONS

The preoperative treatment is believed to be of importance to avoid infection and rectovaginal fistulas. In cases in which the rectum is opened during dissection of the neovaginal cavity, primary closure may be performed.[3] No urethrovaginal or vesicovaginal fistulas were encountered in our series.

Sloughing of the inverted penile skin was observed in fewer than 1% of cases.[2, 3] We believe that this favorable result is realized through the use of the soft and pliable petroleum jelly gauze tampon instead of a firm mold.[3, 10] If as much of the penile fascia is left adherent to the penile skin as possible, inclusion of the dorsal neurovascular bundle has been proved not to be necessary to prevent sloughing. Using the sensate composite glanular flap to construct a neoclitoris, I have generally obtained satisfying cosmetic and functional results.[7] The stumps of corpora cavernosa should not be included for this purpose because this may cause painful protrusion during sexual arousal.[8] Likewise, the funiculus rest should not be used to add to the labial filling.[11, 12]

Although use of the triangular perineoscrotal flap favors

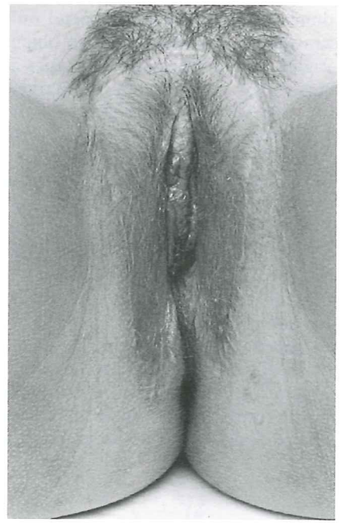


Figure 55–12
The ventral parts of the major labia may be brought together secondarily by bilateral Z-plasty. (From Hage JJ, Karim RB: Sensate pedicled neoclitoroplasty for male transsexuals: Amsterdam experience in the first 60 patients. Ann Plast Surg 36:621–624, 1996.)

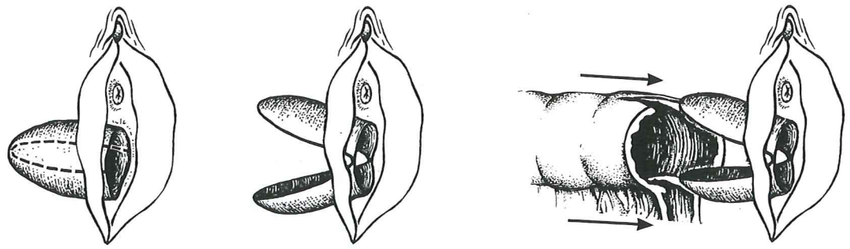


Figure 55–13
To allow the rectosigmoid mucosa to be sutured to the perineal skin in an exaggerated interdigital fashion, Denovilliers space should be approached through bilateral longitudinal incisions, leaving the penile skin remnants to cover the rectum and urethra. (From Karim RB, Hage JJ, Cuesta MA: Rectosigmoid neocolpopoiesis for male-to-female transsexuals: Amsterdam experience. Ann Plast Surg 36:388–391, 1996.)

the introital width,[13] in a minority of cases it is necessary to perform secondary surgical introitus widening and correction of a dorsal introital skin fold by five-flap advancement. Edgerton and Bull pointed out that use of a dorsally pedicled scrotopenile skin flap would prevent such a complication.[14] However, this results in scarring and an unnatural appearance of the pubic region. The dimensions of the perineoscrotal flap should be kept to a minimum to avoid abundant intravaginal hair growth. In some patients, the ventral parts of the labia had to be brought together secondarily by bilateral Z-plasty (Fig. 55–12). Because of the risk of reduction of blood flow in the penile skin flap, we do not advise doing so primarily, as has been advocated by Meyer.[9]

Long-term continuous intravaginal stenting to prevent neovaginal shrinking is not required. However, it is essential to encourage daily intravaginal dilatation. Long-term neovaginal dimensions may further depend on sexual activity.[3, 13] Rectosigmoid transplantation to obtain a deeper and wider vagina was performed only twice in this series.[15, 16] Rectosigmoid neocolpopoiesis should be considered only in cases in which the penile skin inversion technique is impossible or has not led to satisfactory results. Colocolpopoiesis involves major surgery and often leads to disappointing long-term results or serious complications.[16–18] To allow the rectosigmoid mucosa to be sutured to the perineal skin in an exaggerated interdigital fashion, all remaining skin of the previous skin inversion vaginoplasty is needed anyway (Fig. 55–13). Moreover, by approaching Denonvilliers space through bilateral longitudinal incisions at the sides of the vaginal rest, the penile skin remnants may be left to cover the rectum and urethra. Damage to these structures is thus prevented.

For these reasons, any consideration of colocolpopoiesis in male-to-female transsexuals should ideally be preceded by a penile and scrotal skin inversion vaginoplasty.

Acknowledgments

I am grateful to Refaat B. Karim for his preliminary research on this series.

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CHAPTER

56

Vaginal Construction Using Rectosigmoid Colon

GERALD H. JORDAN

The type of procedure used for vaginal construction depends on each particular patient's circumstances. For vaginal construction in intersex and transsexual patients, bowel segments have been widely used. Although the Mayer-Rokitansky syndrome is not fully an intersex condition, affected individuals are in the subset of patients undergoing construction for vaginal aplasia or absence rather than patients who have undergone ablative surgery. The goals are obviously different, because patients who have undergone ablative surgery require bulky vascular tissue in the area of the pelvic defect whereas in patients with aplasia, the tissues are normal, the pelvis often is android, and patients need only a vaginal vault. Because of the android shape of the pelvis in transsexual patients and many intersex patients, bulky musculocutaneous flaps can leave little space for the vaginal vault, although McCraw's modification, which includes only the portion of the rectus abdominis muscle at the periumbilical area, may allow for use of the inferiorly based transverse rectus abdominis musculocutaneous (TRAM) flap in select patients in the group.[1] Better recognition of the mesenteric blood supply and the principles of flap transfer as applied to the bowel have added to the advantages of stapled enteric anastomoses. These procedures thus can be accomplished with more than acceptable results, and bowel segments, according to many, are the tissue of choice for vaginal construction in both intersex and transsexual patients.

A number of bowel segments have been used for vaginal construction. Ileum offers the advantage of having reduced mucus production; however, it tends to be fragile, is easily traumatized during intercourse, and in many patients is not particularly easily brought to the level of the introitus. The transverse colon produces more mucus secretion, is a more durable bowel segment, and can, with some difficulty, be brought into the pelvis. The distal portion of the sigmoid colon offers a good compromise. This portion, when it is carefully tailored, can result in reduced mucus secretion and when mobilized on the inferior mesenteric artery and marginal artery is easily brought to the level of the introitus.

Because of the extremely predictable vasculature, the sigmoid colon is a reliable flap for transfer (Fig. 56–1). Although elevation of the flap requires laparotomy, to date, significant increases in complication rates have not been reported with laparotomy and bowel resection required for this procedure. In addition, the vaginal vault created from sigmoid colon does not require stenting, and thus many of these attendant complications are avoided. To date, adenocarcinoma has not been reported to develop in a colon segment mobilized for vaginal construction; however, this complication cannot be forgotten.

SURGICAL PROCEDURE

Because it is strongly believed that the testicles should not be removed from a transsexual patient until the patient has

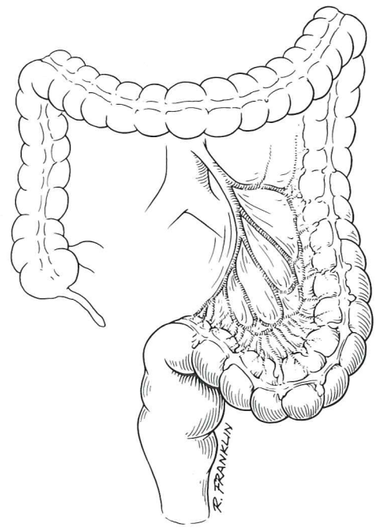


Figure 56–1
Diagrammatic representation of the distribution of the inferior mesenteric artery to the sigmoid colon.

been approved for definitive gender reassignment surgery, vaginal construction is accomplished at the same time as feminizing genitoplasty and bilateral orchiectomy. In our experience, bilateral orchiectomy accomplished at the time of feminizing genitoplasty and vaginal construction adds a small amount of time to the surgery but is not attended by increased morbidity.

The patient is placed in a low lithotomy position to allow for concurrent laparotomy and perineal incision. In a transsexual patient, before the abdominal incision is made, the feminizing genitoplasty is completed. Although this operation is not the topic of this chapter, a brief description is included. A section of the glans penis is preserved and left on the dorsal neurovascular bundle to serve as a glans clitoris.

A circumcising incision is made at the site of the old circumcision scar or (in an uncircumcised patient) approximately 1 cm proximal to the coronal margin. An incision is then made in the ventral midline, and the skin is reflected off the shaft of the penis by dissecting in the dartos fascia layer. At the midscrotal level, the urethra is detached from the corporeal bodies and divided. A catheter is passed to the bladder. The bulbospongiosum and urethra are dissected free to the point where the membranous urethra enters the bulb. The corpus spongiosum must be completely freed from its attachment to the corpora cavernosa and the triangular ligament to allow the remaining bulbous urethra to be straightened, so that the urinary stream can be directed downward.

The corpora cavernosa are dissected to the midportion of the crus and divided. The ends of the crura are oversewn with 4-0 polydioxanone suture. The glans is not removed from the tips of the corpora, but rather the lateral tunica albuginea of the corpus cavernosum is incised. A strip of dorsal tunica is left to support the dorsal vessels and nerves. The strip is folded, and the segment of glans is sutured to the inferior rim of the symphysis. Later, when the perineal incision is closed, the skin of the penis and scrotum will be distributed to form both the labia minora and majora. The testicles are removed with the cords, divided high in the groin through the midline scrotal and penile incision.

In most patients, a true Pfannenstiel incision is made, with the fascial and peritoneal incisions oriented vertically. The android pelvis somewhat limits exposure through the incision.

An incision is then made in the perineum, creating a posteriorly based V flap just anterior to the anus. The dissection is carried immediately superficial to the circular fibers of the anal sphincter, developing the plane along the anterior rectal vault. The rectourethral muscle is identified and divided (a potential source of complication in that tension on the muscle slightly tends to tent the rectum anteriorly). The dissection is continued beneath the prostate, which is not palpable in transsexual patients who have had estrogen therapy. Denonvilliers fascia is usually not visualized from above. The rectovesical space is developed behind the prostate, and the surgeon at the perineum dissects bluntly toward the surgeon at the abdomen, creating a broad vaginal vault. The dissection is relatively bloodless, because the dissection is carried along the rectal wall.

In some centers, perineal dissection is carried out with a more anterior orientation that necessitates division of the transverse perineal muscles. This maneuver allows for a more anatomically correct anterior placement of the vaginal introitus, but the bulbospongiosum bulges into the anterior vaginal wall and can be cosmetically less acceptable than the slight posterior displacement of the vaginal

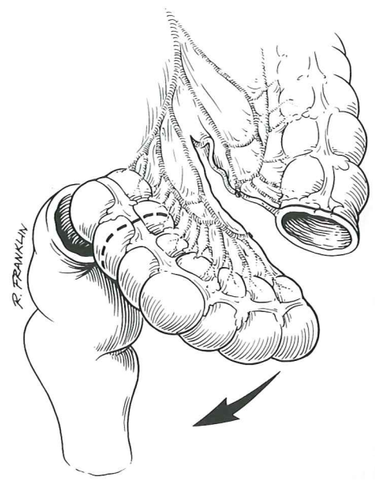


Figure 56–2
The surgeon, working from above, isolates the sigmoid colon on the branches of the inferior mesenteric artery and gains length by sequentially dividing branches. The loop is carried on the marginal artery. To limit mucous secretion, the loop can be shortened as indicated by the dotted line.

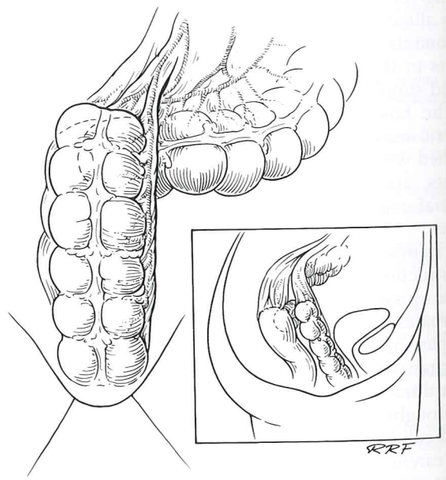


Figure 56–3
The butt of the loop (i.e., the vaginal vault) is closed. The opposite end is brought to the level of the introitus. End-to-end stapled anastomosis is created between the rectum and the colon to reestablish the continuity of the bowel.

vault that occurs when dissection is carried out posterior to the transverse perineal musculature. With sexual stimulation, the bulging bulbospongiosum can be very bothersome to some patients.

The surgeon working from above will have mobilized the colon and, having identified the sigmoid segment, divides it from its continuity with the bowel and mobilizes it so that it easily passes into the area of the perineum (Fig. 56–2). A watertight and airtight low anterior anastomosis of the colon is accomplished using the EEA stapler (U.S. Surgical Corp., 150 Glover Avenue, Norwalk, CT 06856) or Ethicon (Ethicon Endo-Surgery, 545 Creek Road, Cincinnati, OH 45242-2839) and reinforcement with silk sutures.

Proctoscopy is performed after completion of the anastomosis to examine the anastomosis line and to distend the bowel to check for leakage of gas. After the anastomosis has been proved reliable, the bowel segment is passed through the dissected tunnel and incorporated into the perineal closure (Fig. 56–3). Hemostasis is ensured, and the abdominal incision is closed. The colon is then sutured to the posteriorly based V flap, and the skin of the penis is distributed to form labia minora. The scrotum is reduced to become appropriately proportioned labia majora. In some cases, the base of the penile skin is divided; the skin, however, remains elevated on the dartos-based blood supply. This allows the labia to be brought to the midline, anterior to the neoclitoris, to improve the cosmetic results. In cases in which excessive mucus discharge becomes a postoperative problem, intermittent douches with 3% saline have been found helpful.

Patients are allowed to have sexual activity beginning approximately 8 to 12 weeks postoperatively. It is not unusual for patients who do not begin having sexual activity to experience some degree of introital stenosis, but that is easily remedied by reelevating the posterior V flap and advancing it. Likewise, about half of the patients complain of spraying when they urinate. That too is easily remedied by redistributing the periurethral tissues.

Sigmoid colon vaginoplasty has proved to be an excellent procedure from the standpoint of safety, efficiency (i.e., a vagina that allows for intercourse), and aesthetics.

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CHAPTER

57

Use of Tissue Expansion in Male-to-Female Gender Reassignment

ARNOLD MELMAN

Several methods have been used to create a skin-lined neovagina in male-to-female sex reassignment surgery. The first popularly accepted technique used the entire length of vascularized penile skin split along the ventral surface with the distal end sutured to a flap of the scrotum and inverted into the neovagina pouch.[1] The problem with that method is that the scrotal skin, unless first depilated, is both hair bearing and not cosmetically satisfactory. The technique described and popularized by Granato used the entire length of inverted devascularized penile skin to line the neovagina.[2] The method is advantageous because it easily creates a non–hair-bearing surface that closely simulates the normal vaginal skin. With this technique, the glans penis may be included or removed from the inverted

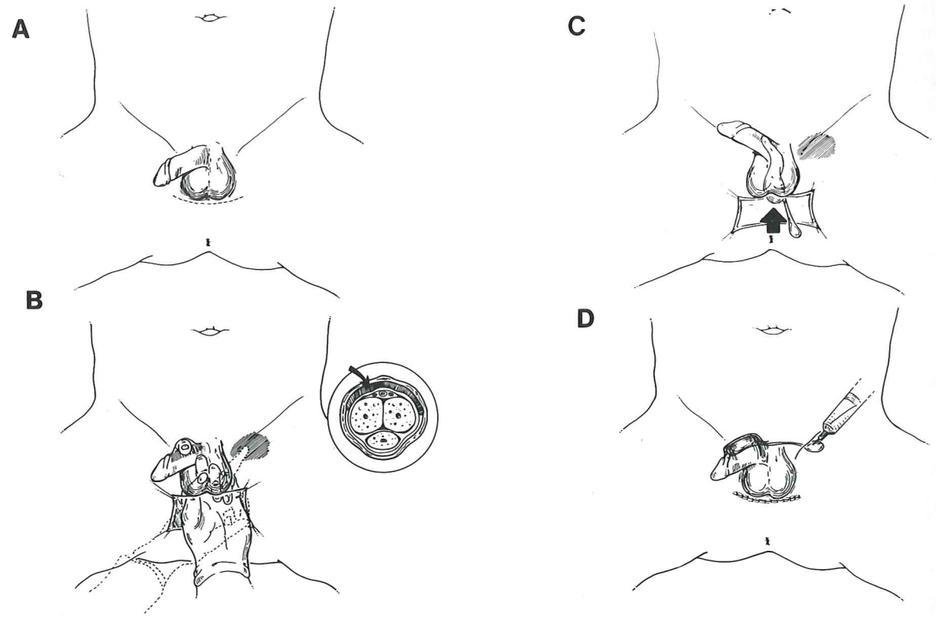


Figure 57–1
Technique of placement of tissue expander as advocated by Granato.[2] *A*: A transverse incision is made at the base of the scrotum. *B*: With the use of blunt dissection, a pocket is created along the entire length of the dorsum of the penis between the dartos and Buck's fascia. A pocket for the injection port is created with finger dissection beneath the Scarpa's fascia of the inguinal area. *C*: The tissue expander is placed through the incision into the two cavities that were created. *D*: The skin wound is closed with a subcuticular 4-0 absorbable suture, and a small amount of fluid is added to the injection port, both to test its patency and to decrease dead space in the surgical area.

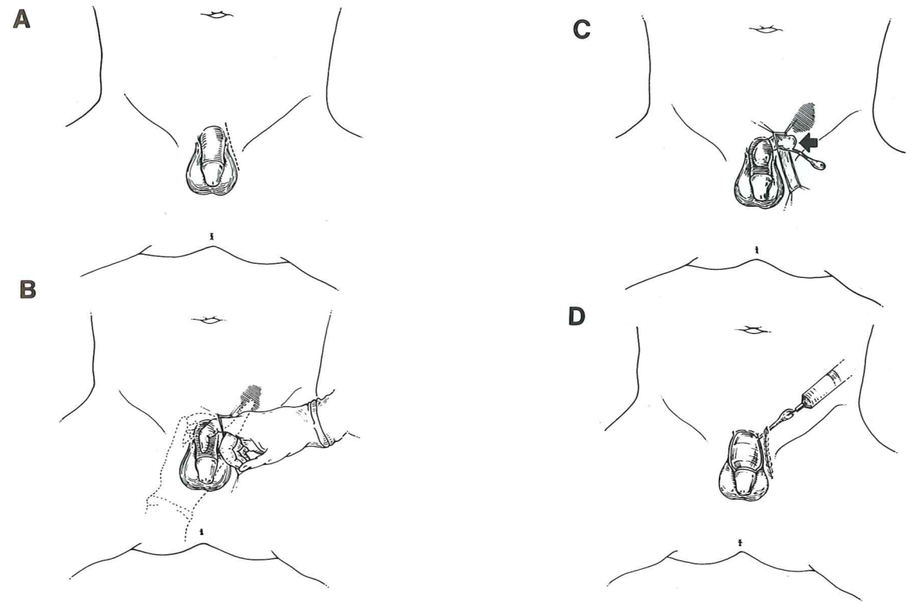


Figure 57–2
A: A modified initial incision is made in the lower inguinal area just parallel to the penile and scrotal base. The incision allows direct development of the penile and inguinal pockets and minimizes potential perineal scar that might impede the creation of the neovagina. *B*: Finger dissection, similar to that in Figure 57–1*B*. *C*: Placement of the tissue expander, similar to that in Figure 57–1*C*. *D*: Wound closure, similar to that in Figure 57–1*D*.

skin tube. If included, the glans usually atrophies but the remnant resembles the cervical os. If the glans, along with its neurovascular bundle, is instead used to fashion a neoclitoris, the entire glans is excised from the end of the inverted tube and the penile skin oversewn with a nonpermanent suture. The skin tube is then placed into the newly created cavity lying between the bladder and rectum. This method works very well in patients with large phalluses, whether or not they have been circumcised.[3] Creating adequate width and depth of the neovagina in patients with a small penis, however, is a problem. Moreover, although many patients claim *preoperatively* that successful coitus is not the major goal for the surgery, I have found that once the surgery is complete, *all* patients expect a functional vagina, even those patients who want only lesbian experiences. Therefore, it is incumbent on the surgeon to plan a neovagina usable for coitus no matter what the patient may claim preoperatively. A surgeon's options were previously limited to four choices:

1. Take a chance that the available penile skin will allow a satisfactory result.
2. Use the combined penile skin–scrotal skin technique with its less than satisfactory appearance and possibly inadequate depth and width of the vagina.
3. Combine the small devascularized, inverted penile skin tube with a split-thickness skin graft sutured to the end of the penile skin tube.
4. Combine the penile skin tube with a segment of sigmoid colon to create a mucus-lined vagina.

The disadvantages of the first two options are obvious. The problem with the third choice, combined skin graft penile tube, is twofold: First, the aesthetic defect at the donor site is of concern to patients. Second, once the graft is sutured onto the penile skin and inverted into the neovaginal space over a vaginal mold, it is inaccessible for treatment. Therefore, proper take of the graft is problematic. Creation of a rectosigmoid vagina, although functionally satisfactory, necessitates a much more complex surgical procedure for patients. Furthermore, as with all sigmoid surgery, the additional intraabdominal procedure adds the possibility of life-threatening postoperative complications.

Another option suggested by Granato minimizes risk to both the patient and surgical outcome and simultaneously guarantees an excellent cosmetic result. The new method expands the penile skin with a tissue expander as a preliminary stage. The method has also been suggested for correcting congenital vaginal abnormalities in young girls.[4] The surgery is performed on an ambulatory basis a minimum of 6 weeks before the planned reassignment surgery. The method offers several advantages. Of greatest importance is that it uses a highly successful technology that is well accepted in the plastic surgical armamentarium from both a methodologic and a device standpoint.[5–8] Tissue expansion allows the use of the penile skin alone to form a widely expansive and deep neovagina with only minimal risk to the patient. It can be used for any patient with an obviously inadequate penile size or for those in whom the size is marginal and the postoperative outcome not secure.



Figure 57–3
The expanded penile skin before creation of the neovagina.

The disadvantage is that an additional operation with its attendant costs is necessary.

METHOD

The surgery can be performed under local, regional, or general anesthesia. The patient is given a single perioperative intravenous injection of 1 g of vancomycin and 80 mg of gentamicin. Although Granato has used an infrascrotal incision with the patient in the lithotomy position, I have modified the approach in the following way (Fig. 57–1). The patient is placed in the supine position, and a transverse 3-cm infrapubic or preferably a longitudinal lower inguinal incision is made. A plane is created with blunt dissection between the dartos and Buck's fascia along the entire length of the penis down to but not beyond the level of the corpus spongiosum (Figs. 57–1 and 57–2). A rectangular tissue expander is then placed into the space. The 4 × 6 cm 100-ml or the 5.0 × 8.5 cm 200-ml expanders are used (McGhan Medical Corp., Santa Barbara, CA; Mentor Corp., Goeta, CA). It is not necessary to suture the expander in place. Care must be taken not to dissect over the urethra. If the expander is filled over the corpus spongiosum, urinary outflow may be obstructed. The space for the injection port is created with blunt finger dissection in a subcutaneous pocket over the inguinal canal. The wound is irrigated with copious amounts of any commercially prepared antibiotic solution, and the wound closed with subcutaneous 3-0 chromic catgut and a 4-0 Vicryl subcuticular suture. The penis is wrapped with a Coban dressing to secure the placement of the expander for 3 or 4 days. After 1 week, weekly injections are begun. The volume of saline injected is dependent on the size of the expander used and the pain threshold of the patient.

The injections are continued until the volume of expanded skin is sufficient for the neovaginal lining (Fig. 57–3). At that time, the standard penile inversion technique can be used. The tissue expander slides out of the pseudocapsular pocket and minimizes the dissection needed to free the penile skin. The option of creating a neoclitoris is at the discretion of the surgeon, as before. However, the thickened pseudocapsule does make dissection of the neovascular bundle more difficult. The choice of a longitudinal lower inguinal incision before the definitive sex reassignment surgery eliminates potential scar at the apex of the neovagina in the region between the new labia or, with the use of a transscrotal incision, in the perineum.

This new method is a safe and effective advance in sex reassignment surgery for those patients who require penile skin enhancement to ensure a successful cosmetic outcome and a functional neovagina.

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TOTAL PHALLOPLASTY

CHAPTER

58

Total Phallic Reconstruction

CHARLES E. HORTON JR.
CHARLES E. HORTON

The penis is a uniquely complex organ because it serves both functional and psychosexual purposes. Its functional capacity as a conduit for urine and sperm can be compensated for with modern technology; however, there is no substitute for the penis as a psychosexual organ. Therefore, loss or absence of the penis is devastating for most males. Total reconstruction of the phallus may be indicated in cases of penile destruction after trauma such as avulsion, amputation, circumcision accidents, burns, or ablative cancer surgery. Patients with congenital anomalies such as penile agenesis, micropenis, intersex conditions, epispadias, or hypospadias may be candidates for penile reconstruction. Finally, more and more female-to-male transsexuals are seeking gender reassignment surgery as newer, more aesthetic and functional phalloplasty techniques have developed.

HISTORY

Borgoras in 1936 first reported using a tubed abdominal flap to build a penis.[1] From that report to the present, many varied procedures have been proposed to achieve a satisfactory reconstruction. Only recently have these attempts culminated in acceptable surgical results. Throughout the 1940s and 1950s, the staged abdominal pedicle flap technique popularized by Gilles remained the major method of phallic reconstruction.[2] However, the Gilles reconstruction and its variations had severe limitations. Orticochea in 1972 reported on the use of a gracilis myocutaneous flap to reconstruct a phallus.[3] Later, in the 1970s, Horton and colleagues used gracilis flaps, rectus femoris flaps, and groin flaps and attempted to achieve sensation in the new penis by wrapping it with scrotal skin that retained its genital sensitivity.[4] The results were better than previous reconstructive efforts but still far from perfect. The penis could be shaped, but erotic sensation was not achieved. In 1979, Horton, Maxwell, and Devine used free microvascular flaps for penile reconstruction. These flaps were taken from saphenous or deltoid donor sites and represented the first attempt to use microvascular free tissue transfers to build a penis. Also for the first time, an attempt was made to innervate the neophallus by coapting the nerve of the sensory flap to the genitofemoral nerve. Expanding this concept in 1981, Horton, Devine, and Terzis used a free microvascular dorsalis pedis flap total penile reconstruction with anastomosis of the pudendal nerve to a sensory nerve of the donor flap.[5] In the assessment of these cases postoperatively, it was determined that the pudendal nerve repair provided actual erogenous sensation to the neophallus.[6] Flaps from the saphenous, deltoid, upper medial arm, upper lateral arm, forearm, dorsalis pedis, gracilis, posterior thigh, rectus femoris, and rectus abdominis muscle all were tried by our group in different cases. In the 1980s, the forearm flap first described by Chang and Hwang in 1984[7] became our method of choice in this evolving field, and to date we have completed more than 35 cases. Excellent erogenous sensation has been reported by 80% of our patients undergoing this type of surgery since we modified the use of the flap by adding pudendal nerve coaptation to the sensory nerve of the forearm free flap.

CURRENT PHALLOPLASTY TECHNIQUE

The radial forearm flap is a single dominant vascular pedicle flap that contains sufficient bulk and (usually) hairless skin and consistently yields adequate arterial and venous pedicles as well as cutaneous nerves. In mobilizing the radial forearm flap, it is important to leave a thin layer of peritenon over the exposed wrist tendons to act as a bed for later skin graft coverage. Postoperatively, functional problems have been almost absent in the donor site; however, the cosmetic blemish is obvious and disturbing to casual observers. The appearance of the donor site is improved by covering it with a thick skin graft, which allows for hair growth on the forearm.

The dorsal branch of pudendal nerve (S2–S4) provides

erogenous innervation of the penis and clitoris. This nerve contains motor, sensory, and autonomic fibers. Within the pelvis, the pudendal nerve gives off three main branches: the inferior rectal nerve, the perineal nerve, and the dorsal nerve of the penis or clitoris. The dorsal nerve separates before entering Alcock canal, then travels through the canal to achieve a dorsal position on the penile shaft or the clitoris. If trauma has caused scarring in the area of the penis or clitoris, the nerve is most easily located along the medial border of the inferior pubic ramus, where it egresses from Alcock canal.

Our radial forearm flap template for complete phallic reconstruction is somewhat different from that of Chang in that the distal end of the flap is divided into an ulnar mushroom-shaped area of intact skin for the glans, lateral deepithelialized areas to cover the neourethral suture line, and a deepithelialized G flap that is folded inside to provide bulk for the glans (Fig. 58–1). The urethra is made from a centralized 3-cm-wide band of skin that extends along the length of the flap with a slight flare of the proximal end. The deepithelialized skin continues along each side of the future urethra in a 1-cm band and terminates 3 cm farther than the tip of the neourethral skin. The remainder of the flap skin is left intact to serve as penile shaft covering. In adults, the length of shaft skin on the flap is approximately 13 cm, with an additional 5 cm for the glans (Fig. 58–2). The edges of the neourethra are approximated over a 16 French silicone Foley catheter, forming a tube within a tube. Three layers of running,

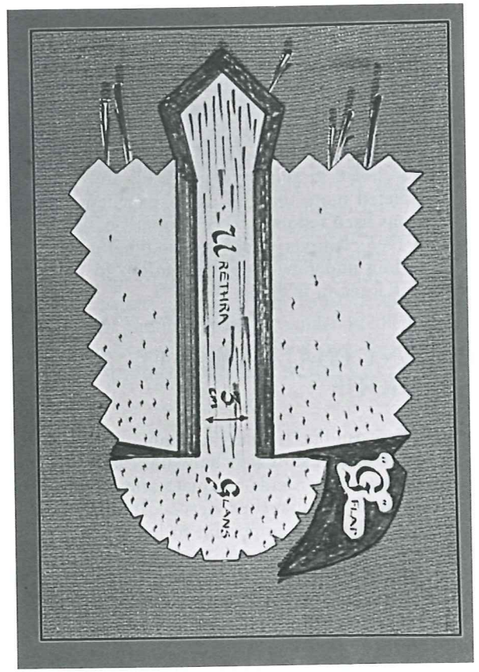


Figure 58–1
Our template for radial free flap phalloplasty.

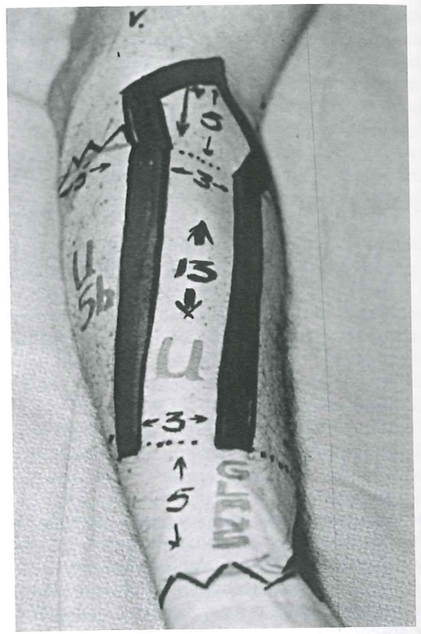


Figure 58–2
Flap dimensions marked on the forearm.

locked polydioxanone suture (PDS) are used for this closure. The shaft skin is then closed over the neourethra ventrally and on the dorsal aspect of the neophallus. This produces two scars on the shaft of the penis, in contradistinction to the one scar of the Chang flap; however, we



Figure 58–3
Early postoperative appearance of the glans and meatus.

have had more success with a centrally placed urethra, and the scars seem to be minimal and acceptable to patients. A series of W-plasties are fashioned in the shaft skin to avoid a longitudinal scar contracture. The glans skin has many small divots to allow eventual folding into a rounded glans configuration. The glans skin is folded over and approximated onto the previously closed shaft skin, with the radial lateral deepithelialized skin tucked under. This results in a wide V-shaped meatus, a new glans of adequate bulk, and a step-off approximating a coronal sulcus. The glans skin can be tattooed at a later date to provide color contrast. This results in a quite acceptable appearance of the neoglans and is a major improvement over the old phalloplasties that produced an appendage with a flat, tubular appearance[8] (Fig. 58–3).

The design of the free flap can be modified to meet specific needs of individual patients. If a patient has only partial loss of the penis with retained corporeal tissue or glass, then portions of the flap can be omitted to tailor the flap appropriately. The neophallus is created in situ on the forearm (Fig. 58–4). The urethra is tubularized, and the shaft and glans formed before detachment of the flap from the arm (Fig. 58–5).

While one surgical team is elevating the free flap, a second surgical team should be preparing the recipient site. Residual corporeal bodies are freed from any overlying skin and are used as a base for the free flap. The free flap is then adjusted in length appropriately. In the distal penile

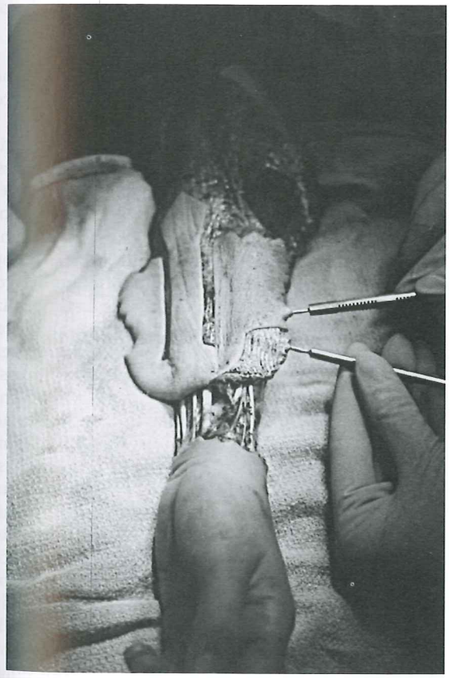


Figure 58–4
Flap being elevated; note the deepithelialized areas.

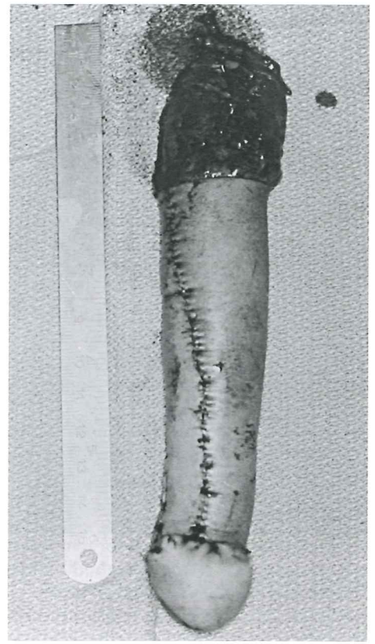


Figure 58–5
Neophallus has been formed and the flap detached from the arm.

stump, the dorsal nerves are found in their usual anatomic location and should be isolated for anastomosis with the medial and lateral antebrachial cutaneous nerves of the forearm. A midline abdominal incision is usually made. The inferior epigastric artery and vein on one side are mobilized for use in microanastomosis between the radial artery and venae comitantes. Approximately 12 cm of saphenous vein is mobilized by dividing the distal vein and leaving its drainage into the femoral vein. The saphenous vein is then tunneled into the pubic region for anastomosis with the cephalic vein. A side branch off the saphenous vein often can also be kept for anastomosis with any other veins that are elevated in the free flap.

The proximal neourethra is configured such that the point of the flared end fits into a spatulated recipient native urethra, thus avoiding a circular anastomosis. The proximal deepithelialized skin cuff is used as a vascularized layer completely covering the urethral anastomosis. Regardless of the clinical scenario, we incorporate, in layers, any available subcutaneous tissue above the dermal cuff to further sheathe the urethra-neourethral anastomosis in an effort to avoid fistula formation.

After the recipient site has been prepared and the neophallus formed on the forearm, the flap, artery, veins, and nerves are clipped and divided. The neophallus is transferred to the recipient site on the pubis. The urethral anastomosis is completed before any vascular work is performed to avoid any chance of disrupting delicate microvascular anastomoses. Microvascular anastomoses are performed immediately after the urethral anastomosis has

been completed. Patients are given appropriate heparin medication. The radial artery is anastomosed to either the inferior epigastric artery or the femoral artery via a saphenous interposition vein graft. A vena comitans is anastomosed to the inferior epigastric vein, the cephalic vein is anastomosed to the greater saphenous vein, and a third venous anastomosis is performed if possible. The medial and lateral antebrachial cutaneous nerves of the forearm are coapted to the right and left dorsal nerves of the penis. If the dorsal nerves of the penis have been destroyed, the pudendal nerve can be approached along Alcock canal. In that case, nerve grafts may be necessary to span the distance.

The donor site on the arm is covered with a deep split-thickness skin graft, approximately 0.030 inches in depth, taken from the thigh. A split-thickness graft approximately 0.014 inches in depth is taken from the opposite thigh and placed on the first skin graft donor site. The thick split-thickness skin graft has resulted in improvement of the donor site deformity of the forearm with return of hair growth. The arm is placed in a splint for approximately 1 week.

The Foley catheter is left indwelling for approximately 2 weeks. A suprapubic tube is placed for temporary urinary diversion. A pericatheter retrograde urethrogram is performed to make sure there is no leakage before removal of the Foley catheter. The neophallus is placed in an elevated position off of the scrotum and abdominal wall for approximately 2 weeks. The use of a specially constructed dressing to keep the penis in an elevated state has been very helpful. Elevation of the neophallus decreases edema and keeps the scrotal and abdominal area dry to prevent maceration.



Figure 58–6
Female-to-male transsexual.

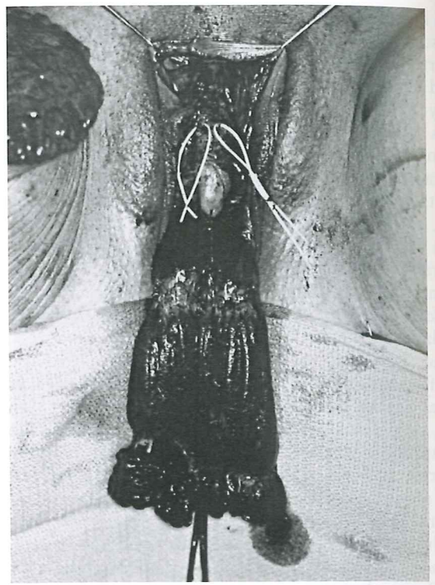


Figure 58–7
Rectus muscle flap brought through the pelvis to the perineum.

TRANSSEXUAL PHALLOPLASTY

Phallus construction de novo in a transsexual with gender dysphoria is often more complicated than phallus reconstruction in a genetic male after trauma. This relates to the presence of female organs including the clitoris, vagina, uterus, and ovaries; the short female urethra; the desire for simultaneous scrotal construction; and the absence of corporeal remnants to act as a platform. Our approach to transsexuals is to perform all surgery at one stage, which often entails total abdominal hysterectomy, bilateral oophorectomy, vaginectomy, free flap phalloplasty, and scrotal construction. Our approach to the clitoris is individualized according to the patient's desires. Some transsexuals prefer the clitoris along with all other female reproductive organs to be excised, but others elect to preserve the clitoris as an effective organ for sexual expression. In cases in which the clitoris is to be preserved, it is mobilized and placed to the side of the neophallus. One of the paired dorsal clitoral nerves is maintained intact, and the other is anastomosed to the nerves of the neophallus. The short female urethra is advanced 2 to 3 cm so that the length is sufficient to meet the proximal neourethra of the flap. This is done by tubularizing a strip of anterior vaginal mucosa extending from the normal female meatus toward the base of the clitoris in a Thiersh-Duplay fashion. The urethral anastomosis is covered by a rectus abdominis muscle flap, which has greatly reduced the incidence of fistula formation. The rectus muscle flap, based on the inferior epigastric vessels, is detached from the costal margin and placed through the vaginal cuff into the pelvic dead space that remains after vaginectomy. This is very beneficial for hemostasis. The end of the rectus flap is brought out between the legs and folded over to bolster the urethra and provide bulk for a neoscrotum. The rectus muscle neoscrotum is covered with either unfolded labial skin or meshed split-thickness skin grafts (Figs. 58–6 to 58–8).

PEDIATRIC PHALLOPLASTY

In the pediatric population, two somewhat different categories of patients may be candidates for total phallic reconstruction. The first group consists of those with congenital anomalies of the penis, who are otherwise normal 46XY genetic males. These patients may have penile agenesis, microphallus, certain variants of testicular feminization, and mixed gonadal dysgenesis with ambiguous genitalia and cloacal exstrophy. Such newborns previously were routinely gender converted and raised as females. However, as more of these patients have had long-term follow-up into adulthood, accumulating evidence shows that these patients do not adapt well to the female gender. Some have hypothesized that this may be secondary to brain imprinting by fetal testosterone during pregnancy. With modern phalloplasty techniques, a viable option may now be to consider maintaining these male infants in their genetic sex, especially if they have normal testes. The ideal timing for phalloplasty surgery in these cases is unknown; however, we recommend construction of a neophallus between the ages of 6 and 8 years, recognizing the significant psychologic pressures on the child and his family.



Figure 58–8
Early postoperative appearance of transsexual phalloplasty and the new scrotum.

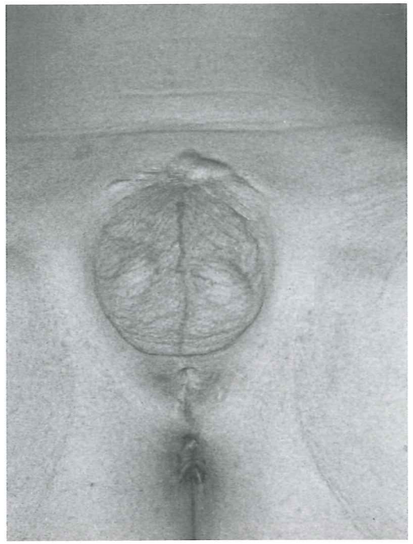


Figure 58–9
This 8-year-old lost his penis in a circumcision accident.

The second category of pediatric patients requiring phalloplasty includes those who have sustained trauma. Most often these are boys who have had circumcision accidents, injuries by machinery, or animal bites. Because these patients are already established in the male gender, gender reassignment surgery is not an option and total phallic reconstruction should therefore be planned, beginning as young as 6 to 8 years of age.

The technical approach to pediatric patients requiring phallic reconstruction is much the same as in adults. In a child, special consideration must be given to sizing of the neophallus. Whether a neophallus constructed from somatic tissue will grow as the child matures through puberty and adulthood remains unknown. The neophallus certainly will not experience exponential growth as a normal penis does when exposed to testosterone at the time of puberty, because somatic tissue lacks androgen receptors. Somatic tissues do grow on a linear scale, however, and we have noted significant growth of the neophallus in six prepubertal phalloplasties with follow-up as long as 6 years. Our current strategy when creating a neophallus in an 8-year-old child is to construct the penis larger than normal for current age but not as large as an adult penis, anticipating some subsequent growth of the organ (Figs. 58–9 and 58–10).

SEXUAL FUNCTION OF THE NEOPHALLUS

The goals of modern phalloplasty are to provide

1. A reproducible procedure that can be performed in one stage



Figure 58–10
Six-month postoperative prepubertal phalloplasty.

2. Tactile and erogenous sensation for the neophallus
3. A cosmetically acceptable neophallus
4. A competent urethra that allows for micturition while standing
5. Adequate rigidity of the neophallus to allow for sexual intercourse

Modern phalloplasty techniques have arrived at reasonable accommodation of the first four goals. However, the issue of sexual function in the neophallus remains problematic. In most cases, the reconstructed penis remains soft and is unfortunately not rigid enough to insert in the vagina unless a stiffener is used. Enough scar tissue occasionally is present on the neophallus so that with adequate lubrication and by using several condoms, intercourse can be accomplished. We have designed a soft plastic external splint that patients wear, and this can allow for intromission. The use of a penile prosthesis has frequently been associated with complications and should be considered only in highly motivated patients. Insertion of a penile prosthesis should never be attempted unless the neophallus is adequately sensate. We use a single inflatable prosthetic cylinder. A polytetrafluoroethylene (Gore-Tex) neotunica sleeve is created. Slits are made in the sleeve to allow for drainage of any serum that may accumulate. The neotunica sleeve is sutured to any corporeal remnants present, or in transsexuals the neotunica is sutured to the periosteum of the symphysis pubis with permanent suture. Residual corporeal elements seem to increase the chance for success with prosthesis implantation. All patients must be counseled about potential long-term complications, including infection or extrusion of the prosthesis, in as many as 50% of cases.[9]

SUMMARY

Loss of the penis is devastating when it occurs at any age. In such circumstances, even young children know that they are not normal and have fears about their future. For an adult, the loss of sexual activity can be catastrophic. During the past 20 years, a great change has taken place in phallic construction from the older techniques of the Gilles and Borgoras tube-in-a-tube pedicle flap through the use of musculocutaneous flaps, through groin flaps and various other flap techniques taken from around the genital area, to the rapid evolution of penile reconstruction from free microvascular tissue transfer. With the use of microvascular flaps and with our addition of approximating the sensory nerve of the flap to the pudendal nerve, a sensate phallus can be reconstructed. The use of tattoo pigment implanted in the distal portion of the penis to simulate the normal color of the glans has been helpful in some cases. The cosmetic appearance of the penis is important to patients and by using the forearm flap, the end results have been quite acceptable. Urethral fistula formation or urethral strictures seem to be the most common complications encountered in phallic reconstruction. In our experience, however, by using the midline urethral reconstruction in the flap and in transsexuals by covering the anastomosis of the neourethra with the rectus abdominis muscle, the incidence of urethral complications has markedly decreased. The donor site on the arm is still a problem from an aesthetic point of view. Most patients readily accept this deformity but should be shown photographs of other patients who have had phalloplasty so that they will know preoperatively about the disfiguring scar that will always be present. The search for a better neophallus continues, but great progress has been made, and at this time a one-stage procedure can be predictably reproduced and can be offered to cooperative patients.

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CHAPTER

59

Radial Forearm Free Flap for Phallic Reconstruction

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LAWRENCE S. ZACHARY

Advances in microneurovascular surgery have allowed reconstructive surgeons to select the most ideal tissue available for penile reconstruction.[1–6] By combining the expertise of reconstructive plastic surgeons and urologists, an aesthetically acceptable and functional phallus can be reliably constructed with minimal morbidity.

The radial forearm free flap was initially selected for penile reconstruction because it is a thin, potentially sensate, minimally hair-bearing flap with enough flexibility that its design can incorporate a vascularized urethra.[1] Since its initial description, several modifications of the radial forearm free flap technique for penile reconstruction have emerged.[7–13]

ANATOMY

The radial forearm neurovascular fasciocutaneous free flap includes the volar forearm skin, its underlying adipose tissue, the sensory medial and lateral antebrachial cutaneous nerves, the basilic and cephalic veins, and part of the deep fascia. All of these are connected to the radial artery and its venae comitantes by a thin intermuscular septum that contains cutaneous perforating vessels. A set of four or five perforating vessels emerges from the proximal and distal thirds of the radial artery. Rarely are significant perforators found in the middle third of the artery (Fig. 59–1).

FLAP DESIGN AND DIMENSIONS

The flap is designed on the nondominant forearm with a centrally located neourethra in continuity with a neoglans. This design avoids a circumferential meatal suture line without sacrificing length and leads to an improved aesthetic result.

The dimensions of the flap depend, to some degree, on the patient's needs and desires, as well as the size of the forearm and amount of subcutaneous tissue present. The width of the flap should vary directly with the amount of subcutaneous tissue present. Although a width of 13 cm was initially described for penile reconstruction, we have found this to be inadequate for tubing the flap and allowing closure without tension.

Additionally, the flap length of 10 cm initially described is generally unsatisfactory for successful intromission. In most cases, our flap dimensions are usually a minimum of 15 × 17 cm. The size of the wrist may limit flap width distally, where it must be tapered to 13 to 14 cm. In situations in which the native urethra ends in the perineum, the neourethra length may be safely increased to 25 cm by designing a proximal extension just above the elbow (Fig. 59–2).

OPERATIVE TECHNIQUE

The nondominant arm is generally chosen as the donor site. A preoperative Allen test should be performed on all patients for whom a radial forearm flap is being considered. Arteriograms are unnecessary.

The patient is placed supine on the operating table, and the arm from which the flap will be harvested is extended on an arm board.

The design of the flap is outlined on the volar aspect of the forearm. The arm should not be shaved. This allows markings for the planned neourethra to be made reliably on the portion of volar forearm with the least amount of hair. At this time, it is helpful to outline the course of the radial artery and major veins. After the extremity is moderately exsanguinated with an Esmarch bandage, a sterile tourniquet is inflated to 250 mm Hg.

Two strips of skin, each 1 cm wide, on either side of the planned centrally positioned neourethra, are deepithelialized from the proximal edge of the flap to within 2.5 to

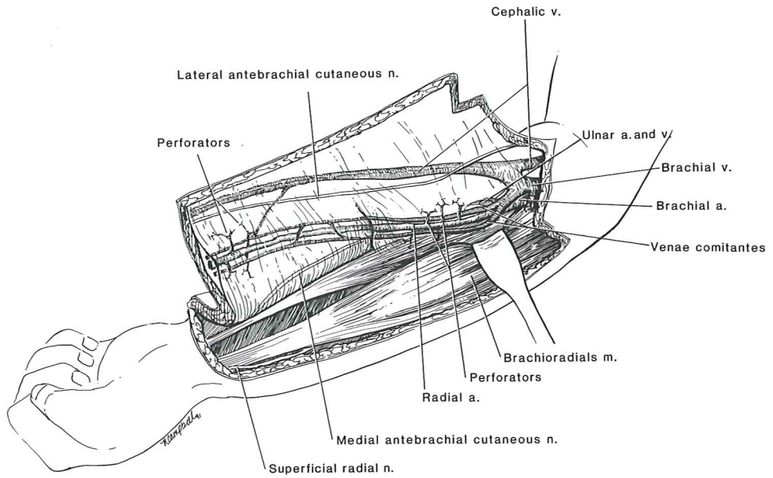


Figure 59–1
Anatomy of a fasciocutaneous radial forearm flap.

3 cm of the distal portion. The deepithelialization should be continued around the proximal end of the planned neourethra. The ulnar side of each of these strips is incised into the subcutaneous layer.

The most distal portion of the flap, which overlies the radial artery, is then incised. The radial artery and its venae comitantes are identified at the wrist and isolated with vessel loops.

An incision is made along the radial border of the flap and carried down through the deep fascia. The dissection then proceeds ulnarly beneath this layer and stops at the thin intermuscular septum, which contains the septocutaneous perforating vessels. The surgeon must be careful to identify and preserve the superficial branch of the radial nerve as it pierces through or beneath the brachioradialis tendon and courses close to the cephalic vein at the wrist.

The proximal incision is made, taking care to identify and preserve the cephalic vein. The medial and lateral antebrachial cutaneous nerves are identified, dissected an additional 3 to 4 cm proximal to the skin paddle, tagged with 7-0 Prolene, and divided.

Next, the ulnar border of the flap is incised and elevated radially beneath the deep fascia. The cutaneous perforating vessels of the ulnar artery should be ligated and divided.

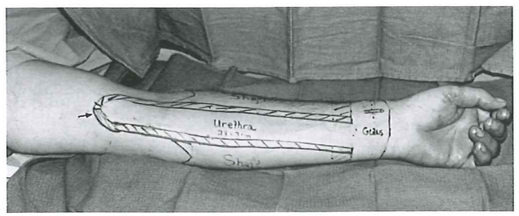


Figure 59–2
Flap design with a proximal neourethral extension. The deepithelialized strip should continue around the proximal end of the planned neourethra (arrow).

This dissection is continued until the ulnar side of the intramuscular septum containing the septocutaneous perforators of the radial artery is encountered.

At this time, the radial artery and its venae comitantes are elevated from their bed from distal to proximal, with careful mobilization of the ulnar edge of the brachioradialis muscle radially. Muscular branches are ligated or coagulated with a bipolar electrocautery. The arterial dissection is continued proximally until the bifurcation of the brachial artery is encountered.

Dissection of the proximal venae comitantes proceeds until the two veins coalesce into one. If this dissection is continued more proximally (this often requires an incision in the antecubital fossa skin overlying the cephalic vein), the venae comitantes, which are now coalesced, join the cephalic vein via the profundus cubitalis vein. This extra dissection makes it possible for one large vein to drain not only the superficial cephalic system but also the venae comitantes (Fig. 59–3).[14]

At this point, full-thickness transverse incisions are made, connecting the distal portion of the centrally placed neourethral skin with the radial and ulnar edges of the flap (Fig. 59–4).

The tourniquet is released, the flap is perfused, and hemostasis is achieved. The flap is now attached by only the radial vascular bundle. Small vascular clamps are applied to the distal radial vascular bundle, and the perfusion of the hand is examined. Only after an adequate ulnar blood supply to the hand has been ensured is the distal radial vascular bundle clamped, ligated, and divided. If, for some reason, the circulation to the hand is deemed inadequate via the ulnar artery, then the vascular clamps are removed. The hand is perfused via the radial artery, and a saphenous vein interposition graft may be harvested to reconstruct the radial artery without prolonged ischemia time in the hand.

The portion of the flap forming the central neourethra is then tubed over a 10 French Silastic urinary catheter by suturing the ulnar neourethral skin edge to the radial

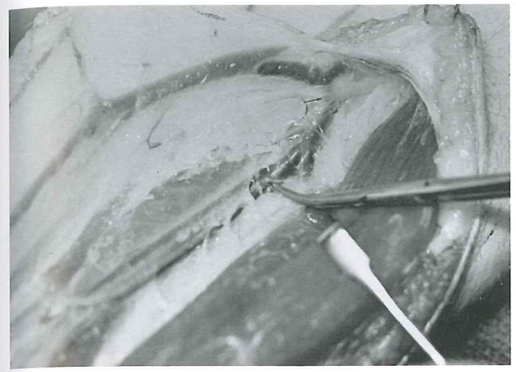


Figure 59–3
Venous anatomy of the flap. Note the coalescence of the venae comitantes (hemostat), which then join the cephalic vein via the profundus cubitalis vein (arrow), crossing above the lateral antebrachial nerve.

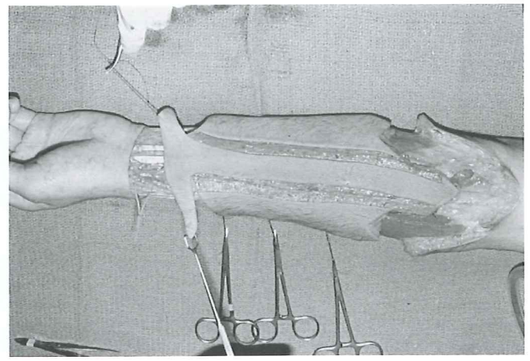


Figure 59–4
Flap elevated. Transverse incisions separate the glans from the shaft. The neourethra is ready to be tubed.

neourethral skin edge in several layers (Fig. 59–5*A* and *B*.) The flap is now turned over, and the dorsal skin closure is performed.

The wings of the neoglans are trimmed to the appropriate shape and rolled back on the shaft. The distal portion of the shaft that will be under the rolled-back neoglans is deepithelialized (Fig. 59–6*A* and *B*). The neoglans is then secured in its rolled-back position with full-thickness nylon mattress sutures. The constructed neophallus is left on the arm, attached to its proximal vascular pedicle, until the recipient site has been prepared (Fig. 59–7).

RECIPIENT SITE PREPARATION

During flap elevation, a separate team prepares the pubic site and the recipient vessels and nerves. Transsexuals and men with perineal urethrostomies are placed in a low lithotomy position during this portion of the operation. Other patients may be positioned supine in a frog-leg position.

Approximately 20 cm of saphenous vein is harvested from the thigh and is left attached to the femoral vein at the fossa ovalis. The divided end of this saphenous vein graft is then anastomosed to the femoral artery, using microsurgical techniques and loupe magnification, to create a temporary loop arteriovenous fistula. This is allowed to flow until the flap is ready for transfer.

If no penile remnant is present, an incision is made over the pubic symphysis. If a portion of the native phallus or clitoris exists, a degloving incision is designed. The dorsal penile (or clitoral in transsexuals) branches of the pudendal nerve should be isolated. If no nerves are apparent, dissection is continued toward the perineum, and the pudendal nerves are identified as they emerge from the Alcock canal and travel along the inferior ramus of the pubis.

The incision used for the saphenous vein harvest is usually connected to the flap recipient bed incision to avoid compression, torquing, or kinking of the vein grafts.

The fully constructed neophallus is detached from the arm, transferred to the pubic area, and secured in place with tacking sutures.

When a primary urethral anastomosis is possible, an end-to-end two-layer spatulated anastomosis with 4-0 absorbable sutures is performed after the urinary catheter

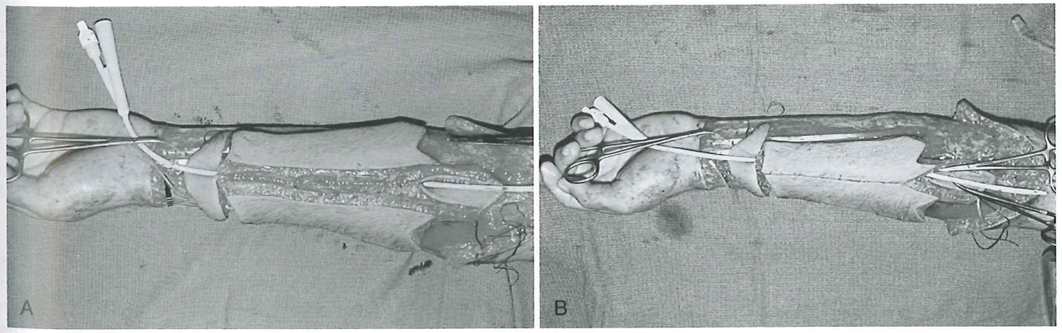


Figure 59–5
A and *B*: Multiple-layer closure of the neourethral tube.

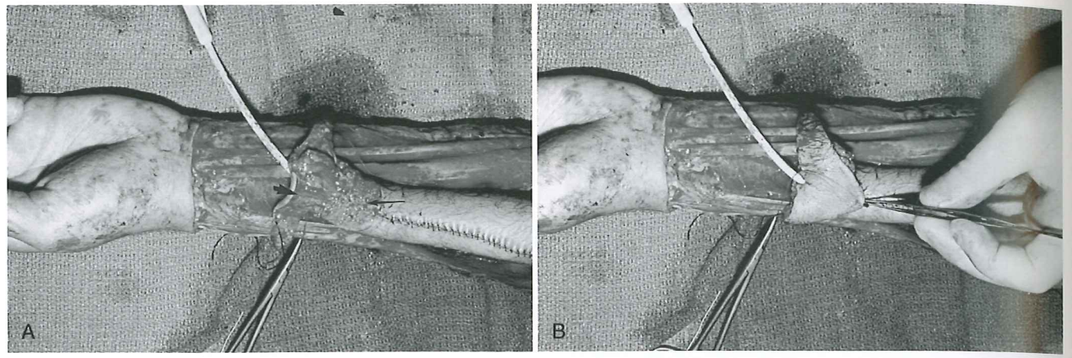


Figure 59–6
Construction of the neoglans. *A*: The arrowhead is on the unfolded extension of the flap ("wings") that will form the neoglans. The distal shaft is deepithelialized (small arrow). *B*: Wings that will form the neoglans are folded back over the shaft.

within the flap is passed through the native urethra into the bladder. The sutures should not traverse the lumen to reduce the possibility of fistula formation.

The saphenous vein loop is divided, and the cephalic vein is anastomosed end to end to the venous limb of the saphenous loop with 8-0 nylon under the operating microscope. This is followed by end-to-end anastomosis of the radial artery to the arterial limb of the saphenous loop with 8-0 nylon.

Epineural microneurorrhaphies between the paired pudendal nerves and the medial and lateral antebrachial cutaneous nerves are performed with 9-0 nylon (Fig. 59–8).

The remaining wounds about the proximal shaft of the neophallus and femoral vessels are now closed (Fig. 59–9). A percutaneous suprapubic catheter is placed to ensure adequate urine drainage away from the healing neourethra. The postoperative dressing incorporates a large Styrofoam coffee cup to keep the neophallus supported in the early postoperative period.

DONOR SITE

The ulnar artery is usually the dominant vessel supplying the palmar arch. The absence of postoperative vascular compromise or cold intolerance has made vascular reconstruction of the radial artery unnecessary in most cases. The forearm muscles in the bed of the flap donor site are approximated together and over any exposed tendons with absorbable sutures to minimize contour irregularities. A thick split-thickness skin graft, harvested from the hip or thigh, is then applied to this muscular bed. A long arm splint is used to immobilize the elbow, wrist, and fingers.

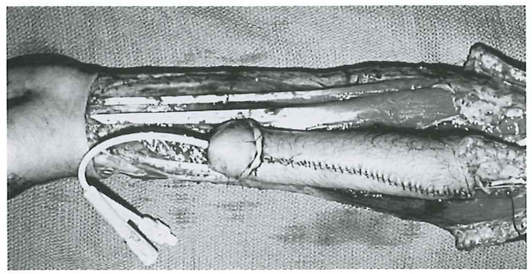


Figure 59–7
Constructed neophallus, attached to the arm by a vascular pedicle.

POSTOPERATIVE CARE

Perioperative antibiotics and low-dose aspirin are administered in all cases. Intravenous antibiotics are discontinued on the second postoperative day, and suppressive oral antibiotic coverage is begun and continued until the urethral and suprapubic catheters are removed. Low-dose aspirin is continued indefinitely.

Flap viability is assessed by clinical examination (i.e., skin color, turgor, and capillary refill), and the pulse is checked hourly by palpation or with a bedside Doppler probe.

Sequential pneumatic lower extremity compression boots are used in the first few postoperative days when the patient is confined to bed. These should probably not be used during the time the patient is in the lithotomy position intraoperatively (for fear of lower extremity compartment syndrome). Physical therapy for the donor upper extremity begins once the initial dressings are removed on the 7th to 10th postoperative day. Xeroform is applied to the graft, and an elastic wrap is applied to the hand and forearm. A compressive garment and wrist splint are then fashioned. The splint is worn an additional 2 weeks, and the garment is worn for 6 to 12 months.

Urine is preferentially drained via a suprapubic catheter, allowing the urethral catheter to be capped. This reduces tension on the neophallus and meatus. In the third to fourth postoperative week, a retrograde urethrogram can be performed by inserting a small catheter alongside the indwelling urethral catheter. The urethral catheter may be removed if there is no evidence of extravasation or fistula.

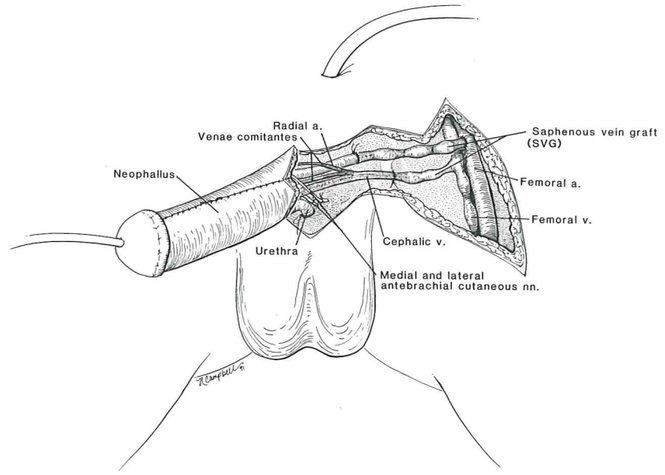


Figure 59–8
Schematic representation of the urethral and neurovascular connections.

The suprapubic tube may be removed 1 to 2 days after normal micturition is established.

CLINICAL RESULTS

The neophallus is insensate for the first month postoperatively; therefore, careful positioning of both the neophallus and urinary catheter is necessary to avoid inadvertent pressure injury. Most patients have recovered gross tactile sensation at 4 to 6 months. By 6 to 9 months, they are usually able to stimulate the shaft of the neophallus to orgasm and have biothesiometry threshold measurements three to four times that of their index fingers. It is safe to consider insertion of a penile prosthesis only after protective sensation develops.[15] Sexually active patients describe erogenous sensation leading to orgasm.

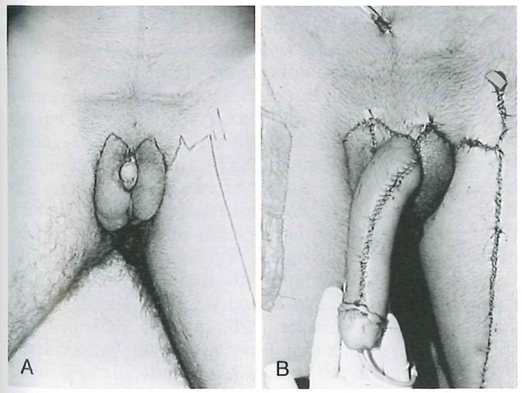


Figure 59–9
A: 18-year-old genetic male with microphallus and ambiguous genitalia. *B*: Neophallus at completion of the operation.

The modified radial forearm flap design has eliminated the otherwise frequent complication of meatal stenosis. Urethral stone formation has not been a problem in our patients. Complications with the proximal urethral anastomosis, including sinuses, fistulas, and strictures, are relatively uncommon. Most fistulas close spontaneously. Proximal anastomotic suture line strictures may be treated with internal urethrotomy. In our experience, one or two neodymium:yttrium-aluminum-garnet laser or cold knife urethrotomies, followed by a short period of self-catheterization, have resulted in a stabilized, widely patent urethra. All of our patients were ultimately able to stand to void.

Maintaining a good coronal ridge is difficult. The suturing technique described in Figure 59–5 has led to variable long-term results. Adding a strip of tendon or dermis does not appear to help much. We have been securing the rolled-back portion of the neoglans loosely with sutures and skin grafting the exposed subcutaneous tissue.

The greatest drawback of the radial forearm flap is the unsightly donor site. The thicker the graft used to close it, the better the aesthetics. Functional disability of the donor extremity has been rare, although one of our patients had a radial nerve palsy that resolved and one patient had postoperative carpal tunnel syndrome that required release. Considering the high quality of penile construction possible with the radial forearm flap, the resultant donor site scar is usually well tolerated by patients.

SUMMARY

The radial forearm flap as part of a cooperative effort among the reconstructive plastic surgeon, urologist, and psychologist allows reconstruction of a neophallus that is aesthetically and psychologically satisfying. This technique allows patients to void in a standing position through a distal meatus. It provides a neophallus that has protective and erogenous sensation and is of appropriate size and shape to allow for placement of a penile prosthesis and permit successful coitus.

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CHAPTER

60

Ulnar Forearm Free Flap for Phallic Construction in Transsexuals

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Phallic construction should (1) be a microsurgical procedure that can be reliably reproduced, (2) preserve both tactile and erogenous sensibility, (3) be created with a competent neourethra that allows voiding while standing, (4) have enough bulk to tolerate the insertion of a prosthetic stiffener, (5) be aesthetically acceptable to patients and their partners, and (6) be associated with acceptable donor site morbidity.

During the past 10 years, we have had a continuing interest in phallic construction. We have developed our own phallic designs and have adopted ideas from others. This experience has modified our phallic goals in transgendered patients by breaking down the phallic construction into three operations extended over an 18-month interval.

The microsurgical free forearm flap has become the mainstay of modern phallic construction. Several flap designs have been devised to allow phallic construction from a single, anatomically predictable forearm donor site.[1, 2] Biemer described a modification of the radial forearm flap design in which the neourethra was centered over the radial artery but the phallic shaft was separated into two periurethral swatches.[3] The proximity of the neourethra to the center of the vascular territory had two implications. First, any urethral breakdown due to ischemia was minimized as a result of the urethral location adjacent to the blood supply. Second, the design allowed the neourethra to be extended proximally and distally along the shaft length, thus achieving a tension-free proximal anastomosis. Unfortunately, centering the urethra over the radial pedicle placed it on the hairiest portion of the forearm, and final closure of the skin island around the neourethra resulted in two external suture lines.

Microsurgical forearm phallic constructions have classically been adapted from the radial forearm flap; however, the flap may also be based on the ulnar artery. The caliber and length of the ulnar artery are superior to those of the radial artery. Experience with the ulnar forearm flap was first described by Lovie and colleagues, who favored the flap for intraoral reconstruction because of the relatively hairless and thin quality of the forearm tissues.[4] We believe these qualities are also advantageous for phallic construction, providing a thin, malleable, relatively hairless, sensate flap that can be sculpted to patients' needs.[5] Hair growth inside the neourethra is unsightly, but more importantly, excess hair possibly promotes bacterial colonization and calculus formation.

All of the flap designs described earlier have two sensory nerves—the lateral and medial antebrachial nerves—that can be elevated to provide innervation for the flap. The lateral antebrachial cutaneous nerve is the sensory continuation of the musculocutaneous nerve located just medial to the cephalic vein. It is the largest forearm sensory nerve and usually does not arborize until it reaches the proximal forearm. The medial antebrachial cutaneous nerve originates directly from the medial cord of the brachial plexus and arborizes in the upper arm proximal to the antebrachial fascia. The branches of this nerve are usually found adjacent to the basilic vein in the forearm.

After reviewing our initial complications, we instituted certain changes in our transsexual procedure.[6] Before a definitive phalloplasty, we carry out a vaginectomy, colpocleisis, and urethral lengthening to prepare for a phalloplasty and incorporated urethroplasty (Fig. 60–1). The vaginectomy is actually a vaginal mucosectomy with preservation of the levator muscles, perineal body, and perineal floor, followed by a colpocleisis (closure of the vaginal cavity). The vaginal mucosa is circumscribed from the introitus circumferentially. An anterior vaginal wall flap based on the parameatal tissues and consisting of vaginal mucosa and subcutaneous tissues extending down to the

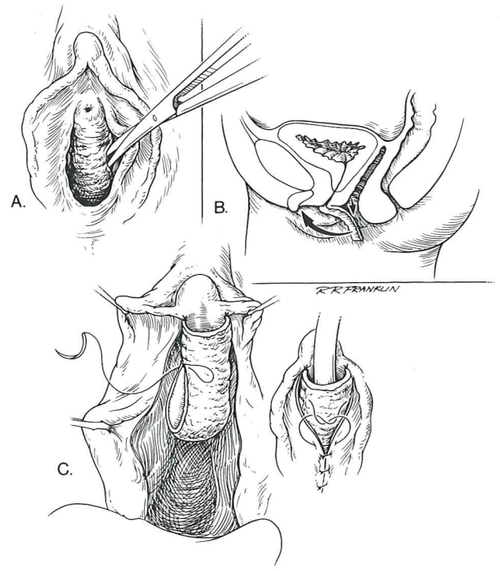


Figure 60–1
The first stage of definitive genital transformation in a female-to-male transgendered patient is a total vaginectomy (colpocleisis) with urethral lengthening. When possible, this surgery may be combined with a hysterectomy and bilateral salpingo-oophorectomy. The purpose of this operation is to advance the short female urethra, thereby preparing for the neourethral anastomosis, and to reduce the risk of surgical contamination by removing the vagina before a definitive phalloplasty. (From Gilbert DA, Schlossberg SM, Jordan GH: Ulnar forearm phallic construction and penile reconstruction. Microsurgery 16:314, 1995.)

urethra and posterior wall of the bladder and measuring about 3 × 5 cm is elevated and preserved on its base (Fig. 60–1*A*). The rest of the vaginal mucosa is elevated up to and including the cervix. When necessary, the cervix, uterus, and ovaries are also removed.

The anterior vaginal wall flap is then rotated 270 degrees until it abuts the introitus (Fig. 60–1*B*). Two parallel incisions are then extended from the meatus out to the base of the clitoris. The flap is then sutured bilaterally into its new advanced position, thereby creating a pseudobulbar portion of the neourethra (Fig. 60–1*C*).

After vaginectomy and colpocleisis, the vaginal cavity is closed front to back and extended from the cervix distal to the introitus (Fig. 60–1*C*). Using a two-stage procedure to elongate the urethra at the time of vaginectomy has allowed us to achieve a significant decrease in our fistula complication rate ($P = .0087$).

OPERATIVE TECHNIQUE

All prospective patients undergo a standard preoperative assessment that includes an Allen test to evaluate and confirm two-vessel patency in the upper extremity. If we have any doubt about the vascular integrity of the forearm vessels, the patient undergoes preoperative upper extremity angiography, venography, or other vascular studies such as a duplex Doppler study. The quality of subcutaneous fat is also assessed in the forearm of each patient. In those patients with thicker subcutaneous fat, phallic shaft coverage is achieved by dissecting the forearm fascia without the overlying skin and subcutaneous tissues and covering the shaft with a split-thickness skin graft. The aesthetic results are amazingly good.

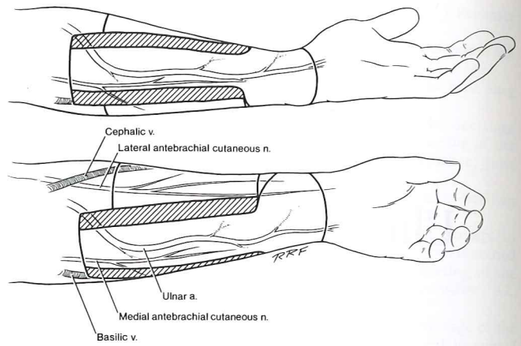


Figure 60–2
The ulnar forearm microsurgical flap is located with the neourethra centered over the ulnar neurovascular bundle. (From Gilbert DA, Schlossberg SM, Jordan GH: Ulnar forearm phallic construction and penile reconstruction. Microsurgery 16:314, 1995.)

Our present design incorporates the original Biemer triple skin design and includes a fourth distal island neoglans (Fig. 60–2). This island, a distal continuation of the neourethral island, is rotated proximally over the deepithelialized distal shaft skin to create a pseudoglans and a palpable step-off at the coronal sulcus. The urethra is at least 12 cm long and 3.5 cm wide, with a neoglans continuation of 6 × 4 cm. Each deepithelialized strip is 12 × 1.5 cm; each lateral swatch is 12 × 6 cm.

Deepithelialization is completed on the urethral borders between the urethral and the lateral skin flaps and over the distal skin flaps adjacent to the neoglans (Fig. 60–3). In our laboratory dissections and clinical cases, we have found that the forearm fascia can be dissected into two layers. The thicker, deep antebrachial fascia is left intact on the forearm musculature while a thinner, superficial layer is elevated within the flap. Over the vascular pedicle, the plane of dissection is directed through the deep investing muscle fascia to incorporate the ulnar artery and its venous branches. The dorsal sensory branches of the ulnar nerve are also preserved. Within the distal forearm, two predictable vascular pedicles from the ulnar artery to the flap are identified. The largest one is usually found at the midforearm level, where the ulnar artery lies deep between the flexor digitorum superficialis and the flexor carpi ulnaris. The second perforator is located distally between the proximal perforator and the wrist (Fig. 60–4).

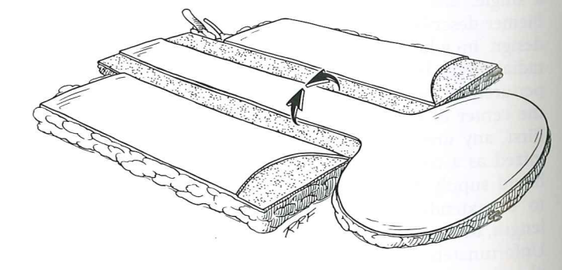


Figure 60–3
The paraurethral deepithelialized strips are designed wide enough to close the urethra and the overlying skin without tension. The distal tips of each hemishaft "swatch" are deepithelialized to maintain subcoronal bulk. (From Gilbert DA, Schlossberg SM, Jordan GH: Ulnar forearm phallic construction and penile reconstruction. Microsurgery 16:314, 1995.)

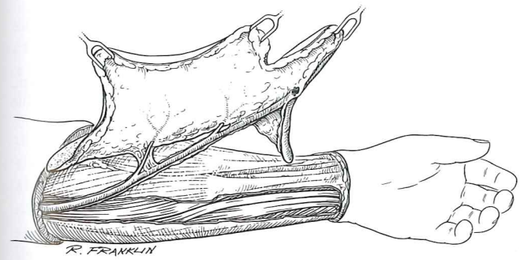


Figure 60–4
The ulnar forearm flap is a fasciocutaneous flap that is nourished by two distal perforators. (From Gilbert DA, Schlossberg SM, Jordan GH: Ulnar forearm phallic construction and penile reconstruction. Microsurgery 16:314, 1995.)

Numerous veins are often encountered at the proximal forearm, but we have favored the basilic and cephalic and the accessory veins for anastomosis.

Depending on the flap design, we try to preserve one of the major superficial veins on the forearm. Although the flap donor site has transient postoperative swelling, we have not observed any chronic postoperative edema, permanent ulnar nerve injury,[7] or reflex sympathetic dystrophy as has been described by others. We have not harvested or incorporated a portion of the radius bone (which we believe is irrelevant for phallic stiffness) into our reconstructions. We also do not believe in preoperative tissue expansion of the forearm at the donor site before the definitive phallic construction.

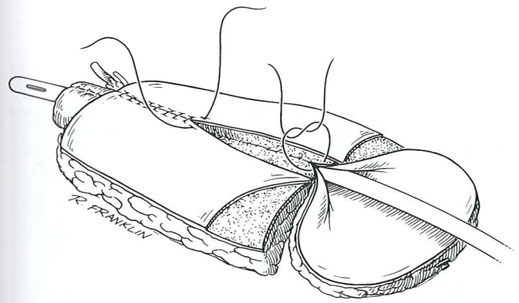


Figure 60–5
The neourethra is folded into a watertight tube with a two-layered closure. The skin and subcutaneous tissues are also closed on the ventral side. (From Gilbert DA, Schlossberg SM, Jordan GH: Ulnar forearm phallic construction and penile reconstruction. Microsurgery 16:314, 1995.)

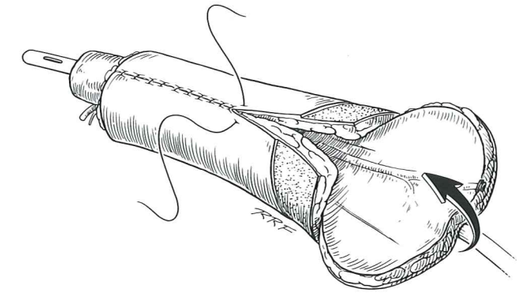


Figure 60–6
When the ventral side is closed, the dorsal side is exposed and closed in two layers. The distal neoglans is then rotated proximally over the distal deepithelialized shaft and loosely approximated. (From Gilbert DA, Schlossberg SM, Jordan GH: Ulnar forearm phallic construction and penile reconstruction. Microsurgery 16:314, 1995.)

Lateral and medial antebrachial nerves are dissected in the forearm, usually close to the cephalic and basilic veins, respectively.

Construction of the neophallus is begun while the flap is still perfusing on the forearm. The neourethra is tubed with a two-layer closure, usually with an absorbable locked suture to achieve a watertight seal (Fig. 60–5). The phallic shaft is crafted by suturing the lateral flaps to each other in a clamshell fashion (Fig. 60–6). Finally, the neoglans is formed by rotating the distal glans paddle proximally over the deepithelialized shaft to create an appropriate cone-shaped neoglans configuration (Fig. 60–7).

Before microsurgical transfer, the length and diameter of the donor and recipient vessels are estimated. The recipient inferior epigastric artery is anastomosed to the donor ulnar artery. If the epigastric artery is absent, an arteriovenous fistula is created by anastomosing a saphenous vein interposition graft between the femoral artery to an adjacent

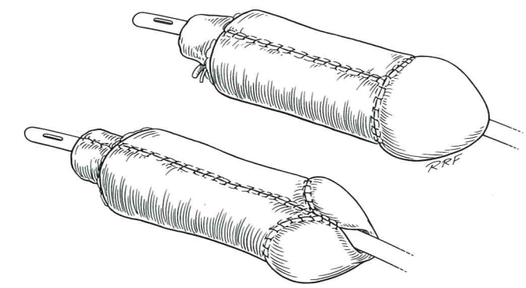


Figure 60–7
The neoglans is inset into the distal ventral shaft. (From Gilbert DA, Schlossberg SM,Jordan GH: Ulnar forearm phallic construction and penile reconstruction. Microsurgery 16:314, 1995.)

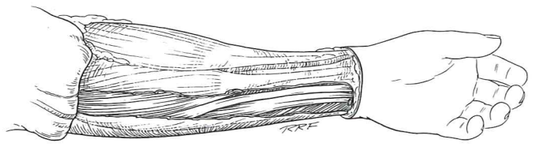


Figure 60–8
Care is taken to leave the premuscular forearm fascia on the forearm. (From Gilbert DA, Schlossberg SM, Jordan GH: Ulnar forearm phallic construction and penile reconstruction. Microsurgery 16:314, 1995.)

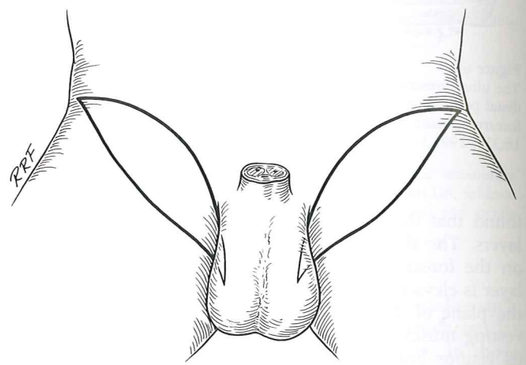


Figure 60–9
Where possible, full-thickness skin grafts are harvested from the groins and applied to the forearm donor site. (From Gilbert DA, Schlossberg SM, Jordan GH: Ulnar forearm phallic construction and penile reconstruction. Microsurgery 16:314, 1995.)



Figure 60–10
Case 1: Before definitive phalloplasty, a patient has been shaved and proposed full-thickness skin grafts to the donor forearm have been marked out. This patient has undergone the first stage of genital transformation. The urethra has been advanced to the base of the clitoris and the vagina removed.



Figure 60–11
Case 1: The proposed ulnar artery-based phalloplasty has been marked out on the left, nondominant, forearm.

saphenous vein loop. This fistula is cut in half, thereby creating a saphenous vein interposition graft that serves as a conduit between the recipient femoral and donor ulnar arteries and provides venous egress.

A urethral anastomosis is completed between the neourethra and native urethra. When possible, this anastomosis is completed with a two-layer closure of long-term absorbable sutures. In transgendered patients, the gracilis muscle is elevated and rotated over the urethral anastomosis for added vascularity at the anastomotic site. The gracilis muscle also provides bulk to the scrotum and, where necessary, is skin grafted to mimic a neoscrotum.

The nerve coaptations are then completed between the donor lateral and medial antebrachial nerves and the recipient genital (clitoral) nerves. As a rule and when possible, we dissect, elevate, and coapt two recipient nerves to complete as much innervation to the flap as possible. To our knowledge, no evidence shows that it is important to preserve one of the dorsal clitoral nerves to the clitoris. In fact, because we amputate the clitoral glans, preservation of the nerves is redundant. It appears that the clitoral body that is retained is well innervated by more proximal branches of the pudendal nerve. Our success rate in achieving erogenous sensibility is 98%. We have little doubt that coaptation of the genital nerves to the donor flap nerves is optimum. When distal branches of the pudendal nerve cannot be located, dissection is carried out to identify the pudendal nerve more proximally at the exit from the Alcock canal. Alternatively, a nonerogenous recipient nerve can be used, but these nonerogenous nerves do not produce the quality of sensation that the genital nerves produce. We have used the ilioinguinal, genitofemoral, saphenous, hypogastric, and gracilis nerves to achieve phallic sensation.

The final step is to cover the forearm flap donor site with a split-thickness skin graft. Advancement of the surrounding skin interface is carried out to diminish the size of the donor site. A thick 0.0021-inch to 0.0025-inch split-thickness skin graft is harvested from the thigh and applied to the forearm. By preserving the forearm antebrachial fascia, we find that the donor site is smooth and bloodless and readily accepts the skin graft (Fig. 60–8). More recently, we have used full-thickness skin grafts harvested bilaterally from the groin to cover the donor site (Fig. 60–9). A nonadherent dressing and a custom splint are then placed on the forearm.

Figures 60–10 to 60–22 show cases of successful phallic constructions.

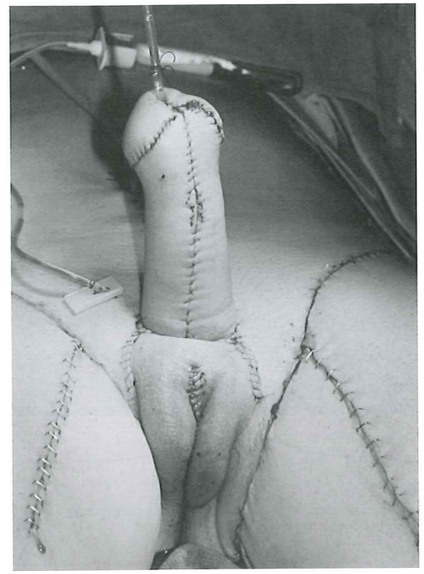


Figure 60–13
Case 1: At the end of the procedure, the forearm flap has been successfully microsurgically transferred to the perineum. Note the direct closure of all donor incisions.



Figure 60–12
Case 1: The flap has been dissected and elevated off of the left forearm, preserving the integrity of the deep forearm fascia.

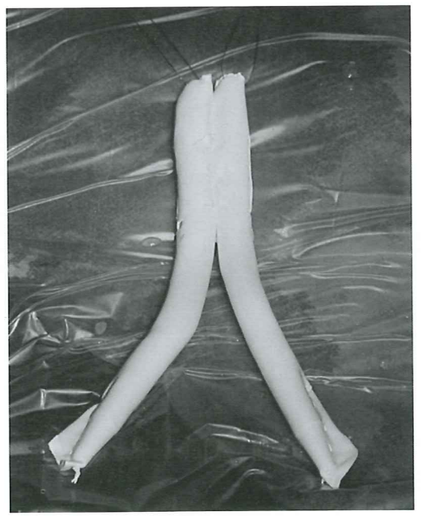


Figure 60–14
Case 1: One year later, the patient underwent insertion of penile prostheses that were covered with Gore-Tex sleeves.

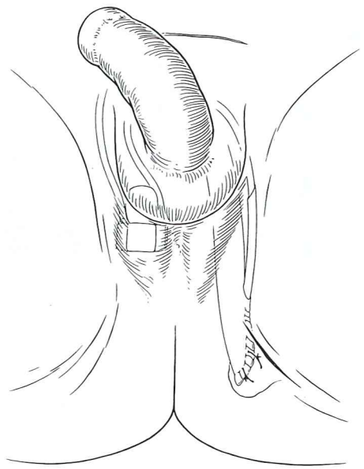


Figure 60–15
Case 1: Fixation of the Gore-Tex sleeves to the periosteum of the inferior pubic rami.

DISCUSSION

The presence of a vascularized urinary conduit surrounded by erectile tissues and the capacity to appreciate erogenous sensibility make the penis a unique component of the male anatomy. To date, a completely successful phallic construction remains elusive and can be achieved only when all goals of phallic construction are met.

The ulnar forearm flap has advanced phallic construction. This flap allows the neourethra to be constructed directly over the vascular supply while taking advantage



Figure 60–16
Case 1: The final result.

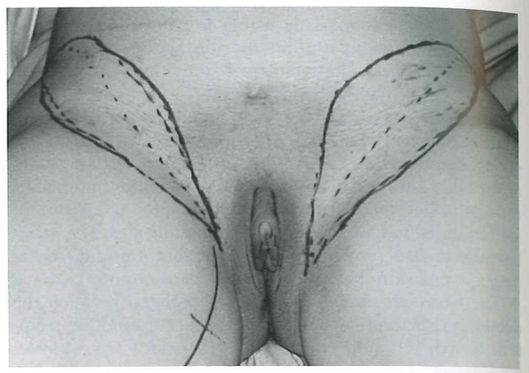


Figure 60–17
Case 2: Before definitive phalloplasty, this patient has undergone vaginectomy, colpocleisis, and urethral lengthening. Proposed full-thickness skin graft donor sites have been marked out over both sides of the groin.

of the relatively hairless skin on the ulnar forearm. The ulnar artery is also somewhat longer and wider in diameter than the radial artery.

A secondary goal has been to limit the forearm donor site morbidity. Some researchers have advocated preoperative tissue expansion; we do not believe that this is useful. Tissue expansion adds an additional procedure that requires intensive follow-up and carries a significant risk of complications. Furthermore, the capsule resulting from expansion may add unwanted bulk to the reconstruction. Preservation of the forearm antebrachial fascia and meticulous harvesting of the skin graft improve the donor site contour and the appearance without the need for additional surgery. The use of full-thickness skin grafts harvested bilaterally from the groin have initially improved the forearm scars and forearm function. Postoperative morbidity is decreased, and early patient ambulation results from a closed rather than open, painful donor site.

Most discussions of the radial forearm flap have described the need for harvesting the flap deep to the antebrachial fascia. We have not found this to be essential, in accordance with a discussion with Dr. Han Kai. During intraoperative and cadaver dissections, we have been able

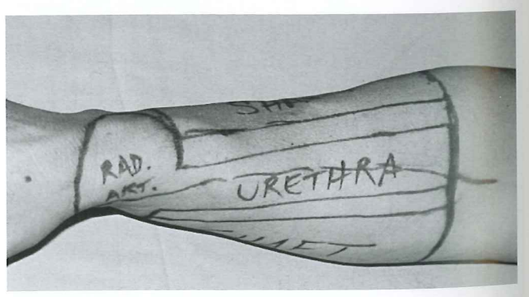


Figure 60–18
Case 2: The right, nondominant, forearm has been marked out with a phallic template following the location of the ulnar artery.



Figure 60–19
Case 2: The right gracilis muscle has been dissected, elevated, and transferred to the perineum to provide neovascularization to the urethral anastomosis and bulk to the scrotum.

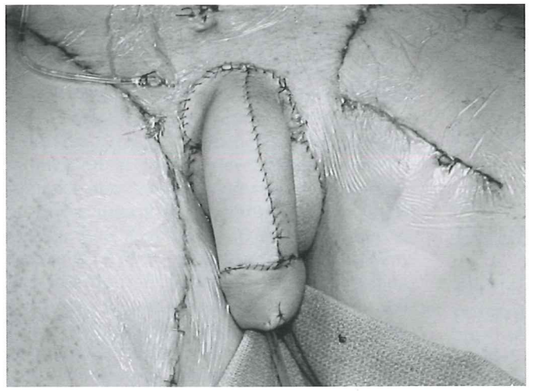


Figure 60–20
Case 2: The completed phalloplasty.

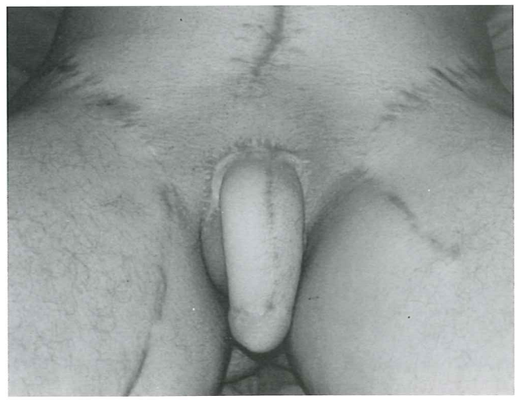


Figure 60–21
Case 2: One year later, the phalloplasty and surrounding scars have healed well.

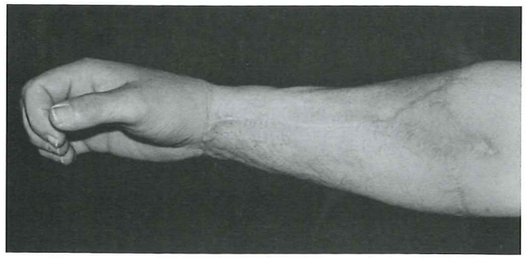


Figure 60–22
Case 2: The right forearm donor site has healed well with full-thickness skin grafts.

to divide the forearm fascia into two separate layers. In raising the flap, one can leave a thick layer of fascia on the forearm and retain a thin, filmy layer with the flap. The deep-layer fascia left on the forearm donor site maintains an added vascular layer over the dorsal ulnar nerve, the superficial radial nerve, and the distal median nerve. It also keeps the forearm muscles in their closely grouped configuration, thereby improving the final condition of the healed skin graft donor site.

During our surgical cases and with cadaver dissections, we have identified two major perforators ending in the flap through the intermuscular septum. The most proximal perforator is located where the ulnar artery becomes superficial after its deep central course from the brachial artery. The other predictable perforator is identified between this proximal one and the wrist. Thus, these two major perforators divide the forearm into thirds and contribute vascularization to the superficial plexus. They give off muscular and occasional fascial branches, but their main pathway is to the subcutaneous tissues. It is our impression that the two perforators are the chief blood supply to the ulnar base flap and supply the flap independently of the deep fascia.

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CHAPTER

61

Forearm Free Flap for Pediatric Phallic Reconstruction

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GERALD H. JORDAN
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BOYD H. WINSLOW

During the past 15 years, we have performed microsurgical phallic reconstructions on 8 prepubertal and 16 adolescent boys. Indications for surgery included posttraumatic amputation, circumcision accidents, developmental anomalies, and micropenis. Total phallic reconstruction consisted of a one-stage microsurgical tissue transfer that included urethral reconstruction, coaptation of erogenous nerves, aesthetic refinements, scrotal reconstruction, and in some cases secondary insertion of phallic prostheses. All prepubertal patients recovered erogenous sensibility and the ability to masturbate with the reconstructed phallus. Surgical indications, techniques, and results are discussed.

Although total autogenous reconstruction of the adult penis has been reported since the late 1930s, little has been written about phallic reconstruction in boys. Phallic reconstruction evolved from historical multistage procedures that were fraught with urethral complications, poor phallic sensibility, and questionable aesthetic value. Although the evolution of arterialized, myocutaneous, and muscle flaps decreased the number of reconstructive stages, these techniques still produced insensate phalluses that were prone to atrophy. The advent of microsurgical tissue transfer techniques provided a means to complete most of the phallic reconstruction in one stage with fewer complications and more predictable results. Our reconstructive team includes plastic surgeons, urologists, and in some cases vascular surgeons. The goals we attempt to achieve for phallic reconstruction in preadolescent and adolescent boys are as follows: to develop a procedure that can be duplicated by others, to produce a phallus with acceptable aesthetic value, to preserve tactile and erogenous sensibility, to provide enough length so that somatic growth would allow the penis to reach adult size at the appropriate time, and to construct a neourethra that permits voiding while standing. Two other goals are to provide enough bulk to allow for the insertion of a prosthetic stiffener and to create an aesthetically acceptable donor site. These two goals usually mandate secondary surgical procedures, and therefore phallic reconstruction cannot be completed in one stage.

INDICATIONS

The surgical indications for phallic reconstruction in the pediatric population have been expanded since our experience began 15 years ago. The indications were initially limited to posttrauma victims who required phallic reconstruction to retain their male anatomy (Figs. 61–1 to 61–

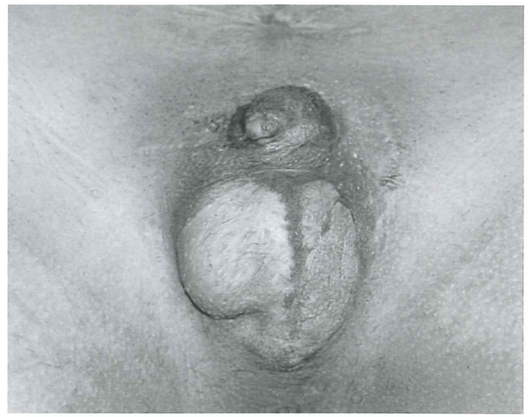


Figure 61–1
Case 1: An 18-year-old youth suffered amputation of his penis in a motor vehicle accident 14 years earlier.

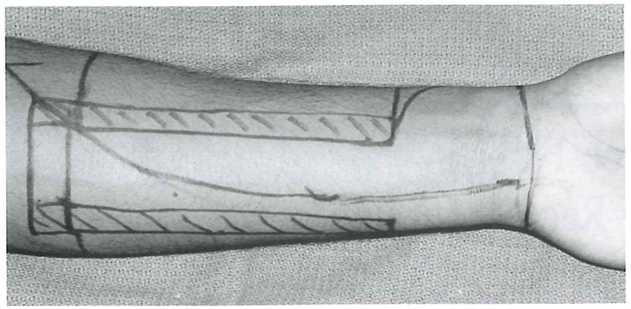


Figure 61–2
Case 1: A proposed ulnar forearm free flap phalloplasty has been marked out on the left, nondominant arm.

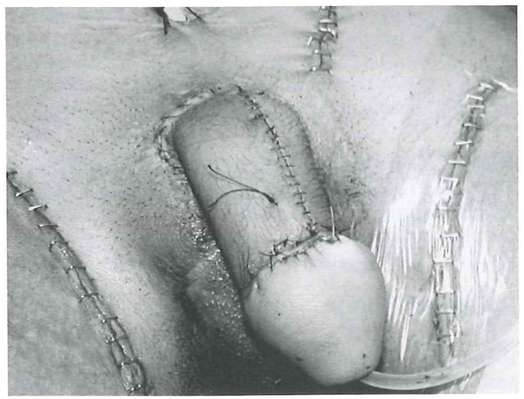


Figure 61–3
Case 1: The flap was dissected, elevated, and transferred to the perineum, where it was revascularized.



Figure 61–4
Case 1: One year postoperatively, the phallus has maintained its bulk and shape.

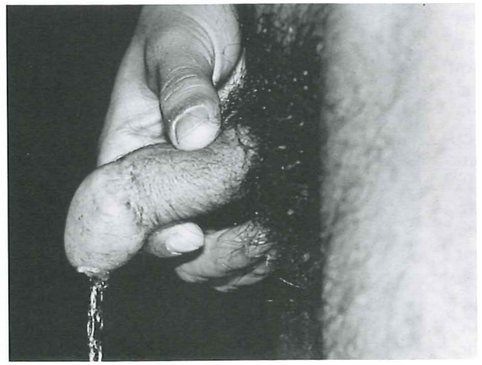


Figure 61–5
Case 1: The patient is able to stand up to void.

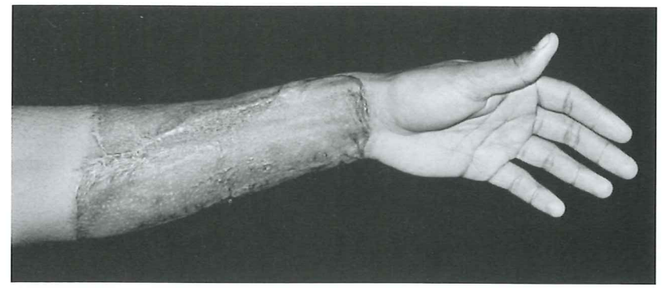


Figure 61–6
Case 1: The donor site has healed well. The hyperpigmentation of the graft site is a common sequela with split-thickness skin grafts.

6). All of these patients retained the rest of their external genitalia and therefore required phalloplasty to meet their goal of normal male genital function. Others had lost all of their external genitalia but had already recognized their male gender and were not willing to convert to the female gender.

After our initial success, surgical indications were expanded to include circumcision accidents, penile agenesis, other genital dysmorphias, exstrophy/epispadias cripples (Figs. 61–7 to 61–12), and micropenis (Figs. 61–13 to 61–17). All of these patient groups present reconstructive surgeons with different challenges based on their anatomic inventory. As a rule, posttrauma victims and patients with micropenis present with the most complete anatomy, and reconstruction may therefore be equated to replacing like tissue with like tissue. However, the more severe dysmorphias often present with additional perigenital deformities necessitating extended vascular access, urinary diversion, and nerve repairs.

SURGICAL TECHNIQUE

All patients underwent a phallic reconstruction that consisted of isolation, elevation, and transfer to the perineum of a fasciocutaneous free flap that was revascularized and reneurotized by microsurgical techniques. Early donor sites included the medial knee, medial upper arm, lateral upper arm, and dorsum of the foot. During the past 14 years, the nondominant forearm has been the preferred donor site. The forearm flap is vascularized by either the radial or ulnar artery and their venae comitantes, perfusing the skin and underlying adipose tissue through the subdermal plexus and the antebrachial fascia. The fasciocutaneous flap also contains the cephalic, basilic, and accessory antebrachial veins and the lateral and medial antebrachial cutaneous nerves. The phallic flap is relatively thin and hairless, is well vascularized by either artery, and has effective venous drainage through the superficial veins and the venae comitantes. The antebrachial nerves provide excellent neurotization of the flap. Care is taken to preserve the epitenon over the distal forearm tendons. The donor site is covered with split-thickness or full-thickness grafts harvested from the thigh or groin.

Successful free tissue transfer from the donor site to the perineum requires meticulous handling of the flap using microsurgical magnification, instrumentation, and sutures. In eight early cases, the transferred flap was revascularized by anastomosing the donor artery and veins to the inferior epigastric artery and its venae comitantes. However, the inferior epigastric artery is often absent or rudimentary in congenital defects and after extensive trauma. In these cases, we have revascularized the flap by incorporating a saphenous vein interposition graft as a conduit from the

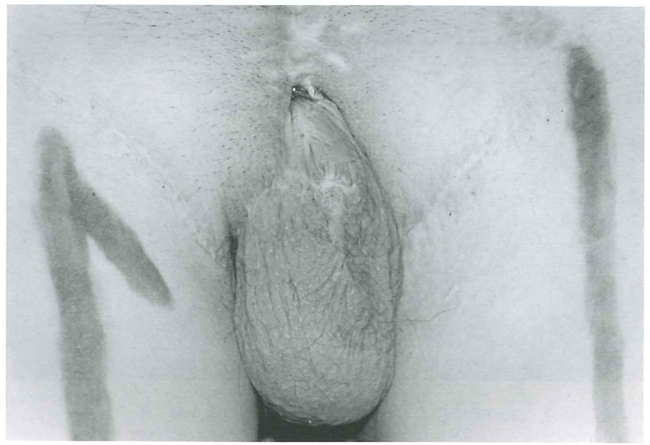


Figure 61–7
Case 2: This 14-year-old boy was born with an exstrophy/epispadias deformity that is reflected by multiple perineal scars, no penile remnant, a short membranous urethra, and a continent diversion (not shown).

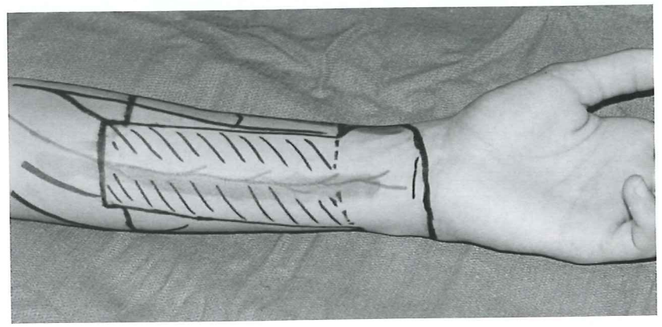


Figure 61–8
Case 2: A preoperative Doppler study confirms the course of the ulnar artery, over which a phallic template has been placed.

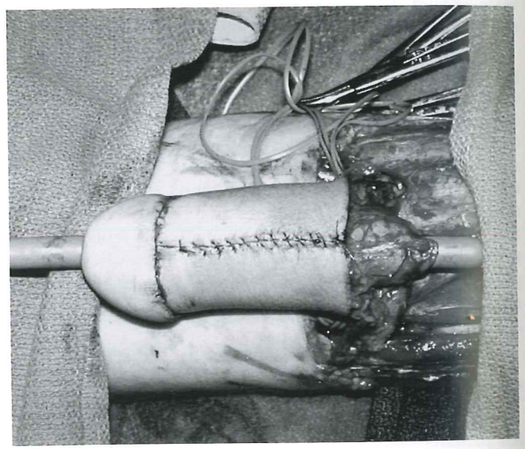


Figure 61–9
Case 2: The phalloplasty has been elevated and molded on the donor forearm before microsurgical transfer.

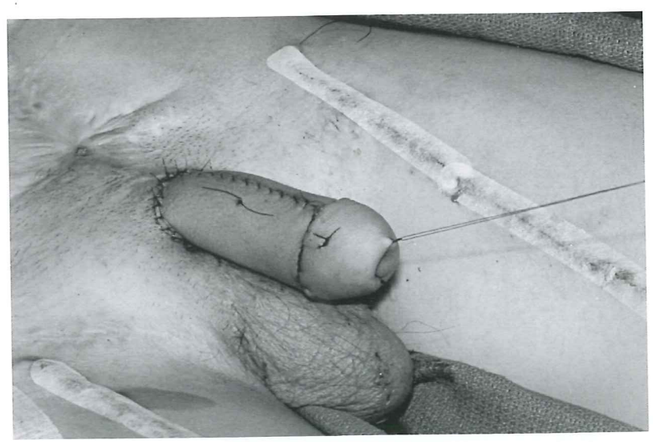


Figure 61–10
Case 2: At the end of the procedure, the phallic transfer is well perfused in its new location. The sutures on the phallus help to locate a Doppler signal.



Figure 61–11
Case 2: Nine months later, the phallus remains in a good position, with some evidence of mild atrophy.

common femoral artery to the donor artery of the flap. The fasciocutaneous flap veins are anastomosed to the saphenous veins bilaterally. When possible, a third venous anastomosis was created between a donor vena comitans and a recipient saphenous vein branch or the deep dorsal vein of the penile stump. Two flap losses were due to anomalous forearm vascular anatomy that eventually did not adequately vascularize the phallic flap. In seven patients, the urethra was reconstructed by incorporating the vascularized portion of the flap as a neourethra. In two patients, a full-thickness skin graft was tubularized to create a neourethra, buried in the gracilis muscle flap, and subsequently wrapped with a free flap to fold the phallus. Two patients did not require urethroplasty; one had an adequate urethra, and one had undergone cystectomy and ileoconduit construction after trauma to the bladder.

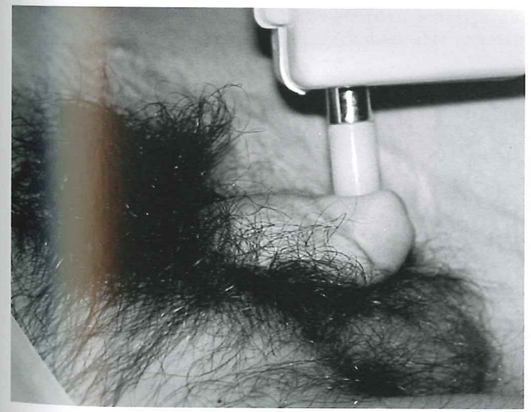


Figure 61–12
Case 2: A bioesthesiometer is the most accurate way to measure penile sensation. When sensation has returned to the phallic tip, the patient may be ready for insertion of a penile prosthesis.

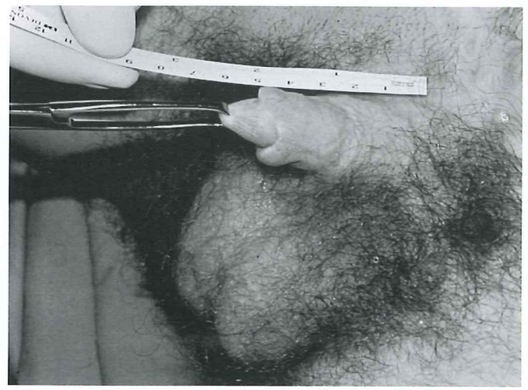


Figure 61–13
Case 3: This is another example of exstrophy with an underdeveloped micropenis in a 14-year-old boy.

In our first case, we coapted the ilioinguinal nerve to the dominant saphenous nerve of the donor flap. The ilioinguinal nerve is not an erogenous nerve, and although the patient had return of tactile sensation, he had no erotic sensibility. We have subsequently coapted all of the phallic flap nerves to the pudendal nerve or large dorsal penile branches when possible. However, just as vascular anomalies may be found in these cases, neurologic anomalies may also be present. In cases in which the pudendal nerve and its branches could not be located, the ilioinguinal, genitofemoral, and hypogastric nerves were substituted. All of our patients report the return of protective sensation, and adolescents also noted return of erogenous sensibility with the ability to masturbate to orgasm when the pudendal nerve was incorporated. During the initial procedure, a few patients required split-thickness skin grafts to complete closure of the phallic reconstruction. In addition, all donor sites were covered with split-thickness skin grafts or, more recently, full-thickness skin grafts harvested from the groin areas bilaterally. Full-thickness skin grafts appear to produce a better donor site result, albeit with an increased risk of hematoma.

Full-thickness skin grafts or buccal mucosal grafts were used for urethral reconstruction or patching when necessary and secondarily to create a coronal sulcus, which improves the aesthetics of the reconstructed phallus. Incorporating the modified Biemer-designed forearm flap phalloplasty (See Chapter 60) improved phallic aesthetics and reduced the need for coronal sulcus reconstruction. If the scrotum was absent, a scrotoplasty was completed by elevating and transferring a gracilis muscle or myocutaneous flap to the perineum.

RESULTS

In the past 15 years, we have performed total phallic reconstructions in 8 prepubertal and 16 adolescent boys.

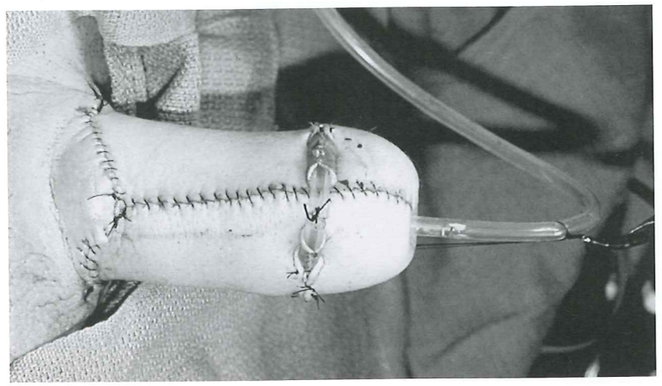


Figure 61–14
Case 3: In this case, an ulnar forearm cricket-bat phalloplasty has been created and inset into the perineum.

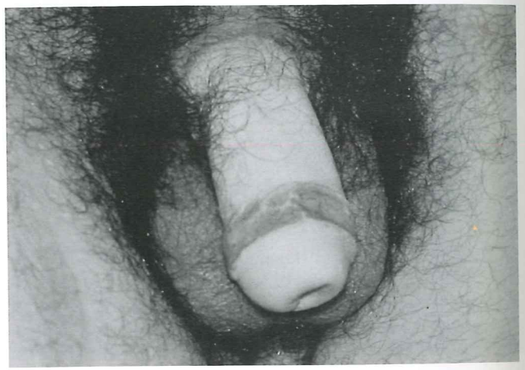


Figure 61–15
Case 3: One year postoperatively, the phallus has healed well and maintains its shape.

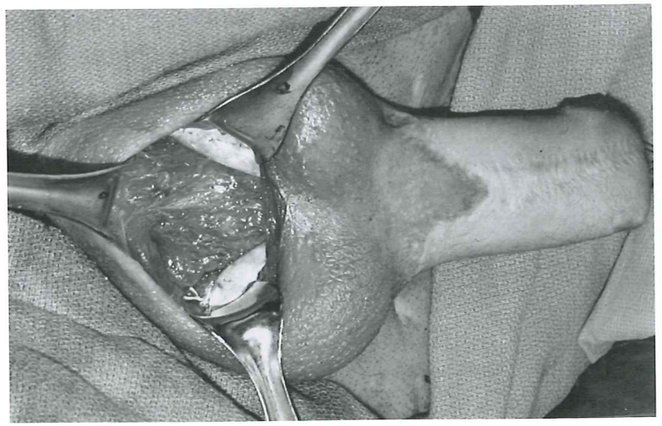


Figure 61–16
Case 3: Bilateral Duraphase penile prostheses covered with Gore-Tex vascular grafts are inserted into the phallus and fixed to the inferior pelvic rami.

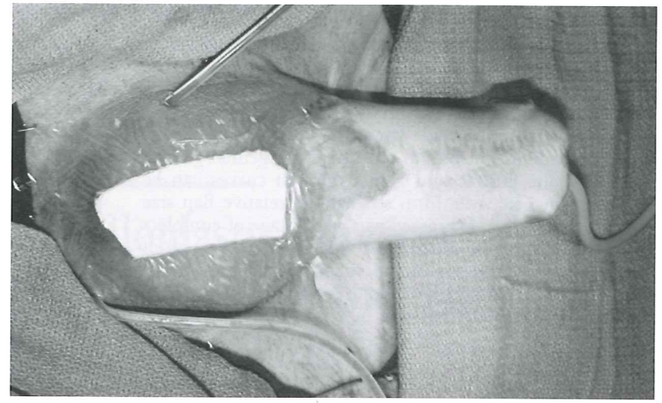


Figure 61–17
Case 3: The final result. Unfortunately, one of the prostheses required a subsequent explantation when the patient was struck with a softball on his phallus.

Complications have included flap failure, urethral fistulas, urethral strictures, meatal stenosis, lack of phallic growth, and the need for secondary surgery.

DISCUSSION

Microsurgical techniques were successfully applied to prepubertal phalloplasty despite the unique challenges of the pediatric population. Although not all goals were achieved in a one-stage operation, is important to complete as much of the reconstruction as possible in a single stage.

The concept of prepubertal phalloplasty generates several questions. For example, why do we favor this surgery if it is easier to construct female genitalia, if elective pediatric microsurgery may have a higher failure rate, if phallic growth into adulthood is questionable, if we do not know all of the psychologic consequences of prepubertal surgery, if patients are incapable of informed consent, and if repeated operations during childhood reinforce a patient's perception that something is wrong with him?

All of the patients in our series were born genotypically male and through phalloplasty surgery were able to retain their male gender. This is the basis of our argument to keep these children as boys. We believe that phallic construction has now reached the point where we can offer a viable alternative to the parents and treating physicians. By keeping these children as boys, we avoid the problems of gender changes. These children and their treating physicians must, however, face the substantial surgical challenge of creating a functional phallus. To date, we have received no reports of long-term follow-up studies on gender conversion to female, the anatomic results of such gender conversions, or sexual function. Until reconstructive surgeons who advocate male-to-female gender conversion can produce these results, we will continue to believe that phalloplasty is a viable and often the best form of treatment for these children.

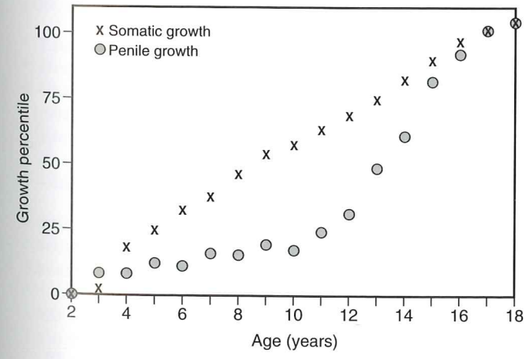


Figure 61–18
Somatic and penile growth percentiles for age.

Our experience was derived from cases of traumatic amputation, micropenis, developmental anomalies, and circumcision accidents that were referred to us. Patients with other severe developmental anomalies were also candidates for reconstruction at an early age. For example, malformations such as penoscrotal transposition, cloacal exstrophy, ill-defined genital dysmorphism, and penile agenesis present perinatally, thereby placing tremendous pressure on the parents and physicians to establish early gender assignment. An anatomic inventory is particularly important before surgery on patients with congenital anomalies. These patients require extensive vascular studies of potential donor site vascularity. Doppler studies, peripheral vascular studies, arteriograms, and even thermograms are helpful in this examination. Corporeal body status is also important, because the presence of corporeal crura on the pelvis is important in the insertion of penile prostheses. The status of the pudendal nerves and their genital branches must be established before surgery. Finally, the location of the urethral meatus and the status of the proximal urinary tract and the proximal membranous urethra are important factors in surgical planning. Dysmorphisms of these genital structures are not normally encountered in males with normal genitals and therefore present a special challenge to reconstructive surgeons.

A final question is, Will the phallus grow during puberty? Growth rates differ between somatic[1] and genital[2] tissues in childhood owing to hormonal influence. The

enzyme 5 α-reductase is present in the genital tissues and, under the influence of dihydrotestosterone, causes the genitalia to grow exponentially. Somatic tissues, on the other hand, do not produce 5 α-reductase and therefore grow on a linear scale. Any phallic flap from a nongenital site must therefore be made larger than the normal genitalia in a preadolescent boy to anticipate the genital growth spurt. Somatic growth and genital growth curves can be computed in percentile form so that the relative flap size required at any age, expressed as a percentage of complete adult growth, can be established (Fig. 61–18). Several of our patients have undergone microsurgical phalloplasty at age 8 years. To meet the demands of phallic growth, we constructed a phallus that was 60% of the normal penile length (13.1 cm), or 7.8 cm. This compares with a median genital size of 6.2 cm in an 8-year-old boy.

The question of phallic growth can be answered only with time and experience. This growth rate presupposes normal influences. We await the final results of these reconstructions as these children pass into adulthood.

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CHAPTER

62

The Postmodern Phalloplasty: Forearm Flap Urethroplasty with Superficial External Pudendal Artery–Abdominal Tube Pedicle Flap

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RODNEY VINCENT HENTZ
GÜNEYT ÖZEK
GAIL S. LEBOVIC

Construction of a penis is a surgical project posing considerable challenges. Many exciting techniques are now reported and in use, and the surgical procedures presented here are a unique compilation of several previously described methods. The three indications for the phalloplasty outlined in this chapter are severe gender identity disorder, traumatic amputation of the penis, and epispadias.

The postmodern phalloplasty consists of an abdominal tube pedicle flap for size and shape, a thick split-thickness skin graft to surface the shaft of the penis for aesthetic appearance, a radial forearm free flap urethroplasty for sensibility and glabrous skin, and a scrotal sac formed from the labia majora. In selecting the techniques, our experience has shown that the following principles, or core values, should be observed

- Choose donor tissues with high sensibility.
- Decrease morbidity at the donor sites.
- Use aesthetic surgery principles as well as reconstructive principles.
- Emphasize safety and reliability in selecting among the more technical alternatives.
- Choose a flap that results in a penis of appropriate size.

Application of the foregoing principles has led to the following special features of the postmodern phalloplasty: a forearm tissue expander, a thick split-thickness skin graft for the shaft, a V-to-Y scrotoplasty with expanded labial tissue, a temporary intentional perineal urethrostomy, and an aesthetic abdominoplasty.

The rationale for the foregoing choices is interesting and is as follows. The radial forearm flap is perhaps the donor tissue of choice for penis construction. The thin skin and subcutaneous tissue can be easily formed and draped; the relatively glabrous skin can be used for urethroplasty; the area has a relatively high sensitivity; and the large artery, vein, and nerve provide for relatively reliable results.[1–6] With other authors a disadvantage is the donor site deficit, which usually requires a skin graft, but our use of a forearm tissue expander allows harvest of a 4.5-cm-wide (45 French) by 2-cm-long strip of skin, and closure of the donor site is with a linear incision. The lateral antebrachial cutaneous nerve innervates sensitive end-organs of the skin in the forearm and wrist at the base of the thumb.

The choice of a skin graft to surface the shaft of the penis is based upon an aesthetic consideration because it eliminates the blobby appearance of almost any flap placed in a pendulous configuration. The size of the abdominal tube flap is able to be adjusted but will be neither too large nor too small. Many other donor sites produce an ungainly size.

A vaginectomy is performed to eliminate a possible site for urinary stasis, and a conservative Bouman urethroplasty flap of anterior vaginal tissue helps to reduce fistula formation at the female meatus–skin urethroplasty junction.[7] Labial tissue is a homologue of scrotal tissue and is natural "like-for-like" donor tissue, but the labia are located more posteriorly than the scrotum. Therefore, they are moved forward into the anatomic position of the scrotum with the V-to-Y–plasty. The urethral construction is associated with more complications than the other parts of the surgery, and an intentional perineal urethrostomy is helpful to maintain hygienic conditions during healing. Cystoscopic confirmation of patency, the glabrous condition, and complete healing before sealing the urethra are helpful. The

distal urethra may then be challenged with the responsibility of being the sole emptying conduit for the bladder.

TECHNIQUE

Stage I: Form Abdominal Bipedicle Tube Flap and Insert Tissue Expanders into Labia Majora (Fig. 62–1)

Planning. Obesity, smoking, and diabetes are contraindications to this procedure. The transverse scar from open abdominal hysterectomy can occasionally be managed successfully. In order to fashion a straight shaft, the parasagittal incisions are not parallel to each other but are between 5 and 10 cm apart, depending on the thickness of the subcutaneous tissue to be included between them.

Execution. The abdominal skin is tubed inside out—that is, turned in to form a skin-lined tunnel, eventually used for the stiffener or baculum, not as a urethra. A segment of Scarpa's fascia slightly wider than the skin is included, and dissection is just under Scarpa's fascia. The structures sacrificed are the inferior epigastric artery, Gillies long and huge vein (inferior epigastric vein to the thoracic area), and the innervation of the ilioinguinal and iliohypogastric to the upper three quarters of the flap. The structures preserved are the two large transrectus perforators immediately inferior to the umbilicus and the superficial external pudendal artery on each side. Technical points are as follows:

- Abdominal tissues are undermined, and high tension is used to close the flap donor site.

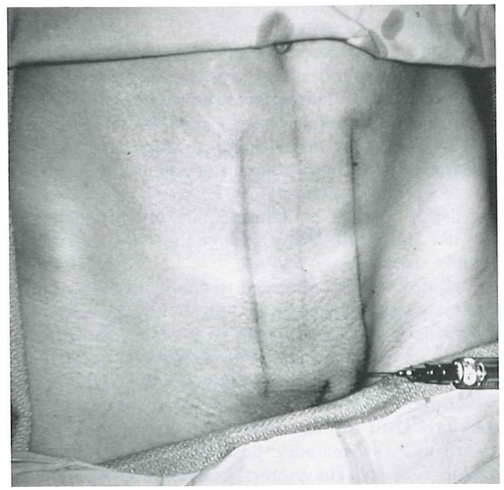


Figure 62–1
Incisions for stage I. These parasagittal incisions will be a variable distance apart in a person with a thicker abdominal subcutaneous tissue (i.e., up to 10 cm apart in the infraumbilical hollow and only 5 cm apart in the mons veneris).

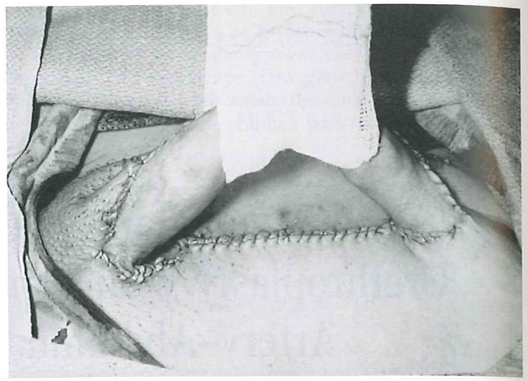


Figure 62–2
Immediately after stage I. The thick split graft is in apposition to the vascular areolar tissue accompanying the Scarpa's fascia.

- Little tension is used in forming the tube pedicle itself in order to preserve internal circulation.
- The tube pedicle is sutured all the way up superiorly as far as the skin incisions extend so that the glans penis eventually results in the correct angle of the corona (more glans on the ventral surface of the penis).
- Testicular tissue expanders are placed via the inguinal canal.
- Blocking sutures are placed to seal off the inguinal canal to prevent the expanders from returning to the abdomen.
- The thick split-thickness skin graft of .0018 inch is harvested from the hip with a Reese dermatome.
- A special dressing of polyurethane foam is sutured around the pedicle in a form-fitting manner to create even pressure.

Postoperative (Fig. 62–2). Allow the dressing to remain in place for a full 10 to 12 days if possible, because venous congestion of the skin graft occurs if pressure is removed sooner. Also, plan a surgical delay of the tube pedicle flap severance if the patient has a transverse lower abdominal hysterectomy scar across the pedicle tissue

Stage II: Release Upper Attachment of Bipedicle Tube Flap, Abdominoplasty, Glansplasty, Scrotoplasty, Optional Abdominal Hysterectomy (Fig. 62–3)

Planning. Placement of a tourniquet on the upper shaft of the tube for 1 hour per day trains the circulation to originate from the lower attachment of the tube. The abdominal tissue surrounding the upper pedicle is used for the glans. A small glans is preferable for tissue viability reasons. A V-to-Y technique moves the expanded labia in an anterior direction to the anatomic position of the scrotum.

Execution. In regard to the abdominoplasty, the upper

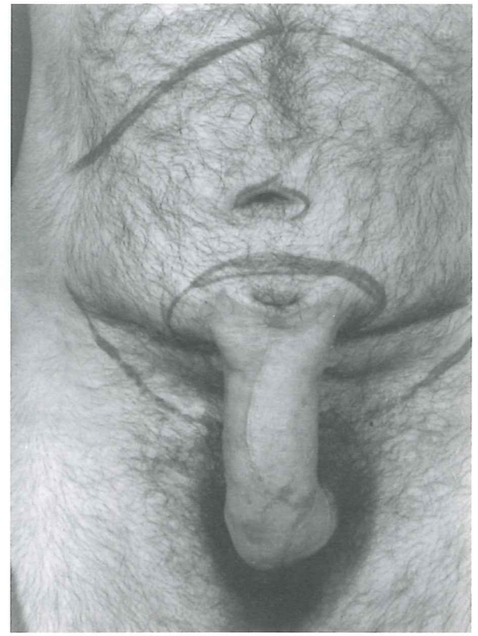


Figure 62–3
The markings before stage II show an abdominal "paddle" around the upper pedicle. The abdominal tissue forms a glans after defatting.

flap is brought down to cover the scars of the lower abdomen (see Fig. 62–3). Hysterectomy and bilateral salpingo-oophorectomy can be performed simultaneously without additional skin incision.

Stage III: Vaginectomy and Placement of Forearm Tissue Expander

Planning. The tissue expander is usually 20 by 4 cm and is placed in the forearm to the ulnar side of the flap to avoid interfering with the perforating vessels from the radial artery, which nourishes the skin of the radial forearm flap itself. The expander can be placed on the radial side of the radial forearm flap if the arm is small.

Execution. To form the space for the expander, the endoscopic technique is preferable, using small incisions and a soft pushing motion and dissecting with periosteal elevators. The vaginoplasty is preferably carried out with an argon beam coagulator in the hands of a gynecologic oncologist. The most vulnerable part of the male urethral construction is the point where the female meatus empties into the neourethra and the stream changes direction by 90 degrees. A Bouman flap of vaginal lining reinforces this area without a suture line in the direct line of the urine stream.

Postoperative. The 4-cm width of skin over the expander should increase to 7.5 cm with the expansion.

Table 62–1
Stages of Postmodern Phalloplasty

1. Abdominal tube bipedicle flap, inside out, based on the superficial external pudendal artery with a thick split-thickness skin graft on the external surface of Scarpa's fascia. Tissue expanders placed in the labia.
1a. Optional—laparoscopic hysterectomy.
2. Release of the abdominal pedicle, abdominoplasty, formation of the glans penis, testicular expanders changed to permanent implants. Optional open abdominal hysterectomy.
3. Vaginectomy, place forearm expander.
4. Micro-free flap urethroplasty with radial forearm flap.
5. Close the urethrostomy.

Notes:
Procedures 1 and 3 can be combined.
Procedures 2 and 4 can also be combined.
Procedure 5 can be combined with touch-ups or mastectomy revisions.

Stage IV: Micro-Free Radial Forearm Flap Urethroplasty

Planning. Two teams can work simultaneously. One prepares the recipient vessels, and another prepares the donor vessels and makes the urethroplasty in situ on the forearm. The micro-anastomoses are the deep inferior epigastric artery and vein to the radial artery and the cephalic vein or other available veins, usually the venae comitantes. Occasionally, a direct connection is made to the femoral arteries from end to side. The neurorrhaphy of the lateral antebrachial cutaneous nerve to the dorsal nerve of the clitoris occasionally presents some difficulty in identifying a specific nerve because it spreads into many branches on

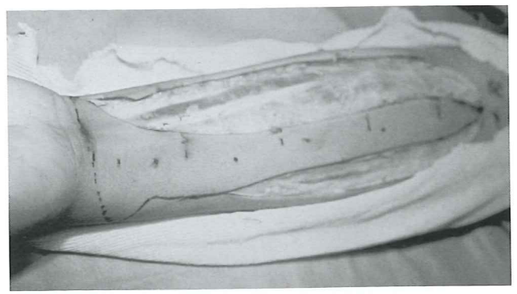


Figure 62–4
The forearm flap measures 4.2 by 20 cm and is innervated by the lateral antebrachial cutaneous nerve, as described by Gilbert and colleagues.[15]

the dorsal side of the clitoris, but it is found under the back side of the corpora cavernosa. The dorsal side of the abdominal tube neopenis is used for the inlay of the urethroplasty, and an additional skin graft is usually needed to cover it. The clitoris is usually moved to the side in the groin crease or deepithelialized and buried over the pubic bone.

Execution. The tube pedicle penis is opened on the dorsal aspect, and the forearm flap is formed into a tube (a urethroplasty). The abdominal tube pedicle penis is opened on its dorsal aspect to accommodate the radial forearm flap urethral tube, which was formed while on the forearm (Figs. 62–4 and 62–5). The tube extends from the glans—where the distal, or sensitive, wrist skin is placed—to the labia minora, which are glabrous and can themselves be tubed as a Thiersch-Duplay type of urethroplasty. A small urethral opening is intentionally made in this area. A perineal urethrostomy with a Foley catheter is a more complete diversion than a suprapubic catheter.

Postoperative. The lateral antebrachial cutaneous nerve coapted to the dorsal nerves allows sensitivity of both the glans and the dorsal shaft. Neurotization of the tube pedicle occurs to a degree.

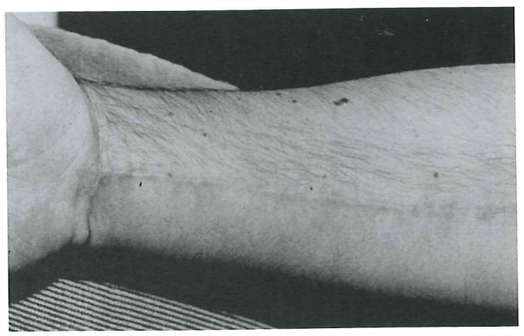


Figure 62–5
Primary closure of the forearm flap donor site is made possible by expanding the forearm skin preoperatively. Eliminating the skin graft to cover the flap donor site partially fulfills the principles of aesthetic surgery.

Stage V: Close Urethrostomy and Make Touch-Up Revisions

Planning. A perineal urethrostomy is allowed to remain until this stage so that postoperative irrigation can be carried out to achieve perfectly hygienic conditions, allowing the wound to heal well before it is challenged by the urinary stream. It is closed in the manner of a hypospadias fistula repair.

EXPERIENCE

We have performed 220 abdominal pedicle flaps phalloplasties (Fig. 62–6) and 14 complete phalloplasties (Fig. 65–7) with microsurgery, urethroplasty, and neurorrhaphy. Complications have occurred as shown in Table 62–2.

DISCUSSION

The first two stages are relatively simple and complication free and result in a functioning organ when the baculum and urinary assist device are used. The urethroplasty is the most complication-prone aspect of these procedures, and thus a urinary assist device is used to bypass these potential problems (Fig. 62–8).

The use of penile implants has historically had a significant complication rate. We have not had extensive experience with inflatable implants because we use a baculum, or stiffener, placed when desired in the accessory skin-lined tunnel of the penis at the time of intercourse (Fig. 62–9). Other techniques use bone, such as the fibula, but whether endochondral bone will remain for a long period without being stimulated by the stress of weight bearing remains to be determined.[8]

Many patients are not emotionally able to withstand a huge single operation. Furthermore, patients may not be able to afford hospitalization if they do not have insurance. Outpatient staged surgery may be reasonable.

Metoidioplasty is an alternative to phalloplasty, but alter-

Table 62–2
Complications of Postmodern Phalloplasty

Complications	Phalloplasty with Stage I and II (n = 210)	Phalloplasty with Stage I–VI Using Micro-Free Flap Urethroplasty (n = 14)
Partial loss of skin graft requiring regraft	21	1
Complete loss of skin graft	1	
Postoperative hematoma		1
Infection		1
Urethral stricture		5
Urinary fistula		1
Complications with vascular anastomosis requiring reexploration		1
Folliculitis of the skin tunnel used for the baculum	19	

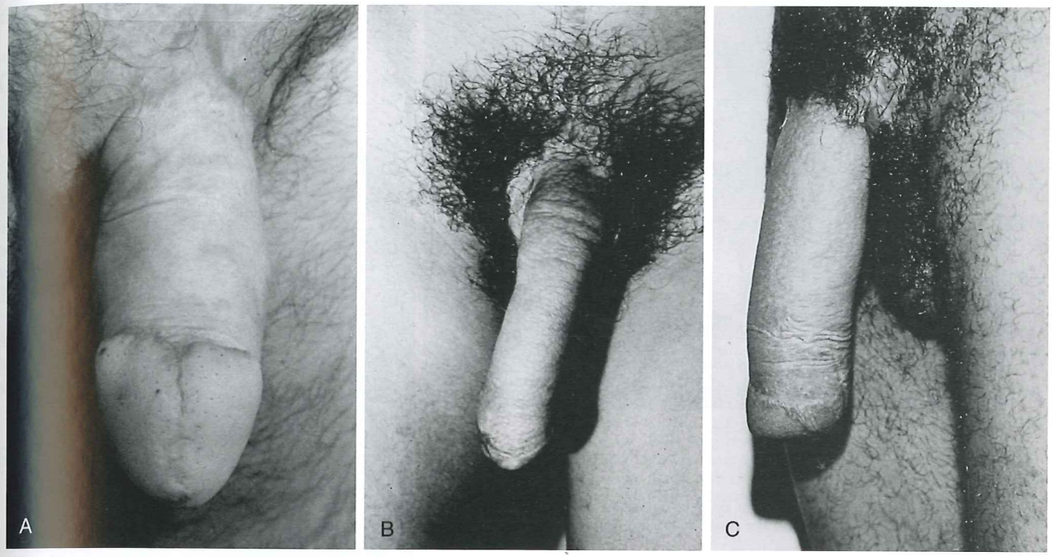


Figure 62–6
A to *C*: Postoperative results of phalloplasty after stages I and II.

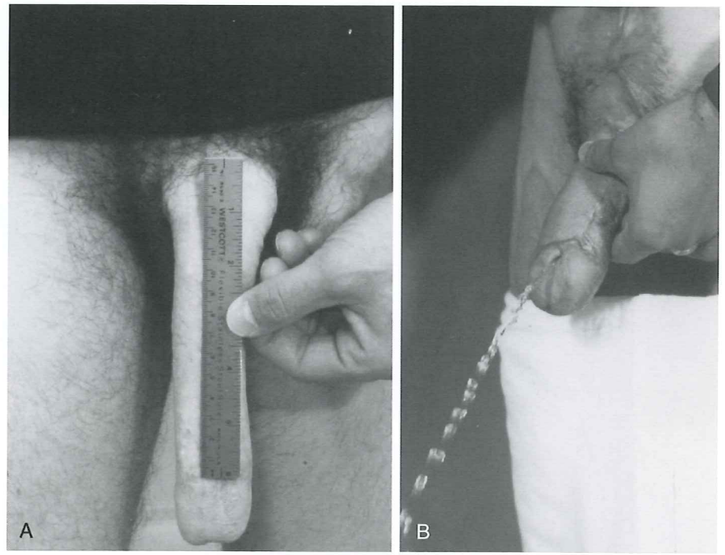


Figure 62–7
A: The postmodern phalloplasty. *B*: Postoperative urinary function using the forearm urethroplasty of the postmodern phalloplasty.

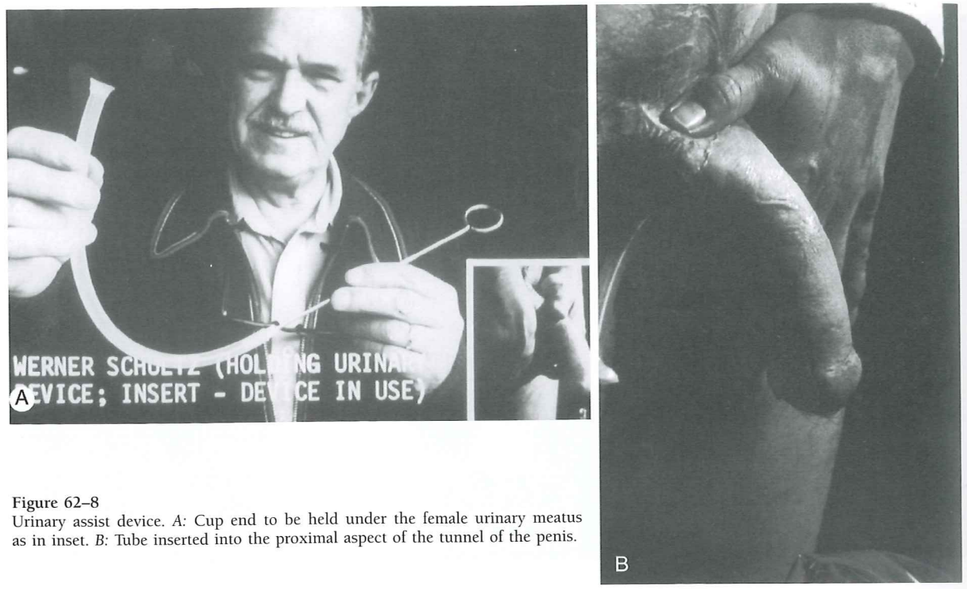


Figure 62–8
Urinary assist device. *A:* Cup end to be held under the female urinary meatus as in inset. *B:* Tube inserted into the proximal aspect of the tunnel of the penis.

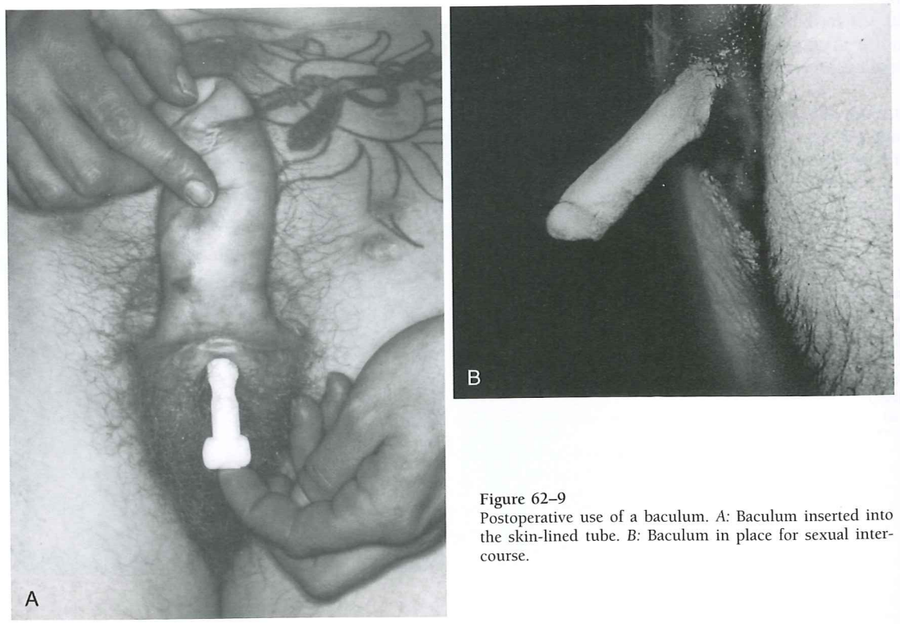


Figure 62–9
Postoperative use of a baculum. *A:* Baculum inserted into the skin-lined tube. *B:* Baculum in place for sexual intercourse.

natives also include the many other techniques for phalloplasty, most of which are brilliantly conceived and enjoy good results.[9–14]

CONCLUSION

This method uses parts of other surgical programs for construction of a neopenis, but it has certain unique features. It allows aesthetic reconstruction of the forearm flap donor site to permit the use of the relatively safe and highly sensitive forearm flap. Other relatively unique aspects are the use of a skin graft on the surface of the penis, an aesthetic abdominoplasty to eliminate the scars at the donor site of the abdominal pedicle, and a formal scrotoplasty. These are the main points in favor of selecting this technique. Postmodern phalloplasty applies those aspects of extant techniques that are advantageous and eliminates the parts that are relatively disadvantageous.

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CHAPTER

63

Total Penile Reconstruction with the Free Sensate Osteocutaneous Fibula Flap

RICHARD SADOVE

Total penile reconstruction is successfully accomplished with the free sensate osteocutaneous fibula flap (Fig. 63–1). The main advantages of this flap lie in its intrinsic rigidity, its superior donor site location, and its long vascular pedicle. The fibula flap provides better bone volume than does the radial forearm flap, which commonly results in a floppy phallus in the absence of bone. Penile prostheses in other flaps have enjoyed limited success. Forearm donor site complications can be avoided. The donor site in the lower extremity can be readily covered with a sock. The vascular pedicle of the fibula flap is of sufficient length to allow end-to-side anastomosis of the flap to the femoral artery. Interpositional vein grafts are unnecessary, and dissection of the inferior epigastric artery system to serve as a donor artery may be avoided. The appearance of the neophallus is excellent.

In addition to the experience in the United States, this operation has enjoyed success in Israel, Italy, Yugoslavia, Holland, Turkey, and Poland. High patient satisfaction and the advantages of the technique provide convincing evidence that the fibula osteocutaneous flap is superior for total penile reconstruction.[1]

OPERATIVE TECHNIQUE

A cutanous island is marked on the lower leg skin over the fibula (Fig. 63–2). This island is raised at the subfascial level, carefully protecting the posterolateral intermembranous septum and the nerve (Fig. 63–3). The fibula is transected both 6 cm proximal to the lateral malleolus and distal to the knee. Access to the pedicle is facilitated by resection of proximal fibular bone. The peroneal artery is ligated 6 cm proximal to the ankle. It is carefully dissected to the bifurcation of the tibioperoneal trunk and its division from the posterior tibial artery, where it is transected. This length is necessary to allow the peroneal artery to reach the superficial femoral artery after transfer. The vascular pedicle is lengthened by subperiosteal resection of proximal fibular bone in the flap. Removal of bone to lengthen the vascular pedicle leaves 10 cm of bone available for the neophallus.

Urethral reconstruction is accomplished by dissection of a full-thickness skin graft from the hairless groin. This graft is tubed on itself around a catheter to form a neourethra (Fig. 63–4).

The skin island of the flap is wrapped around both the fibular bone and the neourethra and is sewn to itself (Fig. 63–5). The neophallus is then transferred to the perineal region and is inset. It is revascularized in an end-to-side manner to the superficial femoral artery and the saphenous vein (Fig. 63–6). Tension on the vascular anastomosis is avoided by subperiosteal resection of proximal bone in the flap if necessary. The native urethra is sewn end to end to the neourethra with interrupted sutures. The two dorsal penile nerves are coapted to the lateral sural cutaneous nerve from the flap. The periosteum of the fibula is sutured to the tunica albuginea at the site of amputation of the corpora. Drill holes are placed in the fibula for passage of sutures that anchor the bone to the tunica. Split-thickness skin graft is placed on the leg donor site. We reconstruct the glans with tattooing and a minor surgical procedure at a later date after all wounds are well healed.

In biologic female transsexual patients, a circumcising incision is placed around the enlarged clitoris for reduction/rotation (Fig. 63–7): The clitoral skin is elevated at the level of Buck's fascia, and this skin flap is then split in the midline to create two flaps. Rotated laterally for lateral coverage of the proximal neophallus, the phallus can be inset superiorly at the correct level, the penopubic junction. The clitoral nerves are identified. One clitoral nerve is sacrificed to allow neurorrhaphy, and that half of the glans clitoris is amputated. The lateral sural cutaneous nerve in the flap is coapted to this same clitoral nerve for innervation of the phallus. The other half of the glans clitoris is sewn to the skin edge between the base of the neophallus and the pubic skin. Thus it is hidden in the pubic hair, and erogenous sensibility is preserved. In biologic male patients the nerve is coapted to the dorsal nerve of the penis.

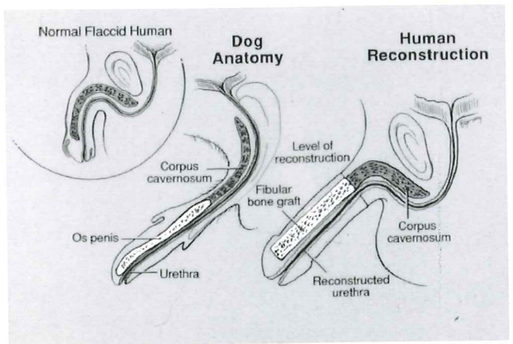


Figure 63–1
Total penile reconstruction with the fibula flap is modeled after the canine phallus with its os penis bone located distal to the corpus cavernosum and firmly attached with fibrous connections.



Figure 63–2
The cutanous island is marked on the lower leg skin, over the fibula from the tibia anteriorly to the posterior midline.

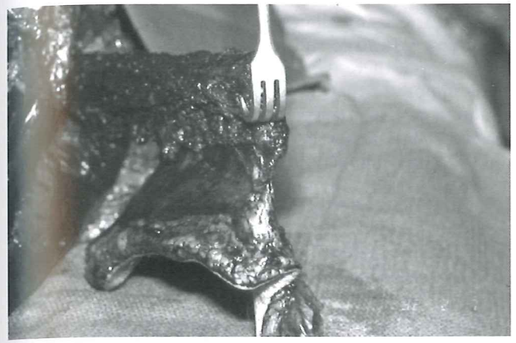


Figure 63–3
End-on view of the dissected flap before transfer demonstrates the bone held by the rake and the skin island hanging by the posterior intermembranous septum.

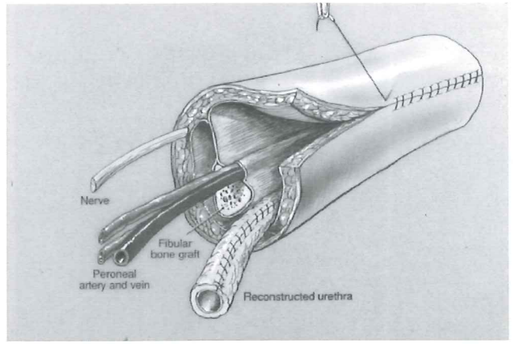


Figure 63–5
The skin island of the flap is wrapped around both the fibular bone and the reconstructed urethra in the course of the operation.

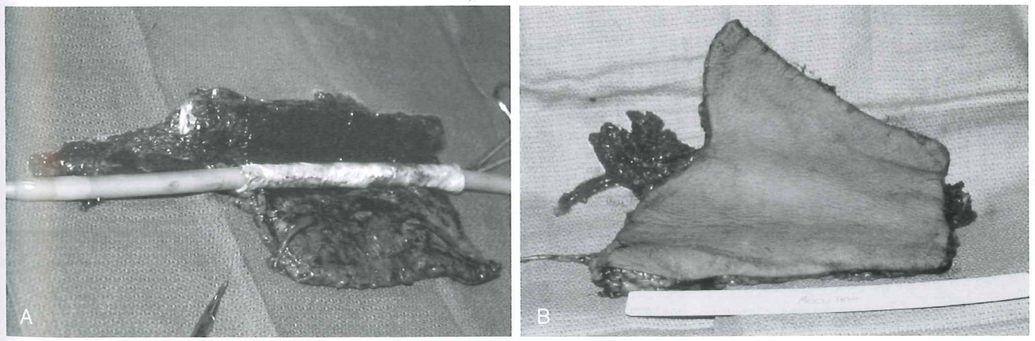


Figure 63–4
A: The flap is seen lying on its cutaneous surface: the full-thickness skin graft neourethra is lying next to the bone and vascular pedicle. *B:* Another flap lying cutaneous surface up, before revascularization.



Figure 63–6
End-to-side anastomosis of the peroneal artery to the superficial femoral artery is performed easily without need for interpositional grafts.

DISCUSSION

Fibula Flaps in Penile Reconstruction

For penile reconstruction specifically, the fibula osteocutaneous flap offers several advantages over the forearm flap. The fibular phallus has good intrinsic rigidity owing to the large volume of bone it contains. The flap itself provides superior bone stock in its volume and strength.[2–4] Satisfactory size can be achieved without compromising the donor site. The lateral sural cutaneous nerve provides sensation. Use of the free fibula osteocutaneous flap results in a neophallus with a diameter that closely approximates that of an authentic erect penis. Palpation reveals a neophallus accurately reproducing the erect norm. The appearance of the neophallus is excellent (Fig. 63–8).

The vascular pedicle of the fibula flap is of sufficient length to allow end-to-side anastomosis of the flap to the femoral artery without the need for an interpositional graft. Previously, the deep inferior epigastric artery was commonly used as the recipient vessel. Using the femoral artery avoids the need for dissection of the deep inferior epigastric artery and allows end-to-side anastomosis into a large artery instead of end-to-end anastomosis into a small one. However, there is no excess in the pedicle length.

It is important that the phallus have sufficient freedom of motion not to interfere with activities of daily living. The neophallus is free to be placed either in a trouser leg or against the abdomen. Rigid fixation of the phallus in an erect posture would be undesirable.

The advantages of the fibula donor site are many. Aesthetically, the lower leg donor site is preferable to either the upper arm or forearm donor site. The forearm donor site is frequently exposed during functional use and daily activities. A clinical study by Swanson and colleagues[5] found 17% patient dissatisfaction with the appearance of even a small forearm donor site. The donor site in the lower extremity can be readily covered with a sock, whereas covering the forearm requires wearing a long-sleeve shirt (Fig. 63–9).

The most important shortcoming of the fibula donor site is temporary interference with ambulation. Patients suffer little long-term discomfort. Most consider the postoperative function of their legs to be normal. Ambulation with assistance (cane or crutch) is required for 4 weeks. The minimal long-term functional loss resulting from sacrifice of the fibula has been described in detail elsewhere and is not discussed here.[6, 7] If as much bone were harvested from the radius as from the fibula, the risk of devastating radius fracture would be a certainty. Loss of function of the lateral sural nerve is an additional source of morbidity.

Radial Forearm Flaps in Penile Reconstruction

Regardless of the donor site, as long as a flap has no intrinsic rigidity, it will be a less desirable alternative in penile reconstruction. The radial forearm flap represented a great advance in reconstruction of the penis.[8–11] Unfortunately, the use of this flap in penile reconstruction has led to several problems. Over time, the flaps become too soft; when penile prostheses are used, erosion occurs in most cases. Radial bone in the penis is thin, unicortical, and

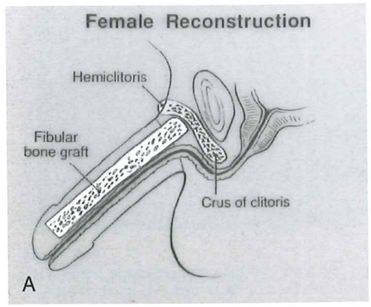




Figure 63–7
A: Biologic female transsexuals have preservation of one half of the innervated clitoris with rotation of the structure dorsal to the neophallus. *B:* Postoperative view of a biologic female transsexual with a preserved hemiclitoris.

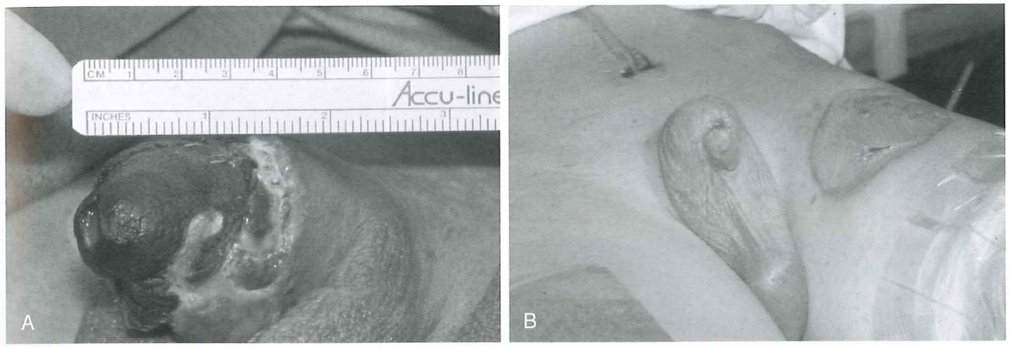


Figure 63–8
A: Representative patient with penile necrosis following a shotgun wound. *B:* Appearance after debridement and healing. *C:* Postoperative standing anterior view. *D:* Bone scintigraphy 24 hours after reconstruction demonstrates excellent uptake of technetium 99.

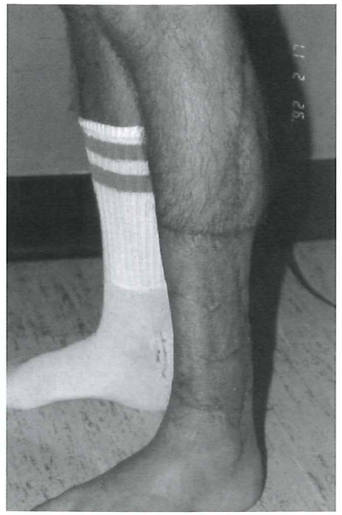


Figure 63–9
The lower extremity donor site is readily covered with a sock and thus is aesthetically preferable to other donor sites.

prone to fracture, and long-term survival of the very different radial bone in the phallus has not been demonstrated satisfactorily. The forearm flap donor site requires the loss of most of the skin of the forearm. Such a donor site scar is unacceptable for many patients. The aesthetics of the radial forearm donor site and others are undesirable for elective surgery.[12–16]

Long-Term Fate of Transplanted Bone and Use of Implants

The fibula, after transfer, remains a vascularized endochondral bone with the periosteum intact but is subject to only intermittent stress. Similarly, in dogs, the proximal end of the os penis bone is attached to the corpora cavernosa by fibrous connections and undergoes only minimal stress.

Vascularized bone grafts are believed to exhibit the greatest degree of bone survival compared with their nonvascularized counterparts.[17] Several factors bode well for the survival of the fibula graft. These are its vascularized nature, the presence of periosteum, and the fact that it will be subjected to the stresses of sexual activity. Factors against its survival are that the bone graft is endochondral, nonfixed, and without bony contact. Some resorption is observed. In all patients, early radiologic evidence demonstrates robust, calcified bone without significant resorption for the first year postoperatively (Fig. 63–10). Given the large volume of strong bone, even if the phallic bone were to suffer 50% resorption over time, it would still probably provide sufficient rigidity for intromission. Paraplegic patients suffer severe resorption of bone, yet enough remains to provide soft-tissue support.

An alternative to the use of living bone is the use of penile prostheses to provide satisfactory rigidity during intercourse. Although the overall success rate of these devices in a normal penis approaches 90%, they can be costly and major complications occur even in 7.8% of normal patients.[18] Additional problems include infection, penile fibrosis, tissue atrophy, and mechanical failures.[19] Indeed, if patients are monitored long enough, surgical revision rates as great as 43% have been reported.[20] In total penile reconstruction, the long-term success of penile prostheses is unlikely. The literature does not support the long-term success of penile prostheses in total penile reconstruction. Only Exner reports long-term success in unpublished data.[21]

Urethral Reconstruction

As the percentage of flap diameter used for urethral reconstruction increases, the amount of skin available for the circumference of the neophallus decreases. This may result in a tight closure and a narrow neophallus. For this reason, we prefer a free full-thickness skin graft urethroplasty that can be completely wrapped within the fascial septum of the flap. The fascia reduces the risk of urethrocutaneous fistulas along the penile shaft. Tension-free skin closure is facilitated. It is preferable to use a full-thickness skin graft from the hairless groin rather than a tube within a tube. The tube within a tube requires a significant increase in flap size. The donor site risk of a large flap, whether from the arm or leg, is that of distal edema. The viability of the graft on this flap, which has robust vascularity, is excellent. Laser technology now provides us with hairless donor sites.

Most fistulas occur at the proximal anastomosis to the native urethra. It was hoped that a vascularized urethra would reduce this problem. However, the presence of fistulas is not necessarily determined by the use of a vascularized urethra versus a full-thickness skin graft. Even total phallic reconstructions with a vascularized neourethra have a high risk of urethrocutaneous fistula at the anastomotic site in transsexuals. Covering the anastomosis with bulky, well-vascularized tissue is more likely to prevent fistula formation than is the type of urethral reconstruction. The risk of stricture can be reduced with the construction of a urethra of 30 French diameter.

Patients and their partners report satisfactory sexual function. Patients report no positional contraindications regarding intercourse. Sengezer has video documentation of patients' masturbating to orgasm and copulating after this operation (Sengezer M: Personal communication, 1996).

Biologic male patients report erections of the corpora proximal to the neophallus, as well as orgasm during intercourse. The ultimate sensory recovery of the lateral sural cutaneous nerve is likely to be comparable to that of the medial antebrachial cutaneous nerve. Only protective sensation is the goal (Fig. 63–11). Patients should be cautioned against unrealistic expectations that we can create or restore erogenous sensibility. The quality of sensory recovery does not necessarily determine the extent of erogenous sensibility.[15, 22] Patients note partial to full sensation in the neophallus, with appreciation of pressure and pain.

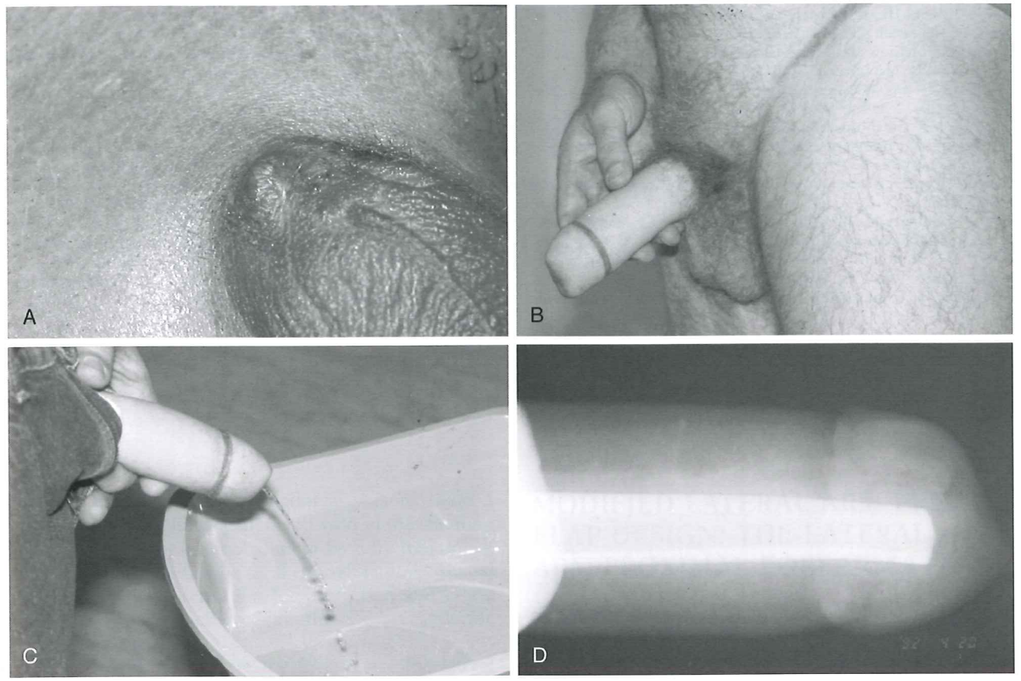


Figure 63–10
A: Preoperative appearance of a 33-year-old man after total traumatic penile amputation. *B:* Natural appearance 3 months after total penile reconstruction. *C:* Voiding view. *D:* Radiologic appearance demonstrates robust calcified bone.

CONCLUSION

The advantages and shortcomings of the use of the free fibula osteocutaneous flap for one-stage total penile reconstruction have been presented. This flap allows for an improved autogenous prosthesis, avoidance of the high complication rate of conventional prostheses, a natural appearance of the phallus in its erect functional state, satisfactory sexual function for patients and their partners, end-to-side anastomosis of the vascular pedicle without the need for interpositional vascular grafting, improved donor site aesthetics, and reduced donor site complications. We recommend its use as the flap of choice for total penile reconstruction.

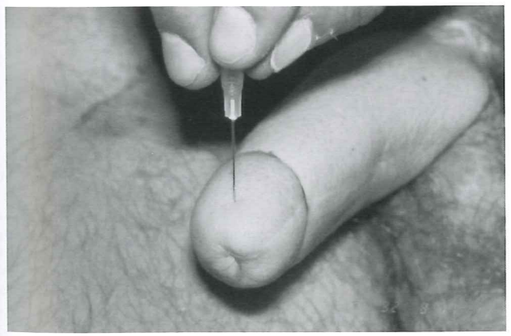


Figure 63–11
Sensory recovery of the lateral sural nerve provides protective sensation.

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CHAPTER

64

Lateral Arm Free Flap Phalloplasty

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VINCENT M. CASOLI

One of the primary goals of phalloplasty is to build a urinary conduit that allows patients to void in the standing position. However, for a neophallus to be fully functional, it must look like a phallus, be rigid enough to allow sexual intercourse, and have sensation for protection and erotic stimulation. We have achieved all these goals with the lateral arm free flap.[1]

Upton and colleagues[2] were the first to use the lateral aspect of the arm for penile reconstruction. The longitudinal axis of the flap overlies the lateral intermuscular septum and extends from the deltoid insertion to a point that may encompass the proximal third of the forearm.[3] The flap includes the posterior radial collateral artery, its venae comitantes, and the posterior cutaneous nerve of the arm (Fig. 64–1). The neophallus is constructed according to the original tube-within-a-tube design.[4] This original design does not provide enough urethral length to be applicable in transsexuals and does not allow incorporation of a prosthesis. These restrictions have led us to modify this design to achieve essentially all the goals of penile reconstruction.[5]

This chapter describes two methods using the modified lateral arm free flap design.[6]

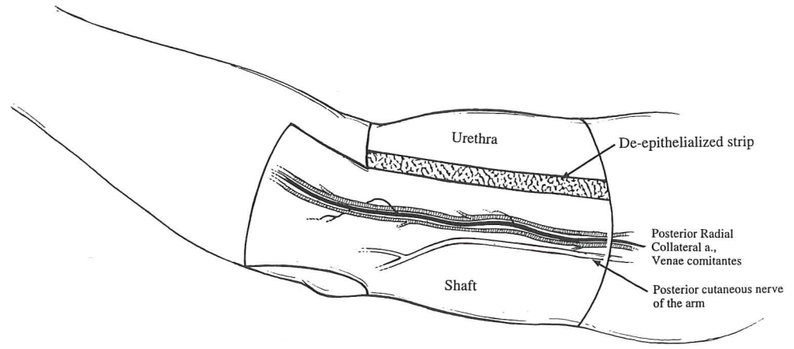


Figure 64–1
The original lateral arm phalloplasty design. The less hirsute anterior upper arm skin will be tubed to become the neourethra. The rest of the flap will be used as the external skin coverage.

MODIFIED LATERAL ARM FREE FLAP DESIGN: THE LATERAL ARM/PROXIMAL FOREARM FLAP

At the level of the proximal forearm, we have found an extensive watershed/vascular plexus connecting the posterior radial collateral vessels with the posterior interosseous artery, the olecranon anastomosis, and the anterior and posterior radial recurrent arteries (Fig. 64–2). This vascular plexus allows us to harvest a flap more distally, down to a level just proximal to the midforearm. This flap includes both the posterior brachial and antebrachial cutaneous nerves.[6] The proximal forearm portion of the flap that is destined to become the glans is very well innervated by the posterior antebrachial cutaneous nerve. This provides excellent sensory return and enables us to maintain a functional inflatable prosthesis without any threat of extrusion. The additional flap length obtained with this design also allows us to create the longer urethra that is needed for more proximal anastomosis in transsexuals.

Depending on a patient's anatomy and preference, one of the following two methods of phalloplasty is selected using our modified lateral arm free flap design.

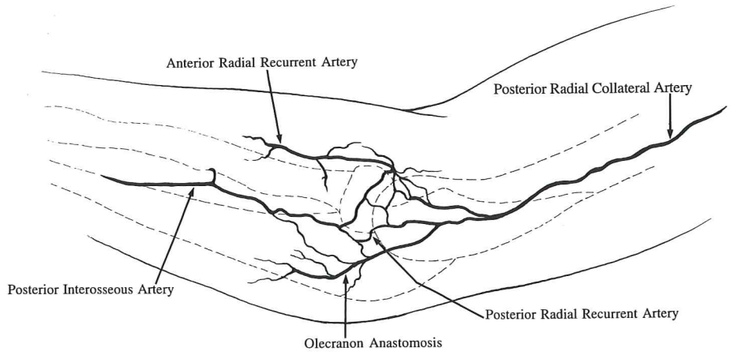


Figure 64–2
The blood supply of the proximal forearm. The vascular plexus around the lateral epicondyle connects the posterior radial collateral artery to the olecranon anastomosis, the radial recurrent vessels, and the posterior interosseous artery.

Method 1: No Prefabrication

A one-stage procedure is preferred if the lateral arm and proximal forearm tissues are not hirsute and if the upper arm circumference enables us to harvest a flap measuring 18 to 20 cm wide (Figs. 64–3 to 64–5). This width is needed to accommodate the urethra and inflatable prosthesis within the phallic shaft. Because the posterior radial collateral artery reliably perfuses only the lateral two thirds of the upper arm circumference, not enough tissue can be harvested from the slender arms of most transsexuals. However, if the flap can be made 18 cm wide around the elbow, leaving behind some intact antecubital fossa and posterior elbow tissue, our preferred design is that shown in Figure 64–3.

Method 2: Prefabricated Urethra

This method requires two stages and is used for patients with slender or hirsute arms.

Stage One. A large full-thickness skin graft is harvested from a hairless area such as the flank or the groin. This graft, which should measure approximately 4 cm wide and 23 cm long, is carefully tubed, epithelial side in, around a 24 or 26 French Silastic catheter. We then embed the construct in the superficial subcutaneous tissue of the

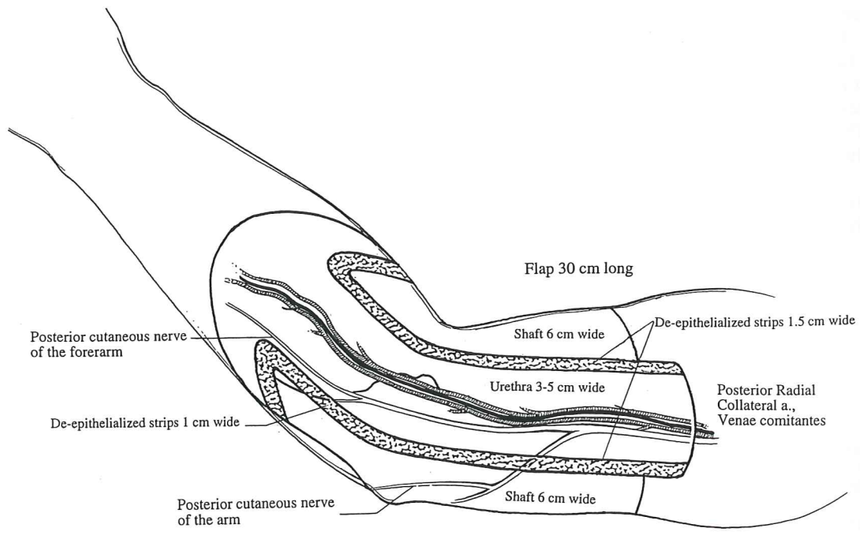


Figure 64–3
Preferred single-stage lateral arm/proximal forearm flap design. To obtain additional length, the flap is designed more distally, down 10 to 12 cm beyond the lateral condyle on the proximal forearm. The proximal, well-vascularized portion of the flap destined to become the urethra is made longer in transsexuals to allow a urethral anastomosis in the perineum. This design is feasible if the patient's habitus permits harvesting an 18-cm-wide flap from the midantecubital fossa to the midolecranon.

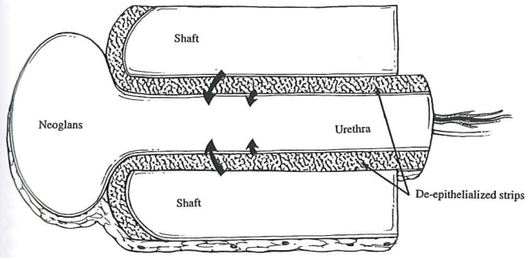


Figure 64–4
Deepithelization is completed on the urethral borders between the urethra and the lateral skin flaps and on the distal part of the lateral skin flaps.

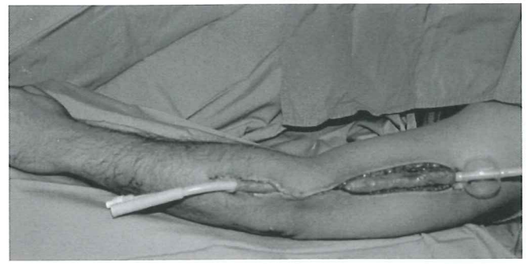


Figure 64–6
A full-thickness skin graft is tubed around a 30 French Silastic catheter, with the epithelial surface facing the catheter. All is buried subcutaneously along the longitudinal axis of the lateral arm flap.

lateral arm, along the axis of the intermuscular septum (Fig. 64–6). The graft remains in place for 3 to 5 months until it matures and contraction is complete. During this time, patients carry the Silastic catheter inside the lateral arm as a stent for the graft and remove it daily to irrigate the new embedded epithelial conduit with water. The viability of the graft is monitored with a flexible fiberoptic endoscope. If any breakdown occurs or if there is less than complete take of the graft, additional grafting is performed under local anesthesia and more lateral arm tissue can be mobilized. Transfer is performed only after the urethral conduit is determined to be satisfactory.

Stage Two. The flap is elevated according to the design shown in Figure 64–7. After the recipient site is prepared and the vascular pedicle of the flap is divided, the neophallus is tubed around an inflatable permanent prosthesis with the prefabricated urethra oriented along the ventral surface. The distal quarter of the flap, which is 1 to 1.5 cm wider than the portion used to form the penile shaft, is fashioned into a glans. This allows us to create a penis 18 cm long and 11 to 12 cm in circumference (Fig. 64–8).

This two-stage method has three main advantages. First, because the neourethra is fully epithelialized and well vascularized when the flap is transferred, the risk of stricture or fistula formation is greatly reduced. Second, complete take of the skin graft is no longer a questionable factor, because the graft has had several months to mature, and in the event of inadequate take, additional grafting can easily be performed in the arm before the tube becomes a urinary conduit. Third, lateral arm flap skin is not "wasted" on the urethroplasty, so the entire width of the harvested flap can be used for the penile shaft.

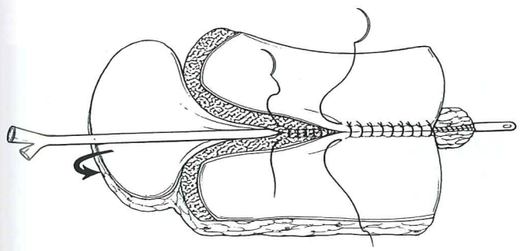


Figure 64–5
The urethra will be tubed on itself, with a two-layer closure. The neophallus shaft will be tubed by suturing the lateral skin flaps to each other. The distal 4 cm is reflected and sutured proximally over the dorsal phallus to become the neoglans.

PREPARATION OF THE RECIPIENT SITE AND FLAP TRANSFER

Site Preparation

A T-shaped suprapubic incision extending toward the perineum is needed for both methods. The horizontal component of the T must allow access to the inferior epigastric vessels where they enter the posterior aspect of the rectus abdominis muscles. In transsexuals, the vertical leg of the T is extended ventrally to the dorsum of the clitoris, which is then degloved. The left and right erogenous branches of the internal pudendal nerve (the dorsal nerve of the clitoris or the penis) should be identified where they enter the clitoris or penile remnant and should be isolated for coaptation.

If an inflatable prosthesis is to be inserted during this procedure, a pocket to hold the reservoir is prepared beneath the rectus abdominis muscle when the inferior epigastric vessels are being mobilized.

Flap Transfer

Once the flap is shaped into a penis, it is transferred to the perineum with a 20 to 24 French Foley catheter inside the neourethra (see Fig. 64–8). The Foley catheter is inserted into the bladder for urinary drainage and acts as a temporary stent for the urethral anastomosis. This catheter is left in place for about 3 weeks.

In males, the neourethra is connected to the existing urethral stump with a wide spatulated anastomosis. In transsexuals, the original urethral meatus is located proximally in the perineum, and it is necessary to use labia minora flaps to advance this orifice to a more anterior position. This is done by making a U-shaped incision that passes around the native meatus with the apex extending 3 to 4 cm into the anterior vaginal wall. The labia minora

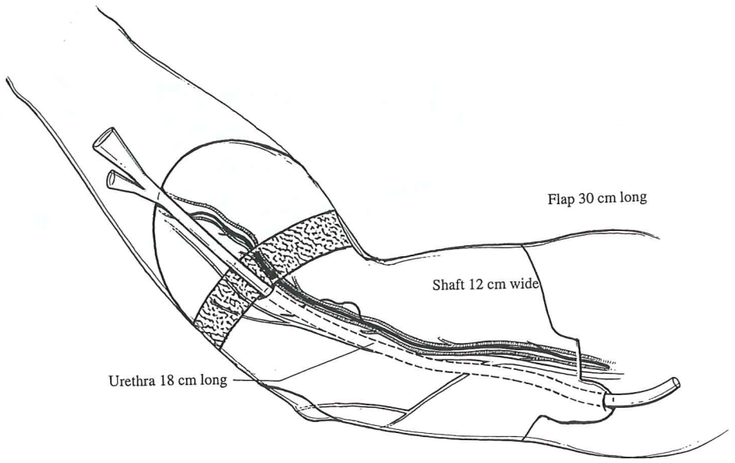


Figure 64–7
Prefabricated lateral arm/proximal forearm flap design. Transfer is performed when the neourethral tube is fully epithelialized, mature, and free of strictures. In transsexuals, additional urethral length is needed and the prefabricated tube extends 5 cm beyond the shaft portion of the lateral arm flap.

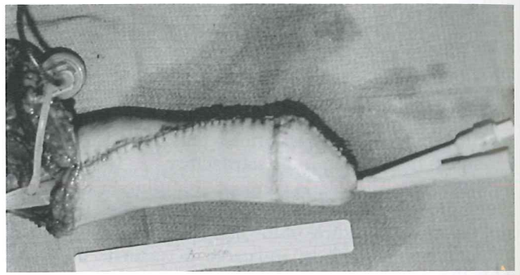


Figure 64–8
Neophallus before inset. The flap is tubed around an inflatable prosthesis. A 20 French Silastic catheter is placed through the neourethra.



Figure 64–9
A female-to-male transsexual 5 years after surgery.



Figure 64–10
The inflatable prosthesis provides stiffness on demand. There is no threatened erosion of the implant.



Figure 64–11
Donor site. The appearance of the skin on the donor upper arm is acceptable.

and vaginal flaps are mobilized and tubed around the catheter using fine inverting sutures. The flap neourethra is then anastomosed to this conduit in a spatulated fashion with similar fine inverting sutures. Additional tissue from the labia minora could be drawn over the anastomotic site to provide another protective layer.

After the urethral anastomosis, the posterior cutaneous nerve of the arm and the forearm nerve are connected to the left and right erogenous branches of the internal pudendal nerve. The vessels are then anastomosed end to end with the inferior epigastric vessels. Venous drainage can be further augmented with a superficial cutaneous vein from the flap connected to a pedicled saphenous vein.

The lateral arm donor site is closed with a skin graft.

To keep the penis in a position perpendicular to the body, a foam scaffold is worn for 5 days. The flap itself must be left uncovered so that its color and temperature can be closely monitored. The urinary catheter is kept in place for 2 to 3 weeks, after which the patient is allowed to void freely through the neourethra. The patient is instructed not to inflate the prosthesis for at least 8 weeks. Sexual intercourse with a protective condom is allowed after the third postoperative month, provided there have been no complications.

Late results in a transsexual are shown in Figures 64–9 to 64–11. Note the anterior placement of the penis to allow penetration (Fig. 64–9). The inflatable prosthesis provides stiffness on demand (Fig. 64–10). There is no threatened erosion of the implant, and the neophallus has light touch sensibility (S3). The skin of the donor upper arm is acceptable and is easily concealed (Fig. 64–11).

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CHAPTER

65

Metoidioplasty

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GÜNEYT ÖZEK
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Metoidioplasty is a technically difficult procedure used in female-to-male transsexual patients who desire sexual reassignment surgery without the complex, multistaged surgical construction of a large phallus (phalloplasty). The objective of this procedure is to create a male appearance of the external female genitalia. This is accomplished by moving the genital structures to a more anterosuperior position, constructing a scrotal sac, and extending the urinary tract. The end result is a transition in the appearance of the external genitalia from female toward a more male configuration (Fig. 65–1). This technique was first described in 1982 in Bordeaux[15] and again in 1985 at the Ninth International Symposium on Gender Dysphoria. Since that time, it has been used and modified by a number of surgeons with expertise in this area (Table 65–1).[1]

The term *metoidioplasty* was derived from the Greek words[2] *meta*, "toward"; *oidion*, "male genitalia"; and *plasty*, surgical molding.

As with any surgical procedure, preoperative preparation and selection of patients are critical for a successful outcome.[3, 4] As mentioned earlier, patients who choose metoidioplasty do not wish to undergo the extensive surgical procedures necessary to create a large phallus but rather simply desire a more male appearance. The functional difference is that metoidioplasty results in a very small phallus-like structure that cannot be used for vaginal penetration. Thus, the choice for this operation includes lifestyle issues dependent on patients' sexual preferences and habits. Surgical candidates should consider this important aspect of the outcome when trying to select the appropriate procedure.[2]

Table 65–1
Metoidioplasty: Reports in the Literature

Durfee and Rowland, 1973[6]
Bouman, 1985,[7] 1987[8]
Gilbert et al, 1988[9]
Eicher, 1989,[10] 1992[4]
Hage et al, 1993,[11–13] 1996[5]
Laub et al, 1974,[14] 1982,[15] 1985,[1] 1987,[16] 1989[2]

PREOPERATIVE PLANNING AND SURGICAL APPROACH

Selection criteria for surgery as well as relative contraindications are listed in Table 65–2. In regard to sexual reassignment surgery, each patient undergoes extensive preoperative preparation. This includes routine history taking and physical examination, completion of psychologic testing, and compliance with the guidelines set forth by the Harry Benjamin International Gender Dysphoria Association. Patients must have a well-documented clinical diagnosis of gender identity disorder, severe: DSM-IV 302.85 (Table 65–3).[3] Surgical transformation of the external genitalia is an irreversible step in the process of transsexualism, and thus patients must be carefully selected.

The operative technique is described in the following section. Phenotypic transformation of the female genitalia

Table 65–2
Metoidioplasty: Preoperative Evaluation

Selection Criteria
Clinical diagnosis of gender identity disorder, severe (DSM-IV 302.85)
Psychologic counseling, endocrine and general health work-up
Testosterone: 200 mg intramuscularly bimonthly for 2 years
Total hysterectomy, vaginectomy
Relative Contraindications
Hypertension
Obesity
Sleep apnea
Hepatic dysfunction
History of smoking
Alcoholism, drug abuse
Polycystic ovarian disease

Table 65–3
Gender Identity Disorder, Severe (DSM-IV 302.85)

I.	A strong and persistent cross-gender identification
II.	Persistent discomfort with his or her sex or sense of inappropriateness in the gender role of that sex
III.	The disturbance is not concurrent with a physical intersex condition
IV.	The disturbance causes clinically significant distress or impairment in social, occupational, or other important areas of functioning

begins with hormonal stimulation of the clitoris and surrounding tissues. In general, testosterone is administered (200 mg intramuscularly bimonthly) for a period of several years during the preoperative period. This results in hypertrophy of the existing female genitalia, which are then used to form the neophallus by local tissue transfer. It is recommended that total abdominal hysterectomy be completed before proceeding with metoidioplasty. Vaginectomy may be performed simultaneously with metoidioplasty, and the anterior vaginal wall used to start the urethroplasty.

OPERATIVE TECHNIQUE

The surgical plan is outlined on the female genitalia after shaving and Foley catheter placement. Markings are made on the labia majora, which are raised as inferiorly based flaps (Fig. 65–1*A*). Markings are made superior to the urethra and along the base of the labia minora (Fig. 65–1*B*). An incision is made around the base of the clitoris, encircling the labia minora, which are elevated from posterior to anterior (Fig. 65–2*A*). Chordee is released. The edges of the labia minora are trimmed sharply. The internal wings of labia minora are fused together using ventral and dorsal anastomoses to create a pendulous urethra. This neourethra is not connected to the urethral meatus at this stage. It remains a nonfunctional tube unless a second-stage urethroplasty is performed. The clitoris and labia minora are moved anteriorly, and the outer labia minora wings are fused in the midline to cover the ventral aspect of the penis (Fig. 65–2*B*).

The inferiorly based labia majora flaps are raised and transposed posteriorly to fill the space previously occupied by the labia minora (Fig. 65–3*A*). They are fused together over testicular tissue expanders, which are placed beneath the dartos fascia and superficial to the Martius fat pad (Fig. 65–3*B*).

Superior local flaps are used to remove fat from the mons veneris and are rotated to fill the space previously occupied by the labia majora. The neophallus is now in a more anterosuperior position (Fig. 65–4). Preoperative and postoperative patients are shown (Figs. 65–5*A* and 65–6*B*).

Some patients request a second-stage procedure extending the urethra from the original position to the tip of the neophallus, enabling them to void while standing (Fig. 65–7). Others do not want to undergo the additional second stage to form the urethra. The one-stage metoidioplasty forms a pendulous neourethra with the appearance of a relatively normal glanular meatus; however, no perineal urethra (pars fixa) is present. This portion of male-type urethra extending from the female meatus under the scrotum to the base of the neophallus is incomplete. The optional second stage forms this portion of the neourethra, using an anterior vaginal wall flap based near the female urinary meatus. Other options for urethral construction include grafts such buccal mucosa or hairless full-thickness skin grafts. Urinary diversion with a perineal urethrostomy or possibly a suprapubic tube is used. Coverage with local tissues is necessary to prevent fistula formation.

The urethroplasty can be the most challenging aspect of metoidioplasty and is often associated with postoperative complications such as urinary fistula and stricture. Hage performs the urethroplasty and metoidioplasty in one stage in a unique technique.[5] A reconstructive urologist should be involved to decrease morbidity.

SUMMARY

Metoidioplasty can serve as an alternative to phalloplasty in appropriately selected patients. This procedure is most commonly used in patients who have a documented history of gender identity disorder and who choose not to undergo extensive surgical procedures to create a large phallus. Rather, these patients desire a transformation of the external female genitalia toward the male phenotype,

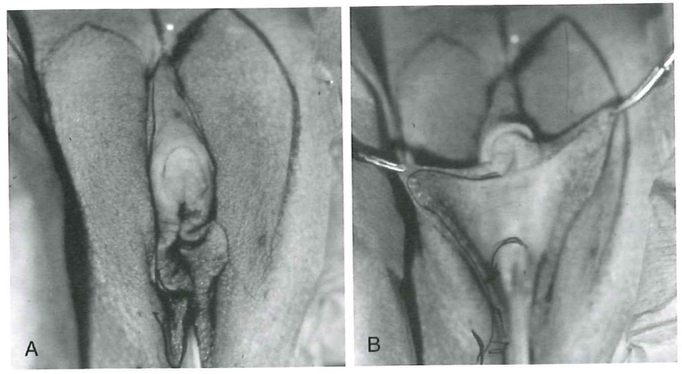


Figure 65–1
A: The surgical plan is outlined on the female genitalia after shaving. Inferiorly based labia majora markings are outlined. *B*: The labia minora are elevated, revealing markings.

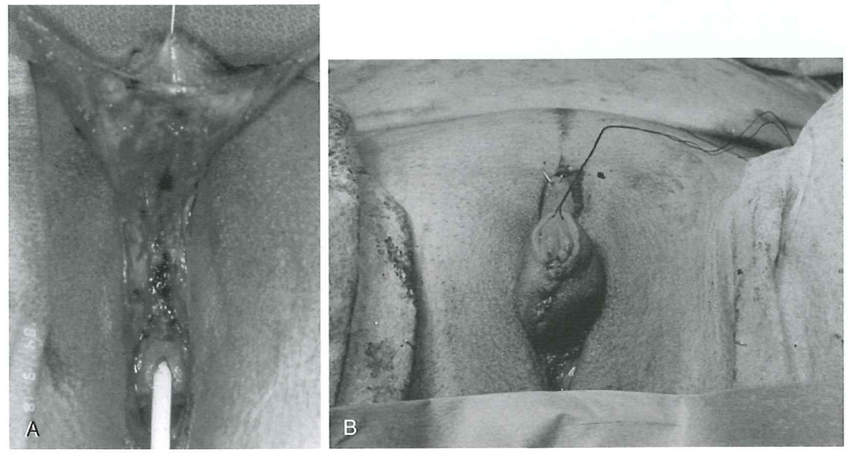


Figure 65–2
A: An incision is made around the base of the clitoris, encircling the labia minora. The labia minora are elevated from posterior to anterior, creating wings. *B*: Postoperative view after the clitoris and labia minora are moved anteriorly. The external labia minora are fused in the midline of the ventral neophallus. The labia majora are moved into the space previously occupied by labia minora. They are fused together, and testicular tissue expanders are placed.

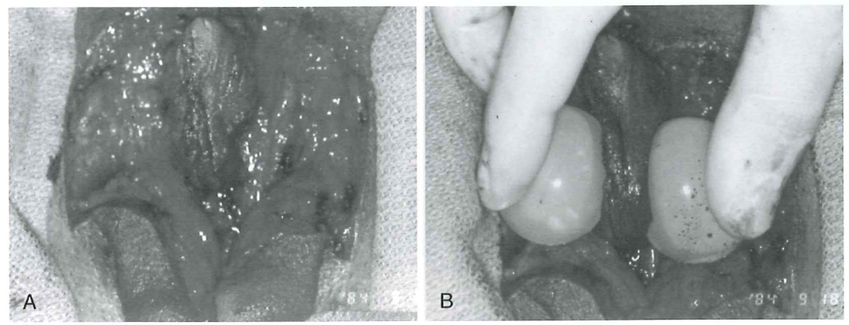


Figure 65–3
A: The labia majora are elevated as inferiorly based pedicle flaps. *B*: Testicular expanders are placed beneath the dartos fascia and above the Martius fat pad.

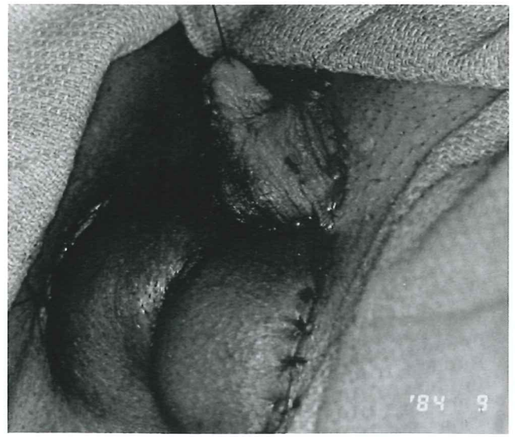


Figure 65–4
The labia majora are moved inferiorly and sutured together in the midline. The neophallus is moved superiorly and anteriorly onto the mons pubis. The mons veneris is defatted, and the flaps are rotated to cover the area previously occupied by the labia majora.

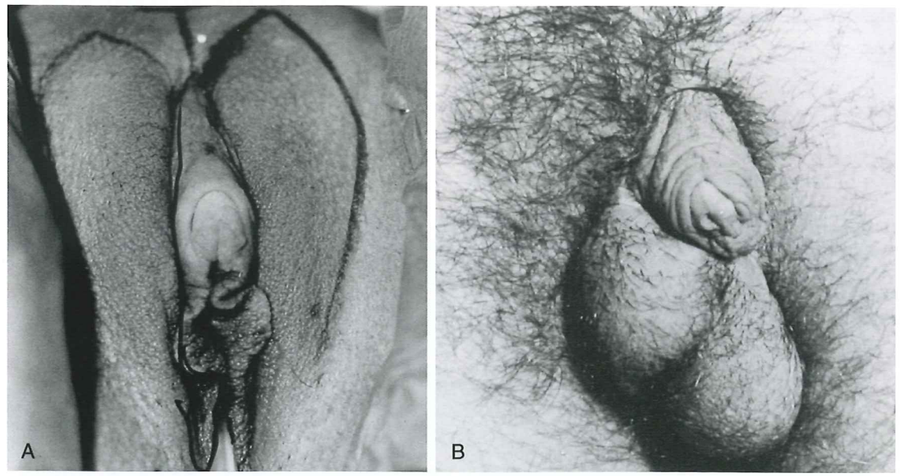


Figure 65–5
A: Preoperative photograph. *B*: Postoperative photograph.

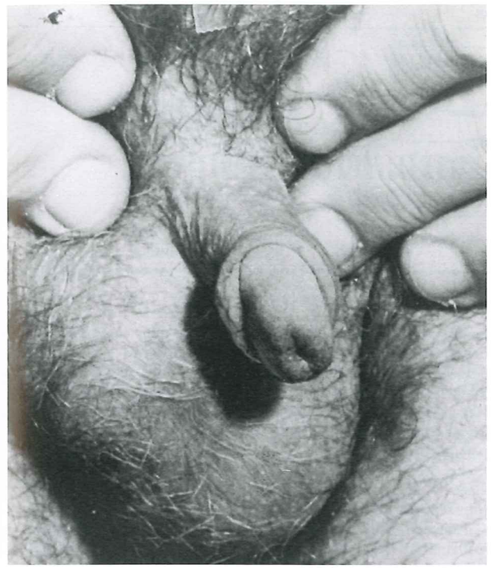


Figure 65–6
Postoperative photograph (different patient from that in Fig. 65–5) revealing a normal-appearing meatus.

Figure 65–7
Postoperative patient urinating with a full stream after second-stage metoidioplasty.

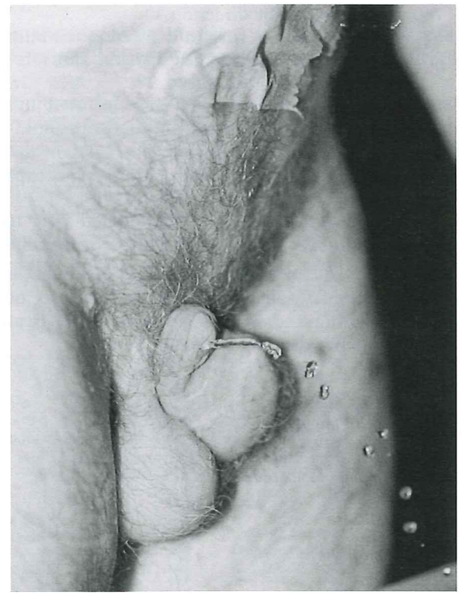


Table 65–4
Male and Female Homologues in the Genitalia Externa

Female Derivative	Primordial Structure	Male Derivative
Clitoris Corpora cavernosa Glans clitoris	←Genital tubercle→	Penis Corpora cavernosa Glans penis
Internal aspects of labia minora	←Urethral fold→	Corpus spongiosum (enclosing penile urethra)
Labia majora and external aspects of labia minora	←Labioscrotal swellings→	Scrotum and ventral epidermis of penis
Paraurethral glands (of Skene) Bartholin's gland	←Urogenital sinus→	Prostate Bulbourethral glands (of Cowper)
Vagina (lower)		Prostatic utricle (vagina masculinus)

and in general, they do not desire the ability to achieve vaginal penetration with the neophallus.

The tissues of the female external genitalia are homologous to the external genitalia in males and are derived from common embryonic structures[5a] (Table 65–4). Metoidioplasty uses this principle to create the appearance of male genitalia with the existing tissues of a female. The end result is acceptable in most cases, because patients obtain a more masculine phenotype, maintain erotic sensation, and in many cases have the ability to urinate in the standing position after urethral extension to the tip of the neophallus.

The surgical goals that are accomplished using the techniques described earlier are as follows:

- The chordee of the clitoris is released to straighten the neophallus and allow movement of the clitoral unit in a more anterosuperior direction.
- The labia minora are surgically fused in the midline, and the external surface becomes the skin and soft tissue of the ventral aspect of the penis.
- The fused labia minora can also be used to create a urethral extension to the tip of the neophallus.
- The labia majora are transposed in relation to the neophallus; they are fused in the midline and expanded to create the scrotal sac.
- The mons pubis and lower abdominal fatty tissue are removed to exaggerate the size of the neophallus.

Although technically challenging, metoidioplasty has been performed safely and effectively in an outpatient surgical setting and is a useful tool in the treatment of gender identity disorder.

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CHAPTER

66

Surgical Formation of the Glans in Phalloplasty

J. JORIS HAGE

Apart from the functional consideration that a urine stream should break cleanly from the phallus, aesthetic considerations imply the construction of a glans-like tip in total phalloplasty.[1, 2] Ideally, the neoglans has a urethral meatus structured as a sagittal slit at its tip. It is conic and has a circumferential ridge (the corona glandis) at its base. The coronal ridge is higher at the dorsal aspect of the neophallus and is accented proximally by a slight sulcus (the collum glandis).[2, 3] The glans may or may not be covered by a preputium-like structure, depending on whether or not a circumcised appearance is desired. Acceptable functional and cosmetic results of surgical formation of the neoglans may currently be obtained. However, none of the techniques presented thus far has enabled a surgeon to address all of the ideal goals.

Munawar was the first to present a technique to create a glans-like structure in phalloplasty.[4] In 1957, he reported circumcising the tip of the neophallus at the level of the corona. After undermining the distal edge of this incision and excising some of the adipose tissue, he created a coronal ridge that was more distinct at the dorsal aspect of the phallus by advancement of the proximal skin toward the base of the distal, coronal skin flap (Fig. 66–1).[5] Although Munawar troubled himself to create a meatal dimple in the center of the rounded tip, he did not provide the neophallus with a urethra.[4] The Norfolk team improved Munawar's method of glans formation by adding the use of a split-thickness skin graft to close the donor area of the coronal skin flap (Fig. 66–2).[6, 7] This Norfolk modification is simple and safe and, quite often, successful.

Puckett and Montie tried to define a clear coronal sulcus by removing a series of diamond-shaped sections of skin of unequal length 3 months after complete detachment of the distal pedicle of the groin flap they used for phalloplasty (Fig. 66–3).[8] They did not construct a neourethra or try to create a pseudomeatus.[8] Like Munawar's original method, this technique should be considered obsolete because it generally results in flattening of the coronal ridge.[1, 7]

The Stanford team initially raised the superior pedicle of the infraumbilical midline skin flap they used for phalloplasty with a transverse elliptic extension, which, after defatting, was folded to form the glans of the phallus (Fig. 66–4).[9] A corona was fashioned by using epidermal-to-dermal stitches to create an overlap of the skin. A comparable method has been used by Gottlieb and Levine in free-flap phalloplasty.[10, 11] In nonobese patients, this more elaborate technique may give favorable results.

Subsequently, the Stanford team used a long and narrow innervated forearm flap with a wider paddle of skin at the wrist to construct a sensate urethra and glans penis.[12, 13]

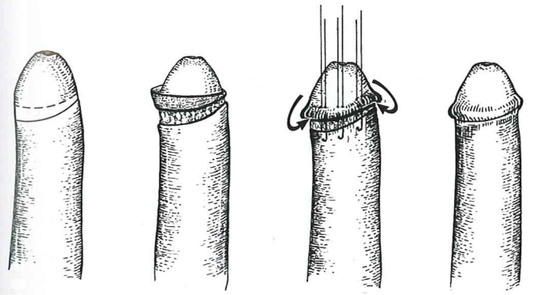


Figure 66–1
The Munawar technique of glans formation. (From Hage JJ, de Graaf FH, Bouman FG, et al: Sculpturing the glans in phalloplasty. Plast Reconstr Surg 92:157–161, 1993.)

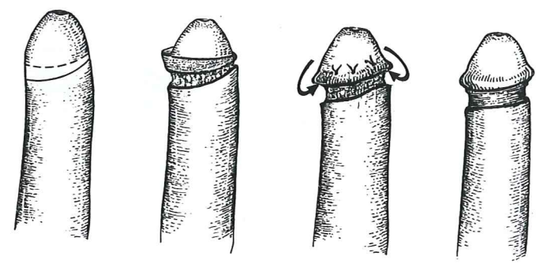


Figure 66–2
The Norfolk modification of the Munawar technique. (From Hage JJ, de Graaf FH, Bouman FG, et al: Sculpturing the glans in phalloplasty. Plast Reconstr Surg 92:157–161, 1993.)

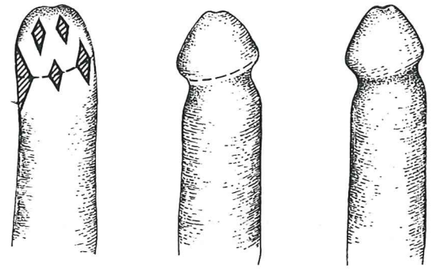


Figure 66–3
The Puckett technique to simulate a coronal sulcus. (From Hage JJ, de Graaf FH, Bouman FG, et al: Sculpturing the glans in phalloplasty. Plast Reconstr Surg 92:157–161, 1993.)

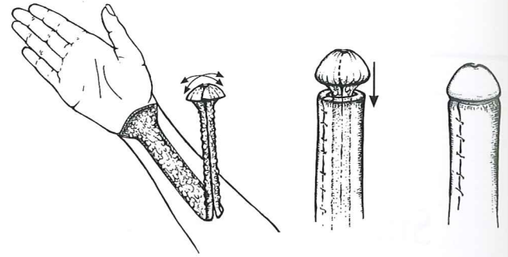


Figure 66–5
The Stanford technique to construct a sensate glans and urethra by incorporation of a free radial forearm flap in the infraumbilical flap used for phalloplasty. (From Hage JJ, de Graaf FH, Bouman FG, et al: Sculpturing the glans in phalloplasty. Plast Reconstr Surg 92:157–161, 1993.)

This free flap was incorporated in the infraumbilical midline skin flap used to fashion the shaft of the neophallus. Its distal paddle was then folded outward and backward to cover the tip of the pedicle flap (Fig. 66–5). Sophisticated methods such as these, combining pedicled and free flaps or even two free flaps, do not always lead to better results.

The same applies to transformer flaps and two-stage procedures using an Esser inlay graft.[14–16] As the researchers remarked in their original article, the cricket bat–transformer flap design sacrifices some phallic length for width, and additional debulking procedures may be needed.[14]

OPERATIVE TECHNIQUE

I have obtained superior cosmetic and functional neophallic results after radial forearm phalloplasty applying the Chinese tube-within-a-tube roll technique.[3] Like Chang and Hwang and others, I prefer to use triangular flaps at the distal end of the flap to give the phallus a conic glans.[2, 17–19] To allow the urethra to reach the tip of this conic glans, it is designed nearly as long as the covering radial part of the flap that includes both triangular flaps. A sagittally slit aspect of the urethral orifice is obtained by folding the triangular tips of both distal tongue flaps inward to fit in corresponding slits in the distal urethra (Fig. 66–6).[3] This also prevents meatal stricture (Fig. 66–7).

To simulate the coronal ridge, I use the Norfolk modification of the Munawar technique. The circumferentially dissected and distally based skin flap may be designed slightly wider than the skin used for the neophallic shaft to obtain a larger coronal circumference. Its donor area is covered with a thin split-thickness skin graft to prevent

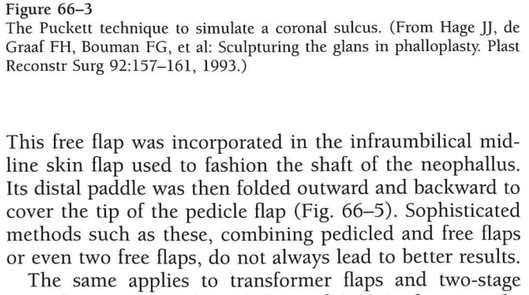


Figure 66–4
The Stanford technique using only the infraumbilical flap for phalloplasty. (From Hage JJ, de Graaf FH, Bouman FG, et al: Sculpturing the glans in phalloplasty. Plast Reconstr Surg 92:157–161, 1993.)

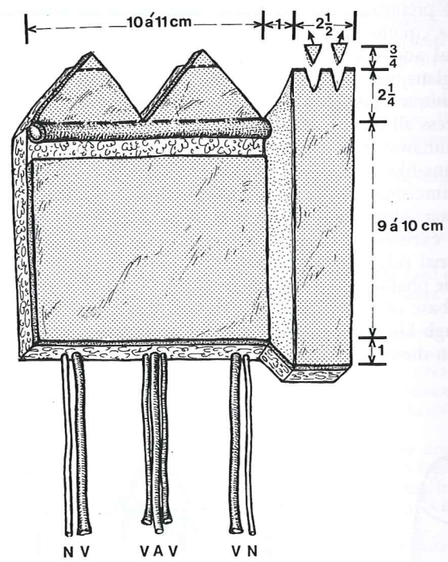


Figure 66–6
Applying the tube-within-a-tube roll technique, triangular flaps at the distal end of the flap are designed to give the phallus a conic glans. To allow the urethra to reach the tip of this conic glans, it is designed nearly as long as the covering, radial part. To obtain a sagittally slit aspect of the urethral orifice, as well as to prevent meatal stricture, the triangular tips of both distal tongue flaps are folded inward to fit in corresponding slits in the distal urethra. A circumferential skin flap is dissected and sutured to its own base to form a coronal ridge. (From Hage JJ, de Graaf FH: Addressing the ideal requirements by free flap phalloplasty: Some reflections on refinements of technique. Microsurgery 14:592–598, 1993.)

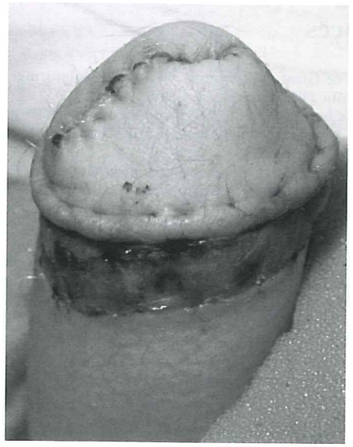


Figure 66–7
Direct postoperative result of sculpturing of a glans in free-flap phalloplasty. To prevent neomeatal strictures, no circular suture line is included.

proximal traction on the coronal skin, as well as to obtain extra constriction of the collum glandis by shrinkage of the skin graft. Using a genitoperineal skin graft adds to the circumcised appearance of the neoglans thus created.[14] Skin grafts, vaginal grafts, or tattooing techniques may help to accentuate the glanular aspect of the neophallic tip but are used neither primarily nor secondarily in my clinic.[15, 20, 21]

In cases in which a pedicled flap is used for phalloplasty, the Norfolk modification may also be used. In such cases, I usually postpone construction of the corona and collum glandis until approximately 1 year after phalloplasty.[1]

DISCUSSION

The Norfolk modification of the Munawar technique may successfully prevent flattening of the coronal ridge in slim patients (Figs. 66–8 and 66–9).[1, 2] More sophisticated and risky methods of transforming or combining flaps are not required in these cases. In obese patients, the coronal ridge is usually lost, even in cases in which the circumferential skin flap was initially designed wider than the rest of the flap (Fig. 66–10).[7] For these patients, no technique seems to suffice, because methods that fold the glans part of the flap proximally to cover the distal part of the flap may also be complicated in these patients.[9, 10, 14] Moreover, Horton and Dean already remarked that the corona may be considered adequate to camouflage the artificial aspect of the neophallus only if the neophallus is satisfactory in length.[7] This is not to be expected when using these methods.



Figure 66–9
Result of the Norfolk modification in another slim patient, 2 years after free-flap phalloplasty.

As an alternative, just a skin graft may be applied to the subcutaneous tissue at the tip of the pedicled or free neophallic flap during the actual phalloplasty. This results in a small visible glanular part at the tip of the phallus, surrounded by a rather distally projected circumferential ridge.[1, 22] A noncircumcised appearance is thus obtained (Fig. 66–11).

The issue of sculpturing a neoglans in total phalloplasty has been addressed. In cases in which a micropenis needs to be augmented, the existing glans may be lifted off



Figure 66–8
Result of the Norfolk modification of the Munawar technique in a slim patient, 3 years after radial forearm free-flap phalloplasty.

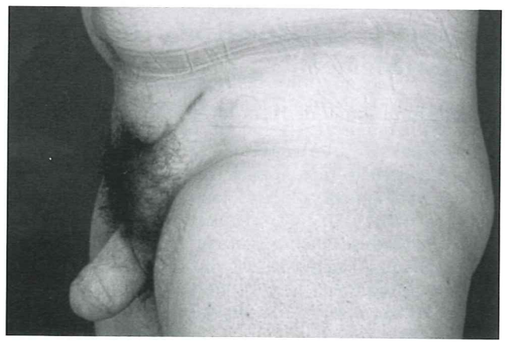


Figure 66–10
Result of the Norfolk method in an obese patient, 2 years after radial forearm free-flap phalloplasty. The coronal ridge is lost.

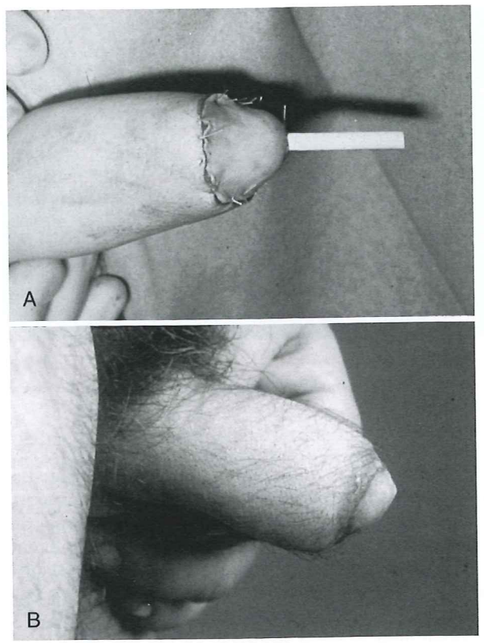


Figure 66–11
When the neophallic subcutaneous tip, at phalloplasty, is covered by a skin graft only (*A*), a noncircumcised appearance is the result 3 years after surgery (*B*).

the corpora cavernosa to be transferred to the tip of the innervated flap used for penile shaft augmentation. I have considered doing so in ectopia vesicae cases but found the dorsal neurovascular bundle not to be suitable for microsurgery owing to surgery previously performed on the penis. In female-to-male transsexuals, the hormonally induced hypertrophy of the clitoris has not been sufficient to allow for a cosmetically appealing result. However, as a functional unit, the natural glans is generally superior to one surgically constructed. A technique that will be universally successful is still to be developed.

Acknowledgment

I am grateful to Ruud de Haan for his artwork.

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CHAPTER

67

Penile Prosthesis Implantation After Total Phalloplasty

GARY J. ALTER
GERALD H. JORDAN
DAVID A. GILBERT

The history of attempts at creating penile rigidity for intercourse in patients having undergone total phalloplasty dates back to 1936, when Borgoras used rib cartilage inside of a tubed pedicle flap construction. For decades, rib cartilage was used; however, it frequently warped and often did not provide adequate rigidity. Nonvascularized bone grafts were also tried, but they inevitably reabsorb. Acrylic splints and semirigid and inflatable prostheses all have been used. In 1978, Puckett and Montie used a single-cylinder hydraulic penile prosthesis in a groin flap. Owing to the high incidence of complications, which include extrusion, migration, seroma, and infection, many surgeons stopped using prostheses. Laub makes a space for temporary insertion of a baculum or stiffener. A neophallus may occasionally have enough intrinsic stiffness to allow intercourse, and others have claimed that intercourse can be successful by using a compressing external prosthetic device. These external prostheses, however, are not available at the time of this writing.

To avoid problems of prosthetics, Biemer includes a portion of the radius in the radial forearm free flap and Sadove uses a portion of the fibula in the fibula osteocutaneous free flap phalloplasty. These investigators propose that carrying the bone on its arterial supply lessens the tendency toward resorption. They make no comment on the propensity of bone to remodel in the presence of force or, in this case, the lack of stressing forces. Biemer has, in fact, reported some bone resorption, and the remaining radius in the arm is susceptible to fracture. Sadove claims adequate persisting fibula bone in the neophallus.

The radial or ulnar free fasciocutaneous forearm flap is currently the most common choice for total phallic construction and free flap penile reconstruction. An aesthetically pleasing sensible neophallus can now be created to enable patients to void while standing. However, providing adequate rigidity for sexual intercourse remains a difficult problem. The radial or ulnar artery is microsurgically anastomosed usually to the inferior epigastric artery or to a vein interposition graft to the common femoral artery. The cephalic vein and the venae comitantes are anastomosed to branches of the saphenous vein and to the inferior epigastric venae comitantes. The medial or lateral antebrachial nerves are coapted microsurgically to the dorsal nerves of the clitoris in a transsexual or to the proximal penile nerves in a genetic male trauma victim. Nerve coaptation produces both protective and erogenous sensation in a neophallus or reconstructed penis.

Protective sensation guards against skin breakdown by pressure necrosis or shear forces. The sensible neophallic construction using the forearm free flap enables successful prosthetic implantation by decreasing the incidence of extrusion and migration. The implant is inserted after the neophallus has regained sensibility, usually between 12 and 18 months after operation. The neourethra must also be patent and proved durable before implantation; a patient must be free of urinary tract infections and voiding difficulties.

SURGICAL TECHNIQUE

The procedure is performed with the patient in a low lithotomy position. Dissection is carried out through a low suprapubic incision to the pubic periosteum at the base of the neophallus (Fig. 67–1). A space for the implant in the neophallus is made with scissors and dilated with sounds or an Otis urethrotome, carefully avoiding the urethra, nerves, and vascular pedicle (Fig. 67–2). No catheter is placed in the urethra, because catheterization may increase the chance of injury; in fact, having a catheter in place often hinders the dilation process. The distal several centimeters of the neophallus are left undisturbed to provide a cushion for the implant. Through a second incision overlying the ischial tuberosity, a space is made for fixation of the prosthesis proximally (Fig. 67–3). Dilation is performed from the suprapubic incision to the tuberosity

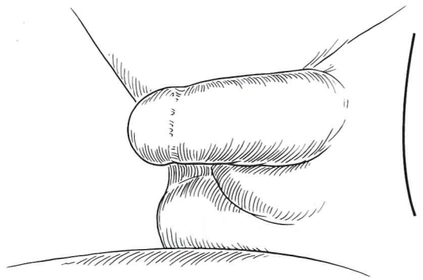


Figure 67–1
With the patient in a low lithotomy position, an incision is made just above the crest of the pubis. The incision is carried down to the fascia and then extended immediately across the pubis into the space at the base of the phallus.

while hugging the inferior pubic ramus (Fig. 67–4). A similar dissection is placed on the opposite side for the second cylinder. We currently use two cylinders in most cases.

Proximal and distal implant migration in total phalloplasty was common owing to lack of a tunica and corporeal bodies, and thus neocorpora cavernosa are created from 14 mm, vascular stretch Gore-Tex (polytetrafluoroethylene) (W.L. Gore & Associates, P.O. Box 1800, Flagstaff, AZ 86002). The implant rod or cylinder is enclosed within the sleeve of Gore-Tex. The distal and proximal ends of the sleeves are closed, and strips or struts of Gore-Tex form the shaft, creating an open system that prevents seroma formation. The cylinders and Gore-Tex corpora are inserted into the flap using the Furlow device. Several sutures of Gore-Tex secure the proximal end of the neotunica to the ischium and periosteum, creating a firm base for the implant. Additionally, the Gore-Tex is sutured to the pubic symphysis. The entire neotunica is not needed in a genetic male with proximal corporeal remnants, and

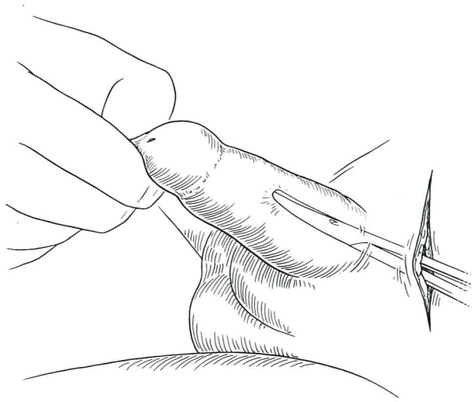


Figure 67–2
Dull-pointed Metzenbaum scissors are used to dilate/dissect the space in the flap to allow placement of the cylinders. Dilation can be facilitated by using an Otis urethrotome.

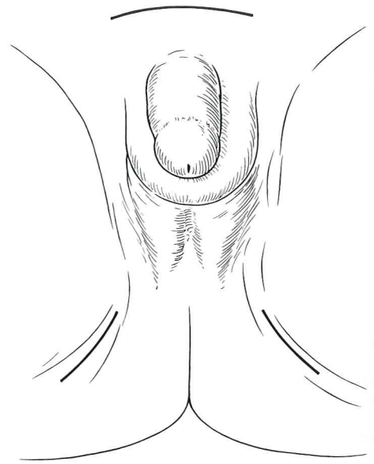


Figure 67–3
Counterincisions are then created either unilaterally or bilaterally over the ischial tuberosity. The dissection is carried down to the tuberosity, and the periosteum is then elevated.

thus a circumferential Gore-Tex strip located proximal to the struts is sutured to the remaining tunica. Tubing from an inflatable cylinder exits through a slit in the neotunica and is secured by tightening the Gore-Tex around the tubing. If a multicomponent inflatable implant is used, the reservoir is placed as usual in the space of Retzius. The pump is inserted in the scrotum in a genetic male or in the neoscrotum in a transsexual (Fig. 67–5).

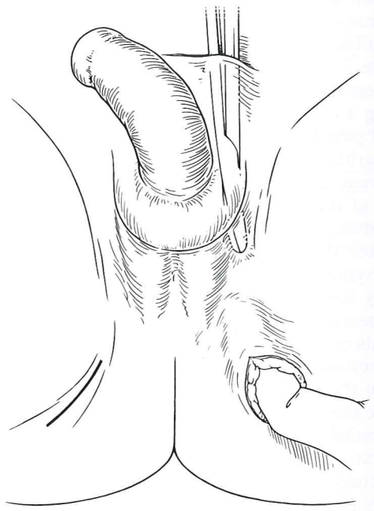


Figure 67–4
Dull Metzenbaum scissors are used, hugging the pubis, to create a space either unilaterally or bilaterally to allow for extension of the proximal portion of the cylinders to the area of the ischial tuberosity.

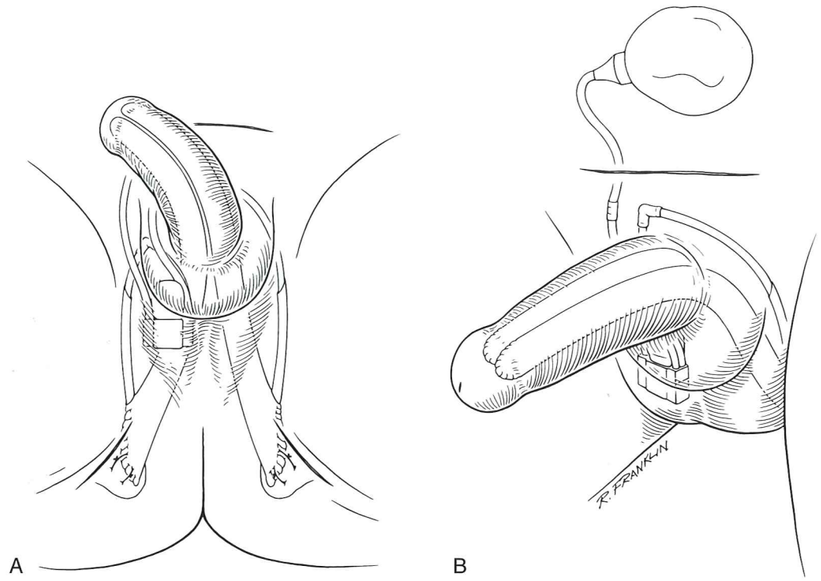


Figure 67–5
A: The device cylinders are placed in Gore-Tex as discussed. The proximal aspect of the cylinders is attached to the periosteum of the ischial tuberosity using Gore-Tex suture. The Gore-Tex is sutured together, beginning at the level of the pubis, and is affixed to the undersurface of the pubis. *B*: A space is developed in the dominant side of the hemiscrota/labia majora. The pump is placed there, and appropriate connections made. In the case of a hydraulic multiple-component prosthesis, a space is created in the space of Retzius for placement of the reservoir, and the final tubing connections are made.

Two rods or cylinders are usually placed, but sometimes only one cylinder or rod fits in the neophallus. Controlled expansion cylinders (American Medical Systems Model 700 CX or CXM) are used. The amount of rigidity and the aesthetic result are greatly improved with the use of two cylinders or rods. We have had extensive experience with the Duraphase device and have found it to be an excellent device in this patient population.

Using TLS drains (Porex Surgical, 4715 Highway, College Park, GA 30349) for 2 days decreases the incidence of postoperative infections and seromas (Fig. 67–6). An aminoglycoside and broad-spectrum antistaphylococcal an-

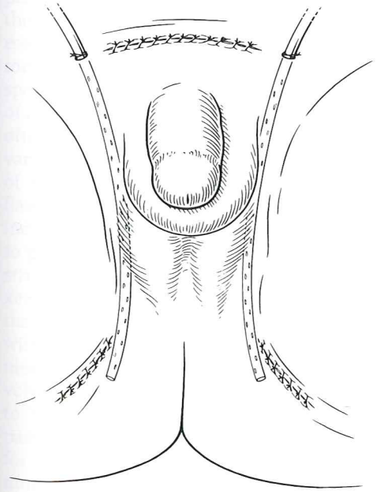


Figure 67–6
The incisions are closed in layers. TLS drains are brought out through separate stab incisions adjacent to the suprapubic incision, and the drain tubing is extended along the space of dissection of the cylinders. Drains in any case are left in no longer than 48 hours.

tibiotic (usually vancomycin) are given preoperatively and continued for 72 hours. They are then replaced by an oral cephalosporin for 14 days.

CONCLUSION

Microsurgical creation of a sensible neophallus from a forearm free flap enables successful insertion of an implant. If no sensation occurs or if the neophallus was created from an insensate flap, sural nerve interposition grafts are coapted to branches of the pudendal or dorsal nerves and laid into the neophallus; it is hoped that they will form sensate neuromas (neurotization). Once sensation is present, a semirigid or inflatable penile prosthesis is inserted. If a patient has poor sensation, a hydraulic penile prosthesis is the implant of choice. The patient must be made aware of the significant chance of future complications such as erosion.

A Gore-Tex neotunica with struts allows implant fixation and stabilization, thereby decreasing previously noted complications. Seromas and infection are decreased by using preoperative and postoperative antibiotics and TLS drains. The overall success rate early in our experience was approximately 60%. After the initial learning curve in those initial 10 implants, we revised our technique to include the drain and antibiotic recommendations already mentioned. Additionally, the dilation technique described evolved during these initial cases; the prosthesis was previously implanted by opening the flap. Our experience now includes more than 20 cases with an overall success rate of about 80%; only one explant has occurred in our last 10 implants. That complication occurred because of spontaneous extrusion of one of the cylinders 8 months after the implant procedure.

Suggested Readings

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MISCELLANEOUS

CHAPTER

68

Surgical Management of Anterior Urethral Strictures

LEONARD ZINMAN

Complex strictures of the anterior urethra constitute the most challenging pathologic findings facing reconstructive urologic surgeons. The anatomy and character of these strictures uniquely differ from those of the posterior or prostatomembranous urethra in that they involve the enveloping corpus spongiosum by either a stenotic or wide-lumen spongiofibrosis that often defies accurate assessment and long-term resolution. Strictures are essentially scars of various depths and densities replacing various portions of the spongiosa with loss of urothelium and subsequent circular contracture of the lumen. The crucial features that dictate the appropriate form of treatment for stricture include the pathology of the stricture process, the intended natural progression, and superimposed iatrogenic complications. Strictures have plagued humankind since the beginning of time, but times have changed, and gonorrheal urethritis, the historical basis of strictures, has been replaced by urethral instrumentation and external trauma as the common causes of stricture disease.[1] This disease is essentially a cylindric envelope of fibrotic and inflammatory tissue that has partially or totally replaced the corpus spongiosum and is often surrounded by a variable degree of avascular, fibrotic periurethral tissue. Strictures are most often located in the proximal portion of the urethra and vary in length, depending on the etiology and the extent of prior endoscopic treatment and instrumentation. Inflammatory strictures continue to appear, with a decreased incidence but with greater length than those secondary to gonorrheal urethritis. The most common inflammatory stricture encountered today is that associated with balanitis xerotica obliterans (lichen sclerosus et atrophicus) and one that often involves the entire urethral length but presents with the deceptive appearance of being limited to the distal meatal and submeatal urethra. This disease classically involves the glans and prepuce but may vary in its extent to include the entire penile skin along with extensive panurethral disease. On rare occasions, it may be the basis for incapacitating scrotal and penile edema. A significant number of strictures have been designated to be of unknown origin but are presumed to follow infection, with a history clouded by the prior effects of repeat instrumentation. The widespread indiscriminate use of multiple endoscopic urethrotomies has further complicated stricture severity by compounding the progressive development of a fibrotic and inflammatory response that partially or totally replaces the corpus spongiosum and produces an unfavorable bed for subsequent urethroplasty.[2] Attempts to classify stricture disease on the basis of depth and length of fibrosis have been thwarted by the difficulty identifying the extent of wide-lumen spongiofibrosis that is not visualized by either traditional retrograde urethrography or contemporary methods of urethral sonography.[3] The mainstay of staging continues to include urethroscopy; oblique, antegrade, and fluoroscopically monitored retrograde urethrography combined with the use of vascular balloon; and standard bougie calibration.

SURGICAL ANATOMY

Because the location and length of a stricture ultimately dictate the appropriate surgical procedure, it is best to consider the urethra as divided into five separate segments.[4] The proximal two divisions are the prostatic and membranous portions, which can be considered together because they both are difficult to access and harbor a sphincter-active area below and proximal to the pubic arch. The anterior urethra needs to be differentiated further into a proximal bulbar or bulbomembranous urethra, a pendulous division, and a submeatal portion or fossa navicularis, because anastomotic and substitution procedures have specific limitations based on this anatomy. The bulbar and membranous segments need to be considered as a unit because the repair of these two locations requires similar exposure and tissue transfer techniques, but the membranous component can be difficult to distinguish from the bulbous component by imaging assessment. The urethra itself is central in location, as it passes through the pendu-

lous section of the corpus spongiosum but changes to a more dorsal, eccentric location in the proximal bulbar site. This anatomic feature permits a relatively avascular proximal dorsal urethrotomy if the corpus spongiosum is first mobilized circumferentially.[5] The blood supply to the genitalia arises from both the internal and external pudendal systems. The penile skin circulation comes from the external pudendal vasculature, both deep and superficial. This vascular tree arborizes with the scrotal blood supply from the scrotal and perineal branches of the internal pudendal.[6] This biaxial system feeds the skin of the penis and scrotum through perforators in a fasciocutaneous complex that permits safe retrieval of skin islands from both penis and scrotum for the entire anterior urethra. The blood supply to the corpus spongiosum arises entirely from the common penile division of the terminal portion of the internal pudendal but divides into a bipedal system. The proximal system consists of the bulbar arteries, which communicate with the distal system coming from the dorsal artery of the penis in a retrograde manner through the glans penis and spongiosa. These two circulations maintain viability of some of the most fibrotic bulbous urethras after transection, partial excision, and a roof-strip anastomosis, if properly mobilized. A unique anatomic aspect of the penile skin is the subdermal blood supply, which maintains viability of all remaining donor site skin after a cutaneous island has been retrieved with the entire dartos fascial envelope and its axial pedicles.

ASSESSMENT OF ANTERIOR URETHRAL STRICTURE DISEASE

Patients with urethral strictures commonly present with a pattern of the insidious onset of irritative and obstructive voiding symptoms, which they have often tolerated for years. On occasion, they may have urinary retention, recurrent responsive urinary tract infection, or spontaneous meatal bleeding on presentation. The physical examination often reveals a firm, almost nodular, palpable urethra that represents advanced spongiofibrosis or periurethral disease. This is an important observation because attempts to manage a palpable stricture with dilation or urethrotomy are futile. Careful examination of the penile and glans skin may reveal various amounts of balanitis xerotica obliterans, which alter the choice of skin substitute used in the repair and forewarn the surgeon of the presence of a more extensive stricture. The anatomy and the character of a stricture ultimately dictate its future course and management. Failure to recognize and define the extent of proximal and distal wide-caliber spongiofibrosis is the major cause of recurrent stricture. This cryptic phenomenon may best be defined by careful scrutiny of retrograde urethrographic studies performed with monitoring fluoroscopy as well as hard-copy silhouettes and the endoscopic examination using both adult and pediatric instruments. Retrograde balloon catheter bougienage has been invaluable during intraoperative evaluation of a stricture when the surgeon is trying to pinpoint the proximal margin of disease. This is best achieved by introducing a number 5 Fogarty catheter, as you would a filiform, distending the balloon with 1 ml (26 French) and withdrawing the balloon until an obstructive point is identified. Wide-caliber spongiofibrosis is subtle and difficult to assess. At this point, endoscopy can be a helpful guide in evaluating an abnormal, pale, rigid urethra that appears radiologically equivocal. This disease is best defined during surgical urethrotomy, when a fibrotic wall can be compared with the normal vascular bed. The question of extension of a stricture from the bulbar urethra across into the transsphincteric membranous segment can be elusive on routine retrograde urethrography. A micturating study may be an additional aid because involvement of the posterior urethra changes the surgical repair dramatically.

OVERVIEW AND GENERAL PRINCIPLES OF URETHRAL STRICTURE MANAGEMENT

Urethral reconstruction has evolved during the past decade in an increasingly complex manner, with technically more challenging tissue transfer methods that fall into the general category of substitution and anastomotic techniques. Regenerative nonsurgical conservative management of urethral strictures includes urethral dilation, direct-vision urethrotomy, intermittent self-dilation, and the adjunct of an implantable stainless steel cagelike stent.

Surgeons embarking on both anterior and posterior urethral reconstruction have at their fingertips a growing armamentarium of surgical procedures that can be selectively applied to specific strictures. The length and location of a stricture, prior failed surgical repair, adverse periurethral tissue beds, and skin diseases, such as balanitis xerotica obliterans, ultimately dictate treatment selection, but optical urethrotomy classically remains the first-line option and standard of care for newly diagnosed strictures that are less than 4 or 5 cm in length.

Urethroplasty should seriously be considered early in the course of all refractory strictures that do not respond to adequate urethrotomy and a 3-month course of self-dilation. All panurethral strictures, hypospadias, complex bulbomembranous pathologic conditions, and segmental loss of the urethra are best managed initially by an appropriate open reconstructive procedure. Urethral dilation continues to be the mainstay of management of strictures in older or poor-risk individuals who require infrequent bougienage, men with postprostatectomy transsphincteric stricture when continence is an issue,[7] and those few patients in whom formidable open urethroplasty has failed and who wish to be treated conservatively. A patient who is selected for a formal open urethroplasty is carefully and exhaustively informed about the potential complications of the procedure, a realistic expectation of the voiding pattern, long-term outlook, and the subsequent need for 5 to 10 years of surveillance.[8]

Surgical repair of a proximal or panurethral stricture is performed with the patient in the dorsolithotomy position, without exaggerated flexion of the thighs. The legs are supported in well-padded dilation and curettage or Allen stirrups with pneumatic compression boots to aid in protection from pressure-induced nerve injury. In patients with large, muscular, heavy legs, the modified low lithotomy position is changed to a supine position every 3 or 4 hours to help prevent injury to the common peroneal nerve as well as the development of compartment space syndromes.[9]

Certain adjunctive measures have as much of an impact on the outcome of urethral reconstruction as the surgical procedure selected. Instruments that permit proper exposure and gentle movement of tissue include a perineal self-retaining ring retractor, a Gelpy single-tooth retractor, a posterior long-blade nasal speculum retractor, bipolar cautery, fine Bishop-Harman forceps, short and medium-length tenotomy scissors, a halogen headlight, and exclusive use of fine Monocryl and Vicryl sutures.

An aggressive stricturotomy with an extension into normal urethra for 2 or 3 cm proximally and distally is a crucial measure in preventing a recurrent stricture. A severely fibrotic spongiosa with a pinpoint lumen in the bulbous urethra needs partial excision after circumferential mobilization and a roof-strip anastomosis before the onlay patch. This latter adjunct enhances the ability to achieve a uniformly patent lumen of even caliber in a proximal urethral substitution procedure.

Wide spongiosal mobilization is required in the presence of a fibrotic urethra to avoid the serious sequela of a ventral chordee. The urethral onlay augments are constructed over a 28 to 30 French catheter template when a graft is used and over a 22 to 24 French catheter when a flap is used. In all patients, diversion is instituted by suprapubic cystotomy for 3 weeks and a number 14 Silastic intraurethral stent is left in place for 7 to 10 days. Patients are monitored at 3 weeks by voiding cystourethrography to identify extravasation before removing the suprapubic cystostomy tube, and retrograde urethrography with flow studies is performed at 3 months, 8 months, and annually thereafter if a change in voiding pattern, urinary tract infection, or decreased flow rate develops.

REGENERATIVE PROCEDURES IN STRICTURE CARE

The simplest and oldest form of stricture therapy is urethral dilation, a procedure that is rarely curative but manages to maintain an acceptable voiding pattern in older men who have stable strictures without the complexity of fistulas, false passages, radiation damage, or full-length spongiofibrosis.

Stricture dilation should be performed gently and gradually, proceeding to the point where significant resistance is felt or pain is intolerable. During the initial period of managing a new stricture, 4- to 7-day intervals are required between each dilation using an indwelling catheter and gentle insertion of filiforms with the use of a flexible cystoscope to avoid false passage until a lumen of 24 French is achieved. There is no place for blind introduction of filiforms without the use of flexible endoscopy. Traditional urethral dilation has been replaced in large part by internal urethrotomy with or without self-dilation or selective use of the newly developed steel alloy urethral stents.

The perception that direct-vision urethrotomy is more effective than dilation has been questioned by many reports of lower cure rates for urethrotomy than had previously been noted.[10–12] A study by Steenkamp and colleagues[13] showed that optical urethrotomy was no more effective than standard dilation in a prospective study of 210 men randomized to undergo filiform dilation (106) or optical urethrotomy (104) on an outpatient basis. Recurrence at 12 months was significantly lower in patients with strictures shorter than 2 cm (40%) as opposed to dilation or urethrotomy for strictures that were longer than 4 cm (80%). No other specific patient or stricture characteristic to predict recurrence was identified in this report, except for length. The researchers recommended dilation for strictures less than 2 cm and direct-vision urethrotomy only when urethral dilation was not possible because of a nonnegotiable stricture. This procedure should be limited exclusively to the bulbar urethra, where a deep cleft is possible.

The logic behind urethrotomy is that a focal, nontraumatic, well-placed incision will create a deep enough cleft in the spongiosa that it will develop an epithelial cover to prevent cross-adherent contracture. The ideal location is the proximal urethra, where there is a thick, relatively normal spongiosa. A deep incision is created at the 6 o'clock position to avoid injury to the corpus cavernosum circulation using a number 5 vascular balloon catheter as a guide to the distal margins of the stricture. When urethrotomy is performed in the pendulous portion, two incisions may be made at the 3 and the 9 o'clock locations to prevent increase in periurethral fibrosis and subsequent ventral chordee. An indwelling silicone-coated catheter should be used routinely for about 7 days to prevent the noxious wound effects of urinary extravasation on an open urethral incision. The value of a subsequent 2- to 3-month posturethrotomy course of self-catheterization dilation is controversial and not clearly proved to enhance a durable, patent lumen.[12, 14]

The more recent development of an indwelling endoprosthetic stent to prevent recurrent stricture after urethrotomy appears to show some promise, but follow-up is less than 5 years, with a low incidence of complications noted at this early date.[15] The present stent is a nonmagnetic alloy of steel that is woven into a tubular mesh with self-expansile properties that produce a 42 French internal lumen diameter.[15] It is currently recommended for use in short strictures located in the bulbar segment of the urethra but has been used successfully in transsphincteric and postradical prostatectomy vesical neck contractures when combined with an artificial AMS 800 urinary sphincter. Recurrent stricture developed in patients with long, posttraumatic, or complete disruption strictures with significant intraluminal tissue growth.[16]

This stent also fares poorly after failed substitution urethroplasty. Most of the obstructing tissue developed at the proximal or distal margin and was managed by transurethral resection of the hypertrophic scar and the addition of another stent either in tandem or placed inside the first stent.[11] Stent migration may occur early, but no instance of erosion, infection, encrustation, or erectile dysfunction has been recorded.[17] We have treated four patients with recurrent strictures and a Urolume stent by segmental resection of the urethra and stent followed by a roof-strip anastomosis combined with a penile or scrotal island flap

onlay urethroplasty. The results of bulbar anastomotic urethroplasty are so successful that short posttraumatic strictures in this location would be better managed surgically rather than to invite the potential risks of a prosthesis in someone with decades of life to live. The short-term results with this technique have been satisfactory, and it will undoubtedly have an important place in the future management of strictures.[18]

SURGICAL REPAIR OF URETHRAL STRICTURES

Definitive resolution of stricture disease is obtained by the appropriate selection of an open reconstructive surgical procedure that either excises the lesion or corrects the obstructed lumen with an extensive stricturotomy and repair. The repertoire of techniques that has been introduced during the past 10 years continues to evolve and will undoubtedly follow the tissue transfer innovations emerging from the investigation of wound care and problems with tissue remodeling noted in other organ systems. The ultimate consistent success of urethroplasty requires techniques that are less demanding in terms of time and the need for specialized skills to avoid the catastrophic results that occur today in the hands of surgeons who infrequently perform this surgery.

Complex strictures in patients in whom conservative maneuvers fail may undergo reliable repair with a 5- to 10-year sustaining success of a stricture-free lumen in 85% to 90% of the cases using one of five contemporary, modified, newly developed concepts.[8, 19] These include circumferential excision and end-to-end anastomosis, penile island flaps, scrotal island flaps, and free grafts of buccal mucosa or skin with and without muscle buttress as well as the multistage mesh graft procedure. The exact role of each of these operations in the management of various strictures has yet to be defined clearly and continues to remain a reflection of the surgeon's bias and experience. The emerging algorithm in stricture care depends, again, primarily on location, length, extension into the transsphincteric segment, and the availability of healthy penile and scrotal skin.

CIRCUMFERENTIAL EXCISION AND PRIMARY END-TO-END ANASTOMOTIC URETHRAL REPAIR

Primary anastomotic urethroplasty is the ideal method of reconstruction and the gold standard for the spectrum of urethral stricture surgery because urethra is clearly the best substitute for urethra. This operation should be limited exclusively to the proximal bulbar and bulbomembranous segments of urethra for posttraumatic strictures less than 2 cm in length, because the elasticity of the pendulous urethra is inadequate to prevent ventral chordee. A tension-free, watertight, spatulated, end-to-end anastomosis is dependent on adequate mobilization of the corpus spongiosum and division of the enveloping Buck's fascia to permit an average extension of 4 cm of elastic lengthening of the proximal urethra. In patients in whom potency is not an issue, 3 or 4 cm of a well-defined posttraumatic stricture can be excised and subsequently repaired by this technique without the concern that a ventral erectile deformity will develop.

Strictures that occur secondary to instrumentation or urethritis are rarely suitable for this technique because they either are longer or may have significant spongiofibrosis that interferes with the normal intrinsic elastic lengthening required for a tension-free connection.

Technique

This procedure is performed with patients in the low lithotomy position, counseling them beforehand that an alternative procedure might be required if a more extensive, wide-caliber stricture is encountered unexpectedly. A midline bifurcated perineal incision is made and carried deep to the bulbocavernosus, which is divided and reflected laterally without injuring the scrotal circulation in the event that a penile or scrotal flap is required (Fig. 68–1*A*). A self-retaining ring retractor (Turner-Warwick) is used to maintain exposure, and a 5 French vascular balloon catheter is introduced into the urethra like a filiform, distended with 1 ml of saline solution, and partially withdrawn to identify the proximal margin of the stricture (Fig. 68–1*B*). A 24 French bougie is then inserted in a retrograde fashion to define the distal limit of the stricture and establish that it is suitable for an anastomotic approach by measuring the distance between these two bougies. This judgment can also be aided by transperineal ultrasonography when the urethrographic length is measured to be 2.5 to 3 cm.[3]

This study is followed by careful but complete mobilization of the bulbospongiosus from the intercrural membrane and membranous urethra to the suspensory ligament to achieve a 3- to 5-cm increase in length. This length is obtained by virtue of releasing the intrinsic elasticity of the bulbar component of the spongiosa (Fig. 68–2*A*). The proximal and distal spongiosal blood flow is controlled with vascular clamps or an occlusive drain tourniquet with the bougie and Fogarty catheter in place (Fig. 68–2*B*). A distal ventral urethrotomy is made to open the urethra in its normal part against the bougie, extending proximally to the midportion of the stricture (Fig. 68–3*A*).

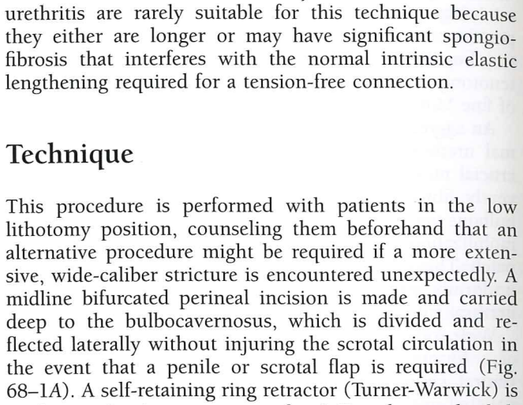


Figure 68–1
A: A midline bifurcated perineal incision offers good exposure for proximal bulbospongiosal mobilization. *B:* Colles' fascia is divided and reflected laterally without injuring the scrotal or penile circulation. (From Lahey Hitchcock Clinic, Burlington, MA.)

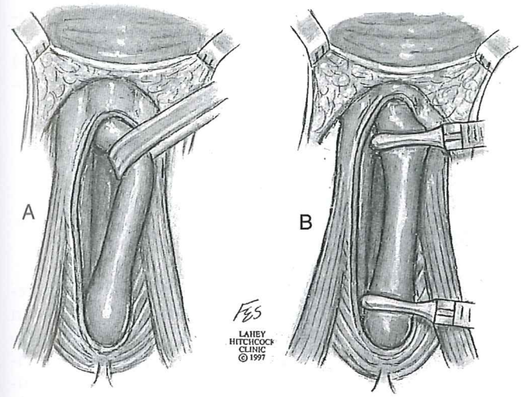


Figure 68–2
A: The bulbospongiosus is mobilized from the membranous urethra to the suspensory ligament to release its intrinsic elasticity. *B:* The corpus spongiosum blood flow is controlled with vascular clamps or occlusive drain tourniquet. (From Lahey Hitchcock Clinic, Burlington, MA.)

To gain vision and excise the precise margin of the fibrotic urethral wall, the stricture is transected at midpoint, and suture tags are placed on both ends (Fig. 68–3*B*). The proximal urethra is incised on its dorsal side, spatulating the lumen wall well into normal tissue (Fig. 68–3*C*). The fibrotic wall can be distinguished readily and excised without much question of its extent, and the two free ends of the urethra are easily brought together without tension if the bulbospongiosus has been mobilized adequately. If tension exists, the distal end can be mobilized farther up to the penile midshaft, with the potential for some ventral chordee. The course of the urethra can be shortened further by separating the proximal corpora cavernosa and incising the intercrural membrane. A 2-cm spatulation should be made of both ends, which may, at times, include some fibrotic wall at this point.

A 20 French suprapubic cystotomy Silastic Foley catheter is placed by introducing a fenestrated van Buren sound with an exaggerated curve to execute a pull-in technique through an incision over the palpable tip, withdrawing the catheter into the bladder from the urethra before releasing the sound from the end of the Silastic catheter.

The inner aspects of the proximal and distal spatulated lumen are first approximated with three sutures of 4-0 Monocryl at the 12 o'clock position, with the knots on the outside (Fig. 68–4*A*). The ends of these three sutures are tacked down to the fascia of the corpora cavernosa to fix the anastomosis while placing all the remaining anastomotic sutures in a uniform manner before finally securing the knots (Fig. 68–4*B*). A number 16 Silastic stent is placed intraluminally at the completion of the anastomosis and sutured to the meatal margin. The bulbocavernosus is approximated with interrupted sutures of 4-0 Vicryl (Fig. 68–4*C*). Colles' fascia is closed with 4-0 Monocryl, and the skin incision is closed completely with interrupted sutures of 5-0 Vicryl.

The urethral catheter is removed in 7 to 10 days, and the suprapubic tube is left for 3 weeks, removing it after

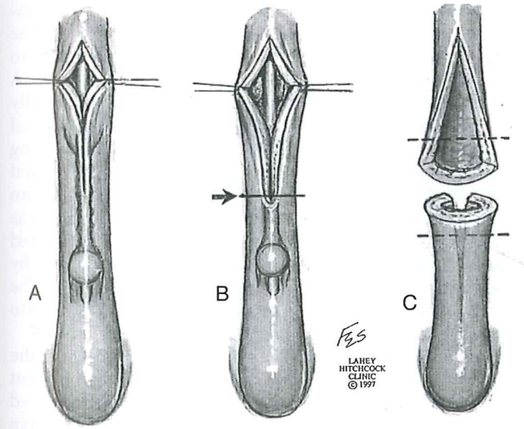


Figure 68–3
A: A distal ventral urethrotomy is initially made into 2 cm of normal urethra. *B:* The urethrotomy is extended proximally to a midpoint of the stricture, where it is transected. The palpable balloon bougie identifies the proximal margin of the disease. *C:* The proximal urethra is incised on its dorsal surface, spatulating the lumen into normal nonfibrotic wall. The diseased edges are excised. (From Lahey Hitchcock Clinic, Burlington, MA.)

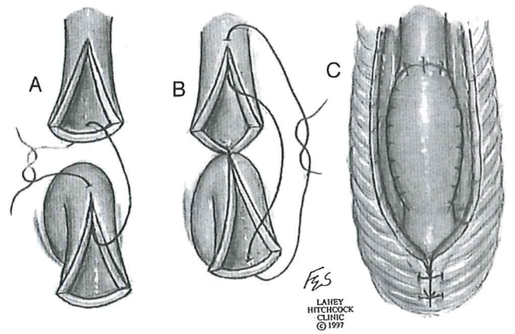


Figure 68–4
A: The inner aspects of the spatulated ends are approximated with three apical sutures of 4-0 Monocryl, which are also tacked down to the fascia of the corpora cavernosa to fix the anastomosis. *B:* The remaining anastomotic sutures are placed in a uniform manner before finally securing the knots. *C:* The bulbocavernosus function can be restored by a midline closure after a watertight spatulated anastomosis is completed. (From Lahey Hitchcock Clinic, Burlington, MA.)

voiding cystourethrography confirms an intact, sealed anastomotic suture line without extravasation. A urine culture is obtained, and the patient is treated with 5 days of antibiotics. Our experience with 43 patients obstructed by short bulbar and bulbomembranous strictures measuring 1 to 4 cm in length and managed by excision and primary anastomosis resulted in a stricture-free lumen in 41 patients (95%). Two failures occurred within 3 months in patients with a 2- to 3-cm stricture and a segment of urethra with a fibrotic wall, which was incorporated as part of the anastomosis. Of these patients, 14 had prior unsuccessful internal urethrotomy, which did not alter the final success, but 3 patients experienced sustained erectile dysfunction. One was successfully treated by an arterial bypass revascularization procedure using the inferior epigastric to dorsal penile artery.

PENILE ISLAND FASCIOCUTANEOUS FLAPS

Penile skin flaps have become the workhorse and mainstay of anterior urethral reconstruction. The use of penile skin as an island one-stage or two-stage procedure has been validated by the observations of long-term success achieved in hypospadias surgery through the decades. These skin islands adapt well to a wet milieu, are nonhirsute, and are well vascularized by a robust biaxial circulation that permits wide mobility. The onlay patch is the most successful design, with the potential for use in every portion of the urethra, depending on the distensibility of the penile skin, a history of prior circumcision, the presence of balanitis xerotica obliterans, and the absence of prior penile surgery.

Orandi[20] first introduced the technique of a penile island flap, which was conceived as a random ventral longitudinal skin strip harvested on a short pedicle adjacent to the penile urethral stricture to be repaired. The penile island, however, is in reality a fasciocutaneous flap with an axial circulation that supplies well-defined skin territories irrespective of the specific penile location or the design.

The penile skin blood supply has been shown by Quartey[21] and Salmon[22] to arise from a group of dorsolateral and ventrolateral branches of the external pudendal artery that arborize with dependable cross-connections from the scrotal branches of the internal pudendal artery. This vascular pedicle is carried on the superficial layer of Buck's fascia, which is the vehicle for penile skin islands. The anatomy of this flap is characterized by two distinct surgical planes: one just deep to the dermis and one below the superficial lamina of Buck's fascia. The superficial plane permits a dissection between the pedicle containing the dartos fascia during flap development. The residual penile skin that is left after extensive mobilization of this dartos pedicle survives by virtue of a unique, rich, supportive subdermal circulation and prevents a penile deformity.

Various penile flap designs can be used for anterior urethral repairs, depending on location and surgeon preference. Ventral longitudinal penile islands (Orandi) and transverse dorsal preputial flaps[23] are particularly suited to the pendulous and submeatal segments. If the ventral preputial tissues are healthy, a transverse ventral flap is ideal for fossa navicularis and submeatal strictures in patients with balanitis xerotica obliterans.[24] Circular preputial[25] and ventral bipedicle island penile flaps (BIPIPS) were developed for panurethral and more proximal bulbomembranous disease.[26, 27]

PENILE FLAP RECONSTRUCTION FOR PENDULOUS AND SUBMEATAL STRICTURES

Short, midshaft, pendulous strictures can readily be repaired by the Orandi ventral linear flap, but this is an uncommon stricture event. Most complex pendulous, meatal, and submeatal strictures that require repair are associated with balanitis xerotica obliterans of the ventral preputial and penile skin and a stricture that extends proximally beyond the penoscrotal junction. Because the dorsal surface of the penis is commonly free of this atrophic, troublesome skin disease, a transverse dorsal preputial flap combined with a lateral or ventral penile skin island resolves most distal urethral disease.

The supine position is usually adequate for exposure of the pendulous penoscrotal and distal bulbar strictures and prevents the lower extremity nerve injury that might occur with a prolonged lithotomy position. In the event that the proximal extent has been misjudged, the patient can readily be placed in lithotomy after the distal urethral pathologic condition has been repaired.

A Fogarty vascular balloon catheter is inserted into the proximal bulbous urethra and drawn out with the distended balloon to help identify the proximal extent of the disease. The presence of hair on the proximal penile skin is marked off, and an incision is started in the ventral shaft of the penis just lateral to the midline, exposing initially the spongiosa (Fig. 68–5*A*). Buck's fascia deep to subcutaneous tissue is reflected off the ventral surface of the spongiosa, where it is readily identified and dissected to the contralateral side where a flap will be developed. A urethrotomy begins distally and is extended proximally well beyond the distended balloon bougie into normal urethra (Fig. 68–5*B*). Bleeding is controlled with a running locked suture of 4-0 plain catgut, and a bridge of submeatal skin is preserved. Some of the preputial and shaft skin can be excised if the patient is disabled by pain or the pruritus of balanitis xerotica obliterans. The urethra is dissected subcutaneously out to the meatus, which is enlarged by lateral extension of the meatal incision (Fig. 68–5*C*). The proximal extent of the urethrotomy should be well into normal spongiosa (2 or 3 cm).

The flap construction is dependent on the length of the urethral defect and the width based on the measurement obtained using a 22 to 24 French catheter template placed against the intact roof strip. The skin incision for the flap begins on the ventral surface after an outline is made with a skin marker. It passes laterally 1 cm proximal to the frenulum and coronal groove into a circumferential extension, depending on the length of skin flap needed (Fig. 68–6*A* and *B*). The skin flap and subcutaneous dartos vascular bundle are dissected laterally, developing the plane underneath the superficial lamina of Buck's fascia all

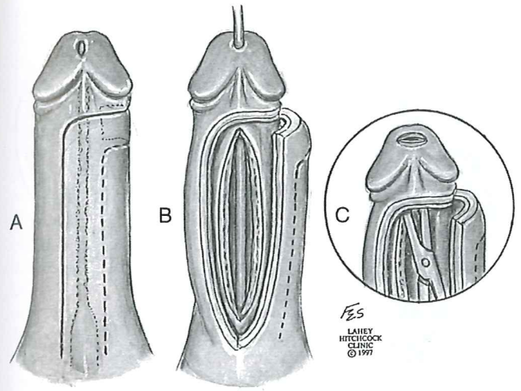


Figure 68–5
A: When the proximal extent of a pendulous stricture has been identified, a midline incision is made medial to the proposed urethrotomy incision, preserving the submeatal shaft skin in preparation for a penile fasciocutaneous flap. *B:* Fascia deep to the subcutaneous tissue (dartos) is reflected off the ventral surface of the spongiosa and dissected to the contralateral side in anticipation of a longitudinal ventral or lateral penile flap. A urethrotomy will begin submeatally and extend proximally into normal urethra. *C:* The urethra is dissected subcutaneously below the glanular and distal shaft skin out to the meatus. (From Lahey Hitchcock Clinic, Burlington, MA.)

the way to the contralateral corpus cavernosum (Fig. 68–6*C*).

A second parallel incision is made lateral to the first, achieving a width of 1.7 to 2.5 cm, depending on the urethral measurements. This incision is deepened into the superficial layer of the subcutaneous tissue, and the flap is created by dissecting in the cleavage plane between the dartos pedicle and the subdermal plexus of vessels. Great care should be taken to prevent injury to the subdermal circulation by keeping the dissection closer to the dartos, avoiding trauma to the dermis. The penile skin is reflected off the vascular pedicle down to the base of the penis, and the dartos pedicle is incised medially to create a mobile flap. The flap is sutured in place, fitting the distal margin of the transverse dorsal circular component under the meatal bridge and suturing first the inner margin with continuous 5-0 Monocryl reinforced with interrupted 5-0 Vicryl.

A number 14 Silastic stent is fixed to the meatal sutures, and the outer side of the patch is sutured in place with running 5-0 Monocryl from distal to proximal apex with reinforcing interrupted sutures of 5-0 Vicryl, widely spaced (Fig. 68–7*A* and *B*). This outer suture line is covered with either some redundant dartos fascia or a separate flap of tunica vaginalis. Any obvious devascularized ischemic skin should be excised and viable skin approximated with a compression dressing that maintains the penis in an elevated position for 5 days. The stent is removed in 7 to 10 days, and micturating cystourethrography is performed in 3 weeks at the time of removal of the suprapubic cystostomy tube. Recurrent stricture is uncommon in pendulous urethral reconstruction because an accurate mucocutaneous anastomosis is easily performed in this location, and the skin flap is rarely ischemic if properly retrieved.

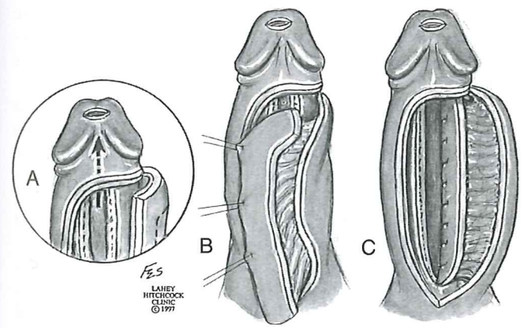


Figure 68–6
A: The skin incision is extended laterally in a hockey-stick design, with the aim of placing the distal flap subcutaneously under the submeatal bridge. *B:* The length of the lateral circumferential incision can be extended around the entire distal penile shaft, depending on the length of the skin flap required. *C:* The skin flap and subcutaneous dartos bundle is separated laterally on the superficial lamina of Buck's fascia all the way to the contralateral corpora. The skin strip is then created and dissected in the subdermal plane until a long, mobile pedicle is developed. (From Lahey Hitchcock Clinic, Burlington, MA.)

BIAXIAL PENILE FLAP FOR BULBAR AND BULBOMEMBRANOUS STRICTURES

The proximal bulbar and bulbomembranous parts of the urethra are the most common locations for strictures and the most challenging sites to treat. The proximity to the

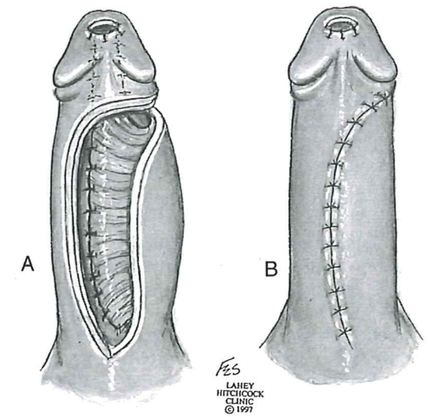


Figure 68–7
A: The medial completed suture line is covered by tacking the subcutaneous vascular tissue over it to the fascia of the corpus cavernosum. *B:* The skin is closed, and a dorsal relaxing incision may be used if tension is found in the closure. (From Lahey Hitchcock Clinic, Burlington, MA.)

distal sphincter and the inaccessible nature of this site in the deep perineum make this urethroplasty a technically more demanding procedure. The most reliable and first choice of urethral reconstruction for this location is the bipedal island penile dartos-based flap (BIPIP), designed and established by Turner-Warwick and Chapple.[26] It is an extremely reliable repair when the length of the stricture does not permit a primary anastomotic procedure. This flap was a natural outgrowth of the Quartey preputial flap and was originally designed to permit the use of penile skin in circumcised patients without the need for total penile subcutaneous dartos mobilization required for the circular flap. It incorporated two robust blood supplies, was nonhirsute, and had the potential of a circular extension to increase its length and mobility so that it could be transferred comfortably to the transsphincteric and prostatic urethra without tension. The hairless distal edge of this flap can readily be used to reach even the bladder neck and to replace simultaneously the bulbar and pendulous urethra. In uncircumcised patients, flap lengths of 17 to 21 cm have been retrieved with the combination of a ventral and distal circular component combined with a scrotal component when a nonhirsute segment exists. Penile strips of skin can also be used as a double composite with scrotal island pedicle flaps when panurethral strictures are too long and burdened by the complexities of fistulas, sinuses, and prior penile surgery. The BIPIP flap concept decreased the ischemic loss of residual penile skin left behind after pedicle mobilization because a dorsal segment of dartos and Buck's fascia remains intact after the flap is transferred.

TECHNIQUE OF BIAXIAL PENILE FASCIOCUTANEOUS FLAP WITH A ROOF-STRIP RESECTION

The standard of care for bulbar and bulbomembranous strictures that are complex and have failed prior treatment is to excise a 2- to 4-cm segment of bulbar roof strip to prevent a complete circumferential replacement. A patient with a proximal stricture may initially be placed in the supine or the lithotomy position, depending on whether the plan is to retrieve the penile skin substitute at the start of the procedure without actually measuring the urethrotomy defect. This limits the time spent in the lithotomy position and therefore prevents peripheral nerve injury. A modified low lithotomy position is adequate with a wedge or gel-pack support under the sacrum and upper buttocks.

The urethra is exposed through a midline bifurcated incision (Fig. 68–8*A*) as for an anastomotic repair. The spongiosa is fully mobilized from the suspensory ligament to the intercrural membrane by separating it from the corpora cavernosa, and a ventral urethrotomy is aggressively extended well into normal, patent distal and proximal urethra over the intraluminal vascular balloon stent. This urethrotomy can be directed onto the dorsal surface if the ventral spongiosal wall is thick and presents the potential for severe bleeding. The narrow segment of urethra is obliquely excised, and the cut ends are spatulated on their ventral sides. These dorsal ends are then sutured

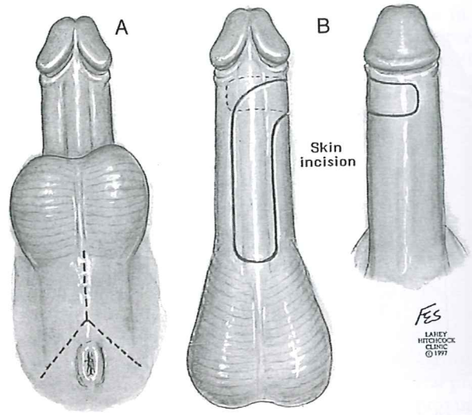


Figure 68–8
A: A penile ventral bipedicle island flap for a proximal bulbar stricture. The urethra is exposed through a midline bifurcated incision. *B:* An appropriate penile flap is outlined with the penile skin maximally stretched, based on the length and width of the prior preparatory urethrotomy measurements. The distal hockey-stick extension is added to the ventral island, creating a penile flap with additional length. (From Lahey Hitchcock Clinic, Burlington, MA.)

together in a tension-free anastomosis with interrupted sutures of 4-0 Vicryl, creating a wider dorsal half of the urethral circumference in preparation for a penile flap to augment and close the urethral defect (see Fig. 68–10*B* and *C*). The defect length and width are measured over a number 24 to 28 Foley catheter template, and suprapubic cystotomy diversion is established by a pull-in technique.

The patient is placed temporarily in the supine position, maintaining perineal wound sterility and cover. A glans suture is placed vertically for traction, and the urethrotomy measurements are used to outline the appropriate penile flap (Fig. 68–8*A* and *B*). The width of this flap varies between 1.8 and 2.5 cm. This is accomplished with penile skin maximally stretched using calipers and a skin-marking pen. The ventral and distal extent of the penile flap is incised just through the dermis into the superficial subdermal plane around the penile circumference, establishing a 240-degree circumference dissection (Fig. 68–8*B*). This dissection is carried onto the proximal scrotum to include the tunica-dartos pedicle and preserve the cross-connections of the internal and external pudendal. The distal transverse incision behind the coronal margin is deepened into the superficial layer of Buck's fascia superficial to the spongiosa and the dorsal neurovascular bundle of the penis as the starting point to lift the penile skin island and its pedicle (Fig. 68–9*A* and *B*). The plane is easily established and extends proximally, incising the lateral border as the dissection progresses and avoiding any major vessels, thus procuring a 240-degree circumferential flap and subcutaneous tissue composite being raised on dartos fascia as the vehicle (Fig. 68–9*C*). The dorsal penile skin and the contralateral shaft skin are maintained in continuity with the glans, thus supporting the subdermal circulation of the remaining skin (Fig. 68–9*C*).

A space is opened to communicate with the prior perineal

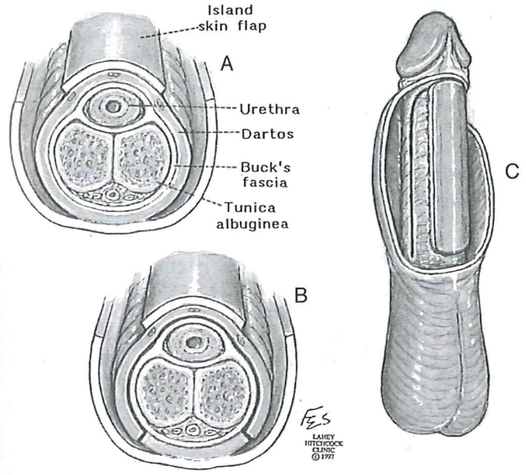


Figure 68–9
A: The dartos fascia is dissected laterally around the penile circumference, avoiding damage to the underlying vascular pedicle and the subdermal plexus. *B:* The dorsolateral portion of the subcutaneous tissue carries the blood supply to the ventral and distal penile skin from the external pudendal vessels. Preserving a dorsal strip of subcutaneous tissue helps maintain residual penile skin viability. *C:* The ventral penile skin island with its subcutaneous tissue pedicle can now be divided from its lateral attachments. (From Lahey Hitchcock Clinic, Burlington, MA.)

dissection, and the tunnel will be formed under the scrotal bridge to reach the prepared proximal urethral defect (Fig. 68–10). Any tension at this point may require further development of the scrotal portion of the pedicle and

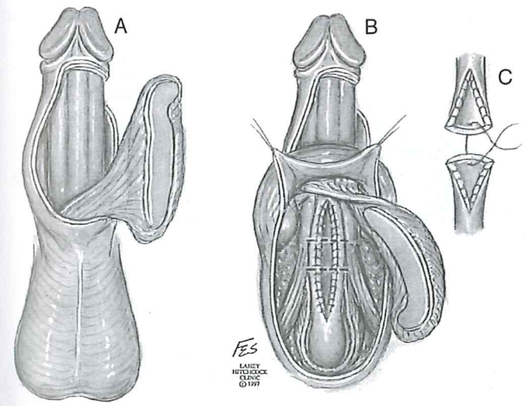


Figure 68–10
A: The penile flap and dartos fascia can be lifted off the spongiosa and corpora cavernosa on the superficial lamina of Buck's fascia. *B:* A wide subscrotal tunnel is developed to reach the proximal bulbous urethra. The narrowest fibrotic segment of urethra is resected. *C:* The dorsal edges are approximated in a roof-strip (or floor-strip) anastomosis with interrupted sutures of 4-0 Vicryl. (From Lahey Hitchcock Clinic, Burlington, MA.)

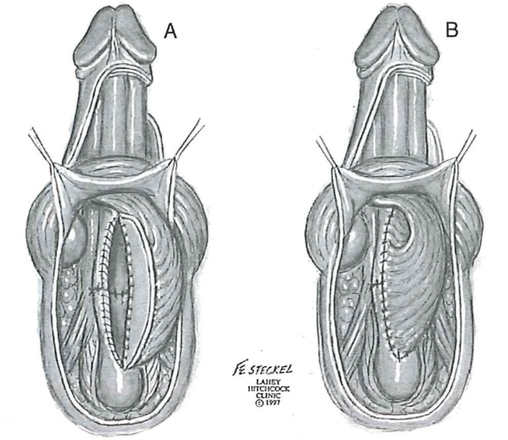


Figure 68–11
A: The skin flap and pedicle are transferred back to the stricturotomy. If tension persists after rotating the patch into the perineum, more length can be achieved by dissecting the pedicle into the proximal scrotum. *B:* The skin flap edges are sutured to the urethrotomy with continuous 5-0 Monocryl reinforced with widely placed interrupted 5-0 Vicryl, and the bulbocavernosus is closed over this to support the repair. (From Lahey Hitchcock Clinic, Burlington, MA.)

lateral division of the penile component of the pedicle. Adequate and viable skin should be available for coverage of the penis using this flap design.[23, 27] The penile flap and pedicle are transferred through the connecting wide tunnel to the perineum and approximated to the urethral mucosal defect with continuous sutures of 5-0 Monocryl reinforced with interrupted 5-0 Vicryl (Fig. 68–11*A*). The redundant skin is excised, if excessive, but the urethrotomy should be extended if it is a matter of 1 or 2 cm of extra length to produce a more uniform lumen (Fig. 68–11*B*).

The bulbocavernosus is overclosed to support this repair and prevent sacculation. This step helps decrease the amount of postvoiding bulbar urethral residual urine. The wound does not need a drain; a 16 French Silastic catheter stent fixed at the meatus suffices. The penile dressing is applied as in the Orandi procedure, and the patient is kept at bed rest for 5 days on suprapubic drainage. Biaxial penile island nonhirsute flap urethroplasty combined with the adjuncts of aggressive use of the extended urethrotomies, partial proximal bulbar urethral excision, and continuous fine Monocryl sutures has resulted in successful, long-term, stricture-free lumens.

GRAFTS

The mainstay and standard of care for urethral reconstruction in the mid-1970s was the full-thickness penile skin graft as popularized by Devine and colleagues.[28] Our early expectations of free full-thickness patches and tube grafts have not been achieved, but the relative simplicity and the numerous potential donor sites are hard to overlook. Grafts are easy to apply, are versatile, have multiple hairless donor

sources, and result in a conduit that most clearly resembles a normally functioning urethra, with rare diverticulum formation. Failure to accomplish this, however, is multifactorial and is associated with the use of an extrapenile donor site, tube graft design, and improper harvesting. The most important negative factor is selection of a patient with a fibrotic or impaired recipient bed in which neovascularity for graft take is unlikely to develop. The best contemporary reported results in graft onlay repairs reveal a recurrent stricture rate of 14% to 30%.[1, 29]

The four major advances in enhancing graft take and rekindling the interest in this technique are the introduction of a buccal mucosal graft, the use of muscle-assisted full-thickness skin graft urethroplasty, the proximal dorsal urethrotomy for graft placement,[30] and the selective application of multistage mesh graft repair for complex and panurethral strictures.

Buccal Mucosal Graft for Urethral Reconstruction

The use of a buccal mucosal patch onlay is a relatively new and promising technique for both pendulous and bulbar strictures. It does not fare well in tubular form or when placed in the transsphincteric portion of the urethra, where graft take is less dependable. Complex hypospadias repairs have been the impetus for the use of buccal mucosa in urethral replacement,[31] but early reports by el-Kasaby and colleagues[32] and Morey and McAninch[33] show superior graft take in stricture reconstruction with short follow-up.

This quality of improved graft take and decreased contracture over full-thickness skin patches is thought to be related to the unique anatomic aspects of oral mucosa. These include a thick epithelium with a large number of basal cells, thin lamina propria with rich vascularity, and a firm body to the graft, permitting greater ease of handling. This tissue has rapid regenerative ability, obvious adaptation to a wet environment, less likelihood of scar formation, and a natural inherent barrier to the threat of local sepsis. Experimental studies comparing skin epithelium with oral mucosal epithelial cells in culture demonstrate that cheek mucosal epithelial cells possess faster proliferative growth curves and more rapid colony formation than skin epithelium.[34, 35] These inherent growth features of buccal mucosa may be the basis for the success of this tissue transfer technique. Grafts, in general, are most often used in shorter bulbar strictures with good results, but the buccal mucosal repair has extended the ability of free graft material to a longer stricture with an early record of success.[36]

Technique of a Buccal Mucosal Onlay Graft

Buccal mucosal onlay graft can be used in both pendulous and bulbar strictures with a potential length of 9 to 12 cm, but instances of successful repair of strictures up to 17 cm have been reported.[33] Pendulous or penile shaft disease is probably best managed through a degloving maneuver after a circumferential, subcoronal incision has been made and the dartos fascial surface well preserved. The more proximal bulbar stricture can be approached by either a ventral or dorsal urethrotomy,[30] depending on the extent of the spongiofibrosis. The graft is fixed into the urethrotomy defect after an appropriate roof-strip excision and anastomosis is completed. The proximal bulbospongiosal urethra is generally mobilized to the suspensory ligament, and the stricturotomy performed well into normal spatulated urethra, starting distally and continuing proximally to the margin identified by the vascular balloon bougie. Transsphincteric extension of the stricture is probably a contraindication to any free graft technique, and a buccal mucosal segment should be abandoned for a penile or scrotal flap if it is available.

The length and width of the defect should be measured over a number 28 catheter template using calipers for accurate estimates. The patient is taken out of the lithotomy position temporarily, and the graft is harvested. It can be retrieved from either the inner cheek or lower lip, depending on the length required. Our technique for harvesting buccal mucosa is to hyperextend the head with some cervical spine support and clean the face, neck, and perioral skin surface. The face and jaw are draped, and a side bit retractor is placed in the mouth with an endotracheal tube and a moist sponge mouth gag to prevent any collection of blood or saliva from reaching the pharynx. This retractor can be replaced by a small Weitlander with a protective guard. Two short right-angle retractors are placed under the lips at the angle of the mouth or cheek of the graft donor site being exposed. A rectangle of buccal mucosa measuring 2.5 by 6 to 9 cm is outlined with a skin marker after excluding and marking the opening to Stensen's duct below the second or third molar (Fig. 68–12*A*). The incision is started just within the cheek margin, and a 5-0 Vicryl tagging suture is placed at each corner of the distal graft edge. The plane between the graft lamina

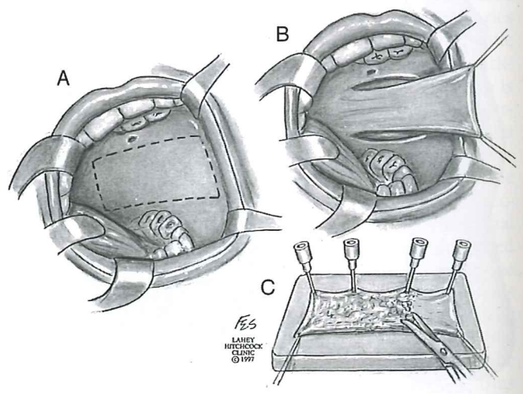


Figure 68–12
A: Retrieving a buccal mucosa graft from one or both cheeks. The opening to Stensen's duct is opposite the third molar and should be preserved. *B:* A 9- by 2.5-cm graft can be harvested from each side if the dissection is carried to the proximal edge of the gum line. *C:* The graft surface is carefully thinned by placing it on the forefinger, followed by repeat removal of any fat or fascia on a Silastic board. (From Lahey Hitchcock Clinic, Burlington, MA.)

propria and the buccinator is developed, taking great care not to injure the muscle or its neurovascular supply (Fig. 68–12*B*). Segments of buccal mucosa are placed in a saline-soaked sponge, and the donor site defect is closed with a running 4-0 chromic catgut. The lower lip defects are often left open to prevent contraction deformity. The graft is carefully cleaned and defatted after fixing it to a sterile Silastic block (Fig. 68–12*C*). The graft is placed in the urethral defect with stabilizing apical sutures of 5-0 Monocryl.

A 3-0 silk traction suture is placed in the glans. The lumen of the urethra is cannulated with a number 5 Fogarty catheter, and a groove director is inserted. A ventral midline incision is made to a depth that includes the urethrotomy over the trough of the groove director selective, using a 6-0 chromic suture to control bleeding (Fig. 68–13). The graft is then placed in the urethral defect with stabilizing apical sutures of 5-0 Monocryl. If several strips of oral mucosa are needed, these are sutured together before the onlay patch is applied. The edges of the graft are sutured to the urethrotomy margins with running 5-0 Monocryl (Fig. 68–14*A*). The skin margins are approximated after the graft surface is firmly covered by quilting sutures between the dartos fascia and the lamina propria of the graft (Fig. 68–14*B*). If wound tension or fibrotic subcutaneous tissue is noted, a tunica vaginalis flap is raised and transferred over the pendulous and submeatal urethral reconstruction. An 18 French Silastic stenting catheter is inserted and fixed to the meatus, with a plan to maintain the stent for 12 days.

The proximal bulbar strictures are the most favorable location for grafts because the bulbocavernosus and Buck's fascia deep to the wound provide a more favorable recipient bed for inosculation. Poor graft take with contracture is less likely to produce a ventral chordee in this perineal location.

The bulb is exposed and mobilized through a wide perineal and scrotal inverted-Y incision (Fig. 68–15*A*). The

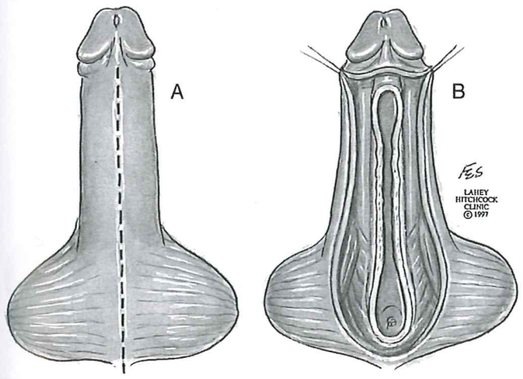


Figure 68–13
A: Midline pendulous and midscrotal incision performed over a grooved directory probe dividing the urethra 2 cm beyond the proximal limit of the stricture. *B:* The urethrotomy can be extended into the distal bulb through the scrotal incision in the supine position. (From Lahey Hitchcock Clinic, Burlington, MA.)

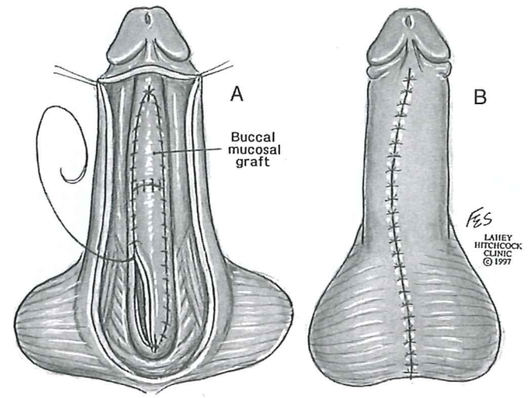


Figure 68–14
A: Segments of oral mucosa from both cheeks are needed for strictures longer than 7 cm. These are first sutured together before developing the onlay. The graft is inserted and sutured to the urethrotomy margins with sutures of 5-0 Monocryl. *B:* Skin edges are closed with two-layer 5-0 Vicryl, securing the dartos against the graft surface and compressing the penile surface in a stent dressing. An 18 French Silastic stenting catheter is inserted and left in place for 12 days. (From Lahey Hitchcock Clinic, Burlington, MA.)

urethrotomy is performed on the dorsal surface to increase compression of the graft and prevent excess blood loss[30] (Fig. 68–15*B*). Bulbar strictures lend themselves to a roof-strip or floor-strip excision of irregular narrow segments that aid in creating a more uniform wide lumen (Fig. 68–15*C*). The buccal mucosal onlay patch can then be applied to the dorsal urethrotomy and fixed to the urethral edges (Fig. 68–16*A* to *C*).

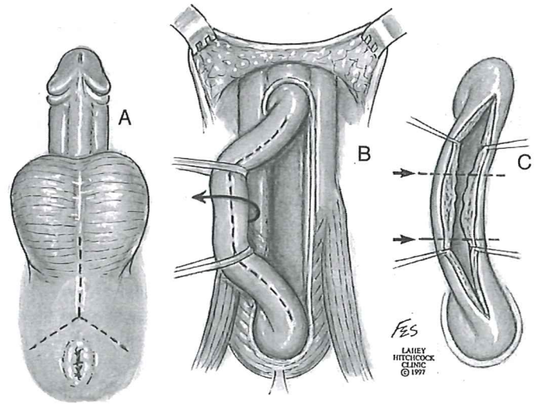


Figure 68–15
A: An inverted Y incision with the apex at the midperineal level is the optimal exposure for the bulbomembranous and proximal pendulous urethra. *B:* The bulbospongiosus segment of urethra is mobilized widely to place the urethrotomy on the dorsal surface. *C:* Bulbous urethral strictures lend themselves to an excision of the narrow segment after the urethrotomy. (From Lahey Hitchcock Clinic, Burlington, MA.)

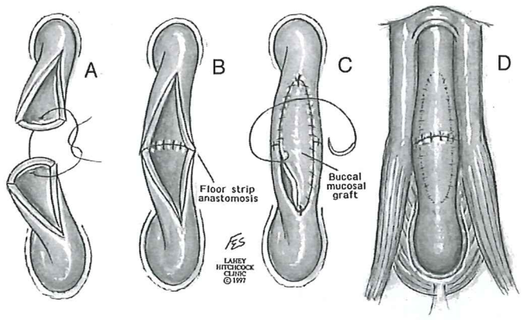


Figure 68–16
A: A floor-strip anastomosis is accomplished with interrupted sutures of 4-0 Vicryl. *B:* The urethrotomy can be extended if the graft or flap is longer. *C:* The buccal mucosal patch is sutured to the urethrotomy edges with running suture of 4-0 Vicryl. *D:* The graft is compressed against the tunica albuginea by the tension of the stretched spongiosa. (From Lahey Hitchcock Clinic, Burlington, MA.)

The graft is compressed by the tension of the stretched spongiosa against the midline fascia between the corpora (Fig. 68–16*D*). The bulbocavernosus is closed with sutures of 4-0 Vicryl and the skin with 5-0 Vicryl. An 18 French Silastic stent is fixed to the meatus, and a 20 French Silastic suprapubic cystotomy diversion is established. A compression dressing is used in all graft reconstructions, including the graft onlay placed in a dorsal urethrotomy position. The stent is maintained for a longer period than that required for flaps, and a voiding cystourethrogram is studied for extravasation at 3 weeks before removing the suprapubic tube to ensure that the graft has healed securely.

Our experience with 21 buccal mucosal graft repairs included 14 patients with onlay patches that varied from 5 to 16 cm in length and 7 patients in whom it was combined with a flap. This latter group had shorter segments varying from 3 to 5 cm. Eight pendulous and 13 bulbar strictures were repaired with the use of this graft, and patients were observed for 3 to 38 months. Recurrent strictures developed in two patients, and a fistula with loss of a graft in association with a complicating, infected hematoma developed in one patient.

Mesh Graft Urethroplasty

Mesh graft, multiple-stage urethral reconstruction was introduced in 1989 by Schreiter and Noll to treat the cohort of patients with complex failed hypospadias, panurethral strictures, or long obliterative strictures with significant urethral loss.[37] This procedure encompasses the use of either full-thickness preputial skin or split-thickness extragenital skin to produce a hairless urethra by first meshing the skin to a 1:1.5 ratio to ensure graft take. This is then applied to the side of the excised or longitudinally opened urethra with a meticulous stent dressing compression, waiting for graft stabilization and secure stomal patency. This graft requires a pliable, vascularized tissue recipient bed to prevent a hypertrophic scar, which occurs when the graft is placed directly on a raw tunica albuginea surface.

A healthy tissue interface can be accomplished by transposing a muscle flap, penile dartos fascia, or tunica vaginalis on the corpora before applying the graft.[38] This intervening tissue permits greater graft mobility, improves second-stage tubularization, decreases graft shrinkage, and decreases the potential for penile chordee. This mesh graft concept can be replaced by a split-thickness (15/1000) skin graft using multiple pie crust incisions, with less resultant contracture if the recipient bed is pliable, vascular, or a healthy muscle (gracilis). The mesh graft onlay, when fully mature, becomes a smooth, supple, and hairless structure with waterproofing qualities and sufficient surface for a uniform wide-lumen urethra with a low risk for development of a pseudodiverticulum.

A second-stage procedure is scheduled for 9 to 15 months later, when a stable, mature skin surface has been achieved and a time-proven, patent, proximal and distal stoma is present. The longer the interval before the second-stage tubularization procedure, the better is the quality of the urethral skin substitute. A long-term, durable, successful outcome depends on careful interim management. Ostial stenosis can be managed successfully by careful calibration with a bougie à boule to ensure a 26 to 30 French caliber proximally and 24 to 26 caliber distally.

Technique of Mesh Graft Urethral Reconstruction for Panurethral Stricture

The surgical exposure for this difficult urethral pathologic condition requires the lithotomy position. The penile and scrotal skin is incised in the midline, splitting the scrotum and suturing the scrotum laterally. An aggressive, full-length urethrotomy is used to open and define normal distal and proximal urethra (Fig. 68–17*A*).

The split skin graft can be retrieved from the inner portion of the posterior thigh, buttocks, or lateral lower groin area. A Padgett dermatome procures a medium-thick-

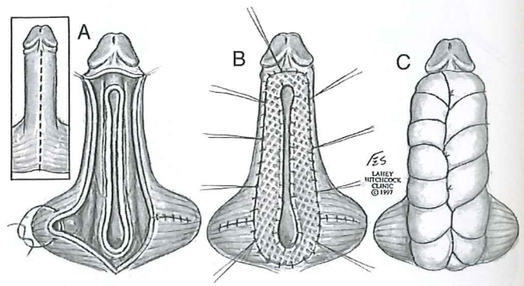


Figure 68–17
A: A full-length urethrotomy is used to define normal distal and proximal urethra. The scrotum is sutured laterally to cover the testes and decrease the wound surface. *B:* The completed graft is placed alongside the open urethrotomy; sutures of 5-0 Monocryl or Vicryl are used. A 16 French Foley catheter is inserted through both stomas. *C:* Bolster compression dressing is tied in with suture ties from the margin of the skin to immobilize the graft. (From Lahey Hitchcock Clinic, Burlington, MA.)

ness graft (0.015 inch), averaging 5 to 8 cm in width and 15 to 18 cm in length, depending on the length of the defect. This depth eliminates any hair follicles, but the accuracy of the setting in the dermatome should be confirmed by measuring the blade interval with a number 15 Bard-Parker scalpel blade edge. The donor site should be covered with DuoDerm and a firm compression dressing. The graft can be meshed with the commonly used Zimmer mesher using a 1:1.5 ratio sheet. It is then sutured to the edges of the urethrotomy with running 5-0 Monocryl and fixed to the recipient bed with interrupted 5-0 Vicryl placed evenly to aid the bolster dressing. Fibrin glue can also be used[39] (Fig. 68–17*B*). The compression stent dressing bolster is placed over a graft cover of Xeroform gauze and sutured with 4-0 nylon fixation sutures to maintain graft fixation and prevent motion (Fig. 68–17*C*). Urinary diversion is routinely accomplished with suprapubic cystostomy drainage and a urethral Foley catheter stent. The dressing remains in place for 5 to 7 days while keeping the patient at bed rest. The Foley catheter is removed in 10 days. The patient is observed closely on a monthly basis for stomal calibration. Graft shrinkage is maximal at 3 months postoperatively, with a 50% reduction in graft size for split-thickness and 20% for full-thickness grafts.

The second-stage reconstruction is the creation of a Thiersch-Duplay tubularization procedure by designing a wide circumferential incision of the graft bed that rolls around a 26 French catheter template, narrowing the strip near the stomas (Fig. 68–18*A*). The width of the strip initially is in excess of the diameter of the catheter and then tapered with Babcock clamps to proper measurements. It is closed with two or three running extraepithelial inverting sutures of 5-0 Monocryl reinforced at intervals with interrupted sutures of 5-0 Vicryl (Fig. 68–18*B*). Penile skin and transected scrotum are dissected laterally to produce a tension-free covering skin closure (Fig. 68–18*C*). If the outer skin is compromised with any skin disease or a fibrotic surface, a tunica vaginalis flap is used to cover the skin tube suture line.

The penile and scrotal skin is widely mobilized, and the penile skin is brought around the ventral surface after incising the glans for a subcoronal meatoplasty. The urethral closure is stented with a 16 French Silastic catheter and drained by a suprapubic cystotomy for 3 or 4 weeks. The urethral catheter is removed in 7 to 10 days, and a follow-up micturating cystourethrogram is obtained at 3 weeks. Graft take after the first procedure is consistently high, with no more than 5% loss observed in any patient. During the interval of observation after the first stage, 20% to 30% of patients require some form of ostial revision in the form of a Y-V plasty.

Mesh graft urethroplasty is technically a challenging procedure with an unprecedented success rate in patients with complex hypospadias, an unresolved stricture, and numerous prior surgical attempts at repair with a deficiency of useful penile skin. It cannot be overemphasized that patients should be counseled that the operation may be a multistage rather than a two-stage procedure.

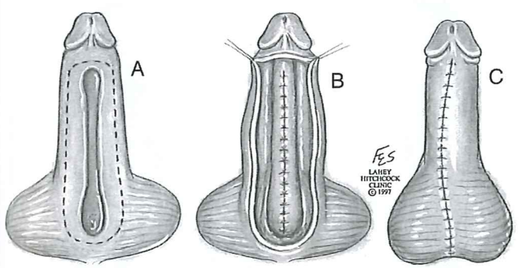


Figure 68–18
A: Second-stage reconstruction requires a wide circumferential incision in the graft bed to create a tube around a 26 French catheter template. *B:* The strip is tapered with Babcock clamps and closed with running extraepithelial inverting sutures of 5-0 Monocryl reinforced at intervals with sutures of 5-0 Vicryl. *C:* Skin closure is accomplished after a wide lateral dissection to produce a tension-free closure. If the outer skin is compromised, a tunica vaginalis flap is used as a buttress over the urethral suture line. (From Lahey Hitchcock Clinic, Burlington, MA.)

Muscle-Assisted Full-Thickness Skin Graft Urethroplasty

A subset of patients with stricture disease complicated by skin loss, avascular periurethral fibrosis, midline perineal decubitus ulcers, associated fistulas and sinuses, or radiation injury have had unsuccessful prior surgical attempts to achieve a stricture-free urethral lumen. These same adversities also preclude the ability of a full skin or buccal mucosal graft to take, because the expectant neovascularity of these structures is unlikely to develop in a fibrotic or infected bed or in a wound with inadequate skin and subcutaneous tissue cover. To help resolve these difficult and challenging strictures, fistulas, and obliterative defects, a number of flaps have been borrowed from the ubiquitous bank of extragenital axial flaps now in use for trunk and limb reconstruction in combination with free skin grafts. The use of the skeletal muscle surface intimately applied and quilted to the dermal side of a skin graft with proper immobilization promotes a more predictable and rapid inosculation and prevents seroma formation and the disruption of new vessel formation.[40] The gracilis is the most readily available and easily mobilized muscle to transfer to the perineum and urethra. The arc of rotation of the gracilis muscle permits this flap to reach comfortably to the penile and bulbomembranous urethra from its major proximal vascular pedicle, the medial circumflex femoral artery.[41]

The sequence for using a gracilis muscle in support of the skin graft is first to prepare the urethra, then retrieve the muscle flap, and then harvest the skin graft to prevent desiccation and ischemic loss. An aggressive stricturotomy is initially started distally on the ventral or dorsal aspect of the bulbous urethra. A dorsal urethrotomy offers a relatively avascular approach when a large proximal bulb has the potential for serious bleeding. Suture control of the spongiosal edge prevents formation of a hematoma and more precise fixation of the graft (Fig. 68–19). When short segments of urethral epithelium are too narrow and fibrotic for a uniform onlay, partial resection with a roof-strip anastomosis is performed.

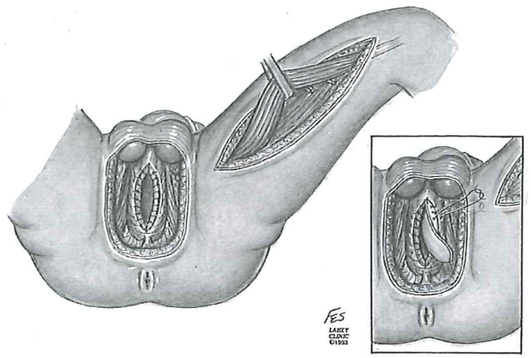


Figure 68–19
The urethral stricture is first prepared by performing the appropriate urethrotomy using a continuous locked hemostatic 6-0 chromic suture on the spongiosal edge. The gracilis muscle is mobilized on its proximal dominant neurovascular pedicle. Inset: A full-thickness skin graft is sutured into the urethrotomy over a 28 French catheter stent with sutures of 5-0 Monocryl. (From Lahey Hitchcock Clinic, Burlington, MA.)

The length and width of the prepared stricture are measured over a 28 French catheter sizing stent. The muscle flap is prepared by initially identifying the distal tendon with a small vertical incision over the palpable tendon on the medial edge of the popliteal space. A drain is placed around the gracilis muscle tendon, which is dissected proximally in its extrafascial plane by inserting an index finger into the space between the anterior muscle surface and the skin before extending the incision. This maneuver facilitates rapid mobilization of the entire structure with good exposure of the pedicles (see Fig. 68–19). The distal two pedicles are ligated and divided, and the proximal dominant pedicle is preserved but not skeletonized to avoid vascular spasm or injury. The nerve to the muscle can be cut to cause muscle atrophy, thereby improving the eventual aesthetics, and to prevent possible muscle twitching on leg adduction. The incision is carried across the groin crease to prevent compression injury from the choking effect of a tight tunnel and an edematous muscle.

A full-thickness strip of skin is excised from a hairless, soft, pliable donor site. Preputial and penile shaft skin is an ideal skin graft with a thinner dermis, but extrapenile grafts succeed if properly buttressed. The skin is placed unstretched, and the subcutaneous fat is removed sharply as the skin patch is raised. The graft is placed in a serum- or blood-soaked sponge, and the donor site closed with a multilayer closure of running sutures of 4-0 Vicryl reinforced with Steri-Strips. The skin patch onlay is measured and tailored for a loose fit over a 28 French catheter and then fixed at either end of the urethrotomy defect with three or four sutures of 5-0 Monocryl (Fig. 68–19 *inset*). The lateral edges are closed with running lock continuous sutures of 5-0 Monocryl. The distal gracilis muscle is transected at the level of the tendon and transferred into the perineal wound through an open trough after a capacious tunnel is first developed, and then the roof of the tunnel is incised to prevent compression injury (Fig. 68–20). The muscle is placed against the dermal surface of the skin

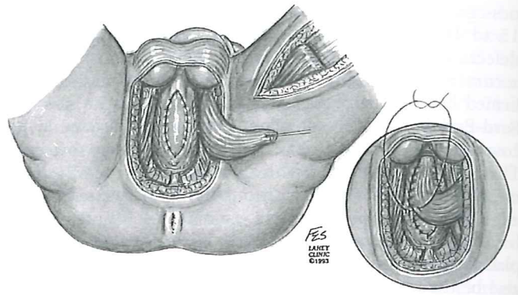


Figure 68–20
The gracilis muscle tendon is detached distally, and the muscle flap is transferred to the perineum through a capacious medial thigh tunnel, which can be opened if there is too much tension. Inset: The muscle is securely applied to the dermal surface of the graft by suturing the muscle margin to the periurethral fascia and quilting the muscle belly to the midline surface of the graft. (From Lahey Hitchcock Clinic, Burlington, MA.)

graft and is anchored firmly to the periurethral tissues (Fig. 68–20 *inset*).

A stricture that is exclusively limited to the bulbar urethra without any transsphincteric component can be prepared through an anterior or dorsal urethrotomy (Fig. 68–21). This is a more hemostatic technique and permits stable fixation of the skin graft against the gracilis muscle surface that has been interposed between the spongiosa and the corpora cavernosa (Fig. 68–22). This is accomplished by mobilizing the entire proximal spongiosa and rotating it clockwise to open the urethra at the 12 o'clock position (Fig. 68–23*A*).

It is important to identify the proximal extent of the stricture with a balloon bougie and rule out transsphincteric involvement, because the membranous location is not

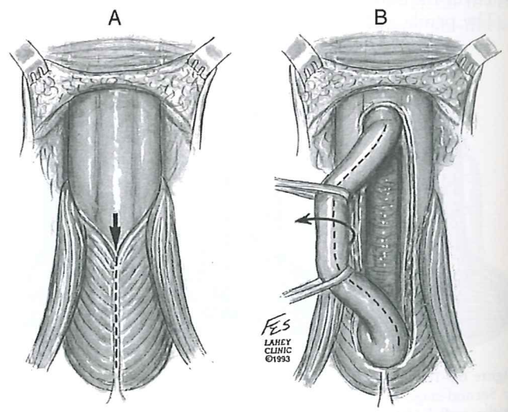


Figure 68–21
A: An anterior or dorsal approach to the urethra is accomplished by dividing the overlying bulbocavernosus and mobilizing the entire proximal spongiosa. *B:* A more hemostatic urethrotomy is achieved by placing the incision at the 12 o'clock position after rotating the spongiosa laterally. (From Lahey Hitchcock Clinic, Burlington, MA.)

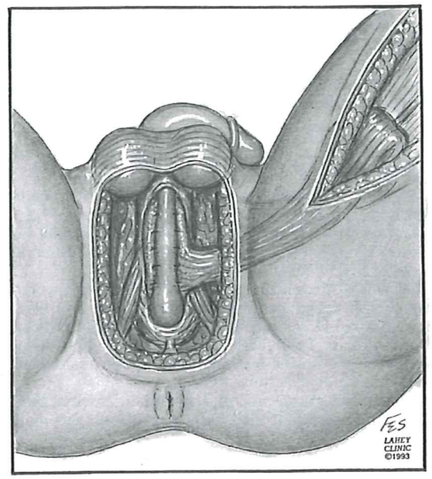


Figure 68–22
The muscle edges are brought around the suture line of the skin graft patch and secured to the spongiosa and intercrural fascia. (From Lahey Hitchcock Clinic, Burlington, MA.)

as suitable for free skin graft urethroplasty as the bulbous portion of the urethra (Fig. 68–23*B*). The distal muscle flap is sutured securely to the periurethral fascia and corpora cavernosa with closely placed interrupted sutures of 3-0 Vicryl to ensure apposition of the flap to the skin graft and to prevent potential disruption of any new vessel formation (Fig. 68–23*C*).

This muscle-supported skin graft technique has been used in 29 patients with bulbar and panurethral strictures measuring 4 to 12 cm in length. Their age range was from

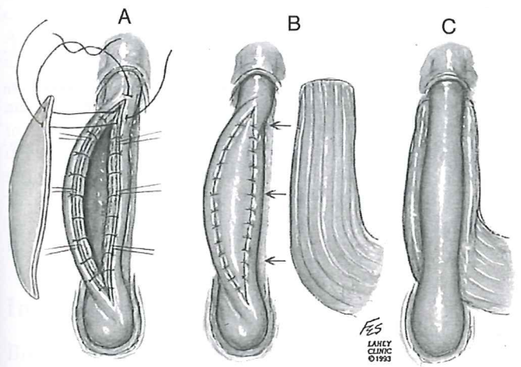


Figure 68–23
A: The skin onlay is fixed to the urethrotomy defect at both apexes with sutures of 4-0 Monocryl. *B:* The suture lines on either side of the skin graft are completed with two running sutures of 5-0 Monocryl. *C:* The muscle flap is brought through the medial thigh tunnel and placed between the urethra and the corpora cavernosa. (From Lahey Hitchcock Clinic, Burlington, MA.)

28 to 74 years. The entire cohort of patients was plagued with chronic stricture disease and complex risk factors that would normally interfere with survival of a traditional free graft reconstruction. These included 4 patients with full-length strictures, 18 patients with extensive periurethral fibrosis, 6 patients who had undergone prior urethroplasty, 3 patients with a history of prior radiation, and 3 patients with an associated perineal decubitus ulcer, 1 patient with a concomitant rectoprostatic fistula, and 2 patients with extensive balanitis xerotica obliterans.

Twenty-seven patients had a unilateral muscle flap, and two patients underwent bilateral flaps for tube grafts that were used to replace the proximal urethra and midurethra after radiation therapy for carcinoma of the urethra.

In four patients (13%), a patent lumen was not maintained, and recurrent stricture developed within 18 months of the failed urethroplasty. In three patients, skin graft had been used to repair a bulbomembranous stricture that had extended across the sphincter. The membranous portion of the reconstruction failed, with the development of a short, recurrent, proximal stricture. The use of a muscle-buttressed skin or buccal mucosal graft is a dependable maneuver to treat some of the patients most disabled by complex strictures and should be an integral part of the armamentarium of complex stricture care.

SUMMARY

Anterior urethral strictures uncorrected by conservative regenerative procedures can be managed successfully by a one-stage urethral reconstruction if healthy penile skin is available for strictures greater than 3 cm in the pendulous and bulbar urethra or by the use of an anastomotic procedure if a stricture in the bulbous urethra is less than 2 cm in length. When adverse local factors or a history of failed prior surgical attempt jeopardizes graft or flap survival, a multistaged or extragenital muscle or fasciocutaneous flap is required. Mundy has compiled and reported the longest follow-up study on substitution flap and anastomotic urethroplasty and has noted a continued but small annual deterioration of techniques using tissue transfer.[8] Patients observed for 1 year demonstrate a success rate greater than 95%, with a 2% to 3% incidence of restricture every year up to a 5-year point. Penile skin onlay flaps had a considerable advantage over tube flaps or scrotal patches. In contrast, patients undergoing anastomotic urethroplasty rarely form new strictures if the lumen is patent at the 3-month point.

The use of excision and an anastomotic procedure is obviously the gold standard in a small, select group of patients with obstructing, midbulbar, or proximal bulb strictures. The use of more aggressive urethrotomy, careful radiologic investigation, and endoscopic scrutiny of a wide-caliber but abnormal urethra, as well as wider use of excision with roof-strip anastomosis combined with penile flap augmentation, has improved long-term urethral patency in patients undergoing urethral reconstruction today. Patients requiring a substitution operation should be offered the penile skin island flap as the first priority, a buccal mucosal graft as the second priority, and a nonhirsute scrotal island as the last option. Mesh graft ure-

throplasty is clearly emerging as the most useful multistage procedure for salvage treatment of strictures that do not respond to traditional measures.

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CHAPTER

69

Reconstruction of Complex Fossa Navicularis and Meatal Strictures

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The fossa navicularis and meatus constitute the glanular segment of the anterior urethra. Embryologically, the epithelium of the fossa navicularis develops by canalization of an ectodermal cord of cells, the glanular plate, that extends from the meatus into the glans. Anatomically, the distal portion of the penile urethra dilates, forming the fossa navicularis, and then narrows again to create a vertical slit, the meatus.

Strictures involving the fossa navicularis and meatus have distinct etiologic characteristics. Moreover, their management is particularly challenging. Reconstruction of these strictures involves creating a functional urethral conduit while maintaining a cosmetically appealing glans penis.

ETIOLOGIC FACTORS

A urethral stricture is a scar resulting from tissue injury after local trauma or inflammation. With healing, the scar contracts, compromising the caliber of the urethral lumen and limiting urine flow. Strictures are classified according to their location and the extent of scarring, including the degree of spongiofibrosis. Unlike other anterior urethral strictures that result from external trauma, infections, or idiopathic factors, strictures of the fossa navicularis and meatus are usually caused by inflammation or iatrogenic injury.

Inflammation

Balanitis Xerotica Obliterans

Balanitis xerotica obliterans (BXO) is the most common inflammatory cause of glanular urethral strictures. It was first described in 1928 by Stühmer, a dermatologist from Münster, Germany.[1] He believed that the cause was glans exposure after circumcision; however, this theory has been disproved by the finding of BXO in uncircumcised males.

BXO is the male genital form of lichen sclerosus et atrophicus. It is a chronic progressive sclerosing process that can involve the glans, foreskin, and anterior urethra. The cause of this disease is unknown, although an autoimmune reaction has been proposed, and a genetic predilection is speculated.[2] The true incidence is similarly obscure, but BXO has been documented in as many as 3.6% of circumcised specimens.[3] It is more frequently identified in middle-aged men, but patients ranging from 5 to 83 years of age have been reported.[4, 5]

The onset of BXO is often insidious. In uncircumcised males, the prepuce is usually involved, most commonly resulting in phimosis. Primary glanular involvement is a common finding in all patients. The lesions appear as diffuse or patchy dry white plaques with well-defined margins, giving the glans a characteristic mottled appearance. Further progression of these sclerotic lesions can include the meatus and fossa navicularis, leading to urethral scarring with proximal meatal migration (Fig. 69–1). The disease occasionally affects the entire anterior urethra, resulting in extensive stricture formation.[6, 7] Besides phimosis, the most common presenting symptom is urinary obstruction, occurring in 47% of patients.[5] A causal relationship between BXO and squamous cell carcinoma has been suggested but not proved.

The diagnosis can be suspected clinically, but confirmation by biopsy is necessary. Histologically, BXO is characterized by marked epithelial atrophy with mild hyperkeratosis. Initially observed is subepidermal edema due to accumulation of acid mucopolysaccharides. This progresses to collagen degeneration, loss of elastin, and lymphocytic infiltration of the dermis.[3] The differential diagnosis includes erythroplasia of Queryat, leukoplakia, scleroderma, and cicatricial pemphigoid.

Vitiligo

Vitiligo is another idiopathic pigmentary disorder that can involve the genitalia. Its peak incidence is in the second



Figure 69–1
Balanitis xerotica obliterans with characteristic proximal meatal migration.

and third decades of life, but it can present at any age. Clinically, vitiligo is characterized by pale white macules that enlarge centrifugally over time.[8] Although these are usually asymptomatic, an inflammatory variant of vitiligo can cause meatal atrophy and stricture. Unlike strictures due to BXO, those due to vitiligo are confined to the meatus. Predominant histologic findings include the absence of melanocytes and an increase in the number of suprabasal clear cells with perivascular mononuclear infiltration.[9] Disorders associated with vitiligo include insulin-dependent diabetes mellitus, pernicious anemia, hypothyroidism and hyperthyroidism, and biliary cirrhosis.

Iatrogenic Injury

Urethral Manipulation

Strictures resulting from urethral manipulation frequently involve the meatus and fossa navicularis. They arise from urethral luminal trauma caused by endoscopic procedures, catheterizations, or subsequent infections. These strictures often extend through the urethral mucosa and involve the surrounding spongiosum; consequently, they may not be amenable to cure by minimally invasive techniques.

Specifically, after transurethral resection of the prostate, a stricture rate of up to 6.3% has been reported, with 41% of these involving the fossa navicularis and meatus.[10] Diagnostic cystoscopy and urethral dilations are more common causes of distal anterior urethral strictures, but their true incidence is unknown. Fulguration or laser therapy of the urethral mucosa, frequently used in treating urethral condylomata acuminata, can similarly result in stricture formation.

Circumcision

Meatal stenosis is the most common significant long-term complication of circumcision. After disruption of the normal preputial-glanular adhesions and excision of the foreskin, the ensuing inflammatory reaction can cause a meatitis with subsequent scar formation.

PREOPERATIVE EVALUATION

The proper diagnosis and adequate characterization of glanular urethral strictures must be based on data obtained from the clinical, radiographic, and endoscopic evaluation.

Clinical evaluation of a stricture involving the glanular urethra is relatively straightforward. Patients present with symptoms of lower urinary tract obstruction, including a decrease in the force of the stream, dribbling or splaying, and prolonged voiding. Progression to acute urinary retention may occasionally occur. The history should identify any prior urethral surgery, instrumentation, or inflammation. On physical examination, a pinpoint opening with perimeatal scarring is pathognomonic of a meatal stricture. Solitary fossa navicularis strictures may also be diagnosed clinically by direct visualization facilitated by manual meatal retraction; otherwise, a small catheter can be passed through the meatus and advanced to the level of the obstruction. It is important to inspect the entire glans carefully in order to identify any coexisting inflammatory process. Urinary flow rates are obtained preoperatively, as a baseline by which postoperative results can be compared.

Radiographic evaluation of glanular urethral strictures may be difficult. The introduction of either a small Foley catheter or a catheter-tip syringe in the distal urethra, which is necessary for retrograde urethrography, may completely obscure the stricture. Sonourethrography, although superior in defining the degree of spongiofibrosis, is similarly limited by the need for distal urethral instrumentation. If properly performed, voiding cystourethrography can be more helpful. Specifically, the bladder should be filled with an enhanced concentration of contrast material (60% solution) and a roentgenogram taken while the patient is voiding. The image quality can be optimized by adjusting the contrast resolution to provide opacification of the entire glanular urethra.

Endoscopic urethral evaluation can be performed to further confirm the length of the stricture and to estimate the degree of spongiofibrosis. A pediatric cystoscope may be used to facilitate visualization.

RECONSTRUCTIVE OPTIONS

Factors affecting the choice of management of fossa navicularis and meatal strictures include the age and overall condition of the patient as well as the specific characteristics of not only the stricture but also the glans and penile skin. Treatment of simple glanular urethral strictures includes dilation and urethrotomy (either direct visual internal urethrotomy or meatotomy). For recurrent or complex glanular urethral strictures, however, surgical reconstruction should be performed. The appropriate reconstructive technique must combine urethral substitution with glans reconstruction in a one-stage procedure.

Dilation and direct visual internal urethrotomy are predominantly palliative procedures with long-term cure limited to only short (<5 mm) mucosal strictures without

associated spongiofibrosis. Urethral dilation should not be used in patients with BXO because this is a potentially progressive inflammatory process that may be accelerated by repetitive instrumentation. Direct visual internal urethrotomy is technically quite difficult to perform in the fossa navicularis. The incision can be inadvertently extended through the surrounding spongiosum, causing excessive bleeding. Therefore, direct visual internal urethrotomy is not practical. Meatotomy is a simple surgical procedure for the incision of selected isolated meatal strictures and can be curative. Because meatotomy creates a mild degree of hypospadias, it should not be performed in an ectopic meatus.

Several techniques have been described for reconstructing the fossa navicularis and meatus. They include glans flap meatoplasty, penile skin graft urethroplasty, and penile flap urethroplasty. For successful repair, a thorough preoperative evaluation and adherence to basic reconstructive surgical principles are mandatory. These principles include the following:

1. Wide exposure of the stricture and surrounding tissue
2. Excision of the entire scar
3. Choice of appropriate healthy tissue for urethral substitution
4. Creation of a tension-free watertight urethral closure
5. Choice of glanuloplasty, depending on the physical characteristics of the glans

Most reconstructive procedures should be performed in one stage, with a two-stage repair planned only for patients with limited remaining viable tissue owing to multiple reconstructive failures.

The choice of the particular reconstructive technique is dictated by the location and extent of the stricture as well as by the surgeon's familiarity and preference. Isolated meatal strictures can be managed using the reconstructive procedure initially described by Devine and Horton for glanular hypospadias repair.[11] It uses a small anteriorly based Y-V glans flap to create a widely patent meatus (Fig. 69–2). This procedure is inappropriate for strictures caused by BXO because it incorporates glanular tissue that is involved by the inflammatory process. For isolated strictures of the fossa navicularis, a patch-graft urethroplasty can be used.[12] This incorporates a full-thickness distal penile skin graft to "repave" the fossa navicularis. The rich glanular blood supply can provide an ideal milieu for successful graft survival.

Penile flap reconstruction for strictures involving both the fossa navicularis and meatus was first described by Cohney in 1963.[13] He rotated a ventrally based penile flap to cover the previously incised glanular urethra. Problems with this technique included glanular torsion and flap necrosis. Several modifications followed, incorporating an inverted U-shaped ventral penile flap to reconstruct the glanular urethra.[14–16] This can be performed as follows: The appropriate subcoronal skin flap is dissected, and the entire glanular urethra is exposed (Fig. 69–3*A*). The apex of the flap is sutured to the proximal urethral mucosa, and an epithelial strip is created using two longitudinal skin incisions (Fig. 69–3*B* and *C*). The flap is then advanced to the tip of the glans and sutured as an onlay, creating

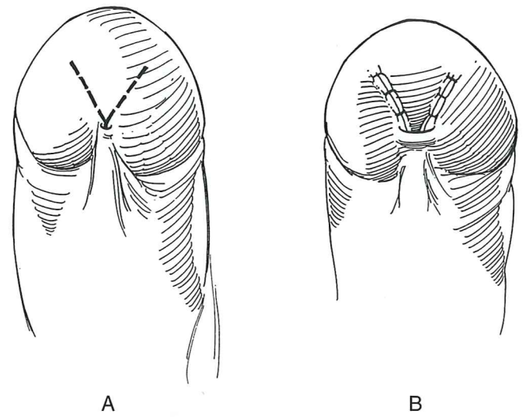


Figure 69–2
Glans flap meatoplasty. *A:* A Y-shaped incision is marked on the anterior glans. *B:* The flap is advanced inferiorly on the dorsal aspect of the urethra to create a wide meatus.

an orthotopic meatus (Fig. 69–3*D* and *E*). The glans is approximated over the neourethra, at the midline (Fig. 69–3*F*). This procedure is limited by its ability to replace only the ventral surface of the glanular urethra; consequently, it cannot be used with circumferential disease requiring tubular urethral substitution.

A more versatile flap is the ventral penile transverse island flap, initially described by Jordan.[17] This is an axial fasciocutaneous flap, based on a broad island of dartos fascia, whose blood supply and drainage are provided by the superficial penile arteries and vein. Because of the relative laxity of the penile tissue, this flap can be easily used in circumcised patients requiring complete glanular urethral substitution.

The glans reconstruction is an integral part of this procedure. When possible, avoiding an incision directly on the glans provides a superior cosmetic result. This is of paramount importance to patients and can overshadow the functional success of the urethroplasty procedure.

RECONSTRUCTIVE TECHNIQUE

The complete reconstructive technique is outlined next. Certain modifications from Jordan's original description have been incorporated, including specific emphasis on the selection of the appropriate glanuloplasty yielding the most aesthetic outcome.

Urethral Exposure

The patient is positioned supine on the operating table. Distal urethroscopy can be performed, using a pediatric cystoscope, to evaluate the meatus and fossa navicularis. Optical magnification, afforded by surgical loupes, is a valuable aid for the reconstructive procedure.

A subcoronal incision is made on the ventral aspect of

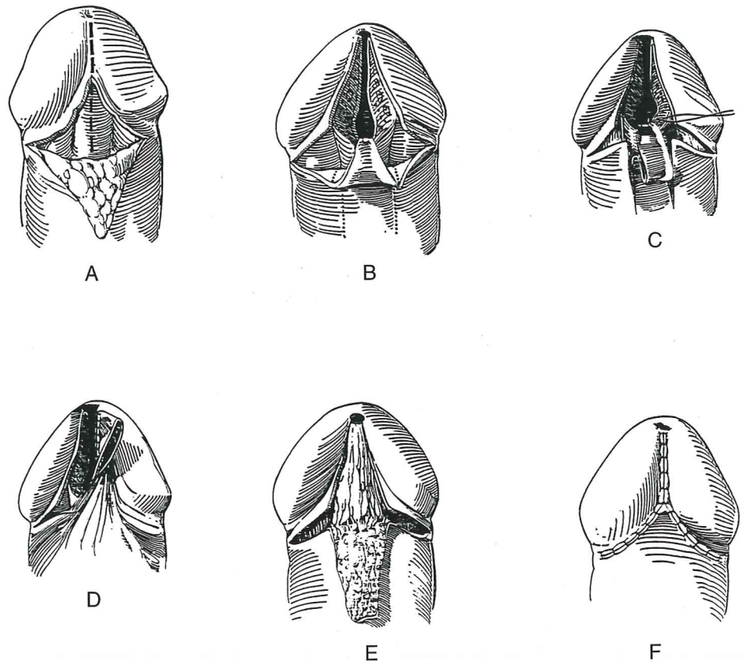


Figure 69–3
Penile flap urethroplasty. *A:* A subcoronal annular flap is raised, and the strictured urethra incised. *B:* The distal flap segment is inverted into the proximal end of the exposed urethra. *C* and *D:* An epithelial strip is created to allow advancement of the flap to bridge the glanular urethral defect. *E* and *F:* The flap can be deepithelialized to permit a more aesthetic glanuloplasty.

the penis and extended circumferentially around the ventral glanular margin, leaving approximately a 5-mm mucosal cuff. The incision is carried down through the dartos and Buck's fascias, exposing the underlying distal anterior urethra (Fig. 69–4*A*). The appropriate glans reconstruction is chosen, depending on the physical characteristics of the glans. If the glans is normal without scarring, inflammation, or distortion, a glans cap–type glanuloplasty should be used; otherwise, a glans wings reconstruction is preferable for reshaping the conical glans configuration. The glans cap repair has the aesthetic advantage in that it preserves the entire glanular integrity. Once the choice of glans reconstruction is made, the fossa navicularis can be appropriately exposed. For a glans cap glanuloplasty, the ventral surface of the glans is dissected off the distal corporeal bodies (Fig. 69–4*B*). For a glans wings glanuloplasty, a full-thickness midline incision is made in the ventral glanular groove, exposing the underlying urethra (Fig. 69–4*C*). The ventral urethral wall is incised longitudinally, at the level of the stricture. It is important to extend the urethrotomy at least 5 mm into the normal urethra (Fig. 69–4*D*). If the involved segment of urethra is circumferentially scarred, it must be completely excised; otherwise, the dorsal urethral surface can be preserved. Once all the scar tissue is removed, the urethra should be calibrated, using metal bougie à boule dilators, to a diameter of at least 24 French.

Creation of a Fasciocutaneous Ventral Penile Transverse Island Flap

The fasciocutaneous ventral penile transverse island flap is appropriately marked after measuring the length of the urethral defect (Fig. 69–4*D*). The width of the proposed flap is dependent on the type of urethral substitution required and can be calculated by using the following formula:

$$\text{Circumferential length} = 2\,\pi r$$

where $\pi = 3.14$ and $r =$ urethral luminal radius. To create a 24 French lumen, necessary for complete urethral substitution, a 2.5-cm flap width is adequate; with an onlay, this width can be halved. The flap is developed by superficially incising the appropriately marked segment of penile skin (Fig. 69–4*E*). This is carried through the subdermal fascia, developing a tissue plane between this and Buck's fascia. The dissection is usually continued to the midpenis but can be extended proximally, as needed, for adequate flap mobilization. Careful preservation of the subdermal fascia is paramount in ensuring viability of the remaining penile skin.

For complete urethral substitution, the flap is tubularized and sutured over an 18 French silicone Foley catheter, creating a watertight seam (Fig. 69–4*F*). The newly created flap is rotated medially, ensuring its unobstructed, tension-free interposition in the glanular urethra. The proximal urethrocutaneous anastomosis is completed using interrupted fine absorbable sutures.

When the dorsal urethral wall can be preserved, a partial urethral substitution is performed. The flap can then be sutured as an onlay using monofilament absorbable fine suture material. One continuous suture is used, on each side, approximating the cutaneous side of the flap to the dorsal urethral mucosa. Long-term success is improved

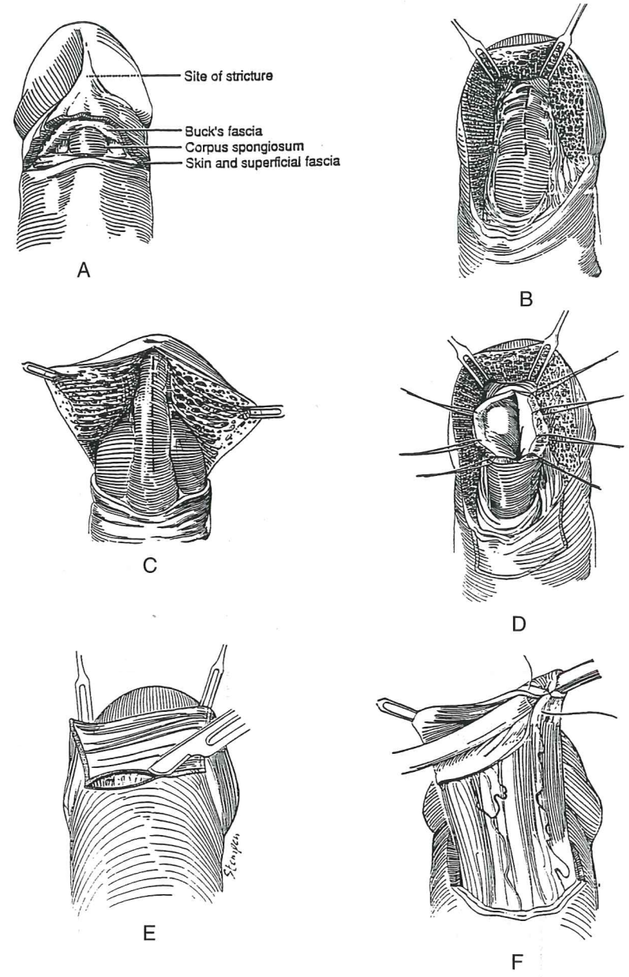


Figure 69–4
Fasciocutaneous ventral penile transverse island flap urethroplasty. *A* to *C,* Urethral exposure. *A:* A subcoronal incision is made on the ventral aspect. The fossa navicularis is exposed using either a glans cap *(B)* or a glans wings *(C)* technique. *D* to *F,* Urethral substitution. *D:* The stricture is incised, and an appropriate segment of penile skin is marked. *E:* The flap dissection is started by creating a plane between the subdermal and Buck's fascias. *F:* The pedicle is completely mobilized, and the neourethra created.

using the onlay technique, making it preferable to a tubularized configuration.

Glans Reconstruction

Once the urethral reconstruction is completed, attention is directed to the glanuloplasty, the choice of which has been previously decided.

With a glans wings type of repair, two full-thickness glans flaps are raised laterally, from the ventral midline (Fig. 69–5*A*). Debridement of any glanular tissue should be limited in order to ensure a tension-free glanular closure. The glans flaps are approximated loosely over the neourethra, using a single layer of interrupted fine chromic sutures (Fig. 69–5*B*). This gives the glans a physiologic conical shape with a ventrally placed linear suture line.

With the glans cap repair, the neourethra is tunneled under the previously elevated glans (Fig. 69–5*C*). A glanular core is taken to ensure removal of all perimeatal scar. The distal end of the flap is sutured to the glans, creating an orthotopic generously patent neomeatus (Fig. 69–5*D*). A shorter-lasting suture material is preferable because it allows for more rapid dissolution of these externally placed sutures.

Penile Skin Closure

Before skin closure, meticulous hemostasis is accomplished using the bipolar cautery forceps. The squared corners of the flap donor site are rounded to permit reapproximation of the penile skin to the subcoronal mucosa. Burrow triangles can be used to eliminate any dog-ears, which can

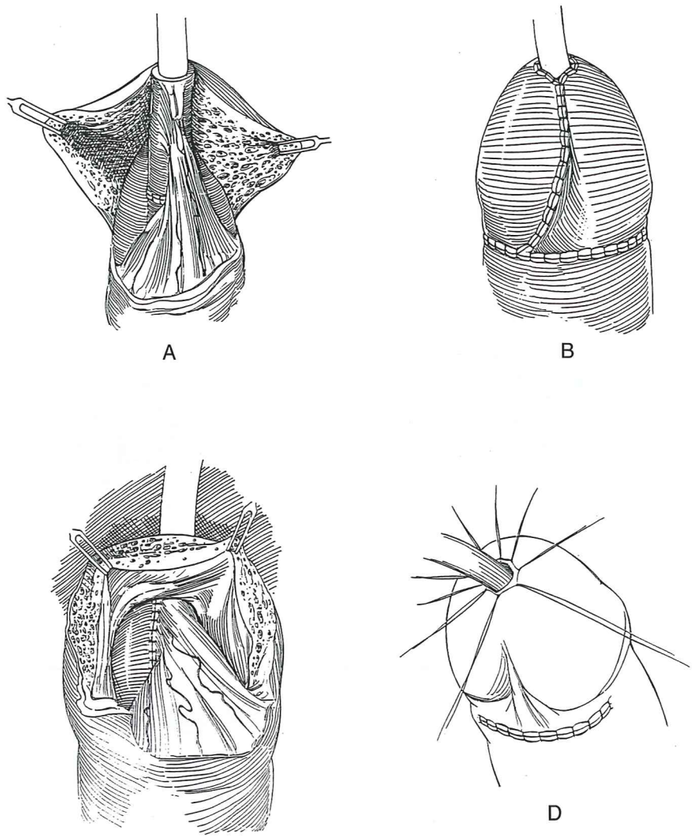


Figure 69–5
Glans reconstruction. *A* and *B*, Glans wings reconstruction. *A:* The newly fashioned neourethra is correctly positioned within the glans. *B:* The glans wings and subcoronal incisions are closed. *C* and *D*, Glans cap reconstruction. *C:* The flap is tunneled under the penile glans cap. *D:* The neomeatus is completed, and the penile skin closed.

occasionally form at the corners of this circumferential closure.

Antibiotic ointment is placed on the suture lines, and a transparent moisture-permeable dressing is used to cover the penis. The Foley catheter should be taped in a nondependent position, on the patient's abdomen, to decrease postoperative edema.

Postoperative Care

Postoperative ambulation is started immediately. Perioperative intravenous antibiotics are continued for 24 hours. The neomeatus should be kept well lubricated with antibiotic ointment to prevent drying. The urethral catheter can be removed at 2 weeks, at which time a voiding cystourethrogram is obtained. Follow-up at 3 and 12 months is conducted using flow rate determinations and urethrography.

Early complications of glanular urethral reconstruction include splaying of the urinary stream and a small degree of glanular torsion. Both of these are usually transient, resolving once the healing process is complete. Delayed complications include urethral restenosis and, rarely, urethral fistulas. Most recurrent strictures occur at the proximal urethral anastomosis and are short, making them amenable to treatment by minimally invasive procedures. Fistulas can be managed by excision and closure, which should be postponed for 6 months postoperatively.

SUMMARY

Correction of complex strictures involving the fossa navicularis and meatus poses a distinct reconstructive challenge. Unlike surgical repair of strictures involving other urethral segments, when the primary concern is restoration of urethral patency, management of glanular urethral strictures requires particular attention to aesthetics. Careful selection of the most appropriate combined urethral substitution and glans reconstruction techniques, as well as meticulous attention to surgical details, is mandatory in achieving a satisfactory functional and cosmetic outcome.

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CHAPTER

70

Skin Graft Urethroplasty and Tunica Vaginalis Flaps for Failed Hypospadias Repairs

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Successful urethral reconstruction after multiple failed hypospadias repairs is a formidable challenge in reconstructive surgery. Despite major advances in the use of well-vascularized flaps and tissue transfer techniques, these patients suffer inordinate scarring and lack of supple tissues with multiple problems considerably worse than the inherent congenital defect. This chapter details our experience with a varied combination of mesh graft split-thickness urethroplasty and tunica vaginalis flaps in 15 cases of failed hypospadias repairs.

Between 1989 and early 1996, we treated 15 patients with a history of not less than 3 previously failed hypospadias repairs (3 had undergone 5, and 1 adult had undergone more than 20 prior repairs). Patient age ranged from 3 to 26 years, including three adults. Previous operative records identifying the type of prior repairs were generally unavailable. Multiple operations included several unsuccessful fistula repairs as well as repair of urethral diverticula, urethral hair removal, and stricture repair, the latter by optical urethrotomy and open techniques. All patients had a history of repeated urinary tract infections, for which two patients required several hospitalizations and intravenous antibiotics. In seven patients, the meatus had been relocated to a proximal or perineal position, one patient had a perineal urethrostomy, three patients had urethral narrowing with marked scarring and difficult voiding, and nine had marked ventral chordee.

Before repair, all patients were free of infection and had negative urine cultures. All patients were admitted to the hospital for day surgery, given cephalosporin antibiotics preoperatively and intraoperatively, and discharged from the hospital after an overnight stay.

TECHNIQUE

The repair began with resection of residual chordee in all patients, as well as a dorsal plication technique with nonabsorbable suture material in seven.[1] Replacement of the tunica albuginea was not required. All patients underwent radical resection of the previously repaired urethra, excising scar and inadequately vascularized tissue down to the tunica albuginea (Fig. 70–1). A pliable vascularized recipient tissue bed was made by transposing penile dartos fascia onto tunica albuginea in six cases. When dartos fascia was inadequate, a tunica vaginalis flap was harvested from the testicle in three patients (Fig. 70–2) and a scrotal-based dartos flap was used in one.[2] These flaps were tacked over the scarred tunica albuginea and used as the recipient bed for a split-thickness mesh graft, creating a pliable stage 1 urethral bed. The glans was split widely by a vertical incision and thinned in some cases. A Padgett's dermatome was used to harvest a medium-thickness graft in four



Figure 70–1
Raw tunica albuginea bed shown after radical excision of scarred urethra.

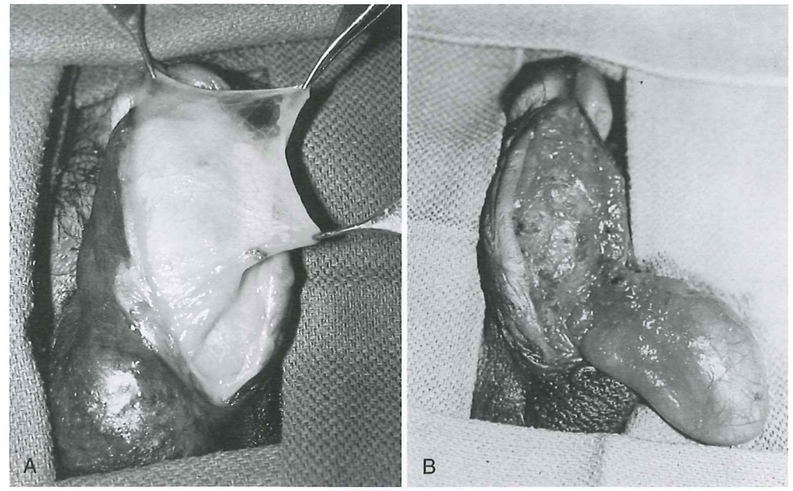


Figure 70–2
Harvested tunica vaginalis flap to be placed on the scarred tunica albuginea after excising former urethroplasty.

patients (0.015 inches from the thigh in two) and then meshed to a ratio of 1:1.5. In six cases, the graft was harvested freehand from the lateral hairless groin, carefully defatted, thinned to the appropriate thickness, and then meshed. The split-thickness skin graft was placed on the dartos fascia or tunica vaginalis and against the dorsal glanular wall to the tip of the glans, allowing subsequent distal placement of the meatus (Fig. 70–3). A pressure bolster dressing was placed for 5 days in all patients. A urethral catheter was used proximal to the bolster dressing and left for 7 days.

A stage 2 Thiersch-Duplay urethroplasty was completed after at least 6 months to allow for graft neovascularity and maturity (Fig. 70–4).[3] The neourethra was covered completely by a tunica vaginalis flap and tacked in place to provide an intermediary layer between the urethral tube and skin closure (Fig. 70–5).[4, 5] A Silastic stent was placed just proximal to the repair, and a punch suprapubic cystostomy was used for 10 days to 2 weeks.

RESULTS

No failures of the mesh graft have occurred to date, and no fistula or stenosis has developed. All patients void

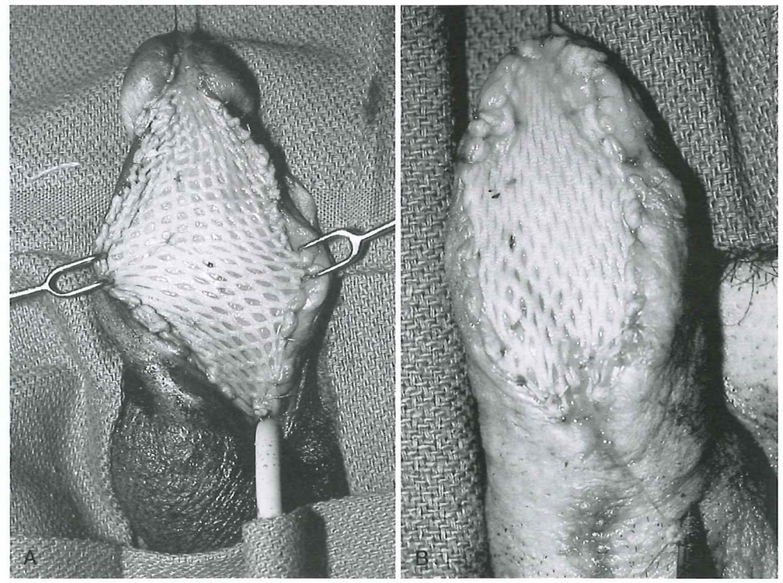


Figure 70–3
A and *B*: Split-thickness mesh graft in place.

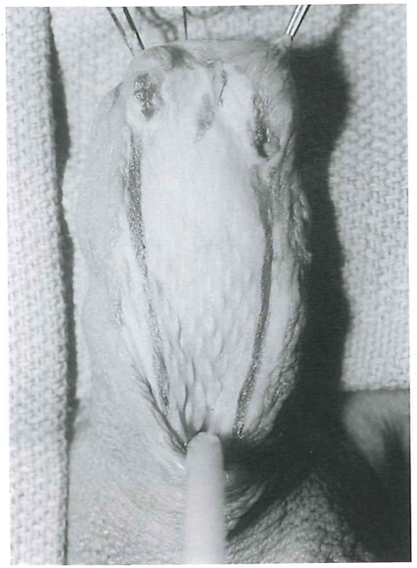


Figure 70–4
Six months after mesh graft, showing a well-vascularized, supple bed before Thiersch-Duplay second-stage urethroplasty.

satisfactorily and are infection free. There were no problems at the graft site, and cosmesis was excellent.

DISCUSSION

In 1966, Culp described the struggles and triumphs with 400 hypospadias repairs, noting "many headaches, heartaches, and poignant therapeutic lessons."[6] Since that time, the art of hypospadias surgery has advanced significantly, using novel combinations of flaps and grafts. We and others have always preferred local penile or preputial flaps over grafts when appropriately vascularized tissue is present. When such tissue is absent or deficient, unique distant grafts using bladder mucosa or buccal mucosa have been successful.[7, 8] These tissues are pliable, non–hair bearing, and readily accessible. Both tissues, however, have inherent problems and are not always applicable or desirable.[9]

Furthermore, and as others have reported, we have been less than enthusiastic about one-stage rolled skin tube grafts from extragenital sites and have abandoned their use.[10] In 1989, Schreiter and Noll reported experience with mesh graft urethroplasty using split-thickness skin grafts or foreskin for complex urethral strictures.[11] We and others have reproduced this procedure for stricture disease with positive results and believe that it is logical to apply these techniques to patients with complex failed hypospadias repairs.[12] Furthermore, because hair follicles are in the deep dermis and subdermal region, split-thickness skin grafts provide a hairless and improved urethral substitute.

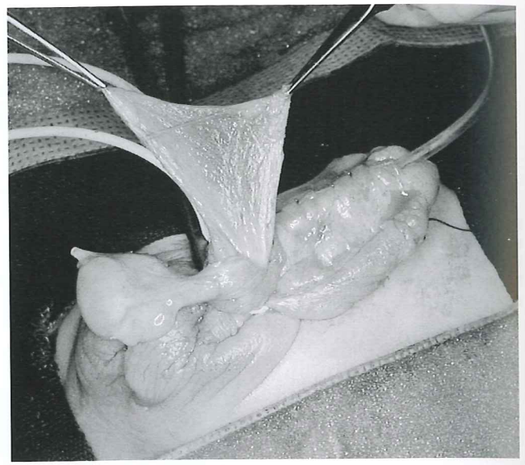


Figure 70–5
Tunica vaginalis harvested and to be placed over the tubularized neourethra.

In these difficult management situations, when all scarred tissue is radically excised, a remaining corporeal bed or raw tunica albuginea that is fibrotic and oozing is less than ideal for a rolled bladder mucosal or buccal



Figure 70–6
Hypospadias cripple after multiple failed procedures with marked ventral scarring and crossing scarred suture lines.

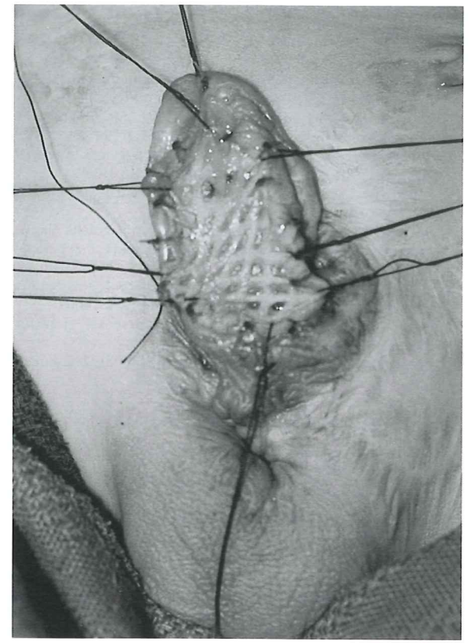


Figure 70–7
Figure 70–6 patient with a meshed graft urethroplasty in place. This patient later underwent a successful second-stage closure.

mucosal graft, which lacks well-vascularized dartos fascia. Ingrowth of neovascularity must initiate from this bed, and we believe that this requirement accounts for the multiple failures reported when using these graft materials.[9, 12] Conversely, others have succeeded in this setting, going so far as to place a bladder mucosal graft on a dermal graft.[13] Despite their experience, this method theoretically violates basic plastic surgical principles in that placement of a graft on a graft jeopardizes potential neovascular ingrowth. Accordingly, in this difficult subset of patients with complex failed hypospadias repairs, a split-thickness skin graft seemed particularly appealing. Moreover, since 1986, we have also favored the use of tunica vaginalis flaps to prevent fistulas and have likewise applied this technique to the mesh graft urethroplasty.[2, 3]

In five patients, a tunica vaginalis flap was harvested from one testis and laid in place over the scarred tunica albuginea, on which the meshed skin graft was applied. This method allowed for pliability and an increased ability to turn the mature skin into a tube at stage 2. To our knowledge, this use of tunica vaginalis has not been reported, and we believe that it adds yet another positive dimension to the procedure when dartos fascia is lacking.[14] At stage 2, an improved ability to roll the graft into a tube was evident and obviously advantageous. Also, the rolled neourethra was then covered by a tunica vaginalis flap harvested from the other testis before skin closure, an additional adjunctive maneuver to prevent fistula formation. In all patients, no fistulas or stenoses occurred and all testes were unremarkable in size and position postoperatively.

Encouraged by the success of this technique, we recently applied it de novo to a 1-year-old patient with unrepaired perineal hypospadias, severe ventral chordee, and minimal preputial skin. After radical chordee resection, a tunica vaginalis flap was placed over the corporal bed and a split-thickness skin graft was applied, achieving complete take of the graft. The second stage proceeded well, with a successful final closure. We now believe that it is not necessary to mesh the skin to achieve a successful result.

We emphasize that this technique is reserved for especially difficult circumstances, and we still prefer local flaps over grafts. However, using tunica vaginalis flaps as a bed and a subsequent cover layer allows for proper neovascularity and prevention of fistulas.

The term *hypospadias cripple* is admittedly pejorative yet aptly describes these unfortunate patients. The psychologic and emotional trauma for such patients and their families has never been appropriately emphasized, and the specter of yet another failure looms large with successive operations. In this setting, we are particularly confident that this procedure will be successful (Figs. 70–6 and 70–7).

Devine and Horton reasoned that "once complications have occurred in hypospadias repairs, the surgeon has a tendency to attempt small operations, hoping to convert failure to success with a minimum of effort. This generally makes matters worse. In these cases, extensive resection of scarring, major shifts of tissues and meticulous reconstruction will usually be found necessary to transform a difficult problem into a therapeutic success."[15] We fully agree with this stance and contend that the use of tunica vaginalis and mesh split-thickness urethroplasty in this difficult cohort of patients is highly advantageous and may represent the supreme fallback position.

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CHAPTER

71

Buried Penis

RICHARD M. EHRLICH
GARY J. ALTER

Many terms are used to describe an inconspicuous phallus, causing considerable confusion. Maizels and colleagues[1] proposed a novel classification system that helps to clarify these entities and their subsequent correction. A concealed penis is frequently referred to as an *inconspicuous penis* because of an overlying fold of abdominal fat and skin.[2] *Buried penis* refers to a penile shaft buried below the surface of the prepubic skin and to a partially or totally obscured penis caused by obesity or a radical circumcision.

The word *micropenis* must not be used interchangeably with *buried penis*. Micropenis is an otherwise normally formed phallus that is more than two standard deviations below the mean in size. A buried penis has normal corporeal length that is palpable under the overlying skin and subcutaneous tissue.

A true buried penis is a rare congenital anomaly that has two components: an abnormally large suprapubic fat pad and dense dysgenetic dartos fascial bands that tether and retract the penis inward[1–4] (Fig. 71–1*A* and *B*). The fat pad extends from the suprapubic region onto the scrotum, perineum, and medial thigh and, combined with a lipoma of each spermatic cord, hides the penis from view. Thick, abnormal dysgenetic dartos fascial bands extend from Scarpa's fascia of the abdomen onto the distal penile shaft, tethering the corporeal bodies proximally (Fig. 71–2). The penile skin drapes over the penile shaft, giving the appearance of redundant skin overlying the glans of the penis with concealed corporeal bodies. Circumcision performed by using a Gomco clamp or a Mogen clamp on an unrecognized buried penis can remove normal shaft skin instead of prepuce, thereby worsening the abnormality (Fig. 71–3). The skin and dartos fascia are mobile, causing the corporeal bodies to move proximally without their normal overlying cover. In a normal infant, inadvertent removal of excess shaft skin during circumcision can leave a variable amount of preputial skin. The incision line constricts on healing, burying the penis by pushing it proximally into the pubic fat (see Fig. 71–5). A secondary circumcision may frequently be incorrectly performed on patients with various causes of concealment. This may prevent repair that requires the remaining penile or preputial skin and may necessitate a skin graft.

A buried penis often exhibits some penoscrotal transposition or penoscrotal webbing, which accentuates the abnormality.

OPERATIVE TECHNIQUES

Understanding the cause of the concealment is imperative in determining treatment. If a patient has not undergone a prior circumcision, the diagnosis is easier. Such a patient usually has a true buried penis and can be treated in the standard manner (discussed later). If a circumcision has been performed, diagnosis of a true buried penis is more difficult. A large suprapubic fat pad helps in the diagnosis. Treatment of a true buried penis or a hidden penis resulting from radical circumcision differs, depending on the amount of shaft and preputial skin remaining. Adequacy of the shaft skin often cannot be determined until the patient is under anesthesia and the constrictive ring around the penis or the penile adhesions are released.

Buried Penis with Adequate Shaft Skin

Through a lower Pfannenstiel incision, fat is resected inferior to the umbilicus down to the rectus fascia and is tapered cephalad and laterally to prevent a step-off deformity or an unsightly concavity (see Fig. 71–1*C* and *D*). Care is taken not to thin the abdominal flap too much. Subcutaneous fat and tissue in the inguinal region are not removed, and only minimal fat is eliminated in the scrotum, because this could decrease sensation to the penile shaft or could cause lymphedema. Liposuction of the suprapubic fat is not as effective as lipectomy. The spermatic cords are carefully identified as they exit from the external inguinal ring to avoid injury. Large lipomas are usually removed from the cords. Dense fibrous bands of dartos fascia, which travel from the distal penis to Scarpa's fascia, tether the corporeal bodies (see Fig. 71–2). These bands are identified during lipectomy and are easily excised,

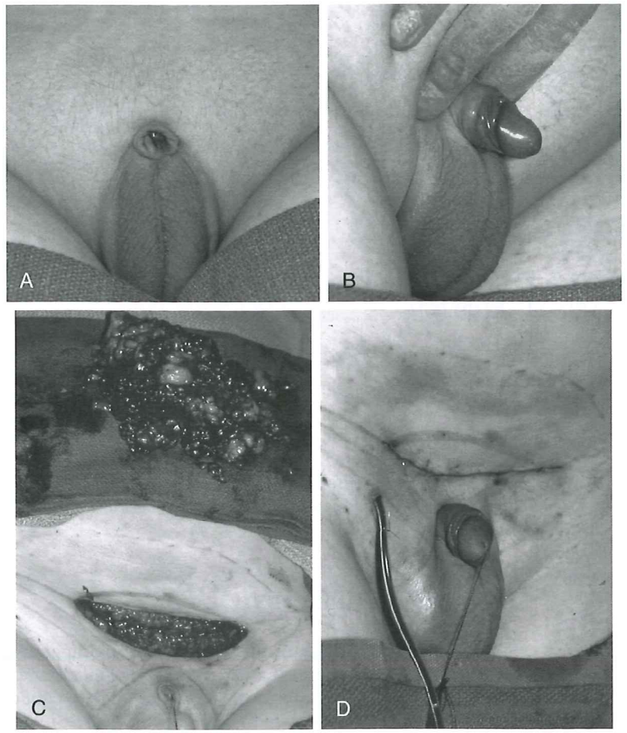


Figure 71–1
Three-year-old with a buried penis and adequate penile skin. *A:* Large suprapubic fat pad and an almost completely obscured penis. *B:* The penis is made visible by pushing on the suprapubic fat and retracting the penile skin. *C:* A large amount of suprapubic fat is excised. The penis remains obscured. *D:* The penis is now visible. The suprapubic subdermal tissue is tacked to the rectus fascia. A closed suction drain is in place.

thereby lengthening the penis. Further lengthening is performed by partially releasing the suspensory ligament of the penis. Several tacking sutures of 2-0 nonabsorbable material are placed from firm subdermal tissue at the pubis to the rectus fascia or pubic periosteum, preventing the suprapubic and penile skin from descending over the corporeal bodies (Fig. 71–4). Other tacking sutures of 3-0 Ti-Cron or Ethibond are placed from the ventral penoscrotal subdermal tissue or dermis bilaterally to the proximal tunica albuginea just lateral to each side of the urethra.



Figure 71–2
Dysgenetic bands of Scarpa's fascia extending onto the penile shaft tether the corporeal bodies. (Courtesy of C.E. Horton and C.E. Horton, Jr.)

Care must be taken with all tacking sutures to prevent dimpling and deformities. Penoscrotal tacking sutures are mandatory to maintain penile shaft skin on the proximal shaft and to prevent retraction of the penis.

A child with a buried penis may also have excess suprapubic or lower abdominal skin, which creates an overhanging panniculus. The amount of excess skin is determined with the child standing and is marked preoperatively. Removal of this skin and fat raises the pubis and escutcheon, providing better visibility of the penis. The lower margin of the transverse elliptic excision is above the expected pubic hairline, and the upper margin is usually a natural skin line created by the panniculus.

The subcutaneous tissue is approximated over a suction drain, and the skin is closed with interrupted buried intradermal sutures and a subcuticular skin closure (see Fig. 71–1*D*). These children may also have penoscrotal webbing, which can be corrected by a Z-plasty at the penoscrotal junction (see Fig. 71–3*B* and *D*). Penoscrotal transposition may need to be corrected at another stage, owing to fear of further dividing the lymphatic and blood supply.

Penis Without Adequate Normal Shaft Skin

A patient who has a true buried penis can undergo suprapubic lipectomy and tacking as outlined earlier.

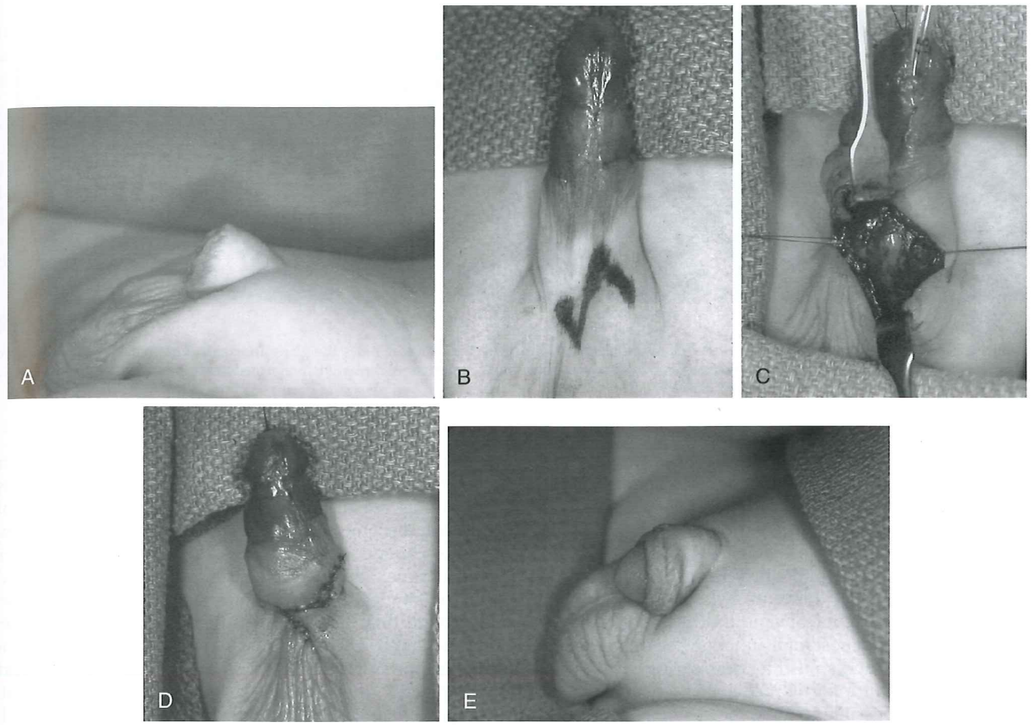


Figure 71–3
A circumcision resulted in removal of normal shaft skin instead of prepuce. *A:* The penis is concealed, and the glans is not visible. *B:* The preputial skin provides most of the shaft coverage. A Z-plasty at the penoscrotal junction will increase ventral penile skin length. *C:* Bilateral tacking sutures are placed from the subdermal penoscrotal junction to the tunica albuginea adjacent to the urethra. *D:* The Z-plasty wound is closed, resulting in lengthening of ventral skin and a more defined penoscrotal junction. *E:* The penis looks normal (3 months after operation).

The increased length of the penile shaft requires coverage with penile skin. If the patient had a previous circumcision with a true buried penis or if he had a radical circumcision without a true buried penis, he may now have inadequate skin available for coverage.

After the circumferential circumcision scar is released, an inner preputial layer is often available for coverage. If enough inner preputial layer remains despite a shortage of shaft skin, the distal circular incision may allow the inner layer to peel down to replace the lost external skin (Fig. 71–5). This circular scar is sometimes constricting, thereby preventing proximal advancement of preputial skin. To

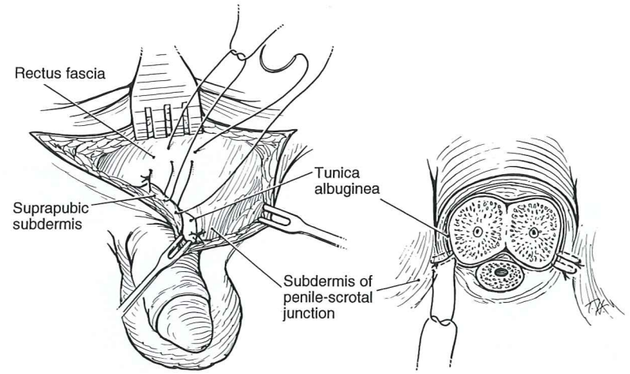


Figure 71–4
The technique of tacking the suprapubic subdermal tissue to the rectus fascia and bilateral tacking of the subdermal penoscrotal junction to the periurethral tunica albuginea.

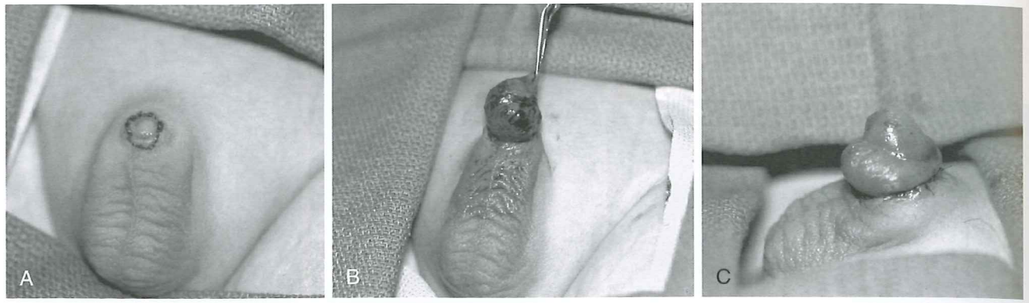


Figure 71–5
A circumcision resulting in removal of most of the shaft and preputial skin. *A:* A circular scar hides the glans and shaft. The incision line is marked. *B:* The scar is incised. The preputial skin is freed. *C:* The hidden preputial skin is unfurled. A Z-plasty is performed ventrally to release the cicatrix. A skin graft may eventually need to be performed.

release the constriction, a small Z-plasty may enable the remaining skin to be advanced proximally. This preputial skin is unfurled and wrapped around the shaft, keeping any longitudinal scars on the ventral aspect of the penis whenever possible. If skin is inadequate, a large Z-plasty or double Z-plasty in the pubis may help to advance skin onto the penile shaft, but this skin is thicker and may not be helpful. Minor deficiency of ventral skin can be resolved by a Z-plasty at the penoscrotal junction (see Fig. 71–3*B* and *D*). A full- or thick split-thickness skin graft may be used as a patch to fill a partial deficiency. This should be placed ventrally if possible to allay the cosmetic deformity. A severe absence of skin necessitates a full-thickness skin graft to cover the entire penile shaft, but only as a last resort (Fig. 71–6). Full-thickness skin is not of the same consistency and color as normal shaft skin; it may not heal ideally and may grow hair. Full-thickness skin grafts are obtained from hairless areas such as the lateral groin or inner upper arm.

DISCUSSION

On examination, differential diagnosis of a small or absent penis includes micropenis, penile agenesis, buried penis, webbed penis, intersex states, radical circumcision, and other congenital anomalies. A patient with a buried penis has normal corporeal length that can be palpated through a prominent suprapubic fat pad that usually extends into the scrotum. Many infants are born with a prominent suprapubic fat pad that tends partially to hide the penis. The parents are usually told that their child's penis will eventually become normal in appearance. However, some of these patients never outgrow the concealment of their penis despite adolescence and mature enlargement. We advocate surgical treatment for such children, because we have found that they tend to suffer low self-esteem. They are ridiculed by their peers for having a small phallus, and they become introverted and require psychologic support. Their parents often request surgical repair. In a neonate with postcircumcision concealed penis, repair is usually delayed until the age of 6 months to a year, if the child is voiding satisfactorily.

A true buried penis is partially or completely hidden in the subcutaneous fat despite normal corporeal and shaft length. The prepuce appears continuous with the scrotum and the abdominal wall skin. Crawford used S-shaped skin flaps to correct the hidden penis and described the need to incise the abnormal dartos fascial bands tethering the penis.[2] Donohue and Keating unfurled the prepuce for coverage.[6] Boemers and DeJong proposed resecting abnormal dartos attachments, unfurling the prepuce, and creating preputial skin flaps to wrap around the penis for coverage.[7] Various other techniques have been advocated.[8–15] Liposuction to remove the suprapubic fat has not been as effective as open lipectomy because the tissue is more loculated than abdominal fat.[1] Moreover, an incision is still required to tack the penile, scrotal, and pubic skin

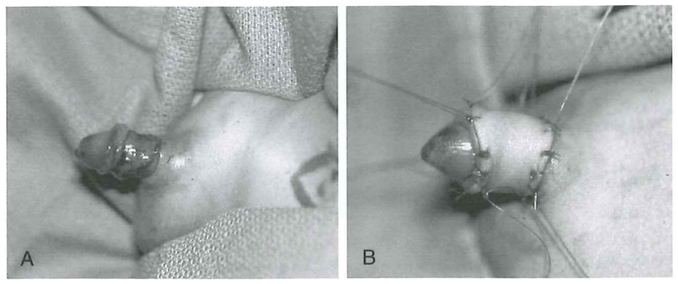


Figure 71–6
A penis with no remaining penile skin after a neonatal circumcision. *A:* The penile shaft is freed after releasing scar tissue at the previous circumcision line. The donor site for a full-thickness skin graft is taken from the lateral hairless groin. *B:* The full-thickness skin graft is applied.

and to release the restrictive Scarpa's fascia bands. Ventral tacking of the penoscrotal skin to the tunica albuginea is imperative.

The surgeon must be prepared intraoperatively to perform any of the many procedures required to eliminate the concealment, including Z-plasties, skin grafts, and local flaps. As in hypospadias cases, the exact operation is not determined until the defect is exposed and the cause elucidated. Ideally, a urologist and a plastic surgeon collaborate to provide a multidisciplinary approach to treating these children.

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CHAPTER

72

Circumcision

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GEORGE W. KAPLAN

Circumcision is the most commonly performed operation in males in the United States. According to the National Center of Health Statistics, 61% of the 1.19 million boys born in the United States in 1987 were circumcised.[1] Based on this statistic, the cost of universal circumcision in the United States would be $140 million per year.[1] The incidence of male circumcision in other countries varies, such as 48% in Canada and 24% in the United Kingdom. Circumcision is quite uncommon in northern European countries, Central and South America, and Asia.[2] Although 90% of newborn boys in the United States were circumcised in the 1950s and 1960s, the rate of circumcision in the United States has declined as debate over the indications for neonatal circumcision has called the procedure into question.[1, 3] The Committee on the Fetus and Newborn of the American Academy of Pediatrics in 1975 declared: "There are no valid medical indications for circumcision in the newborn period."[4] Lay anticircumcision groups (e.g., National Organization of Circumcision Resource Centers and the International Organization Against Circumcision Trauma) have attempted to discourage circumcision by applying pressure to third-party payers and by using lawsuits to intimidate physicians.[3] Studies have suggested that circumcision of neonates has medical benefits, and the American Academy of Pediatrics has again revised its recommendations to reflect this change in conclusions.[5, 6]

HISTORY OF CIRCUMCISION

Circumcision is one of the oldest planned operations known. One of the first records is a bas relief on the tomb of Ankh-Mahor at Saqqara near Cairo, which clearly depicts circumcision (Fig. 72–1).[7] Ritual circumcision, bris milah, has been practiced by Jews for centuries. The origin for this rite is found in Genesis 17:10: "Every man among you shall be circumcised."[8, 9] Ritual circumcision is also practiced by Muslims, black Africans, Australian aborigines, and other groups in different parts of the world.[10]

PENILE DEVELOPMENT

A review of the normal development of the phallus is needed to understand the circumcised and the uncircumcised state. At the third month of intrauterine development (fetal length = 65 mm), a fold of skin develops at the base of the glans and grows distally. This fold ultimately becomes the prepuce. The dorsal aspect of the fold grows more rapidly than the ventral, and thus only the dorsum is initially covered. When the glanular urethra closes, so does the ventral prepuce. The ventral fusion of the prepuce is marked by the frenulum. Preputial formation is normally complete by the fifth month of intrauterine life (fetal length = 100 mm).[11] When the glans is completely covered, the inner epithelium of the prepuce and the epithelium of the glans fuse. Later in gestation, presumably under the influence of androgens, the squamous cells begin to keratinize and to arrange themselves into whorls.[12, 13] Desquamated cells between the prepuce and the glans form pockets. These pockets increase in size and coalesce, resulting in separation of the inner preputial epithelium and the epithelium of the glans (Fig. 72–2). This separation process is normally incomplete at birth but continues through childhood.[14] Infants and toddlers may experience a mild, transient inflammatory reaction at some stage of this separation process because the smegma becomes infected. Organisms were grown from encysted smegma in 80% of prepubertal boys (Kaplan GW: Unpublished data).

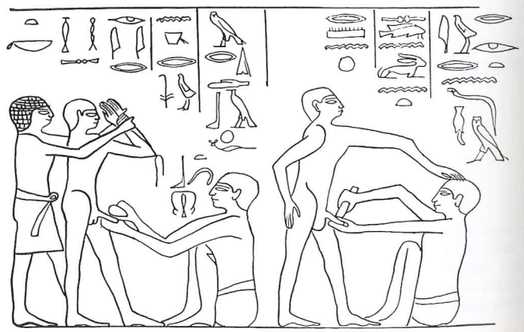


Figure 72–1
Line drawing from a relief on the tomb of Ankh-Mahor, showing a surgeon performing a circumcision.

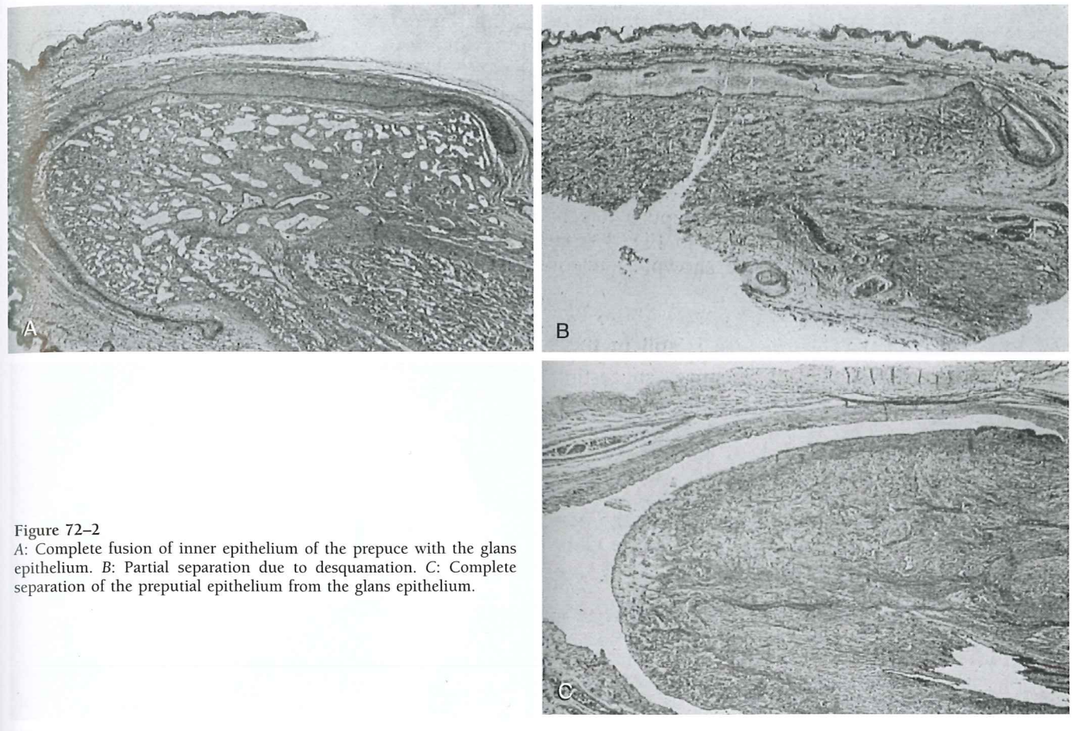


Figure 72–2
A: Complete fusion of inner epithelium of the prepuce with the glans epithelium. *B:* Partial separation due to desquamation. *C:* Complete separation of the preputial epithelium from the glans epithelium.

At birth, the prepuce is retractable in only 4% of boys.[14] In almost half of newborn boys, it cannot be retracted sufficiently even to permit visualization of the external urethral meatus. At 6 months of age, the prepuce can be completely retracted in 20% of boys, and at 3 years of age, 10% of boys have a nonretractile foreskin.[14] Complete separation of the foreskin from the underlying glans, even if the prepuce is partially retractable, has occurred in only 37% of 6-year-old boys.[15] At 17 years of age, the foreskin is completely retractable in almost all boys.

Because most males in the United States are circumcised, there is little opportunity to observe the natural history of the uncircumcised penis in large numbers. If phimosis is defined as only the inability to retract the foreskin, then obviously almost all newborn males have phimosis; however, this is usually a physiologic entity and not a pathologic entity. When phimosis is defined as the inability to retract the foreskin, resulting in balanoposthitis or obstructive uropathy, the incidence of phimosis in childhood is very low. If episodes of balanoposthitis produced by infected encysted smegma during the process of preputial separation from the glans were further excluded, the incidence of phimosis would be even lower. Another error in diagnosis of phimosis occurs in attempts to examine the uncircumcised penis by drawing the skin of the shaft proximally (toward the penile base); a pinpoint opening is frequently noted, which would lead to the conclusion that there was a truly pathologic phimosis; however, if the prepuce were drawn distally instead, it would be seen that the preputial opening is quite wide and could in no way interfere with voiding.

Some physicians are convinced that the prepuce must be retractable at an early age and forcibly free the prepuce from the glans in infancy.[16] This maneuver usually results in pain, bleeding, and occasionally paraphimosis. Forcible retraction is in our opinion unnecessary because spontaneous separation occurs in 99% of males without such maneuvers. Additionally, these manipulations are fruitless unless they are repeated, because the glans and the prepuce rapidly readhere to each other if the glans and the inner preputial epithelium are not sufficiently epithelialized to prevent fusion. No special care of the uncircumcised penis is required. Once physiologic separation has occurred, the child should be encouraged to cleanse the area under his prepuce.

INDICATIONS

There are some true medical indications for circumcision, but none in a newborn. Pathologic phimosis, paraphimosis that is not iatrogenic in origin, and recurrent balanitis not secondary to encysted infected smegma are indications for circumcision (Fig. 72–3). It is estimated that as many as 18% of uncircumcised boys may develop one of the indications by 8 years of age.[17] One study documented

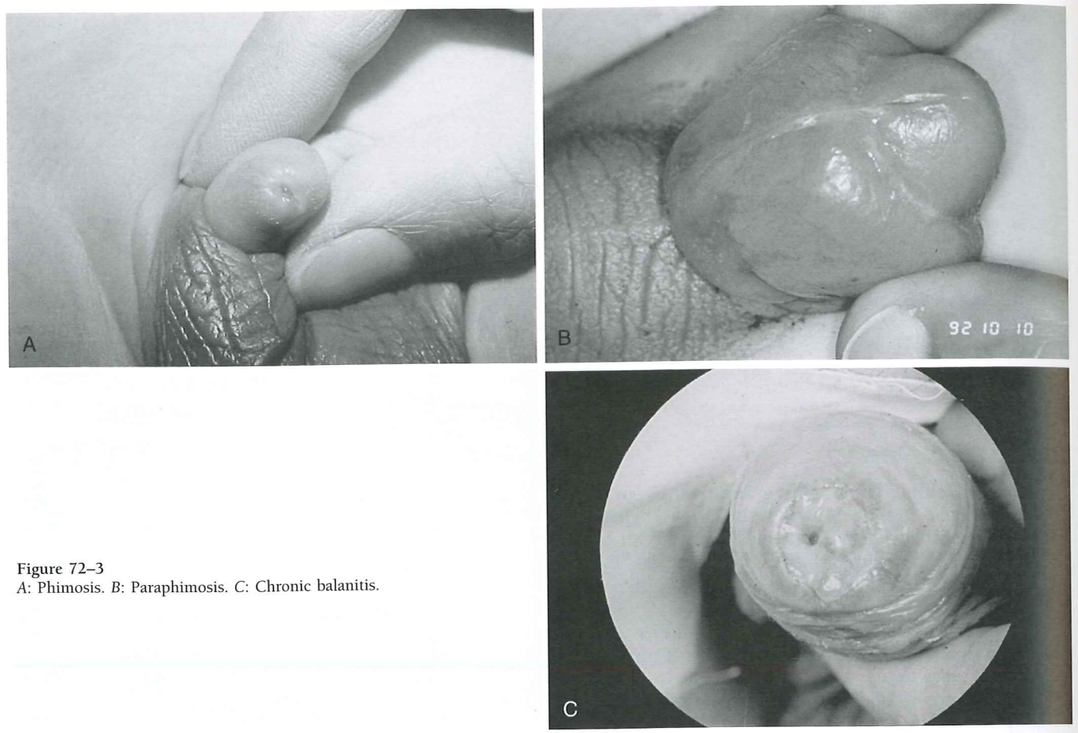


Figure 72–3
A: Phimosis. *B*: Paraphimosis. *C*: Chronic balanitis.

lichen sclerosus et atrophicus as a relatively common cause of phimosis (10%).[18]

URINARY TRACT INFECTION

Many reports have indicated an increased incidence of urinary tract infections (UTI) in uncircumcised male infants. In 1982, Ginsburg and McCracken reviewed data on 109 infants who were between the ages of 5 days and 8 months and who had experienced UTI.[19] They found a predominance of male infants in the infected group, contrary to the situation later in life, in which females predominate, and 95% of the boys with UTI were uncircumcised. In 1987, Wiswell and colleagues reviewed the records of 427,698 infants (219,755 boys) born in U.S. armed forces hospitals.[20] They documented a 10-fold higher rate of UTI among uncircumcised boys than circumcised boys. They also noted that in the years during which the rate of circumcision fell, the incidence of UTI in male infants rose. Wiswell and Geschke also found that the high incidence of UTI in the first month of life in uncircumcised boys was accompanied by high percentages of bacteremia and meningitis in the patients with UTI.[21] Herzog similarly observed a higher incidence of UTI among uncircumcised boys in an outpatient setting.[22] Wiswell and Hackey reviewed the data and performed a meta-analysis of all the previous reports on the circumcision status of boys with UTI.[23] These studies revealed a 5- to 89-fold higher risk of infection in uncircumcised boys than in circumcised boys.

Roberts hypothesizes that circumcision protects male infants against UTI by preventing bacterial colonization of the preputial sac.[24] He believes that colonization of the prepuce, with subsequent bacterial adherence to epithelial cells, leads to periurethral colonization and eventual UTI.

In the report by the International Reflux Study in Children, the rate of enrollment of boys with reflux was significantly higher in Europe than in the United States (24% versus 10%).[25] Considering that 95% of the European boys in the study were not circumcised (compared with 38% of U.S. boys in the study) and that most of the children in the study were enrolled because they saw a doctor for UTI, these data further support the relationship between lack of circumcision and the incidence of UTI.

SEXUALLY TRANSMITTED DISEASES AND AIDS

Some researchers have proposed a relationship between an intact prepuce and sexually transmitted disease. A higher rate of genital herpes, syphilis, condyloma acuminatum, and chancroid in uncircumcised men has been reported.[26] Reports have indicated that uncircumcised men had a greater risk of becoming infected with human immunodeficiency virus (HIV).[27–29] Some investigators have noted a

significant increase in the risk of HIV transmission in a heterosexual population of uncircumcised men independent of other factors. Although most of these studies demonstrate an increased incidence of sexually transmitted diseases in uncircumcised men, they are retrospective studies and may not take into account other variables that could affect the data. The American Academy of Pediatrics' most recent task force on circumcision found these reports to be inconclusive.[5] Epidermal Langherhans cells (ELC) have a role in the recognition and processing of antigens. They presumably represent the first contact of viral antigens with the cellular immune system of the skin and squamous mucosa of the human prepuce. Weiss examined the density of ELC on the inner and outer prepuce and found a relative abundance on the outer prepuce and a paucity on the inner prepuce.[30] It was postulated that this lack of ELC on the inner surface may result in reduced immunologic responsiveness to cutaneous antigens.

CANCER OF THE PENIS

Neonatal circumcision greatly reduces the risk of development of penile cancer (Fig. 72–4). The annual incidence of cancer of the penis in U.S. men has been estimated to be 0.7 to 0.9 per 100,000 men. The mortality rate of penile cancer is as high as 25%.[31] Using a life-table analysis, Kochen and McCurdy estimated the risk in uncircumcised males to be 1 in 600.[32] Leitch could find only seven reported cases of penile carcinoma occurring in circumcised males.[2] In Israel, where all males are presumably circumcised, the incidence of penile carcinoma is less than 0.1 per 100,000 men.[31] Although circumcision at birth seems to be protective, later circumcision at puberty or during adulthood is not. Other factors may contribute to the development of penile cancer. Human papillomavirus types 16 and 18 DNA sequences have been found in 31 of 53 cases of penile carcinoma, indicating a possible relationship between these viruses and the development of this penile cancer.[33] These viruses are found more often in uncircumcised males than in circumcised males.



Figure 72–4
Carcinoma of the penis. (From Kaplan GW: Circumcision: An overview. Curr Probl Pediatr 7(5):1, 1977.)

CANCER OF THE CERVIX

Cancer of the cervix is much less common in Jewish and Moslem women than in groups in which male circumcision is not practiced.[10] Epidemiologic studies have indicated a strong correlation between squamous cell carcinoma of the cervix, multiple sexual partners, frequent sexual intercourse, and sexually transmitted disease.[34, 35] Human papillomavirus types 16 and 18 are the viruses most commonly associated with cancer of the cervix.[34] Nevertheless, evidence linking lack of circumcision to cervical cancer is inconclusive.

CONTRAINDICATIONS

Neonatal circumcision is contraindicated in premature infants and in those with blood dyscrasias, a family history of bleeding disorders, and penile abnormalities in which foreskin may be needed for later reconstruction. Such abnormalities include hypospadias, epispadias, megalourethra, webbed penis, and chordee (Fig. 72–5). In a review of 5882 circumcisions of newborns, 35% of newborn boys with hypospadias were circumcised.[36]

METHOD OF CIRCUMCISION

There are many methods of circumcision. The goal of each is to remove enough shaft skin and inner preputial epithelium so that the glans is sufficiently uncovered to prevent or treat phimosis and to render the development of paraphimosis impossible. Even though the clamp methods are usually used by primary care physicians, especially for neonates, it is important to understand the principles common to all forms of circumcision in order to prevent complications. The pitfalls of each individual method must be recognized. Because a urologist is often faced with the management of circumcision complications regardless of which physician performed the original circumcision, each method is addressed here.

Four principal factors are common to all forms of circumcision: asepsis, adequate excision of skin, hemostasis, and protection of the glans penis.

Strict asepsis is a factor that is almost uniformly adhered to in theory; however, in practice, it probably is violated frequently, especially in neonatal circumcision. Because inoculated wounds only rarely become frankly infected, violation of this principle often results in no harm.

The likelihood that adequate amounts of outer and inner preputial layers are excised varies with the method chosen. Circumcision methods can be classified into one of four types or combinations thereof: dorsal slit, shield, clamp, and excision.

Dorsal slit is common to many techniques and occasionally is used alone, especially in the presence of acute inflammation. An incision is made on the dorsum from the preputial orifice to the coronal sulcus through both the inner and outer preputial layers (Fig. 72–6). Dorsal slit prevents both phimosis and paraphimosis but usually is cosmetically unacceptable if preputial tissue is not also excised.

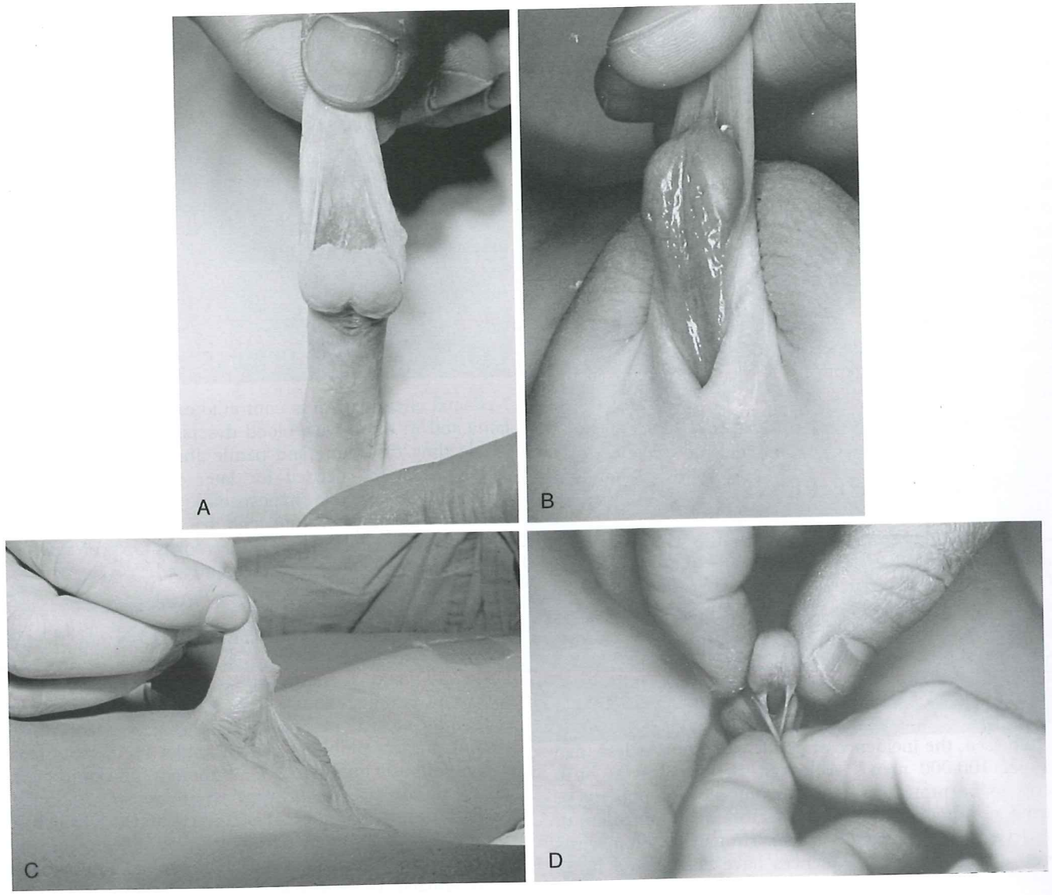


Figure 72–5
A: Hypospadias. *B*: Epispadias. *C*: Webbed penis. *D*: Megalourethra.

A shield is used routinely in ritual circumcision. In this technique, the glans is forced down by a grooved shield that is placed over the stretched prepuce. The excess prepuce is excised, and hemostasis is secured. The inner preputial layer must then be folded back off the glans to ensure full exposure of the glans after healing. The Mogen clamp uses this principle (Fig. 72–7).

Other clamps have been developed primarily for use in neonatal circumcision. The Gomco clamp (Allied Healthcare Products, St. Louis, MO) and the Plastibell (Hollister, Libertyville, IL) are the most widely used (Figs. 72–8 and 72–9). The Gomco and Plastibell clamps are often used without anesthesia. After separation of the inner preputial epithelium from the glans, a dorsal slit is made to facilitate the placement of the bell of the Gomco clamp or the Plastibell over the glans. The outer prepuce is marked with ink at the level of the coronal sulcus before the dorsal slit to help determine the amount of tissue to be excised. The appropriately sized bell is placed over the glans, and the prepuce is drawn over the bell and held in place. The Gomco clamp is assembled and tightened. The marked area is then excised. A cautery unit should never be used to excise the foreskin when any metal clamp is in place. When a Plastibell is used, the previously marked area of the coronal sulcus comes to lie over the groove in the Plastibell, and the foreskin is excised past the outermost groove. The bell is then snapped off, leaving the ring to slough off several days later. The incidence of complications is very similar with both the Gomco and the Plastibell methods, except for a higher rate of wound infection when the Plastibell is used.

Surgical excision can be accomplished either by dorsal or dorsal-and-ventral slit and excision of all tissue distal to the coronal sulcus or by a sleeve technique in which a sleeve of tissue is removed distal to the corona (Fig. 72–10). These methods are the only ones in which sutures are routinely used to coapt skin edges to ensure primary wound healing.

The excision techniques are usually performed under general anesthesia in children and under local anesthesia

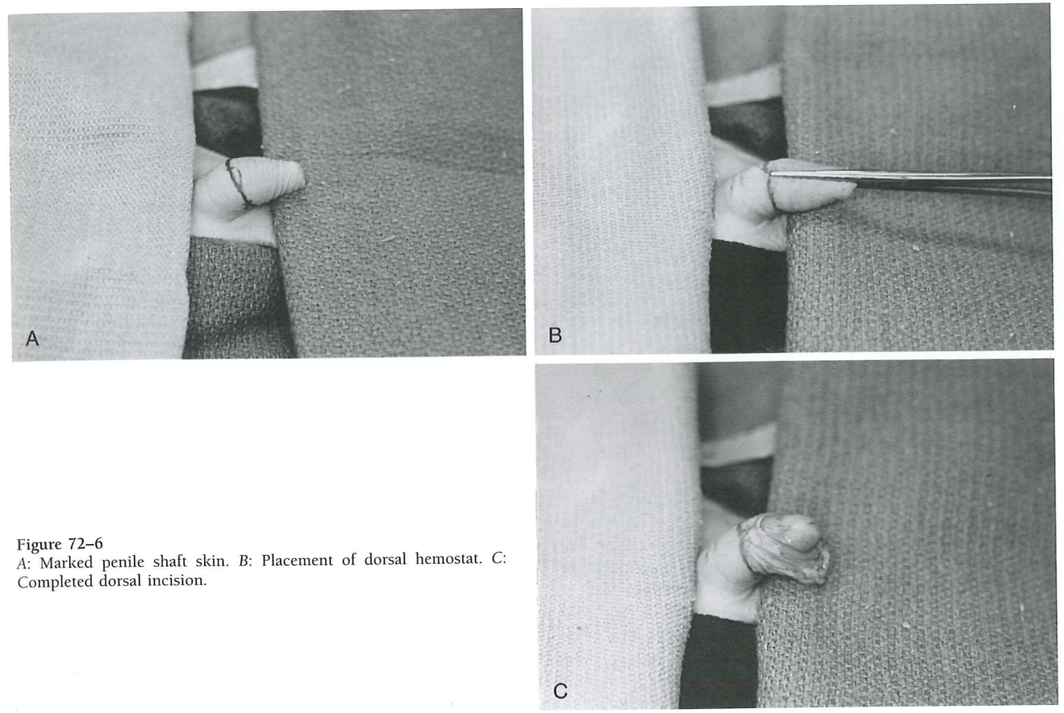


Figure 72–6
A: Marked penile shaft skin. *B*: Placement of dorsal hemostat. *C*: Completed dorsal incision.

in adults. A circumferential incision is made in the inner prepuce about 1 cm proximal to the coronal sulcus. The prepuce is then pulled over the head of the glans penis, and a second circumferential incision is made on the outer prepuce at the level of the coronal sulcus. The sleeve of tissue between the two incisions is sharply excised. After adequate hemostasis, the skin edges are reapproximated with absorbable suture. Other methods for the skin approximation have recently been introduced. Histoacryl has been applied in a thin layer around the edges as a sutureless circumcision.[37] McConnell and colleagues have introduced subcuticular suture between the penile skin and the inner preputial epithelium for improved cosmetic results.[38]

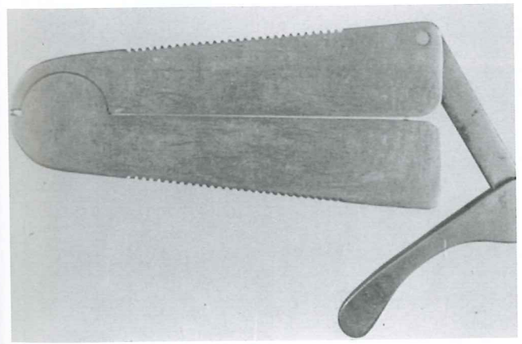


Figure 72–7
Mogen clamp. (From Grossman EA: Circumcision: A Pictorial History. Great Neck, NY, Todd & Honeywell, 1982.)

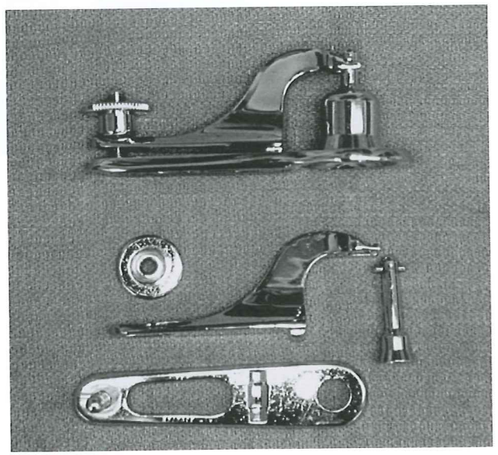


Figure 72–8
Gomco clamp, assembled and unassembled.

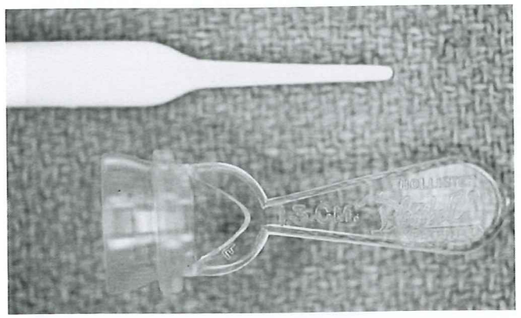


Figure 72–9
Plastibell device with probe.

COMPLICATIONS

The true incidence of postoperative complications after circumcision is unknown. In a large series of newborn circumcision, the complication rate was found to be between 0.2% and 0.6%.[36, 39] The incidence of postoperative complications in children beyond the neonatal period is reported to be 1.7%.[7] No fatalities occurred in 500,000 consecutive circumcisions in New York City; however, deaths due to neonatal circumcisions have been reported as isolated case reports.[40] Because circumcision is a surgical procedure and can be associated with morbidity and mortality, risks and benefits of the operation should be discussed before the operation is performed.

Bleeding

Bleeding is the most common complication associated with circumcision.[36] The reported incidence of bleeding after circumcision is between 0.1% and 35%.[17] Most of these bleeding episodes are minor and are controlled by pressure on the wound. It is very rare that bleeding is significant enough to require a blood transfusion.[17] Thrombin, silver nitrate, epinephrine, and fibrin have been used to control postcircumcision bleeding, as have electrocautery and suture.[36, 41]

Phimosis

Phimosis is a relatively common result of inadequate circumcision (Fig. 72–11). In these instances, insufficient skin has been removed from the shaft of the penis and the inner preputial epithelium. During the healing process, contraction of the wound in the preputial ring leads to phimosis. Adequate skin removal should prevent this complication. The treatment of phimosis is a repeat circumcision.

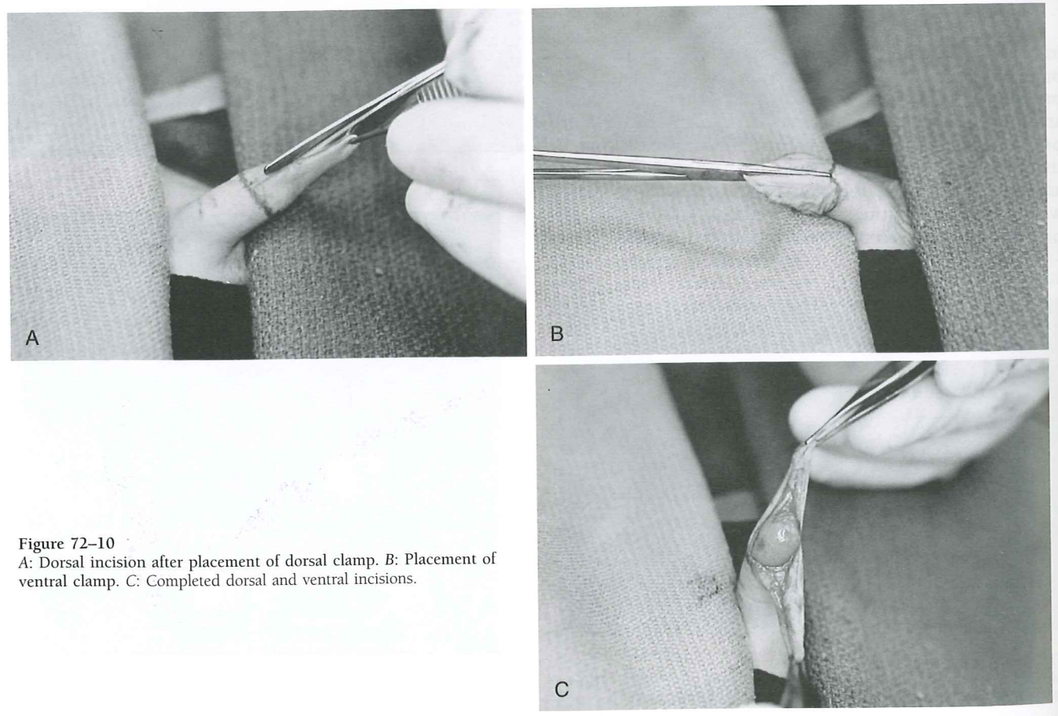


Figure 72–10
A: Dorsal incision after placement of dorsal clamp. *B*: Placement of ventral clamp. *C*: Completed dorsal and ventral incisions.



Figure 72–11
Postcircumcision phimosis resulting in concealed penis.

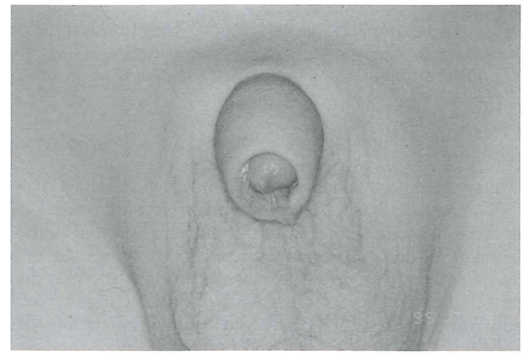


Figure 72–12
Incomplete circumcision.

Wound Separation

Separation of the wound may occur in adult patients secondary to tension at the surgical anastomosis caused by periodic erections. Amyl nitrite aromatic capsules can be inhaled at the onset of erection to induce corporeal smooth muscle dilatation, thus aborting the erection. Caution is advised because orthostatic hypotension can be induced as well.

Concealed Penis

Concealed penis occurs when excessive skin has been removed from the shaft of the penis but an inadequate amount of inner preputial epithelium is removed. As healing progresses, the penile shaft is forced into the suprapubic fat and the stenotic preputial ring that results lies at or just above the skin level of the abdominal wall (see Fig. 72–11). Prevention of this complication depends on adequate penile skin excision and complete mobilization of the inner preputial epithelium from the glans. The treatment of concealed penis is a repeat circumcision. Kaplan recommended the following method for repair of this complication: A circumferential skin incision is made at the former circumcision line, and the shaft of the penis is freed.[10] The stenotic ring is then excised, and the preputial epithelium is folded back over the shaft of the penis to be used as a skin cover. The new suture line would lie in the mid to proximal penile shaft. With use of this type of initial incision rather than a dorsal slit, the need for skin grafts for coverage is minimized.

In one series of consecutive circumcisions, 9.5% of patients had circumcision repeated for an inadequate initial operation.[2] Many repeat circumcisions are performed largely for cosmetic reasons (Fig. 72–12). Inadequate skin excision may make it appear as though the patient has not been circumcised. A surgeon can prevent these errors of inadequate or excess excision of foreskin by marking the site of the corona sulcus on the penile skin surface before any incision and by completely freeing the inner preputial epithelium from the glans, which should ensure an adequate skin excision and prevent many of the previously mentioned complications.

Skin Bridge

Another complication of circumcision is formation of a skin bridge between the penile shaft and the glans (Fig. 72–13). These skin bridges may result in tethering of the erect penis, with resultant pain or penile curvature. In addition, smegma may accumulate under the bridge. The cause of this problem is unclear. Some investigators have suggested that injury to the glans at the time of circumcision, with resultant fusion to the circumcision wound, leads to their formation.[42] Kaplan believes that incomplete separation of the inner preputial epithelium at the time of circumcision and subsequent fusion of the inner preputial epithelium from the glans result in bridge formation.[10] The

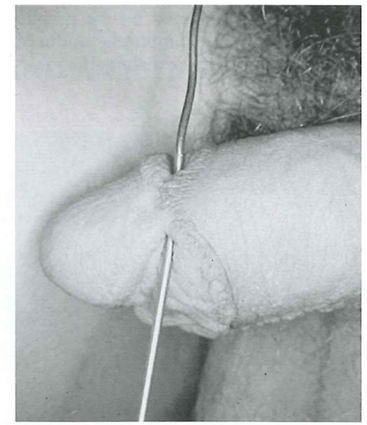


Figure 72–13
Flexible probe passed beneath skin bridge between the glans and shaft skin. (From Kaplan GW: Circumcision: An overview. Curr Probl Pediatr 7(5):1, 1977.)

treatment is simple surgical division. These bridges often contain many vessels and may require hemostasis.

Urinary Retention

Urinary retention usually caused by a tight circular bandage may occur after circumcision; it is best treated by removal of the bandage.[10] It has even been reported to lead to renal failure.[43] When tincture of benzoin is used in a dressing for circumcision, it may occlude the urethral meatus and cause urinary retention.[10] In older children, pain and fear may lead to urinary retention. Renal failure has been reported to result from tight circumferential bandages and is remedied by bandage removal.[43]

Infection

Infection is the second most common complication reported in some series.[36] The incidence of infection in two large series was between 0.2% and 0.4%.[7, 36] In one series, the incidence of infection was significantly higher when the Plastibell was used than when the Gomco clamp was used.[36] Most of these infections are minor; however, infection can lead to necrotizing fasciitis (Fournier's gangrene),[44, 45] sepsis,[46, 47] and meningitis.[48]

Meatitis

Meatitis or meatal ulcer is another complication of circumcision (Fig. 72–14). The reported incidence of meatitis is between 8% and 31%, and meatitis usually occurs while the child is still in diapers.[49–51] Meatitis and meatal ulcers are more common in circumcised than in uncircumcised boys.[52] Meatitis may develop after circumcision because the glans is no longer protected by the prepuce and the urethral meatus is injured by ammonia produced by bacterial action on the urine-soaked diapers.[17]

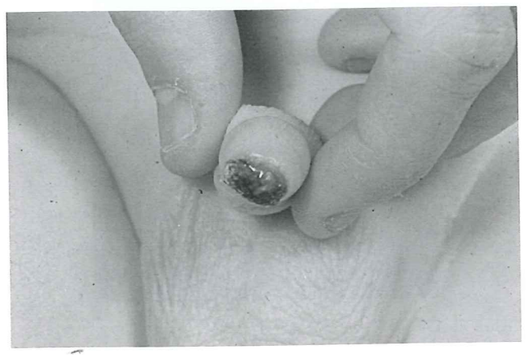


Figure 72–14
Meatitis.

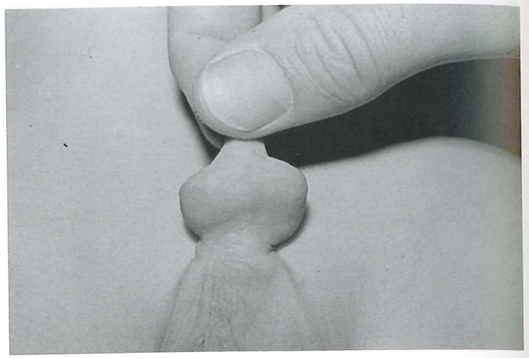


Figure 72–15
Postcircumcision preputial inclusion cyst. (From Kaplan GW: Circumcision: An overview. Curr Probl Pediatr 7(5):1, 1977.)

Chordee

Chordee is a rare complication of circumcision. Circumcision performed during an acute episode of balanoposthitis can lead to a dense band of scar in the area of the frenulum and cause chordee on erection. A dorsal slit rather than circumcision at the time of inflammation may prevent this complication.[10]

Inclusion Cysts

Inclusion cysts have been reported to occur in the circumcision line (Fig. 72–15).[10] Cysts may be caused by implantation of smegma in the circumcision wound or by surgical rolling in of epidermis at the time of circumcision. The cysts can become large or infected. They are distinguished from penile epidermoid cysts only by their location. The treatment is surgical excision.

Lymphedema

Penile lymphedema may be caused by wound infection or separation after circumcision.[8, 10] This condition resolves with treatment of the infection or as healing continues. Conservative treatment is recommended.

Fistula

Urethrocutaneous fistulas have been reported to occur after circumcision (Fig. 72–16).[8, 53] Fistulas are commonly associated with the use of a clamp or Plastibell in circumcision or use of sutures in the area of the frenulum to control bleeding. The fistulas are produced by injury to the urethra. The urethra either is pulled into and crushed by the circumcision clamp or is incised during the procedure. Urethrocutaneous fistulas also have been reported to occur in a few patients with an unrecognized congenital megalourethra.[54]

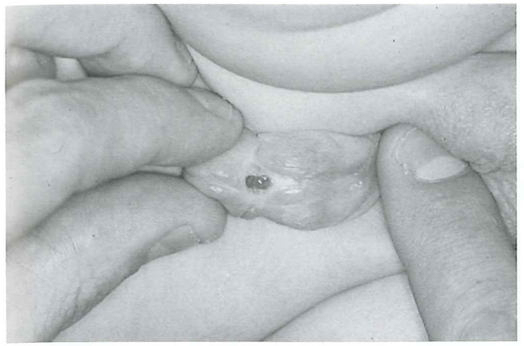


Figure 72–16
Urethrocutaneous fistula following circumcision.

Necrosis

Necrosis and slough of the glans or the entire penis have been reported.[55] Necrosis can result if cautery is applied directly to a metal clamp. Necrosis can also be caused by use of solutions containing epinephrine, prolonged use of a tourniquet, or attempts at hemostasis with suture or cautery.[55, 56] When the entire penis is lost at birth, it may be best to consider changing the child's sex of rearing to female. Such changes are most successful if accomplished before 18 months of age.[55]

Penile Amputation

Traumatic penile amputation can occur accidentally during circumcision (Fig. 72–17).[57] This complication has been treated with microreimplantation of the penis, with good results. Partial amputation of the glans may occur, especially if the Mogen or Sheldon clamp is used. Although the amputated tip can be reattached, good results are also obtained when it is not. Sherman and colleagues reported seven cases of amputation of the glans following circumcision with a Mogen clamp. Half of the attendees at the 1995 meeting of the section on urology of the American Academy of Pediatrics had treated such a complication.[58]



Figure 72–17
Partial amputation of the glans during circumcision.

Retained Devices and Denuded Penile Shaft

The Plastibell circumcision device carries a unique complication. In contrast to a standard operative circumcision and Gomco circumcision, this method is designed to leave the plastic bell in place. Subsequent sloughing of the residual redundant prepuce normally results in shedding of the plastic bell. Migration of the plastic bell onto the distal penile shaft can occur when too large a bell is selected (Fig. 72–18*A*). Inadequate breakdown of glanular adhesions with subsequent overuse of penile shaft skin to obtain the "needed" amount of excised prepuce can result in wound separation and a denuded penile shaft (Fig. 72–18*B*). In general penile shaft of the newborn spontaneously reepithelializes, with satisfactory cosmetic results without the need for skin grafts.

Hypospadias and Epispadias

Both hypospadias and epispadias may result if the glans penis is split at the time of a dorsal or ventral split in preparation for actual excision of the prepuce. These iatrogenic injuries should be easily distinguishable from congenital hypospadias and epispadias and can be prevented by avoiding the performance of any part of the procedure blindly.

Other

Keloid formation at the anastomotic site has been reported and is treated with triamcinolone injections.[59]

PAIN AND ANESTHESIA

Neonates who are circumcised without anesthesia feel pain. Neonates respond to painful stimuli with cardiovascular, hormonal, and behavioral changes.[60, 61] The cardiorespiratory changes include increased heart rate and blood pressure, decreased oxygen saturation, and palmar sweating.[60, 61] Neonates show markedly increased plasma cortisol levels during and after the procedure. Behavioral change includes changes in the cry pattern, irritability, and altered sleep patterns. These responses are of short duration, lasting minutes to hours, with no evidence of long-term sequelae. There has been increased interest in the use of local anesthesia for the performance of neonatal circumcision and for postoperative pain relief. Dorsal penile nerve block (DPNB) has been used for this purpose. Small doses of bupivacaine can be injected in a single midline injection to achieve a DPNB. The toxic dose for bupivacaine is 3 mg/kg.[62] DPNB has been shown to provide pain control for as long as 6 hours after circumcision.[62] The degree and

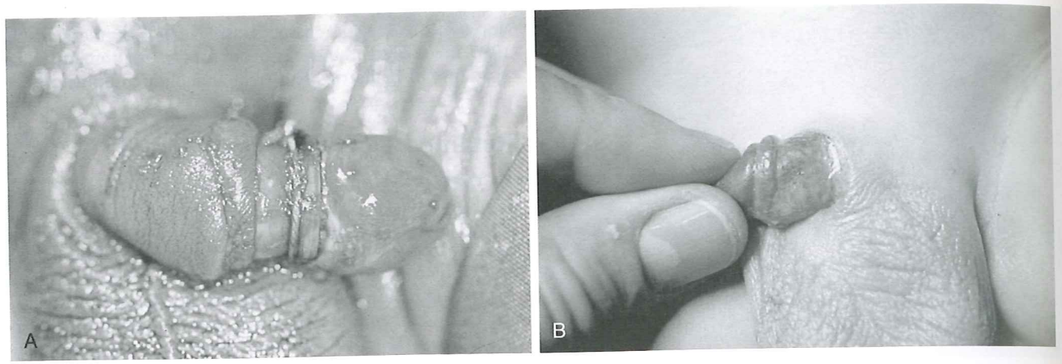


Figure 72–18
A: Retained Plastibell device following circumcision. *B*: Denuded penile shaft skin following circumcision.

duration of postoperative pain were similar in two groups of patients with caudal block or DPNB.[63] Nevertheless, complications have been reported to occur with the use of DPNB.[64] One large study documented the safety and efficacy of DPNB in 1022 neonatal circumcisions.[65] The complication rate was 1.2% (12 cases), in which 11 were small ecchymoses at the injection sites and 1 case was excessive bleeding from the needle stick. There were no reports of lidocaine toxicity, voiding delay, or vascular compromise.[65] Topical application of lidocaine 2% or eutectic mixture of local anesthetics (EMLA) also significantly diminished the pain response in neonates after circumcision.[66, 67] When applied topically outside of the prepuce 45 to 60 minutes before circumcision, EMLA decreased the associated pain significantly when compared with placebo. EMLA currently is not approved by the Food and Drug Administration for use in children younger than 1 month because of reports of methemoglobinemia. Many of these methods show promise; however, wide experience with some of these procedures is limited.

CONCLUSION

Evidence has again suggested possible medical benefits of neonatal circumcision. The 1988 American Academy of Pediatrics Task Force on Circumcision indicated that "newborn circumcision has potential medical benefits and advantages as well as disadvantages and risks." Since 1988, the number of circumcisions performed has again increased.[20] Circumcision is usually a safe and simple operation when performed by an experienced operator. Its disadvantages are short term, and its advantages are long term. The medical benefits of circumcision appear to exceed the risks of the procedure; however, its cost-effectiveness has been questioned, especially by third-party carriers. When circumcision is being considered, its benefits and risks should be discussed with parents, and informed consent should be obtained.

Circumcision, one of the most common minor operations, is bunglingly done in many instances, notwithstanding its simplicity. Many a surgeon has lost his best clients, and likewise many a good prospect has gone glimmering because of the unfortunate outcome of this little operation.

S.L. KISTLER[68]

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CHAPTER

73

Genital Skin Loss and Scrotal Reconstruction

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JACK W. MCANINCH

Loss of skin from the male genitalia can present a formidable challenge for a genitourinary surgeon. Infections, burns, and trauma are the three leading causes of genital skin loss injuries. Appropriate treatment of these patients varies considerably, depending on the cause and magnitude of the tissue defect. For reconstructive procedures to be successful, correct timing, careful wound preparation, and meticulous surgical technique are required.

Necrotizing gangrene of the genitalia is the most important cause of significant skin loss injuries of the male genitalia. Affected individuals are frequently debilitated by various comorbidities that may complicate their care. Successful management of these difficult cases requires early and aggressive medical and surgical therapy. Skin grafting, when necessary, should be appropriate to the functional status of the patient and is often delayed until the infection is adequately controlled. In contrast, most traumatic injuries to the male genitalia should be explored and repaired primarily.

NECROTIZING INFECTION

Pathogenesis

In more than 60 patients with significant genital skin loss treated at San Francisco General Hospital, infection has accounted for the overwhelming majority of cases. Gangrenous infections of the genitalia typically are polymicrobial, with *Streptococcus, Bacteroides*, and *Escherichia coli* appearing most commonly.[1] The frequent observation of three or more organisms cultured from patients with necrotizing genital infections suggests the probable importance of bacterial synergy in the pathogenesis of this disease, known commonly as Fournier gangrene.[2]

Clinical Presentation

Gangrene involving the genitalia usually begins at either the skin, the rectum, or the urinary tract. Pain and swelling are the usual symptoms. Fever, leukocytosis, and systemic signs of sepsis may occasionally be present. Gas may be produced by these organisms, causing crepitus, which may be noted on physical examination. One report suggests that ultrasonography may be a useful adjunct in the early detection of gas-producing, potentially destructive infections.[3] Gas in an abscess appears sonographically as dirty shadowing behind an echogenic focus.[4]

Rapid spread to the penis, thighs, abdomen, and flank is common in gangrenous infections of the genitalia. Spread typically occurs in an avascular plane beneath the dartos fascia. However, the penile corpora and testes are usually spared because they have their own blood supply.[5] These patients frequently have multiple comorbidities, including diabetes mellitus, chronic neurologic disorders, hypertension, peripheral vascular disease, and acquired immunodeficiency syndrome.[6] Other significant predisposing factors such as poor hygiene and long-term Foley or condom catheters may also complicate management.

INITIAL MANAGEMENT STRATEGIES

Necrotizing Infection

Prompt administration of intravenous high-dose penicillin, metronidazole, and an aminoglycoside is critical in all cases while cultures are pending.[7] Urine may require diversion by cystostomy or urethral catheterization in many cases. In the event of perirectal involvement, colostomy should be performed. In the absence of frank perirectal disease, a more conservative approach including bowel rest and hyperalimentation may be adopted.

It is important but sometimes difficult to distinguish necrotizing infections from simple cellulitis of the genitalia. This distinction may be difficult in the absence of systemic illness or obvious tissue necrosis. Surgeons should usually err on the side of early exploration to obtain cultures and assess the viability of the underlying tissues.

The urge for radical excision of tissue must be tempered by the need to preserve tissue potentially useful in reconstruction. Several Penrose drains may be placed in edematous or crepitant surrounding areas without full-thickness skin and subcutaneous necrosis.[8] Serial debridements are usually performed over a period of several days. In 50 patients treated for significant genital skin loss at San Francisco General Hospital from 1976 to 1991, multiple surgical procedures were required in 35 (average 3.8 operations per patient).[6] If tissues are found to be frankly necrotic at the time of surgery, nonviable skin should be excised back to bleeding margins. Copious irrigation should be used, and residual infected tissues should be cleaned briskly with an ordinary sterile surgical scrub brush. Saline-soaked dressings should be placed and changed twice a day until delayed reconstruction is performed, usually 5 to 7 days later.

Burns

Primary and secondary flame burns usually require only topical care. The initial approach should be conservative to allow every opportunity for spontaneous wound healing. Only nonviable tissue is excised. Surgery should be necessary in fewer than 8% of burn patients, and these should be patients with full-thickness burns in which the eschar is excised and a skin graft is applied. Penile circumferential burns may require escharotomy rarely.[7] A urethral catheter should be inserted in any patient with major genital burns to prevent urinary retention and to monitor output.

In cases involving electrical burns, a conservative approach is again adopted initially. However, these patients may sustain substantial deep tissue injury even though the overlying cutaneous burn may appear small. Ascertaining the demarcation of viable from nonviable tissue may take days to weeks. The amount of tissue destruction may be significant and may require extensive excision.[9]

The initial approach to chemical burns should involve immediate removal of overlying clothing and copious irrigation with water. As with first- and second-degree thermal burns, local wound care and topical application of silver sulfadiazine burn cream usually ensure complete healing.

Trauma

Avulsion injuries of the scrotum are much less common now than in the early decades of this century, secondary to improved safety measures related to power farm machinery. The most common cause of traumatic scrotal avulsion currently is deceleration injuries.[6] Scrotal avulsions usually propagate along a subdartos plane. Subsequently, they frequently track up to the phallus and are relatively avascular. The testicles and spermatic cords are frequently uninjured because of the multiple distinct fascial layers surrounding them.[10]

Repair of penetrating injuries of the penis and scrotum should usually be immediate. Delay invites bacterial colonization of the wound, which may compromise subsequent reconstruction.[11] The majority of traumatic injuries represent partial loss of the scrotum and may be closed primarily owing to the excellent blood supply and elasticity of the tissues. Debridement should be minimal. Scrotal flaps can be mobilized to provide tension-free closure with a high probability of success. If immediate closure is attempted, the surgeon must ensure that the wound margins contain clean, viable tissue and that hemostasis is excellent. Also, the injury must be recent (<8 hours), and the patient must be otherwise stable.[5] Small Penrose drains may be used but should be removed within 48 hours.

Constrictive injuries represent an important contemporary cause of penile skin loss. Neglected condom catheters in institutionalized patients and constrictive rings used to prolong erections accounted for half of the 14 patients recently treated at our institution for traumatic penile skin loss.[5] Dog bites and human bites on the penis can also result in significant skin loss.[12, 13] Contaminated wounds such as bites should not be closed primarily. For small, clean, noncircumferential penile skin defects, mobilization of a local flap of skin is adequate. For larger areas, skin grafting is appropriate. Retrograde urethrography should be performed if urethral injury is suspected.

PENILE RECONSTRUCTION

Special Considerations

All functioning tissue should be preserved. In general, wounds are debrided judiciously, as one would debride a hand or face. Debridement of the glans should be avoided. In elderly patients, the penis may be buried beneath a flap of scrotal skin as an alternative to more extensive reconstructive procedures (Fig. 73–1).

Preparation of the injured area for skin grafting involves excision of edematous skin, including the distal prepuce, up to the coronal sulcus. Penile skin that is left in place distal to a skin graft becomes markedly edematous owing to disrupted lymphatic and venous channels.[14, 15] Vigorous cleansing and irrigation of the wound is performed, such that the entire graft bed consists of fresh, healthy, beefy-red tissue. Hemostasis is then achieved with electrocautery.

Technique of Penile Reconstruction by Skin Grafting

Split-thickness skin grafts are preferred because they do not grow hair, the donor site does not require grafting, and the chance for graft survival is high. The usual donor site is the lateral thigh. The medial thigh may also be used but is more likely to be irritated by overlying trousers. The area is shaved and prepared widely and lubricated with mineral oil. A Padgett dermatome is applied with slow, steady pressure, and the graft is tailored to fit the defect.

Biobrane II (Dow Hickam Pharmaceuticals, Inc., Sugar Land, TX) is a semipermeable silicone membrane that effectively provides a simple, flexible covering for the donor site. The Biobrane dressing is usually taped or covered

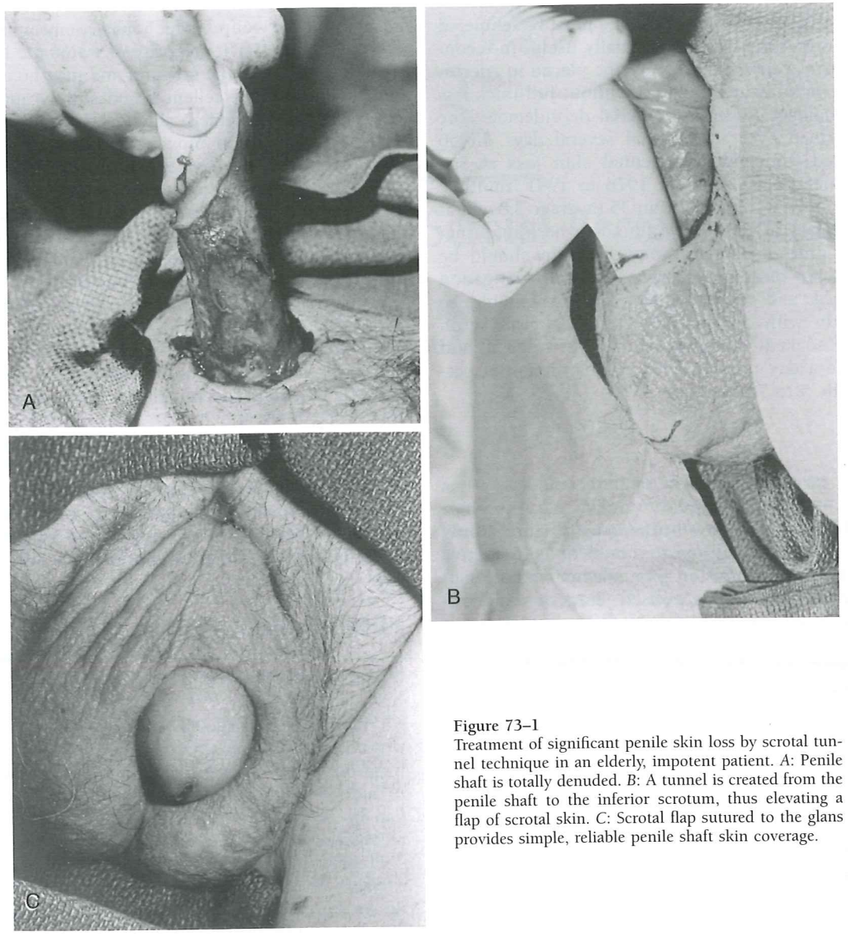


Figure 73–1
Treatment of significant penile skin loss by scrotal tunnel technique in an elderly, impotent patient. *A*: Penile shaft is totally denuded. *B*: A tunnel is created from the penile shaft to the inferior scrotum, thus elevating a flap of scrotal skin. *C*: Scrotal flap sutured to the glans provides simple, reliable penile shaft skin coverage.

with a gauze wrap until it adheres to the wound, usually after 24 to 36 hours. The redundant edges of the dressing are then trimmed. The adherent part of the dressing remains intact for 2 to 3 weeks until the wound heals, whereupon the Biobrane falls off spontaneously.

For impotent patients, thinner split-thickness grafts (0.014 to 0.016 inch) are used and may be meshed, thus ensuring the greatest possible likelihood of graft survival. Meshing gives expanded skin coverage and allows free drainage of potential fluid collections, thus reducing the risk of graft loss. The graft seam is placed ventrally, to mimic a median raphe, and fixed in place with 5-0 chromic sutures. Vicryl or silk sutures may be placed intermittently and tied over a bolster dressing of Xeroform gauze, cotton soaked with mineral oil, and fluffs. The penis is immobilized in the vertical position with a plastic splint.

Thicker split-thickness grafts (0.016 to 0.018 inch) are preferred in potent patients, because thicker grafts are more resistant to contraction (Fig. 73–2). Meshing of the graft is avoided in sexually active patients to prevent contraction. Once healed, the loose areolar tissue outside of Buck's fascia allows the grafted skin to slide easily, making erections usually quite satisfactory. Further, thick split-thickness skin grafts tend to stretch during penile erections, which act as a natural tissue expander. Sensation is absent in grafted skin, but deep touch sensation is normal.[16]

Postoperative management includes a period of strict bed rest for 5 days. Immobilization of the penis in an extended position is critical for graft survival. A penile dressing splint has been described as highly effective in preventing a telescoping effect from penile retraction.[17] Oral ketoconazole therapy may be used to prevent erections if they become troublesome in the immediate postoperative period. An indwelling urethral catheter and subcutaneous heparin for prophylaxis of deep vein thrombosis are useful adjuncts. Administering broad-spectrum antibiotics for several days postoperatively is appropriate. The first dressing change is performed on postoperative day 5. Subsequently, whirlpool baths or sitz baths twice daily

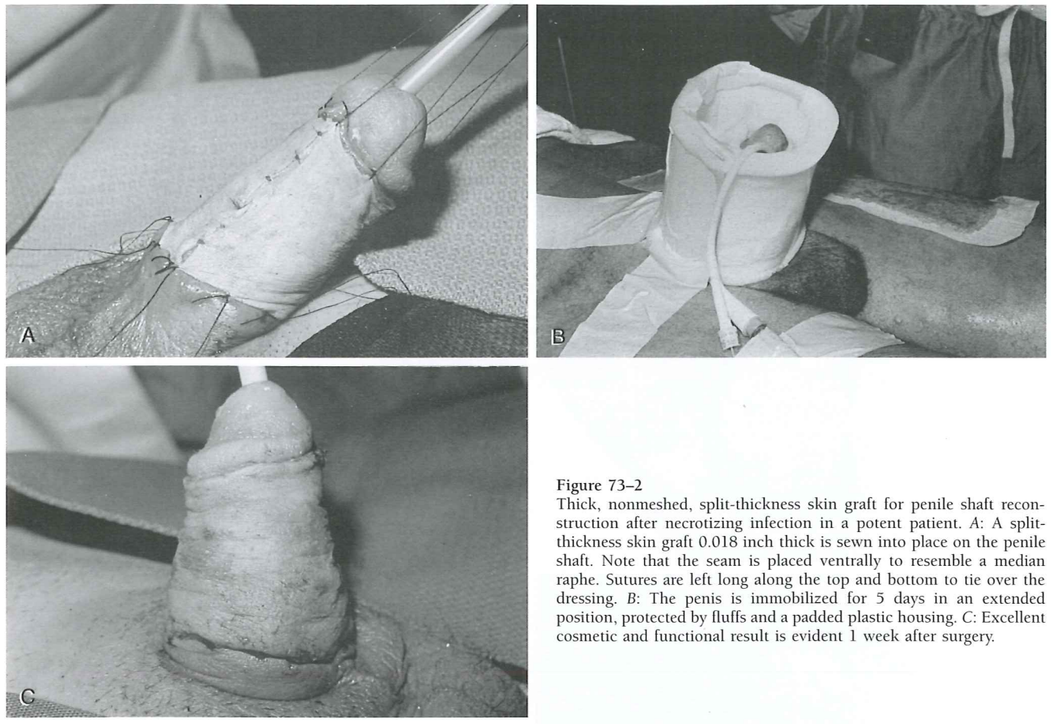


Figure 73–2
Thick, nonmeshed, split-thickness skin graft for penile shaft reconstruction after necrotizing infection in a potent patient. *A*: A split-thickness skin graft 0.018 inch thick is sewn into place on the penile shaft. Note that the seam is placed ventrally to resemble a median raphe. Sutures are left long along the top and bottom to tie over the dressing. *B*: The penis is immobilized for 5 days in an extended position, protected by fluffs and a padded plastic housing. *C*: Excellent cosmetic and functional result is evident 1 week after surgery.

effectively enhance epithelialization and reduce bacterial proliferation.

SCROTAL RECONSTRUCTION

Partial Scrotal Loss

The majority of traumatic scrotal wounds should be closed primarily after thorough cleansing. Because the scrotum is well vascularized, minimal debridement should be done.[10] All foreign material and hair should be removed, and hemostasis obtained. A two-layer closure with interrupted 4-0 chromic suture is preferred. Flaps from neighboring scrotal tissue may be raised and advanced or rotated to cover the testes even after nearly half the scrotum is lost (Fig. 73–3). It is helpful to tack large scrotal flaps to the underlying testes with a small absorbable suture to reduce tension. If scrotal skin remnants are not sufficient to gain complete closure, a spot graft of meshed split-thickness skin is appropriate to make up the remainder.

Total Scrotal Loss

Preparation for Reconstruction

Infection accounts for the majority of cases of total scrotal loss. A surgeon's primary initial goal is to control the infection adequately. Serial debridements over several days are commonly necessary (Fig. 73–4). The testes should be left uncovered initially, protected only with saline-soaked bandages, which are changed twice a day. After the infection is controlled, the testes may be placed in pouches beneath the fat of the anterior medial thigh. Thigh pouches are created by gentle finger dissection. The testes need not be sutured into position in thigh pouches. Thigh pouches may be the only necessary treatment for elderly or disabled patients. Alternatively, if thigh skin is lost, the testicle and cord can be placed subcutaneously on the lower abdomen.

Younger patients in whom subsequent fertility is of concern should have their testes placed in thigh pouches for protection only temporarily, until a subsequent reconstructive procedure is performed. Elevated temperatures have been reported beneath the deep subcutaneous fat of the thigh and may impair spermatogenesis. Therefore, when thigh pouches are necessary in younger patients, testes should be placed more superficially, where normal spermatogenesis has been reported.[17] In this event, the testes are placed as close to the skin as possible, with little or no intervening subcutaneous tissue.

Total Scrotal Reconstruction Using Meshed Skin Grafts

Scrotal reconstruction is performed 5 to 7 days after initial debridement, after serial subsequent debridements, when

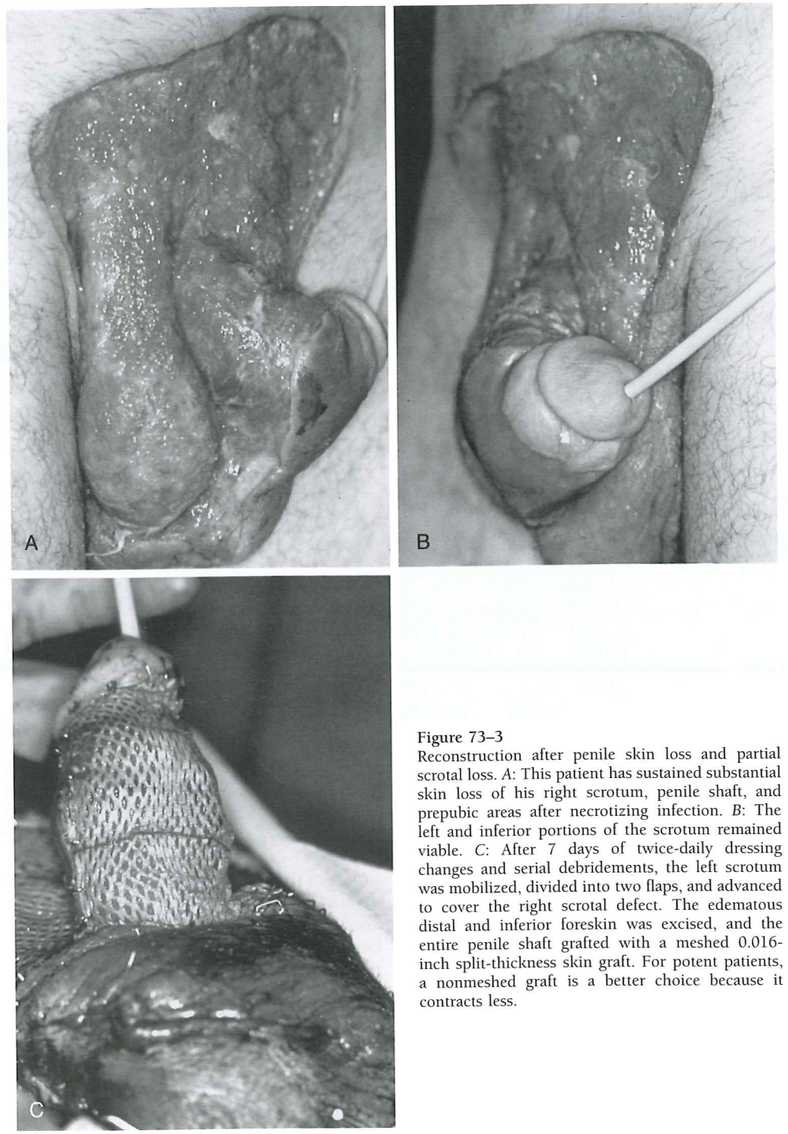


Figure 73–3
Reconstruction after penile skin loss and partial scrotal loss. *A*: This patient has sustained substantial skin loss of his right scrotum, penile shaft, and prepubic areas after necrotizing infection. *B*: The left and inferior portions of the scrotum remained viable. *C*: After 7 days of twice-daily dressing changes and serial debridements, the left scrotum was mobilized, divided into two flaps, and advanced to cover the right scrotal defect. The edematous distal and inferior foreskin was excised, and the entire penile shaft grafted with a meshed 0.016-inch split-thickness skin graft. For potent patients, a nonmeshed graft is a better choice because it contracts less.

the patient has stabilized in an anabolic state. At the time of scrotal reconstruction, the testes are removed from the thigh pouches and the wound is prepared. Granulation tissue that is chronically infected should be scraped away with a knife blade, and the edges of the wound are sharply trimmed. The wound is scrubbed and irrigated. Hemostasis must be meticulous.

The spermatic cords are mobilized up to the inguinal area to ensure that the testes assume a dependent position. The testes and spermatic cords are then sutured together to prevent a bifid neoscrotum (Fig. 73–4*C*), and the graft is applied. A meshed split-thickness skin graft is ideal for scrotal reconstruction because it is highly reliable, conforms easily to the contour of the testes, and gives a natural, rugated appearance once healed (Fig. 73–5). The grafting technique is similar to that outlined earlier for penile reconstruction, but a 0.014- to 0.016-inch graft thickness is appropriate for the scrotum in all cases.

After grafting, the neoscrotum is then immobilized in close apposition to all surfaces of the underlying perineum, testes, and spermatic cords. A dressing of Xeroform gauze, mineral oil–impregnated cotton, and gauze is tied securely into place

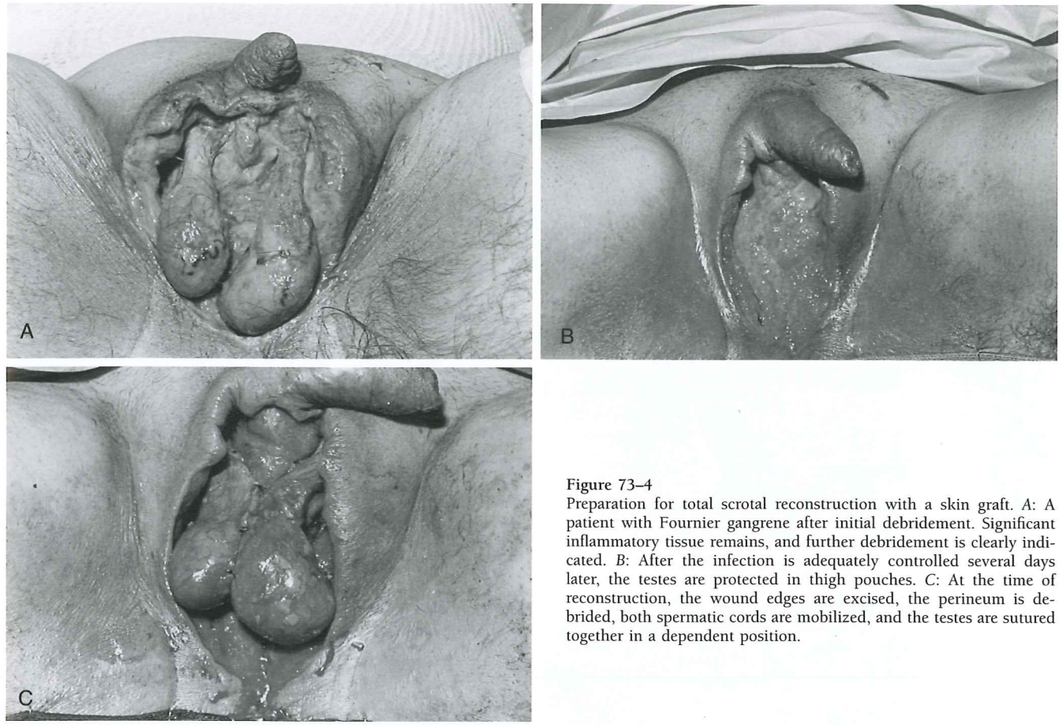


Figure 73–4
Preparation for total scrotal reconstruction with a skin graft. *A*: A patient with Fournier gangrene after initial debridement. Significant inflammatory tissue remains, and further debridement is clearly indicated. *B*: After the infection is adequately controlled several days later, the testes are protected in thigh pouches. *C*: At the time of reconstruction, the wound edges are excised, the perineum is debrided, both spermatic cords are mobilized, and the testes are sutured together in a dependent position.

with bolsters. Postoperative management is similar to that of penile reconstruction, detailed earlier. Drains are not necessary.

Long-term follow-up has shown that the neoscrotum may initially contract for about 3 months postoperatively. By placing the testes in a dependent position, a natural tissue expander is created. The neoscrotum then stretches slowly during the next year, allowing the testes to assume a stable, dependent position.

Total Scrotal Reconstruction Using Thigh Flaps

Thigh pedicle flaps may be used to achieve neoscrotum formation after complete scrotal loss.[18] Before the era of skin autografting, thigh skin flaps were the preferred method of repair for total scrotal denudation.[6] It is important that patients selected for this technique have loose skin overlying the thighs so that enough skin may be mobilized to form the flaps without requiring grafting of the donor area. Thigh flaps may be combined with perineal and penile skin grafts if necessary.

The testes are first sutured together in the midline after removal from the thigh pouches. The flaps are raised by incising through the skin to the level of the superficial fascia of the medial thigh and are then rotated medially, where they are sutured together with interrupted chromic sutures (Fig. 73–6). The neoscrotal flaps should be well drained to prevent transudate accumulation. Bed rest is encouraged initially to prevent undue tension on the flaps.

Best results are obtained when the thigh flaps are superiorly and laterally based, preserving the branches of the external pudendal, obturator, and medial circumflex arteries (Fig. 73–7). Nerve supply, which is from branches of the ilioinguinal and genitofemoral nerves, is similar to that of the normal scrotum and is usually preserved using this approach.[7] Cosmetic and functional results tend to be excellent, because the skin is hair bearing and sensation is left intact.

Normal spermatogenesis has been reported after total scrotal reconstruction with thigh flaps.[18] If fertility is an issue, thigh flaps may be created with minimal subcutaneous tissue overlying the testes, thus maintaining them at a temperature slightly less than that of the body core. Because skin grafting is simpler and provides equivalent functional results, thigh flaps should rarely be necessary. Whichever technique of neoscrotal formation is used, Leydig cell function usually rebounds to normal. Serum testosterone levels usually improve from near-castrate levels at the time of the acute illness to within the normal range after a few months.[7]

Other Options

Avulsed skin has been successfully used in repair of skin loss injuries of the genitalia. Without an attached pedicle,

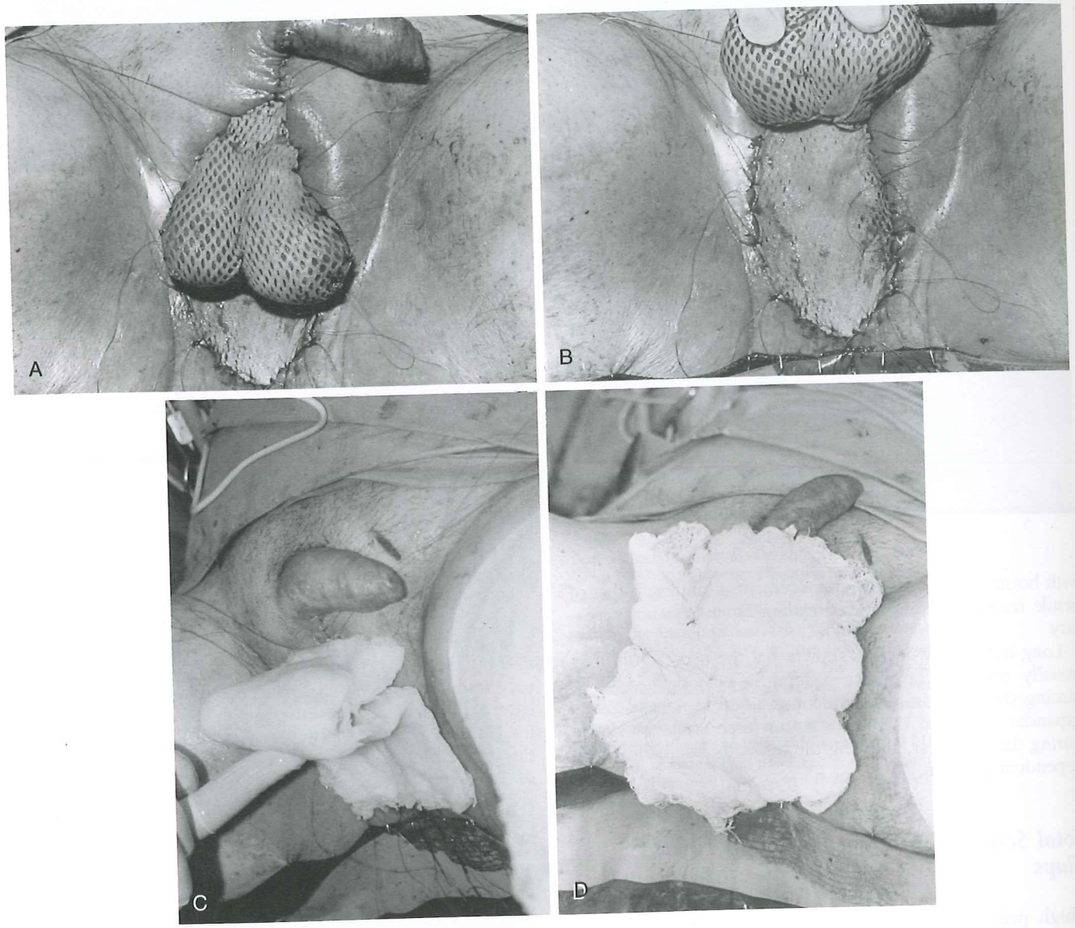


Figure 73–5
Technique of total scrotal reconstruction with a split-thickness skin graft in the same patient shown in Figure 73–4. *A*: Viable skin beneath the penis has been mobilized and closed primarily. A neoscrotum is configured using a 0.014-inch-thick meshed skin graft. *B*: The graft extends over the posterior and inferior aspects of the testes and onto the perineum. *C*: After application of Xeroform gauze, mineral oil–impregnated cotton is placed snugly over all grafted surfaces, ensuring apposition to the graft bed and a dependent position of the testes. *D*: Gauze dressings are placed on top and immobilized with bolsters tied from long 4-0 silk sutures at the graft periphery.

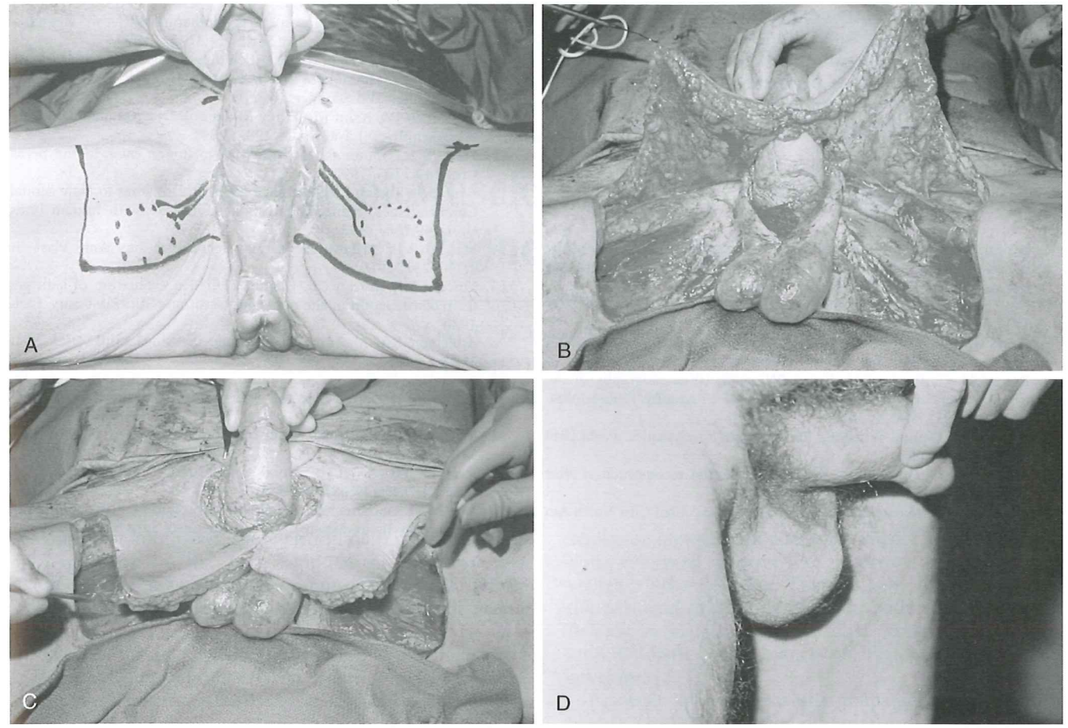


Figure 73–6
Technique of scrotal reconstruction using thigh flaps. *A*: Thigh flaps are outlined, superiorly and laterally based. Testes are residing in superficial thigh pouches as depicted. *B* and *C*: Testes and spermatic cords are mobilized from thigh pouches and sewn together. Thigh flaps are mobilized, rotated medially, and sutured together in the midline. *D*: Cosmetic and functional results are excellent 3 months postoperatively.

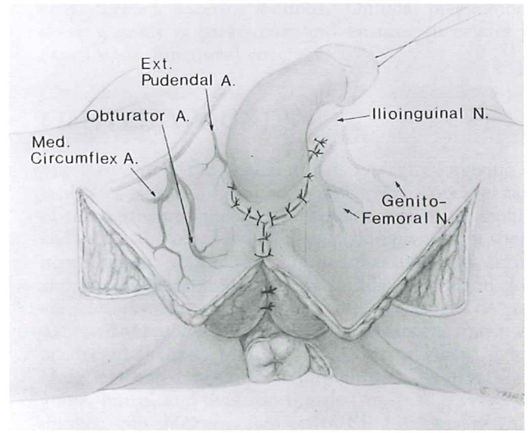


Figure 73–7
Blood supply and innervation of thigh flaps are similar to that of a normal scrotum, thus making this an excellent choice for total scrotal reconstruction.

however, it is usually nonviable and results have generally not been good.[5, 15] Soft tissue expanders have been successfully used to stretch perineal skin adequately for testicular coverage. Gradual filling of one or two tissue expanders of 200 to 250 ml capacity is performed over 6 to 12 weeks. The expanders are then removed, the testes are mobilized from thigh pouches, and orchiopexy is completed.[19, 20]

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CHAPTER

74

The Use of Muscle Flaps for Coverage of Perineal Defects

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CHRISTINA Y. AHN
WILLIAM W. SHAW

Reconstruction of pelvic and perineal defects is a challenging endeavor in the most optimal of circumstances. Wounds are characteristically composite, radiated, heteroplanar, and continuously doused with an array of hostile enteric pathogens. Reconstructive surgeons must use their armamentarium of vascular, anatomic, and oncologic principles to ensure definitive closure and asepsis, as well as to optimize residual sensibility and ambulation. In addition, the psychologic makeup of these patients must be considered, because the physical loss has great significance for residual sexual potency, self-esteem, and reproductive potential.[1] The ultimate goals of reconstruction are preservation of excretory, sexual, and reproductive function; anatomic coverage; and maintenance of aesthetic form.

ETIOLOGY AND WOUND PREPARATION

The mechanism, progression, and duration of injury are crucial factors in the recontructive design. Avulsion or scalping injuries of the genitalia and perineum typically involve farm machinery, mills, or assembly equipment.[1] Appendages are usually spared but stripped to their fascial compartments owing to the overlying skin laxity in this region. Blast and penetrating injuries require thorough operative exploration to ensure vascular as well as enteric integrity. Pulsatile irrigation and debridement of devitalized tissue, particularly poorly vascularized adipose, is essential in avoiding fulminant septic complications. Chronically infected wounds involving severe hidradenitis suppurativa, Fournier's gangrene, and "watering-pot" perineum due to inflammatory bowel disease, and urethral stricture necessitate interval and serial debridement, intensive wound care, and either residue-free alimentation or diversion before definitive coverage. Bites by humans, animals, snakes, and spiders not uncommonly manifest as synergistic or necrotizing infections, endangering diabetic, senile, or immunodeficient individuals. These wounds require emergent "ablative-like" resection and operative surveillance before closure. Thermal and chemical injuries of the perineum frequently result in adduction contractures. Release is necessary for effective application of topical antimicrobials, maintenance of hygiene, and access for coverage.

Evidence of a successfully prepared recipient site includes a well-vascularized granular bed, acceptable microbial control (usually $<10^5$ bacteria/mm^3), and advancing epithelial margins. Thorough surgical debridement and pulsatile irrigation is the most expeditious and cost-effective means of wound preparation. Secondarily, various dressings (saline, Dakin's solution, etc.) and topical antimicrobials (silver sulfadiazine, etc.) may assist the host in achieving bacteriologic dominance over these often chronically infected, festering wounds.[1] Optimal preparation of these wounds is paramount and ensures successful and expeditious, functional coverage.

LIMITED WOUNDS

The anatomy of the genital area is typically forgiving and facilitates closure of limited wounds. The concave saddle of the perineum, and the remarkable resilience, mobility, and expansion of scrotal and labial skin precipitate spontaneous wound contraction.[1] Limited pressure sores, fistulas, and premalignant lesions may be locally excised and closed via advancement, after moderate undermining. The versatile, well-vascularized labia may be advanced, transposed, or deepithelialized to fill limited and adjacent defects. More extensive wounds resulting from Fournier's gangrene, burns, and avulsion injuries are best covered with meshed split-thickness skin grafts. Chronic open or granulating wounds and hypertrophic burn scars frequently prompt adduction or flexion contractures, and necessitate release, grafting, Z-plasty, or VY advancement. Hairless

medium or full-thickness grafts may be harvested from the groin, inguinal, or gluteal fold regions, enabling primary donor site closure. Graft success mandates immobilization with bolster dressings or well-secured, bulky compression dressings. Splints help to reinforce and stabilize dressings, thereby minimizing the risk of shear and graft failure.[2]

INDICATIONS FOR FLAP COVERAGE

Defects due to pelvic and perineal tumors, debilitating infections, neglected pressure sores, and adjuvant high-dose radiotherapy necessitate replacement with abundant, well-vascularized muscle or myocutaneous flaps. Management of gynecologic, urinary, and gastrointestinal cancers has in recent years been characterized by earlier diagnosis in younger patient subgroups. Surgical treatment in turn has tended toward safer, less radical ablation that preserves function without sacrificing curability.[2] The maintenance of sexual function, as well as intestinal and urinary integrity, mandates careful consideration and planning beyond that required for simple coverage.[2] The flaps described are available to meet various and specific individual, functional, and ablative needs. In contrast, pelvic exeneration necessitates anatomic restoration. Reconstructing pelvic and lower abdominal defects minimizes herniation and the fluid sequestration of "pelvic burn": an empty, deserosalized pelvis is equated with the morbidity and lethality of a 20% full-thickness burn. Although the pedicled omentum provides a sling, it is insufficient in providing complete obliteration and is not discussed further.[3] Immediate reconstruction of these defects therefore decreases the incidence of postoperative abscess and small bowel obstruction, providing consistent and less morbid recovery.

Today, adjuvant radiotherapy is commonly used in the treatment of lower GI, urinary tract, and perineal malignancies. The advantage of maximal-dose radiation, however, may prompt ischemic fibrosis, lymphedema, and osteoradionecrosis. The management and reconstruction of radiation ulcers mandates (1) complete excision of all offending tissue and (2) the introduction of abundant, well-vascularized, extraportal regional tissue.[4] Primary closure, skin grafts, and adjacent random flaps are associated with higher failure rates. Conversely, coverage with vascularized myocutaneous flaps provide the optimal and definitive physiologic coverage for chronic or contaminated radiation defects. In addition, pedicled muscle flaps provide delivery of essential components including immunoglobulins, complement, and phagocytic lymphocytes.[5] The flaps provide greater wound conformity, superior resistance to bacterial inoculation, and a higher oxygen tension, which helps to override local hypoxia and fibrosis.[5]

ANATOMIC PARAMETERS

Surgeons who incorporate flaps in their reconstructive armamentarium, for pelvic and perineal defects, must have a sound understanding of the iliofemoral blood supply and the potential excursion of various pedicles, whether muscular, myocutaneous, or fasciocutaneous flaps are used. The most efficient flap optimizes the regional vascularity, carries the greatest volume, and has the widest excursion. The internal iliac artery supports the expansive gluteus and posterior gluteal thigh flaps through the superior and inferior gluteal arteries. A short pedicle limits axial advancement of the gluteus myocutaneous flap to coverage of pelvic and posterior perineal wounds. In contrast, the fasciocutaneous extension of the posterior gluteal thigh flap allows a wide arc of rotation and coverage of ischial, perineal, and sacral defects (see Figs. 74–2 and 74–9*B*). The external iliac artery, above the inguinal ligament, provides a robust, dominant inferior epigastric pedicle to the rectus abdominus myocutaneous flap (see Fig. 74–3). This flap, as discussed later, is the workhorse for burrowing anterior perineal and groin wounds. The remaining flaps for perineal reconstruction are derived from the thigh and are supplied, in their upper third, predominantly by branches of the deep profunda femoris artery.[6] In addition, a rich cruciate network between the proximal profundus and gluteal systems potentiates coverage of expansive, complex hip defects.[7, 8] In general, pelvic collateralization provides flap alternatives for patients with individual functional or sensory needs.

FLAP ANATOMY AND SELECTION

Ten well-described local flaps are available and have been effectively used to treat the majority of perineal wounds. Only occasionally is free tissue transfer necessary to provide coverage beyond that available with local flaps. The indications, anatomic details, arcs of coverage, and technical points are discussed next.

Groin Flap

The groin flap, originally described by McGregor in 1972, may be raised as a pedicled or island flap[9] (Fig. 74–1). It represented the first clinical free tissue transfer in 1973. Its arc of rotation reliably covers the lower abdominal, suprapubic, anterior perineal, and anterior thigh regions[1] (Fig. 74–2). The superficial circumflex iliac artery (SCIA) and superficial inferior epigastric artery (SIEA) originate, in a radial pattern, 1 to 2.5 cm below the inguinal ligament, and alternately dominate in supplying this substantial (20×35 cm) fasciocutaneous flap.[10] The SCIA passes superolaterally, penetrates the lateral sartorius fascia, and continues in the subcutaneous layer toward the anterior superior iliac spine (ASIS). The SIEA, initially more superficial, crosses anterior to the inguinal ligament and passes toward the umbilicus.

The flap is oriented along a line between the ASIS and the femoral artery, 2 cm below the inguinal ligament. Approximately two thirds of the flap lies above and one third below this axis.[11] Flap elevation is initiated by exposure of the venous pedicle through a longitudinal incision, immediately inferior to the saphenous bulb.[11] After completing the incision, the flap is rapidly elevated off the external oblique fascia, from lateral to medial. The sartorius fascia, due to the adherence of the SCIA pedicle, must be incised and elevated with the flap. This provides visualization of the vascular pedicle and allows completion of the inferomedial dissection. The groin island flap provides a wide arc of rotation, a well-concealed and primarily closed donor site, and negligible donor morbidity. The pedicled flap may assist lymphatic drainage and aid resolution of a lymphedematous wound or lower extremity. Because of the sensitivity and caliber of the superficial vessels, transcutaneous monitoring (i.e., Doppler) may be futile or misleading. Finally, this flap should be avoided in reconstruction of low rectal, anal, or vaginal malignancies due to the potential for regional cutaneous or lymphatic involvement.

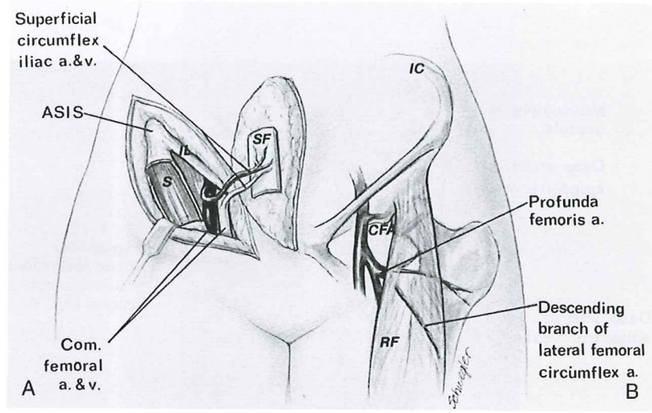


Figure 74–1
A: Groin flap. ASIS anterior superior iliac spine; IL, inguinal ligament; S, sartorius muscle; SF, sartorius fascia. *B*: Rectus femoris myocutaneous flap. CFA, common femoral artery; IC, iliac crest; RF, rectus femoris.

Rectus Abdominis Flap

The rectus abdominis flap is a powerful, bipedicled (type II), highly versatile, and dependable muscle or myocutaneous flap (Fig. 74–3). The inferiorly based transverse or vertical myocutaneous flap is perhaps unparalleled in its vascularity, excursion, design flexibility, and ability to provide bulk (Fig. 74–4). It is the flap of choice for intrapelvic and pelvic floor postexeneration defects. In addition, it is ideal for perineal, groin, and anterior thigh defects and is commonly used for phallic and vaginal reconstruction (see Fig. 74–2).

The rectus abdominis originates from the symphysis pubis, spans the abdomen, and inserts into the fifth to seventh costocartilages.[10] The dominant, deep inferior epigastric pedicle crosses anteromedially from the external iliac artery, immediately above the inguinal ligament, and travels 7 to 12 cm superomedially, before dividing and entering the posterior surface of the muscle. Sixty percent of the musculocutaneous perforators, arranged in medial and lateral rows, reliably encompass a zone extending 8 cm inferior, and between 2 and 5 cm lateral to the umbilicus.[3] The perforators are direct cutaneous branches of the deep inferior epigastric artery (DIEA) and enable great flexibility in the design of transverse, vertical, or oblique skin paddles.

After circumferential release of the umbilicus, the flap is elevated toward the ipsilateral medial and lateral musculocutaneous perforators. A fascial incision, adjacent to the perforators, consistently minimizes the fascial defect to 1.5 to 2.0 cm. This allows a doubly reinforced fascial closure below the arcuate line. The lateral rectus sheath is raised, demonstrating the lateral edge of the rectus muscle. Careful elevations of the muscle here exposes the deep inferior epigastric pedicle. The flap is lifted away from the posterior rectus sheath, divided superiorly, and rotated into the defect. Extrapelvic rotation necessitates a precise transfascial passage to avoid pedicle impingement. Alternatively, the flap may be deepithilialized and used to obliterate an

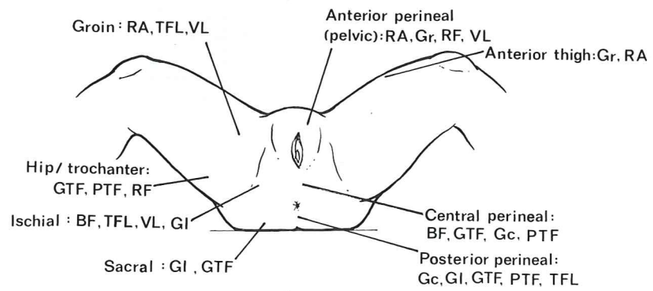


Figure 74–2
Regional flap selection, based on arc of rotation. BF, biceps femoris; Gc, gracilis; GI, gluteal flap; Gr, groin flap; GTF, gluteal thigh flap; PTF, posterior thigh flap; RA, rectus anbdominis; RF, rectus femoris; TFL, tensor of fascia lata flap; VL, vastus lateralis.

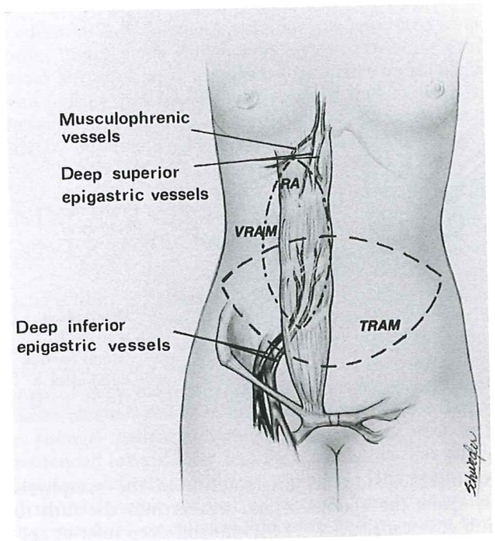


Figure 74–3
Rectus abdominis myocutaneous flap. RA, rectus abdominis; TRAM, transverse rectus abdominis myocutaneous flap; VRAM, vertical rectus abdominis myocutaneous flap.

empty pelvis or used purely as a muscle flap. The contralateral rectus remains intact and may provide support for ancillary ostomies or feeding tubes.[3] It is important to ensure patency of the DIEA early if prior radical groin lymphadenectomy or high-dose radiotherapy was a component of prior therapy. In addition, prohibitive abdominal scarring and the desire for subsequent childbirth must be considered before flap selection. Postoperative abdominal herniation may be minimized by fastidious abdominal closure. This flap represents a highly predictable reconstructive "lifeboat" and can independently salvage the most impressive defects.

Gracilis Myocutaneous Flap

The gracilis muscle (type II) is a versatile and expendable muscle commonly used for central perineal, pelvic, phallic, and vaginal reconstruction (Fig. 74–5). This long, sinewy, functional muscle is well suited for sphincter restoration and repair of various perineal fistulas (Fig. 74–6). McCraw and colleagues originally described its use for vaginal reconstruction after abdominoperineal and pelvic exeneration in 1976.[12]

The gracilis is a thin, flat, straplike muscle originating at the adductor tubercle of the symphysis pubis. It extends superficially along the adductor compartment and becomes tendinous 10 cm before its insertion into the medial tibial condyle. The medial femoral circumflex artery (MFCA) (1.2 to 1.8 mm) originates from the profunda femoris, passes inferomedially between the adductor longus and brevis muscles, and enters the muscle 8 to 10 cm below the pubic tubercle.[11] A minor distal segmental pedicle may be present but is sacrificed during elevation. Both motor function and sensibility can be preserved via the anterior branch of the obturator nerve.

A proximal longitudinal incision along the posterior edge of the adductor longus identifies the intramuscular cleft between itself and the gracilis muscle.[10] Retraction of the adductor exposes the vascular pedicle and obturator nerve. A second, distal longitudinal incision exposes the gracilis tendon between the anterior sartorius and posterior semimembranosus tendon.[13] Retracting or "bowstringing" the muscle through both incisions enables centralization of the skin paddle, thereby ensuring viability. The distal segmental pedicle and tendon are divided, and the flap is drawn through the intervening subcutaneous tunnel and then rotated as needed. The muscle may span 12 to 15 cm into the pelvic space, to obliterate limited defects, or may provide functional muscle for sphincter restoration.[1] The width of the skin paddle should be limited to 6 to 8 cm, ensuring reliable viability and primary closure of the donor site. Tacking the skin to the underlying muscle helps to avoid inadvertent disruption of the delicate fascial interface. Also, the vascular pedicle may limit excursion, and cause subsequent rotation, to form an inconvenient upper medial thigh fullness.

In 1989, Soper described the short gracilis myocutaneous flap for limited central perineal and vulvovaginal defects. This flap is supplied through its symphyseal origin by terminal branches of the obturator artery. Sacrificing the MFCA pedicle enables greater excursion and proximal mobility, but limits especially cutaneous reliability. This flap is not reliable after extensive groin irradiation or hypogastric ligation.[14]

Tensor of Fascia Lata Flap

The predominantly fasciocutaneous tensor of fascia lata (TFL) flap (type I) provides ideal coverage of irradiated postlymphadenectomy groin wounds (Fig. 74–7). The tenacity and expanse of available fascia also proves ideal as a substitute for full-thickness lower abdominal defects (Fig.

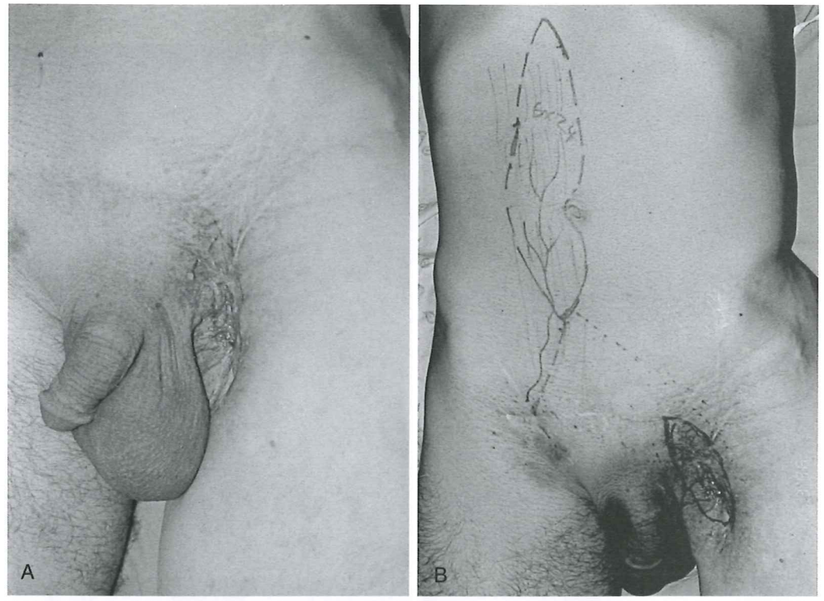
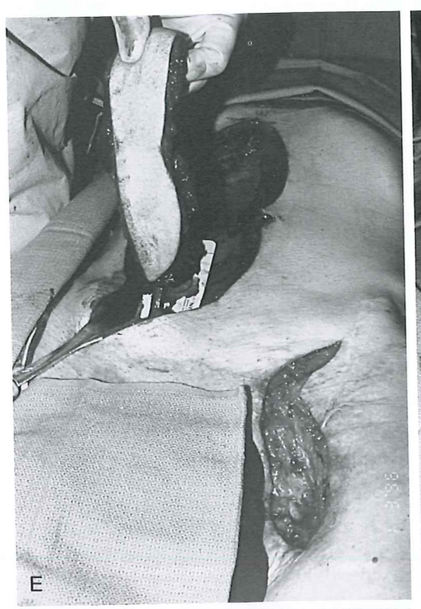


Figure 74–4
The patient is a 42-year-old active male who 23 years ago underwent multiple wide excisions, radical groin lymph node dissection, and high-dose radiotherapy for recurrent desmoid tumor. *A*: The patient presents with refractory, nonhealing left groin ulcer. *B*: Design of contralateral vertical rectus abdominis myocutaneous island flap. Note the intersecting right inguinal McBurney and herniorrhaphy incisions. *C*: Angiographic confirmation of right deep inferior epigastric patency. *D*: Flap harvest and debridement of groin ulcer.





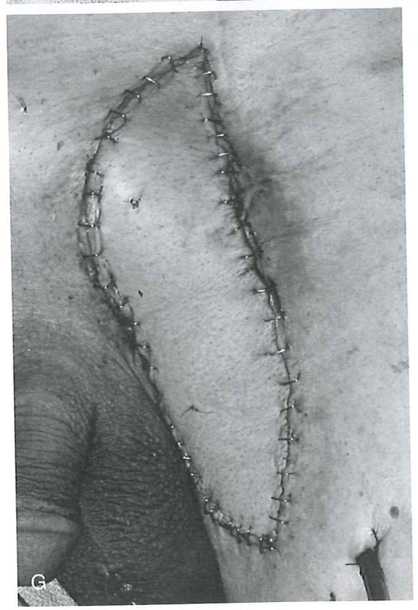


Figure 74–4 *Continued*
E: Elevation of the contralateral vertical rectus myocutaneous flap and mobilization of the deep inferior epigastric pedicle. *F*: Transfer of the island flap through a suprafascial suprapubic tunnel. *G*: Flap inset.

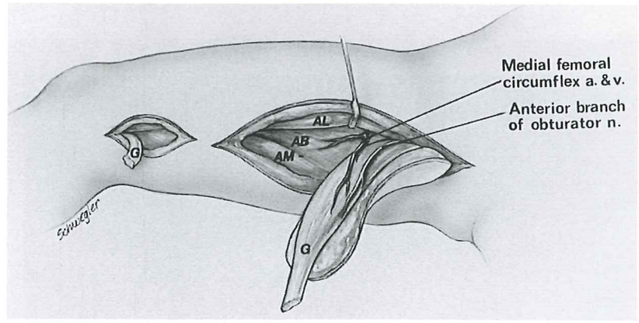


Figure 74–5
Gracilis myocutaneous flap. AB, adductor brevis; AL, adductor longus; AM, adductor magnus; G, gracilis muscle.

74–8). The TFL flap allows transposition of protective sensibility to ischial and congenital lumbar defects (i.e., meningomyelocele) through preservation of the lateral femoral cutaneous nerve and T12 intercostal branches.

The TFL flap is a fish-shaped flap originating from the anterior iliac crest. It inserts into the iliotibial band at the proximal-middle third junction.[10] The complex provides lateral knee stability and supplements hip flexion and medial rotation. The TFL is supplied by the lateral femoral circumflex artery (LFCA), the first branch of the profunda femoris artery. The transverse branch of this artery courses laterally over the vastus intermedius, deep to the rectus femoris and sartorius muscles. The pedicle emerges medial to the greater trochanter, 8 to 10 cm below the ASIS, and enters the proximal third of the muscle.

The ultimate size of the TFL flap is remarkable (14×45 cm) in view of its disproportionately small underlying tensor muscle.[1] If a broad proximal cutaneous base is maintained, the entire anterolateral thigh tissue may be elevated. The anterior border of the flap corresponds to a line between the ASIS and the lateral edge of the patella. The posterior border extends from a point 5 cm posterior to the ASIS and passes anterior to the greater trochanter, toward the lateral condyle of the femur. Skin margins can reliably exceed the anterior and posterior margins; however, the inferior extent should end 15 cm proximal to the knee.[10] Subfascial flap elevation may proceed rapidly, from distal to proximal. Medial retraction of the rectus femoris exposes the vascular pedicle. Posteriorly, the muscle is detached from gluteus insertions, enabling optimal excursion. The lateral femoral cutaneous nerve (LFCN) should be preserved as it passes 1 to 2 cm inferomedial to the ASIS. The flap may be transfered as a broad-based pedicle, island, or free flap.

A flap wider than 6 cm routinely requires a skin graft for closure. Seromas frequently plague donor site healing, and depressed scars cause significant asymmetry. Infrequently, some degree of lateral knee instability requires prolonged rehabilitation.[1] Traction injury to the LFCN results in meralgia paresthetica and should be carefully avoided. Finally, the flap contributes minimal muscle and should not be expected to eradicate contaminated defects.[1]

Rectus Femoris Flap

The muscular rectus femoris flap (type I) attains a wide arc of rotation, incorporates a thick tenacious fascial layer, and can provide a considerable amount of malleable and well-vascularized tissue. It is the flap of choice for full-thickness or attenuated lower abdominal and suprapubic wounds and is a reliable standby for trochanteric and hip defects. Although the muscle averages only 6 cm in width, an expansive fasciocutaneous component (15×20 cm) can be transferred reliably.

The muscle, averaging 36 cm in length, spans from the ASIS to the central patellar tendon and represents the central portion of the quadriceps complex (see Fig. 74–1*B*). The descending branch of the LFCA enters the deep surface of the muscle 10 to 15 cm below the ASIS. The centralized skin paddle may approach dimensions of 10×30 cm, but should remain within the borders of the sartorius and TFL.[10] Once the distal central tendon is identified, the entire muscle is rapidly elevated, through a bloodless plane to the limits of its vascular axis. It reliably stretches to a point 5 cm above the umbilicus.[10] Extensor weakness is minimized by approximating the vastus lateralis and medialis above the patellar tendon. The majority of patients achieve 80% of maximal extensor function within 6 months, without rehabilitation.[15] The rectus femoris is therefore highly versatile, relatively expendable in ambulatory patients, and one of the simplest flaps to elevate.

Vastus Lateralis Flap

The vastus lateralis (type II) muscle, the largest of the quadriceps complex, accounts for the majority of thigh bulk, and is a secondary choice in perineal reconstruction. It provides abundant and well-vascularized conforming muscle to cover complex, irradiated, and infected wounds. Its arc of rotation is similar to the often concomitantly raised TFL, because it reliably covers the anterior perineum, groin, ischium, and lower abdomen. It is unsurpassed in providing muscular bulk for deep and varied defects.

Access is gained through an incision extending from the ASIS to the lateral edge of the patellar tendon. The cleft between the vastus lateralis and rectus femoris is extended proximally until the LFCA pedicle is identified. The muscle is then elevated away from the underlying vastus intermedius. Posteriorly, the dissection is imprecise due to the fusion of the vastus lateralis, biceps femoris, and vastus intermedius as they insert onto the greater trochanter and femur.[10]

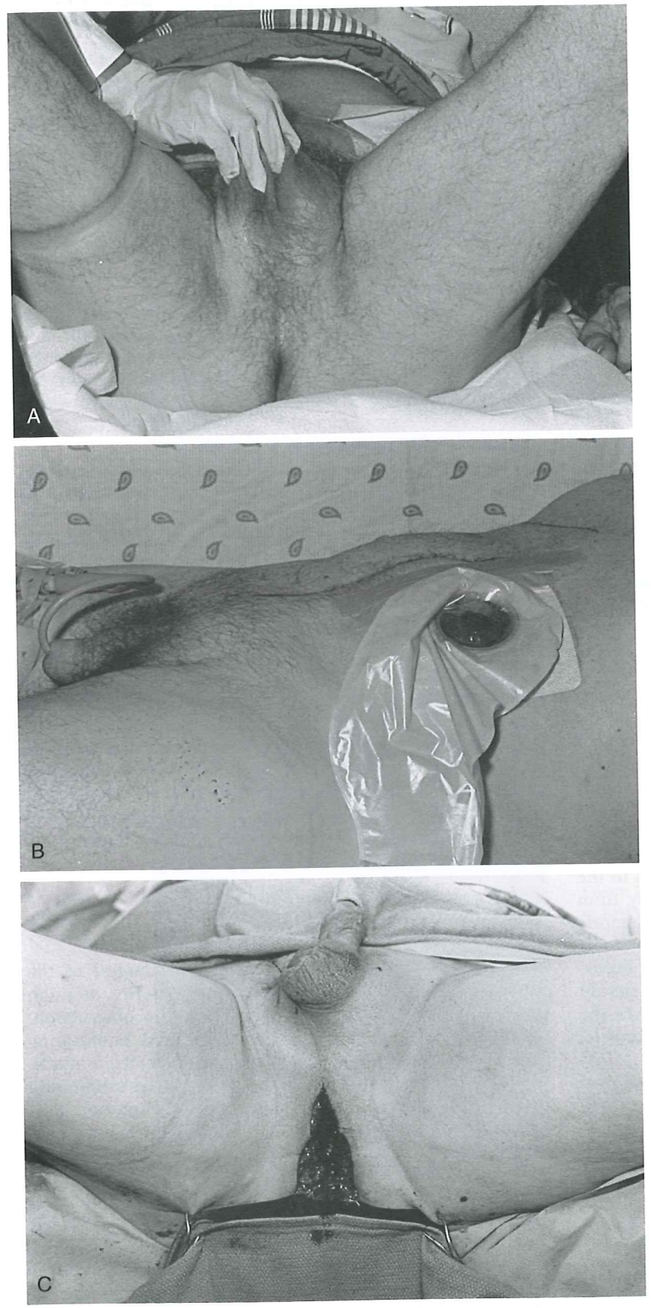


Figure 74–6
The patient is a 62-year-old male with *A*: Refractory recto-urethral fistula following radical prostatectomy. *B*: Note the diverting loop colostomy, midline appendectomy, and cholecystectomy incisions. *C*: Prostatectomy defect.

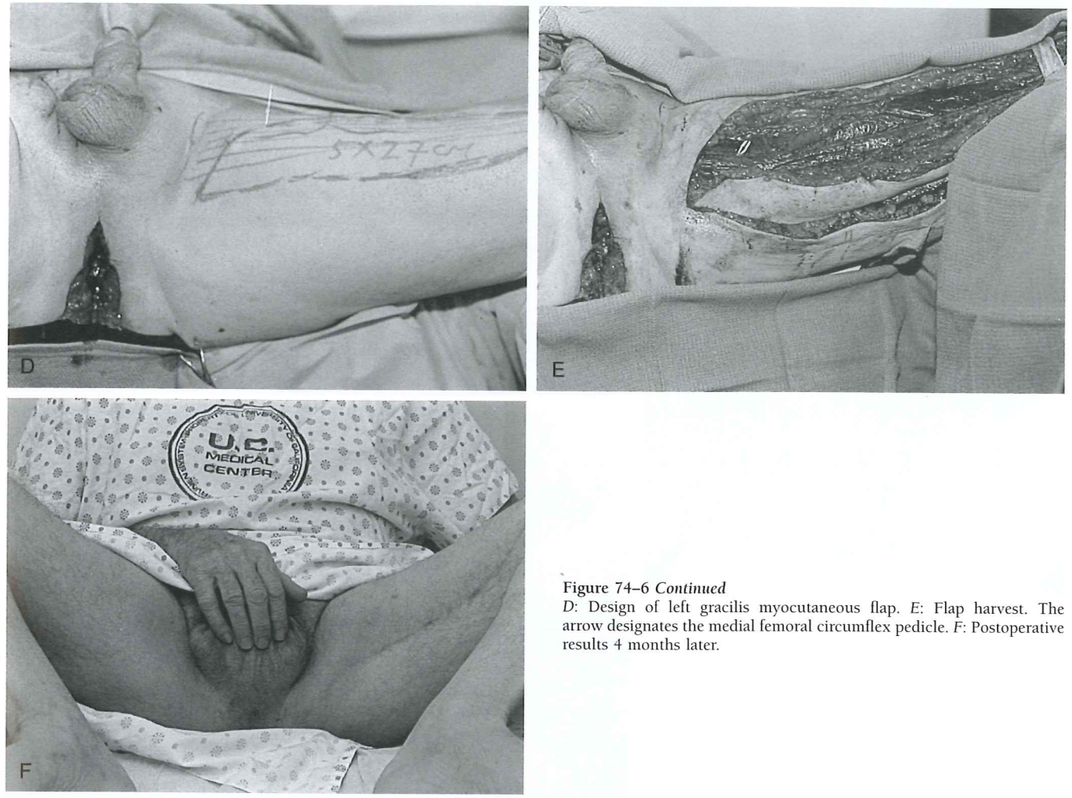


Figure 74–6 *Continued*
D: Design of left gracilis myocutaneous flap. *E*: Flap harvest. The arrow designates the medial femoral circumflex pedicle. *F*: Postoperative results 4 months later.

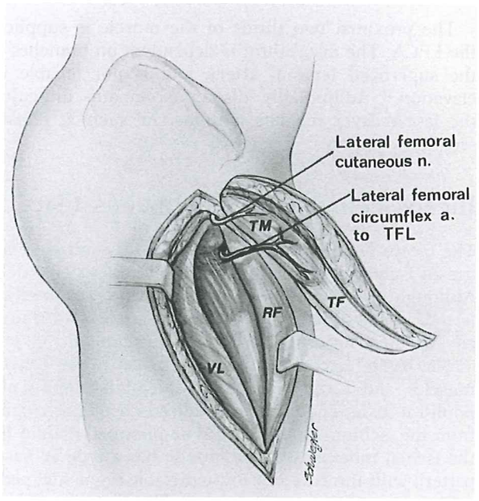


Figure 74–7
Tensor of fascia lata myocutaneous flap. RF, rectus femoris; TF, tensor fascia; TM, tensor muscle; VL, vastus lateralis.

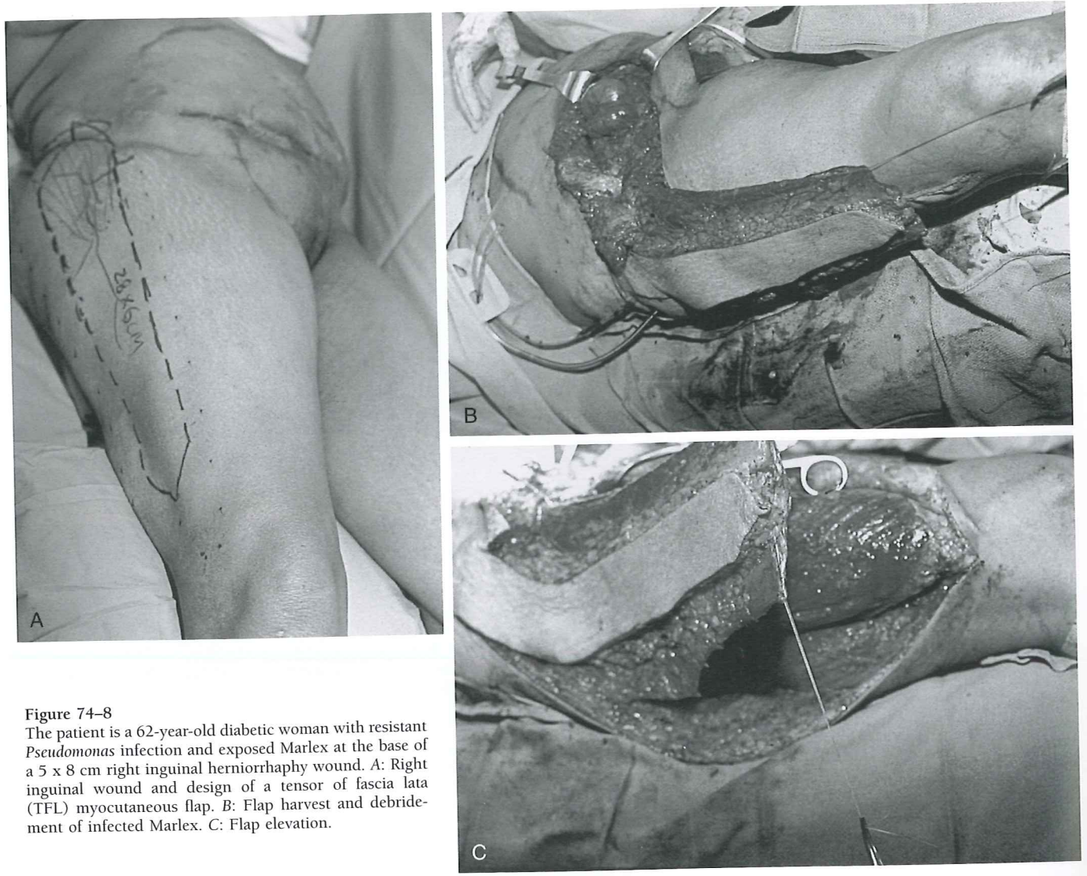


Figure 74–8
The patient is a 62-year-old diabetic woman with resistant *Pseudomonas* infection and exposed Marlex at the base of a 5 x 8 cm right inguinal herniorrhaphy wound. *A*: Right inguinal wound and design of a tensor of fascia lata (TFL) myocutaneous flap. *B*: Flap harvest and debridement of infected Marlex. *C*: Flap elevation.

The proximal two thirds of the muscle is supplied by the LFCA. The distal third is dependent on branches from the superficial femoral artery, and is not reliable upon elevation.[10] Additionally, dissection remains difficult and the fascial layer remains tenuous. As such, it remains a secondary option.

Biceps Femoris Myocutaneous Flap

The biceps femoris myocutaneous flap is limited to coverage of ischial pressure sores and central perineal defects. Although this was one of the first flaps to be raised as an island, its questionable vascularity has relegated it to a VY advancement flap with limited local excursion.

The biceps femoris is the most lateral of the hamstring muscles and forms the visible lateral boundary of the popliteal fossa. The flap is centralized on an axis extending from the ischium to the knee. The proximal margin lies at the ischial tuberosity.[10] The muscle has a type IV vascular pattern with three to four unpredictable segmental pedicles arising from the deep profundus. The absence of an axial or collateral circulation restricts elevation and excursion.[10]

After the long and short heads are transected distally, the muscle is separated from the vastus lateralis and medial semitendinosus and advanced proximally, maintaining the segmental circulation. The flap is limited in bulk and not infrequently disrupts due to excess tension. This exemplifies the common disparity of flap excursion and regional soft tissue demands.

Gluteus Maximus Myocutaneous Flap

The expansive, bulky gluteus maximus myocutaneous flap is the recommended choice for large, contaminated sacral wounds. As a type III muscle, it may be split into independant superior and inferior myocutaneous flaps for substantial coverage of sacral and perineal wounds, respectively[7] (Fig. 74–9*B*).

The muscle extends broadly from an origin including the posterior ileum, sacrum, and coccyx to insert into the iliotibial band and greater trochanter. It represents the strongest extensor and external rotator of the hip and is

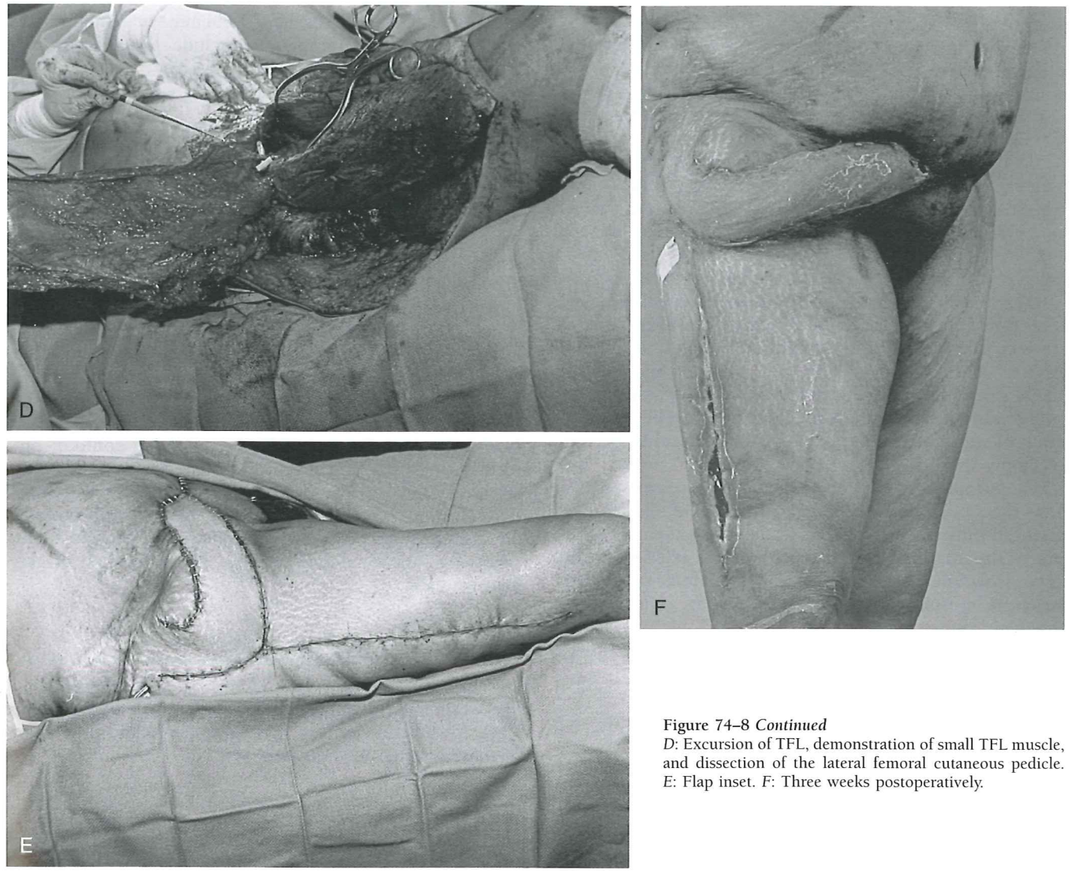


Figure 74–8 *Continued*
D: Excursion of TFL, demonstration of small TFL muscle, and dissection of the lateral femoral cutaneous pedicle. *E*: Flap inset. *F*: Three weeks postoperatively.

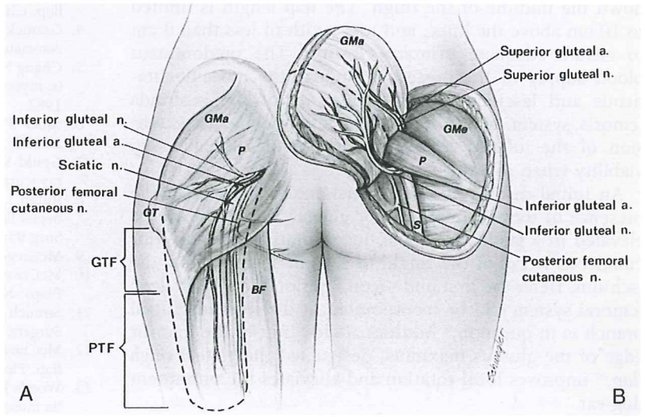


Figure 74–9
A: Posterior and gluteal thigh flaps. BF, biceps femoris; GMa, gluteus maximus; GT, greater trochanter; GTF, gluteal thigh flap: P, piriformis; PTF, posterior thigh flap. *B*: Gluteal myocutaneous flap. The dotted line designates superior and inferior flaps. GMe, gluteus medius; S, sciatic nerve.

paramount to exertive ambulation.[16] In addition to the codominant superior and inferior gluteal arteries, a rich collateral network composed of superior lumbar and deep profundus perforators exists, and enables considerable design flexibility.[7,8] The two dominant pedicles emerge superior and inferior to the piriform muscle and travel 3 to 4 cm inferolaterally before entering the muscle. The inferior gluteal artery continues inferiorly, midway between the ischium and greater trochanter, as a direct cutaneous branch and accompanies the posterior femoral cutaneous nerve of the thigh.

The gluteal flap involves elevation and VY advancement of the entire hemibuttock for coverage of sacral wounds. Dissection of a superior or inferior flap, however, necessitates vascular centralization and variable mobilization from iliosacral and femoral attachments. Superior and inferior gluteal rotation or island flaps require further dissection or skeletonization of the short pedicles. This enables mobilization of substantial bulk for posterior perineal or proctocolectomy wounds.[17]

Anatomically, the superior island flap encompasses the most functional portion of the muscle and therefore is sacrificed only in less active or sedentary patients.[16] Conversely, the inferior island flap harbors the inferior gluteal nerve. Isolation of the inferior flap, therefore, denervates the entire muscle and is indicated only in bedridden or paraplegic patients.[16]

Posterior Thigh Flap

The posterior thigh flap, originally described in 1956 and popularized by Paletta in 1993,[18] is the flap of choice for surface contour replacement of perineal defects[15] (Fig. 74–9). Its arc of rotation allows reliable coverage of central perineal, ischial, and trochanteric defects. The transfer of sensibility, via the posterior cutaneous nerve of the thigh, is immensely beneficial in its ability to simulate pressure as well as erotic stimulation of the perineum.

The flap is centered over a line bisecting the distance between the ischium and greater trochanter, continuing down the midline of the thigh. The flap length is limited to 10 cm above the knee, and to a width of less than 8 cm to ensure adequate primary closure.[8] The predominant blood supply of the posterior thigh is the musculocutaneous and fasciocutaneous perforators of the profunda femoris system. A less consistent fasciocutaneous extension of the inferior gluteal artery provides reliable flap viability when present.[19]

An initial distal transverse incision should confirm the presence of the terminal inferior gluteal artery. The flap is elevated in a subfascial plane, incorporating the posterior cutaneous nerve of the thigh, to a point 10 cm below the ischium. Here, the first and second perforators of the deep femoral system can be incorporated, if the inferior gluteal branch is in question.[8] Additional elevation of the inferior edge of the gluteus maximus, designated the *gluteal thigh flap*,[20] improves local rotation and alleviates the prominent dog-ear.

Although well vascularized, the flap lacks muscle and is a poor choice for radiated, ischemic, or contaminated wounds.[8] Patients' complaints include loss of posterior thigh sensation and an unsightly dog-ear.

CONCLUSION

Successful reconstruction of complex and challenging perineal defects requires a comprehensive evaluation of the structural, metabolic, and pathologic deficits. Successful wound closure is dependant on the consistent execution of standard surgical techniques and principles, and the motivation of an attuned, dedicated multidisciplinary team. Preservation of excretory, sexual, and ambulatory function is the primary goal. Vigorous regional myocutaneous flaps are essential in providing durable, reliable, well-vascularized bulk for anatomic restoration of ischemic, contaminated, and radiated wounds. Regional sensate fasciocutaneous flaps provide the anatomic contour, protective sensibility, and sexual incentive necessary for complete physical and psychologic rehabilitation. Customized flap selection, surgical anatomy, and the surgeon's expertise are critical factors in achieving safe, effective, and highly gratifying functional and aesthetic reconstruction of perineal wounds.

Acknowledgments

We would like to especially thank Janice Schwegler, MS, CMI, for her time, effort, and expertise in the production of these original illustrations.

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CHAPTER

75

Vulva Reconstruction Using Gracilis V-Y Advancement Flaps

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JAMES R. BOSSCHER
DAVID L. DOERING

Gracilis muscle-skin V-Y advancement flaps provide highly reliable and functional reconstructions of vulvectomy and perineal defects. These flaps carry skin, subcutaneous tissue, and muscle from the upper inner thigh on a vascular supply from several sources composed of musculocutaneous perforators from the gracilis muscle as well as axial subcutaneous and fasciocutaneous vessels through a preserved dorsal or ventral cutaneous and fascial pedicle.[1] The enhanced vascularity provided by these diverse vascular supplies increases the reliability of flap transfer and lessens healing complications, as compared with alternative reconstructive methods for these defects. Vulvectomy wound reconstructions are especially prone to healing complications of necrosis, infection, and dehiscence, particularly when combined with regional lymphadenectomy. Because of the perineal location of these wounds, the reported incidences of healing complications of these procedures are among the highest of all reconstructive procedures.[2] These complications substantially lengthen hospital stays, and associated secondary intention healing creates perineal contractures and strictures that impair voiding, perineal hygiene, and sexual activity. Accordingly, gracilis V-Y advancement flaps are a preferred method for vulvectomy and perineal reconstruction because of the quality of repair and the reduction in associated healing complications that they provide.

INDICATIONS, ADVANTAGES, AND DISADVANTAGES

Gracilis V-Y advancement flap reconstructions are indicated for virtually any vulvectomy defect, unless the defect is too massive or the flaps are anatomically unavailable or heavily irradiated. Their principal use has been for reconstruction of oncologic resections, although we have also used them for trauma-related defects and for perineal pressure ulcer reconstruction.[1] The latter circumstances most often arise in paraplegia with abnormal weight distribution due to severe scoliosis or previous ischiectomy, which can transfer pressure anteriorly on the ischiopubic arch and create vulvar or perineal ulcers.

In patients who undergo prior or concurrent inguinal lymphadenectomy, gracilis V-Y advancement flaps remain a most useful vulvectomy reconstruction. In this circumstance, the abundant blood supply is preserved by using the dorsal cutaneous pedicle that carries internal pudendal branches, as the supply from the femoral vessels to the ventral pedicle is wholly or largely divided by the lymphadectomy. Defects with transverse dimensions up to 10 to 12 cm on each side can be reconstructed by this flap, and somewhat larger defects can be addressed if the inner thigh tissue is more redundant.

This flap should not be used in patients with transecting scars from preexisting incisions across the skin paddle and with massive perineal defects that extend substantially onto the medial thigh and ablate much of the potential flap. These massive defects are better addressed by large transposition flaps, such as the rectus abdominis[3, 4] (see Fig. 47–2*B*). Prior high-dose irradiation with fields encroaching onto the flap also warrants choosing other reconstructive techniques.

ANATOMY

Anatomic features of the gracilis V-Y advancement flap are shown in Figure 75–1*A*. This muscle-skin flap unit includes the gracilis muscle and the overlying upper inner thigh skin. The muscle originates on the ischiopubic arch lateral to the introitus and extends along the medial thigh just beneath the subcutaneous tissue and superficial to the adductor muscles. Its distal tendon crosses the medial aspect of the knee joint, where its insertion forms a component of the pes anserinus tendon complex. The primary neurovascular pedicle to the muscle is from the medial

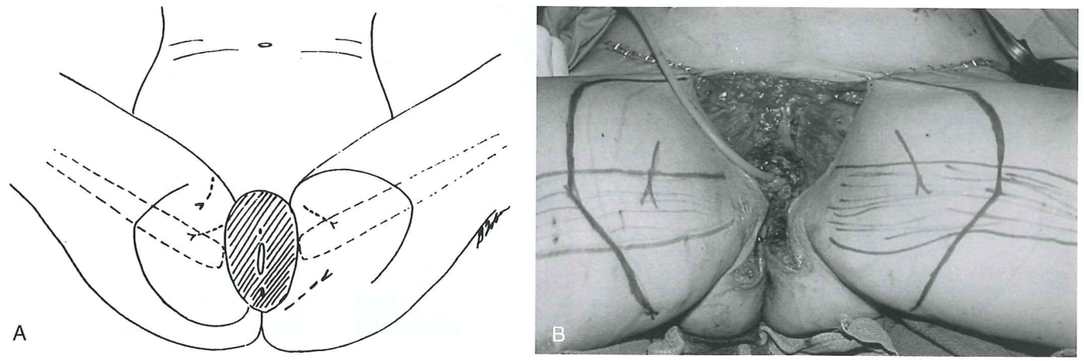


Figure 75–1
A: Gracilis V-Y advancement flaps designed for a large bilateral vulvectomy defect (shaded). The flaps illustrated have a dorsal cutaneous pedicle on the left leg and a ventral cutaneous pedicle on the right leg. *B:* Gracilis V-Y advancement flaps outlined on a patient after bilateral vulvectomy. Both flaps have dorsal cutaneous pedicles, because the patient also had bilateral inguinal lymphadenectomies (see text). (From Tobin GR: Pelvic, vaginal, and perineal reconstruction in radical pelvic surgery. Surg Oncol Clin North Am 3:397, 1994.)

femoral circumflex vessels, which enter the muscle on the ventral deep surface 8 to 12 cm distal to the muscle origin. The upper inner thigh skin donor site of this flap occupies a vascular watershed that is perfused from several sources. These include musculocutaneous, fasciocutaneous, and axial vessels passing from their major trunks through various anatomic paths to the subcutaneous tissue and skin. The gracilis muscle provides musculocutaneous perforators to the overlying skin. Dorsal to the muscle, the superficial perineal branch of the internal pudendal vessels provides an axial blood supply to the uppermost thigh skin adjacent to the gluteal and labial creases, as well as a fasciocutaneous contribution to the vascular plexus on the deep fascia underlying the subcutaneous tissue of the flap. Ventral to the muscle, branches of the deep external pudendal vessels provide an axial supply to the flap donor site skin and a fasciocutaneous supply that also includes contributions from medial femoral circumflex and obturator vessels. These dorsal and ventral vascular supplies are connected by an anastomotic plexus in the perineum and adjacent uppermost thigh.[5] A virtue of this flap design is that several of these sources are preserved in transfer, giving the flap an enhanced vascular supply (see Figs. 75–1 to 75–3).

OPERATIVE TECHNIQUE

Steps of the operative technique are shown in Figures 75–1 to 75–3. The skin paddle is designed according to the perineal defect (see Fig. 75–1). Once marked, the flap is dissected as a unit that contains the proximal half of the gracilis muscle and its primary vascular supply from the medial femoral circumflex vessels, along with the overlying cutaneous territory on the upper inner thigh. We described this flap with the design of an additional blood supply from a retained dorsal or ventral cutaneous and fascial pedicle. This pedicle carries fasciocutaneous and axial sub-

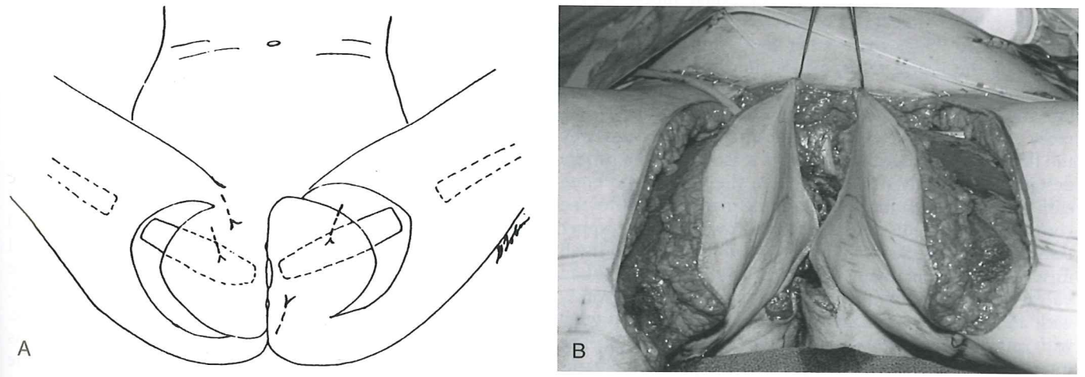


Figure 75–2
A and *B:* The muscle-skin flaps and their vascular pedicles are dissected, mobilized, and advanced into the vulvectomy defect. (From Tobin GR: Pelvic, vaginal, and perineal reconstruction in radical pelvic surgery. Surg Oncol Clin North Am 3:397, 1994.)

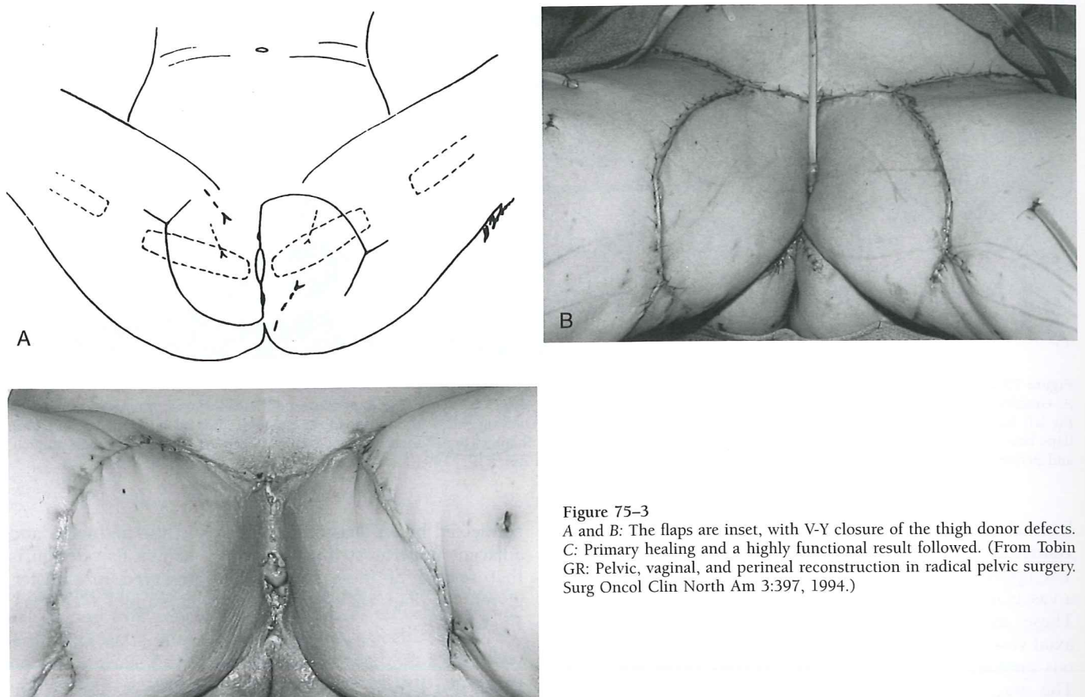


Figure 75–3
A and *B*: The flaps are inset, with V-Y closure of the thigh donor defects. *C*: Primary healing and a highly functional result followed. (From Tobin GR: Pelvic, vaginal, and perineal reconstruction in radical pelvic surgery. Surg Oncol Clin North Am 3:397, 1994.)

cutaneous vessels from branches of the superficial femoral vessels, when the cutaneous pedicle is retained ventrally, and from the branches of the internal pudendal vessels, when the cutaneous pedicle is retained dorsally.[1] Alternatively, Peled described a similar flap with the cutaneous paddle converted to a complete island that is based only on the musculocutaneous circulation from the gracilis muscle.[6] However, retention of a dorsal or ventral cutaneous and fascial pedicle and its additional blood supply permits reliable transfer of a larger cutaneous paddle (see Figs. 75–1 to 75–3) than either the island V-Y design of Peled[6] or the island transposition flap that McCraw and colleagues originally introduced for vaginal reconstruction[7] but that is also useful for vulvar reconstruction.[8] Thus, more extensive defects can be more reliably addressed by the flap that we described. Another reason why the paddle design we currently use differs from the alternatives cited earlier is that the dimension of the flap parallel to the course of the gracilis muscle extends over only the upper third of the thigh, leaving the distal two thirds of the thigh unscarred postoperatively (see Figs. 75–1 to 75–3). When vulvar reconstruction is performed after or concurrently with an inguinal lymphadenectomy, the paddle is designed with only a dorsal cutaneous pedicle (see Fig. 75–1*B*). The internal pudendal blood supply of this pedicle remains intact, whereas the femoral branches that supply the ventral cutaneous pedicle are ablated by inguinal lymphadenectomy. In other circumstances, either option of pedicle location (see Fig. 75–1*A*) appears to provide equally reliable flaps.

After the design and the incision of the cutaneous paddle, the subcutaneous tissue is incised, taking care to preserve the saphenous vein ventrally. The underlying deep fascia is then incised in a pattern identical to that on the skin. The flap is elevated in the plane just deep to the fascia, up to the leading edge of the gracilis muscle. At this point, the dissection proceeds around the deep surface of the gracilis muscle, taking care to preserve both its major vascular pedicle from the medial femoral circumflex vessels and the cutaneous perforators to the overlying skin paddle. The dissection in this plane does not interrupt skin blood supply from the gracilis musclocutaneous perforators or from the fasciocutaneous network on the deep muscle fascia beneath the subcutaneous tissue. The origin of the gracilis muscle is detached from the pelvis, and the midportion of the muscle is transected near the level of the most distal extent of the skin incision and well distal to the primary neurovascular pedicle. This permits central advancement of the muscle and skin paddle across the perineal defect and coverage of the wound (see Fig. 75–2).

The advanced flap is inset first along its leading edge. The lateral margin on the side opposite to the cutaneous pedicle is then closed. This leaves a donor defect at the caudal end of the flap, which is closed in a V-Y fashion (see Fig. 75–3). Before skin closure, closed suction drains are placed beneath the flap.

The postoperative care of this reconstruction is routine, with regular cleansing and application of antibiotic ointment to the incision. A light, dry absorptive dressing is kept in place for the first few days, and closed suction drains are retained until they return less than 1 ml per hour.

DISCUSSION

The principal advantage of this method of vulvar reconstruction is the reliability of the flap that is conveyed by the ample blood supply described earlier. Many alternative flap reconstructions of the vulva and perineum have been described, including those cited earlier.[2–18] None, however, simultaneously preserves the musculocutaneous, fasciocutaneous, and direct axial cutaneous blood supply, as this flap does. Our experience with this flap spans the past 17 years and confirms its reliability. We have had no complete flap losses, no major partial flap losses, and no losses of the part of the flap covering the perineal defect. The only loss of tissue that we have experienced to date has been a rare, small, partial paddle loss at the level of the V-Y closure; this was easily revised.

CONCLUSION

In summary, the gracilis V-Y advancement muscle-skin flap is a highly reliable, versatile technique for vulvar and perineal reconstruction. It is readily adaptable to large defects, bilateral defects, and defects made concurrently with or after radial inguinal lymphadenectomy. Our experience with this technique confirms the reliability conveyed by its diverse blood supply, which favors this reconstruction over other methods of vulvar reconstruction for oncologic or traumatic defects.

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CHAPTER

76

Treatment of Penile and Testicle Amputation

PHILIP WERTHMAN
GARY J. ALTER

Traumatic amputation of the male external genitalia is fortunately an infrequent injury. Penile amputation may result from an assault by a disgruntled lover, an animal bite, self-mutilation, or a devastating circumcision complication. Accounts of penile amputation throughout ancient history relate that conquering armies emasculated their enemies to prevent propagation of foreign races.[1]

An epidemic of penile amputation was reported in Thailand during the 1970s when humiliated Thai wives severed their husbands' members with kitchen knives. More than 100 cases were treated at three major Thai hospitals during this period.[2]

Circumcision is the most common operation performed on American males.[3] Complication rates vary from 1.5% to 15.0%, probably because the procedure may be performed by individuals who have had little surgical training.[4] In rare instances, tragedy occurs when part or all of the glans is inadvertently grasped in a clamp and amputated along with the prepuce. Several such reports have appeared in the literature describing successful repair.[4, 5]

A patient who presents with autoemasculation, or Eshmun complex (named after the Phoenician god of spring, who castrated himself to avoid the advances of the mother goddess), poses a more difficult situation. As many as 85% of self-mutilators are believed to suffer from acute psychosis at the time of injury; either drugs or alcohol was a contributing factor in 55% of cases reviewed.[6, 7] Surgical repair is technically challenging; moreover, further self-destructive efforts may compromise an otherwise good result.[8] Studies have shown that this patient group is heterogeneous and has a high likelihood of mental rehabilitation; therefore, penile replantation should be performed.[6, 9]

Media attention to penile amputation has increased during the past several years, not only because of the bizarre methods of injury but also because excellent replantation results are now achieved with modern microsurgical techniques. This chapter provides a historical overview and describes various methods of penile and testicular replantation.

PENILE AMPUTATION

Management strategies for penile amputation must consider the multiple functions of the male phallus, which is the conduit for urine and semen as well as an erogenous organ that has a critical role in sexual identity and self-esteem.[10] The ideal reconstruction is a single-stage procedure achieving an aesthetically pleasing phallus capable of sensation, erections of adequate length and rigidity, and a competent urethra allowing the man to stand to void.[11] A thorough knowledge of penile anatomy is crucial before planning any such repair. The unique anatomic structure of the penis allows it to survive as a graft even when direct arterial and venous microsurgical anastomoses are not performed.

Penile Anatomy

The penis is composed of two erectile bodies or corpora cavernosa and the ventrally located urethra lying within the thinner corpus spongiosum. The corpora cavernosa smooth musculature is surrounded by the thick elastic tunica albuginea. The three corporeal bodies are surrounded by the deep (Buck's) and superficial (dartos) fascial layers. Penile skin is extremely thin and mobile because of its attachment to the loose areolar dartos fascia.

The rich blood supply of penile skin and dartos fascia derives from branches of the external pudendal vessels. These vessels travel dorsally and ventrolaterally and have extensive collaterals across the midline. Many small perforating vessels form a vast subdermal plexus allowing the penile skin to be mobilized.[12] Partial penile transections, even those with a thin skin bridge, have a much lower incidence of distal necrosis owing to extensive subdermal vascular collaterals.[13] The paired penile neurovascular structures travel within Buck's fascia on the dorsal surface, flanking the medially located deep dorsal vein. The superficial dorsal vein is located within the dartos fascia.

The corporeal blood supply derives from the internal pudendal system. The common penile artery, a branch of the internal pudendal artery, pierces the perineal membrane and trifurcates into its terminal branches: the bulbourethral artery, dorsal penile artery, and cavernosal artery. The bulbourethral artery enters the penile bulb, travels in the corpus spongiosum, and terminates in the

glans penis, eventually communicating with the dorsal arteries. The dorsal artery is the terminal branch of the internal pudendal artery, traveling in a constant position along the dorsum of the penis. This artery similarly terminates in the glans, supplying the glans and urethra with a dual blood supply. The dorsal artery provides as many as 10 circumflex arteries that travel laterally around the corpora. The proximal circumflex branches may also supply the urethra. The cavernosal artery extends through the center of each corpus cavernosum, traveling the entire length of the penis. This artery gives off spiral helicine arteries, which drain into the cavernous sinuses and provide increased blood flow for erection. The cavernosal artery occasionally emanates from an accessory pudendal artery that arises from the obturator artery.

Venous drainage of the penis is provided by superficial, intermediate, and deep systems. The superficial veins course through dartos fascia and unite to form a single vein, usually draining into the left saphenous vein. The intermediate system comprises the deep dorsal vein and circumflex veins. The deep dorsal system, located in Buck's fascia, passes beneath the pubic symphysis and between the puboprostatic ligaments, draining into Santorini's plexus on the prostate. The cavernosal and crural veins provide the deep venous drainage of the penis. The cavernosal veins travel in the penile hilum and drain into the prostatic plexus or internal pudendal vein. The crural veins drain into the internal pudendal vein, which then empties into the internal iliac vein.

The penis has dual innervation. The cavernosal nerves contain the parasympathetic and nonadrenergic noncholinergic efferents responsible for erection. The pudendal nerves provide sensory innervation to the penis.[14] After complete or partial penile transection, some degree of erectile capability usually returns. Proximal corporeal innervation is preserved, because the penis is severed distal to the main neurovascular trunks.[13]

Historical Perspective

The first case of autoamputation was described in the medical literature by Stroch[15] in 1901, and the first penile reattachment was reported by Ehrlich[16] in 1929. Since then, several cases of successful replantations without microvascular reanastomosis of the blood vessels have been described, provided meticulous reapproximation of the corpora was achieved. It was initially believed that the penis survived as a composite graft, but later studies revealed that arterial blood filling the corpora provided nourishment to the glans.[17, 18] Early replantation efforts were complicated by necrosis of various amounts of distal penile skin and urethra. Such patients eventually underwent grafting and fared well.[19, 20] McRoberts and colleagues[21] summarized the literature and proposed that in order to avoid early complications, the distal penile skin should be removed, the shaft buried subcutaneously in the scrotum with the glans protruding, and a suprapubic catheter placed to divert the urine. Two months later, the second stage was performed by separating the penis from the scrotum, using scrotal skin to cover the shaft. Siamese surgeons slightly modified McRoberts' principles while performing their large series of replantations. They demonstrated that replantation with acceptable cosmetic results was possible at any general hospital, without the use of specialized microsurgical techniques.[2]

Engelman and associates[20] elucidated the three alternatives for surgical management: primary anastomosis, plastic reconstruction, or local reshaping if reattachment was contraindicated. They were the first to theorize that microsurgical repair could offer superior results with improved sexual function and better preservation of the distal epidermis.

The first microsurgical replantations were performed in 1976 by two independent groups. Tamai and coworkers[22] repaired both dorsal arteries and nerves as well as the dorsal vein. Their patient was given low-molecular-weight dextran throughout the procedure. Cohen and colleagues[23] added reanastomosis of the cavernosal artery to their procedure and treated the patient with urokinase. Henriksson and associates[24] monitored postoperative penile arterial flow with serial Doppler examinations, which allowed prompt intervention if necessary.

In 1985, Carroll and coworkers[13] compared the results of the two techniques of penile replantation and concluded that microsurgical repair was superior to simple corporeal reattachment because it avoids skin necrosis by immediately reestablishing subcutaneous circulation rather than relying on corporeal blood flow to nourish the skin. They offered a precise strategy for initial management of these patients.

Matloub and colleagues[25] in 1994 temporarily implanted an amputated penis ectopically in the forearm because of extensive contamination and hematoma in the patient's perineum. The dorsal artery and vein were anastomosed to the distal radial vessels, and the shaft was buried beneath the skin of the forearm. Four weeks later, the patient underwent transfer of the penis to the perineum. The postoperative course was complicated by a urethrocutaneous fistula, which was later repaired satisfactorily.

Management

When presenting to the emergency room, a patient is evaluated by a multidisciplinary team, including a urologist, plastic surgeon, and psychiatrist. The amputated part is washed of any gross contamination, wrapped in a sterile saline-soaked gauze, sealed in a plastic bag, and immersed in saline ice water.[13] Cold ischemia is well tolerated by penile tissue, and successful replantation using microsurgical techniques has been reported as late as 16 hours after amputation.[26] Reattachment should still be considered with ischemia as long as 24 hours.[27] Stable patients should therefore be transferred to a facility with microsurgical capabilities.

Resuscitation with appropriate fluids should be begun, and broad-spectrum antibiotics should be administered. Vascular control of the proximal penile stump can be rapidly obtained if needed by applying a Penrose drain tourniquet. Bleeding vessels should not be clamped, inasmuch as this could render microsurgical reanastomosis more difficult, and nerves may be inadvertently injured.

Once a patient has been stabilized, replantation is performed. The wound and opposing surface of the dismembered organ are carefully debrided. A suprapubic catheter is placed in the bladder for urinary drainage. A 16 French silicone Foley catheter is inserted into the urethra, stenting the urethral anastomosis and stabilizing the penis. The urethra is spatulated and reapproximated using 5-0 polydioxanone suture (PDS). The spongiosum is closed as a separate layer with 5-0 PDS. The cavernosal arteries are dissected from the surrounding tissue and anastomosed with 11-0 nylon suture only if the injury is very proximal. The corpora are reattached with 3-0 PDS. The dorsal arteries and vein are repaired with 10-0 nylon. Both dorsal nerves are coapted, allowing sensation to return. Diminished sensation is frequent when no neural repair has been performed.[28] Dartos fascia is closed, and the skin is reapproximated. Yamano and Tanaka[29] advocated the use of urokinase, but several reports warned of anticoagulation because possible hematoma formation can jeopardize the graft.[13, 23] If the penile skin is avulsed at the time of injury, the penis can be replanted using the foregoing technique and then buried in the scrotum. The second-stage repair can be performed in 2 months. If the injury is too extensive to permit reconstruction, the penile stump can be contoured in a manner similar to a partial penectomy. In cases of total penile loss, total phallic reconstruction can later be performed.[10]

Postoperatively, patients are maintained on bed rest for 1 week and kept well hydrated. The penis is slightly elevated to reduce edema. Serial Doppler examinations are performed to assess the patency of the penile vessels. The Foley catheter is removed on day 14, and a urethrogram is obtained at 3 weeks. The suprapubic tube is removed if no urinary extravasation occurs. Psychiatric counseling and social support must be provided from the outset.

Results

The results of penile replantation are surprisingly good. Einarsson's[28] summary of 58 reported cases in the literature concluded that microsurgical repair was superior to corporeal reattachment because of less chance of skin necrosis and a better return of sensation. Ischemia time did not correlate with the presence of urethral stricture, fistula, the return of erectile function, or the degree of sensation. Microsurgical repair did not appear to be necessary for return of erectile function.[30]

TESTICLE AMPUTATION

Solitary amputation of a testis at the level of the spermatic cord is a rare injury. Because unilateral testicular loss poses little threat to overall health and fertility, repair is often not performed. Prosthetic replacement improves cosmesis. In the event of bilateral amputation or injury to a solitary testis, successful microsurgical replantation can be performed. In 1976, MacMahon and colleagues[31] conducted a series of experiments in which they replanted testes in dogs as a prelude to replanting cryptorchid intraabdominal testes in children. That same year, Silber and Kelly[32] successfully performed a testicular autotransplant in a cryptorchid child. Lin and associates[33] reported two cases of traumatic testicular amputation with microsurgical replantation. On follow-up, both testicles were viable, the vasa deferentia were patent, and no evidence of atrophy was present.

SUMMARY

Genital amputation is a rare and psychologically devastating injury. Penile and testicular replantation can frequently be performed with good results using microsurgical techniques. A multidisciplinary team approach is paramount.

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CHAPTER

77

Penile Revascularization for Erectile Dysfunction

HARIN PADMA-NATHAN

Revascularization of the corpus cavernosum has evolved to be a well-defined therapeutic option in the management of traumatic arteriogenic erectile dysfunction. The current success rates are significantly greater than those reported historically as a result of the following factors:

1. Selection of young trauma (pelvic, penile) victims, usually 45 years of age or younger, with rigidly defined hemodynamically significant and anatomically focal arterial occlusive pathology
2. Exclusion of any patients with corporeal veno-occlusive dysfunction, which is reflective of the late ischemia-induced tissue alteration of corporeal smooth muscle loss and replacement with collagen
3. Exclusion of patients with systemic metabolic diseases such as diabetes mellitus, neuropathies, and evidence of proximal diffuse atherosclerosis
4. The development of surgical approaches based on functional and anatomic principles specific to the hypogastric cavernous arterial system

This chapter focuses on these functional and anatomic surgical approaches to corpus cavernosum revascularization.

PATIENT EVALUATION AND SELECTION FOR PENILE REVASCULARIZATION

Patients presenting with arteriogenic erectile dysfunction historically relate diminished erectile rigidity that is slower in onset but relatively well maintained (reflecting the underlying normal veno-occlusive function) with greater nocturnal erectile rigidity than those erections associated with sexual stimulation.[1] The blunt or penetrating penile, perineal, or pelvic trauma may have occurred immediately before the onset of the erectile dysfunction or may have predated it by years. Some patients may not relate a history of trauma but rather are found to have identical hemodynamic aberrations as those patients with such an overt history.[2] The ideal candidate for a penile revascularization procedure is younger than 45 years and has no systemic metabolic (diabetes), neurologic, or atherosclerotic problems. The patient must undergo a complete erectile function evaluation to determine and characterize the presence of focal hemodynamically significant arterial occlusive disease in the presence of normal corporeal veno-occlusive function. Functional evaluation of the cavernosal artery is performed by both a color flow duplex ultrasound determination of the peak flow velocity in the cavernosal arteries[3] (Fig. 77–1) and the cavernosal artery opening pressure determination at dynamic infusion cavernosometry and cavernosography.[4] The latter study also encompasses dynamic (pharmacocavernosometry) and radiographic (pharmacocavernosography) evaluation of the corporeal veno-occlusive mechanism. Finally, the anatomic pattern of the arterial occlusion is demonstrated by selective internal pudendal pharmacoarteriography.[5]

Appropriate surgical candidates demonstrate hemody-

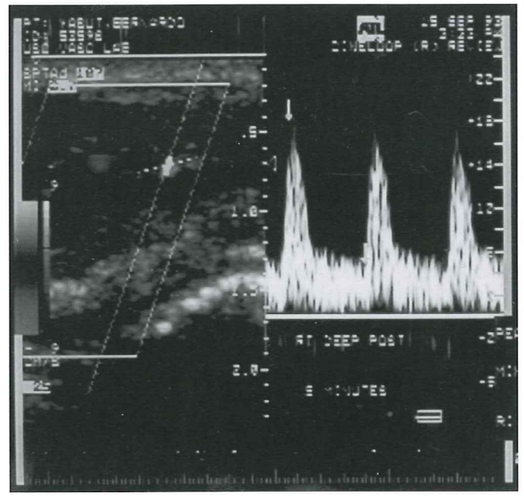


Figure 77–1
Color flow duplex ultrasonography with the cavernosal artery demonstrated on the right and its corresponding flow histogram on the left. The peak systolic velocity determined on this study is 18.0 cm/sec.

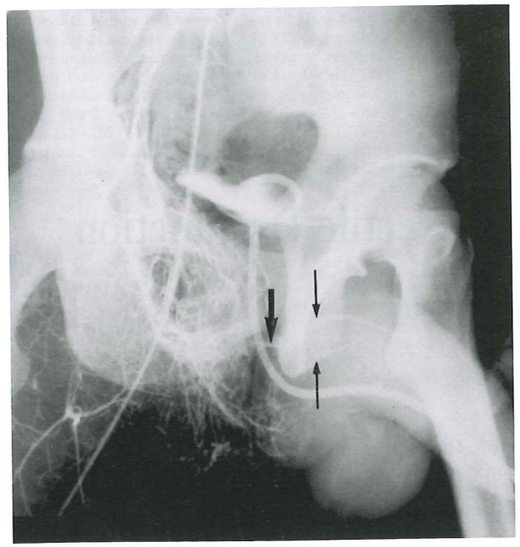


Figure 77–2
Selective internal pudendal arteriogram demonstrating a proximal occlusion of the internal pudendal artery with distal reconstitution (wider arrow) before the bifurcation into the deep and dorsal penile arteries (narrow arrows).

namically significant arterial flow (duplex ultrasonography determined)[3] and pressure (cavernosal opening pressure determination at dynamic infusion cavernosometry and cavernosography [DICC])[4] parameters in the presence of a normal dynamic (pharmacocavernosometry) and radiographic (pharmacocavernosography) evaluation of the corporeal veno-occlusion mechanism. Selective internal pudendal arteriography (pharmacoarteriography) confirms the focal nature of the arterial pathology and the presence of an appropriate neoarterial source and ultimately directs the selection of the specific revascularization approach.[5]

SELECTION OF THE REVASCULARIZATION APPROACH

Attempts to revascularize the corpora cavernosa have historically included anastomosis of the neoarterial source (1) to the tunica albuginea directly (Michal I),[6] (2) retrograde into the dorsal artery (Michal II),[7] (3) to the dorsal vein (Virag,[8] Furlow-Fisher[9]), and (4) using a combination of the latter two (Hauri).[10] The first procedure was, as expected, associated initially with a high rate of priapism and later a high rate of anastomotic failure. The Hauri procedure, an end-to-side anastomosis of the neoarterial source to a previous side-to-side arteriovenous fistula between the dorsal vein and dorsal artery, was developed as primarily an arterial revascularization with a venous anastomosis to enable continuous runoff to prevent an arterial thrombosis. However, the flow pattern is preferentially to the lower-resistance dorsal vein in both the flaccid and erect state, and thus this revascularization appears to be the functional equivalent of the venous arterialization procedure. Attempts at direct revascularization of the cavernosal artery have historically been fraught with technical difficulties and subsequent corporeal scarring. Today, depending on the underlying anatomic arterial occlusive pattern, a modified Michal II dorsal artery revascularization and a modified dorsal venous revascularization are the only procedures used at our institution.

The modified Michal II penile revascularization attempts to deliver neoarterial blood flow and pressure to the corpora by using the deep dorsal artery (inferior epigastric artery end to the proximal end of the dorsal penile artery) in a retrograde fashion. This approach is effective only if the arterial occlusion is proximally placed in the common penile artery, thus preserving the bifurcation of the common penile artery into the dorsal and deep (cavernosal) branches (Fig. 77–2). The original end (internal epigastric artery to side dorsal artery) Michal II revascularization may be used if a penetrating deep dorsal branch communicates with the cavernosal artery (Fig. 77–3). In all other cases, including occlusion of the deep or dorsal artery, a venous arterialization approach is used (Fig. 77–4). An arterialized isolated dorsal venous segment with large emissary veins from the corpora (Fig. 77–5) may theoretically be used for reverse flow of arterial blood into the corpora, and in fact, this approach has been demonstrated to be effective in delivering arterial blood with sufficient flow and pressure to reestablish normal erectile function. In one study, this arterialized venous segment when examined histologically 10 months later did not demonstrate any abnormal histologic alteration including myointimal proliferation.[11]

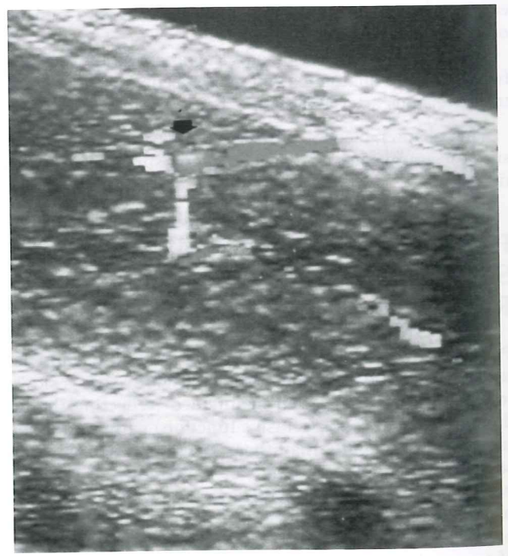


Figure 77–3
Color flow ultrasonography demonstration of a penetrating branch from the deep dorsal artery into the deep penile artery (arrow). In such cases, a neoarterial source may access the deep system through an end-to-side anastomosis into the dorsal penile artery.

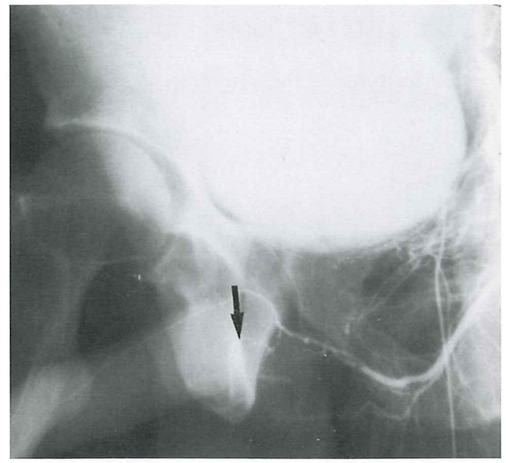


Figure 77–4
Selective internal pudendal arteriogram demonstrating a complete occlusion of the deep penile artery (arrow). Such a patient is a candidate for a venous arterialization procedure only.

SURGICAL TECHNIQUE

The surgical procedure consists of the following steps: (1) preparation of the penile recipient vessel, either the dorsal artery or deep dorsal vein; (2) harvest and preparation of the neoarterial source; and (3) the arterioarterial or arteriovenous microscopic anastomosis. The first two steps are performed with the assistance of loupe magnification (3- to 4-fold magnification) and the third step with the assistance of a surgical microscope (up to 10-fold magnification).

Immediately before entry into the operating theater, patients are administered an antiplatelet agent (325 mg acetylsalicylic acid per rectum) to retard the potential for early graft thrombosis. Patients are placed in a supine position during the procedure.



Figure 77–5
Deep dorsal vein (broad arrow) with large emissary veins (narrow arrows).

Preparation of the Recipient Penile Vessel

The recipient penile vessel is approached through a small 2-cm semilunar incision at the base of the penis, following the skin lines of Langer, and is fashioned with the penis on stretch in a way that minimizes abnormal scarification and penile shortening (Fig. 77–6). The subsequent dissection through Buck's fascia to expose the penile dorsal neurovascular bundle is performed directly in the midline over the readily visible dorsal vein. It is very important to preserve the integrity of the penile suspensory and fundiform ligaments during this dissection. Inadvertent transection of these suspensory ligaments may result in subsequent healing of the penis in a foreshortened manner. The radiographically patent dorsal arteries should be identified both visually and by continuous wave Doppler (9 MHz) ultrasonography. The two dorsal nerve bundles and their main branches should be identified and avoided.

The recipient dorsal artery selected may be prepared under microscopic magnification at a later stage. The deep

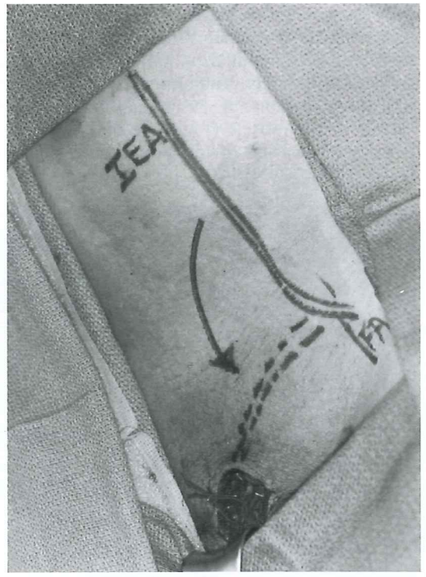


Figure 77–6
The penile incision is demonstrated with vessel loops placed around the recipient deep dorsal vein. A drawing of the planned harvest of the inferior epigastric artery and transfer to the penile base is shown. IEA, inferior epigastric artery; FA, femoral artery.

dorsal vein, however, is a significantly larger vessel and in the proximal penis is very thick walled. It may therefore be prepared at this stage (Fig. 77–7).

The inferior epigastric artery classically is anastomosed end to side to an isolated segment of the proximal deep dorsal vein. I have used the following modifications: (1) The proximal segment of the vein is not ligated to facilitate a low-pressure runoff in the flaccid state and decrease the potential for postoperative thrombosis. (2) The distal vein is ligated twice with 5-0 monofilament nonabsorbable suture, and the proximal venous segment is mobilized to identify any deeper branches that may result in hypervascularization of the glans penis postoperatively and to facilitate the subsequent end-to-end anastomosis of the dorsal vein to the inferior epigastric artery. The end-to-end anastomosis has two advantages over the more traditional end-to-side approach. First, it is associated with a lower incidence of anastomotic stricture. Second, the presence of any venous valves does not require addressing by a traumatic and potentially thrombotic valvulotomy, because the arterial flow is antegrade in the vein in its entire course.

Harvest and Preparation of the Inferior Epigastric Artery

The inferior epigastric artery is the most common arterial source. The femoral artery with an interposed reverse saphenous vein graft may serve as an alternative arterial source in the rare case in which at least one inferior epigastric artery is not available. The inferior epigastric artery is unique in its ability to remain relatively pristine even in the presence of systemic atherosclerosis. The inferior epigastric artery originates from the distal external iliac artery. It is accompanied by paired venae comitantes as it travels under the rectus abdominis muscle, communicating with the superior epigastric vessels through choke vessels in the rectus muscle (Fig. 77–8). The inferior epigastric artery is harvested through a paramedian incision,

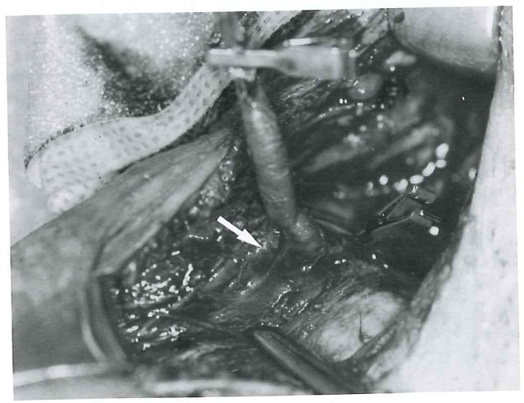


Figure 77–7
Deep dorsal vein in preparation for anastomosis. Atraumatic microaneurysm clamps are placed to prevent back-bleeding. A large emissary vein is demonstrated (arrow).



Figure 77–8
The inferior epigastric artery (broad arrow) and its paired veins (narrow arrows) before harvest. The entire three-vessel bundle will be harvested in toto to prevent arterial spasm. The rectus abdominis muscle (stars) is retracted medially.

carefully retracting the rectus abdominis muscle and preserving the intercostal nerves. This incision enables harvest of enough arterial length to provide a tension-free anastomosis. A tunnel for transferring the inferior epigastric artery to the penile base incision is developed through the rectus fascia at or near the external inguinal ring. The origin of the inferior epigastric artery is then clamped with an atraumatic microvascular clamp, and the vascular bundle is hemoclipped at its distal dissection, transected, and transferred to the penile base. The transfer is aided by elevating the roof of the transfer tunnel using a Penrose drain (Fig. 77–9). After the transfer, the proximal microvascular clamp is briefly removed, and excellent pulsatile flow from the artery must be demonstrated to ensure that the vessel was not twisted or kinked in transfer. The clamp is then reapplied distally.

Microvascular Anastomosis

The microvascular anastomosis is performed in an end-to-end fashion regardless of whether it is an arterioarterial or arteriovenous procedure. Although the inferior epigastric artery branches in its distal portion, a bifurcated anastomosis to two dorsal arteries or to a dorsal artery and a dorsal vein is not performed. It is critical to use the main body of the inferior epigastric artery to enable the largest-caliber



Figure 77–9
A tunnel for vascular transfer is developed at the level of the external inguinal ring from the origin of the inferior epigastric artery to the penile base. The roof of this tunnel is elevated by a 1/4-inch Penrose drain, and fine-tipped tonsil forceps are passed from the penile base (broad arrow) to the level of the inferior epigastric artery. These forceps are applied to the distal vessel (narrow arrow).

anastomosis, decreasing the risk of postoperative stricture. Additionally, the greatest flow and pressure are transferred to the corpora from the larger-caliber arterial source. The two vessels are prepared by first ensuring that they are of similar caliber (Fig. 77–10). If one vessel is disproportionately smaller in caliber, it can be trimmed at an angle to increase the diameter of the ostium.

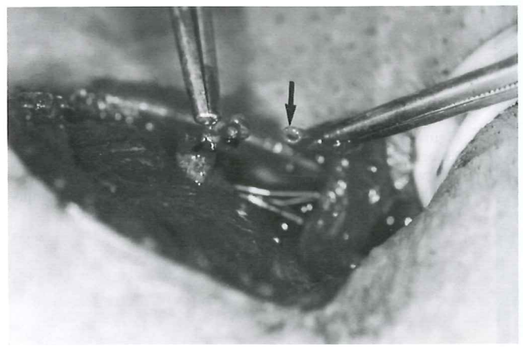


Figure 77–10
The diameters of the neoarterial source (arrow) and the recipient artery are nearly identical.

The anastomosis is performed using 9-0 (arteriovenous anastomosis) or 10-0 (arterioarterial anastomosis) monofilament nonabsorbable (nylon) suture (Fig. 77–11). If no anastomotic leakage occurs by back-bleeding after removing the distal clamp, the arterial clamp is released to demonstrate anastomotic integrity. Transference of arterial flow to the venous segment is then confirmed both visually and by Doppler ultrasonography. In addition, the vein uniquely demonstrates an enhanced diastolic runoff of this arterial inflow. The glans penis is then inspected visually and with the assistance of continuous wave Doppler ultrasonography to detect any early arterial flow to the glans penis that might later present as hypervascularization and venous ischemia of the same.

The surgical wounds are closed in the standard way without drains. The incision is reapproximated in a cosmetically optimal manner using a 5-0 monofilament absorbable subcuticular suture closure. A Foley catheter is left in place overnight, and the patient is started on long-term daily pediatric doses of aspirin on the first postoperative day. The patient is advised against masturbation and intercourse for at least 6 weeks to ensure adequate anastomotic repair and tensile strength.

COMPLICATIONS

In addition to the general complications of surgery, penile revascularization may result in postoperative numbness, penile lengthening or shortening, or glans hyperemia. Penile sensory and length alterations have seldom occurred since the exclusion of patients with veno-occlusive dysfunction. These patients required a concomitant extensive dorsal vein dissection, ligation, and excision with its associated transection of the suspensory ligaments. Hypervascularization of the glans penis may occur in fewer than 5% of cases either early or late, including years after the procedure. It may result in ischemic necrosis of the glans



Figure 77–11
A completed anastomosis between the inferior epigastric artery and deep dorsal vein (arrow). Arterial flow into the corpora is confirmed by the presence of a large diastolic component in addition to the systolic flow into the vein.



Figure 77–12
Hypervascularization of the glans penis as a result of arterial inflow from the arterialized deep dorsal vein into the glans penis. This is readily treated surgically. However, prevention at the time of surgery is usually possible by ligation of all venous channels communicating between the deep dorsal vein and glans penis.

and requires immediate attention (Fig. 77–12). The initial management should be to reapproach the penis through a circumcising incision and ligate all arterialized venous feeders to the glans penis. If this fails, the graft may have to be sacrificed. This complication has not developed since the institution of the previously described end-to-end arteriovenous approach.

FOLLOW-UP

In addition to a subjective historical evaluation of erectile function restoration, patients are closely monitored with objective demonstration of graft patency (color flow duplex ultrasonography) (Fig. 77–13) and restoration of normal erectile rigidity by ambulatory nocturnal rigidity evaluation (Rigiscan, Dacomed Corp., Minneapolis, MN) (Fig. 77–14) 3 to 6 months postoperatively.

Table 77–1
Results of Penile Revascularization Procedures with 3 to 5 Years of Follow-up

Results	Pathology	Success (%)	Follow-up (Years)
Lizza and Zorgniotti, 1994	Mixed	56–40	1–5
Hatzichristou and Goldstein, 1993	Mixed	50–60	1–5
CURSG, 1995	Mixed	53	1–8
Sharaby and Melman, 1995	Mixed	44	5
Padma-Nathan, 1995	Pure arterial	60	3

RESULTS

The potency restoration rates following a penile revascularization have historically varied greatly, ranging between 25% and 80%.[10] These data reflected the inclusion of patients who demonstrated nontraumatic arterial occlusions with diffuse atherosclerosis and significant veno-occlusive dysfunction due to ischemic or metabolic (diabetic) irreversible corporeal tissue alterations. The modern results of penile revascularization using the principles listed in the introduction represent a more homogeneous patient population undergoing more standardized surgical procedures. The subjective and objective confirmation of potency after either an arterioarterial or arteriovenous anastomosis in such a patient population is 50% to 65% at 3 to 5 years of follow-up in both our experience and that of other investigators (Table 77–1). The reasons for failures include anastomotic thrombosis, inadequate arterial or emissary venous runoff, or the development of de novo site-specific corporeal veno-occlusive dysfunction after a penile fracture incurred during sexual intercourse. These cases may be salvaged, and erectile function reestablished by intracavernosal pharmacotherapy.

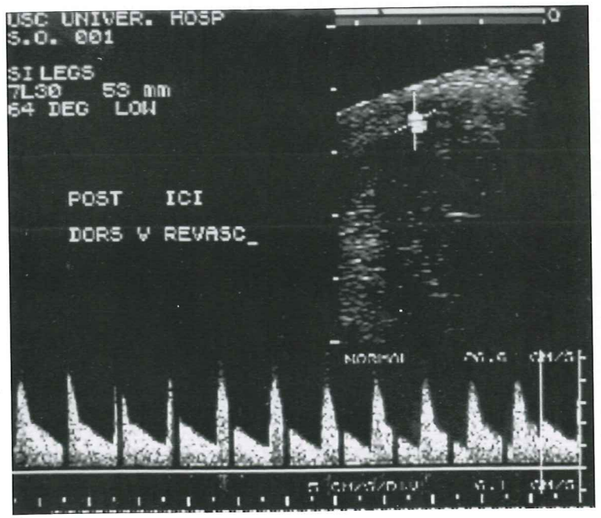


Figure 77–13
Color flow duplex ultrasonography of an arterialized deep dorsal vein with a corresponding flow histogram demonstrating excellent peak systolic flows (> 250 cm/sec) and a diastolic component indicative of corporeal access via emissary veins.

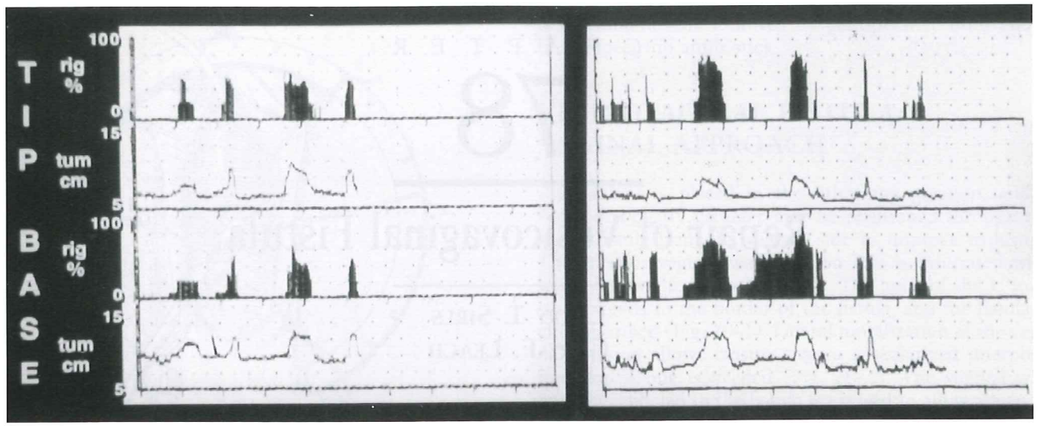


Figure 77–14
Prerevascularization (on August 17) and postrevascularization (on October 15) (venous arterialization) nocturnal penile tumescence and rigidity studies. This 20-year-old patient who had suffered a pelvic fracture objectively demonstrates abnormal preoperative (left dark bars) nocturnal penile rigidity and excellent postoperative nocturnal penile rigidity (right dark bars). He was able to resume sexual intercourse.

CONCLUSION

Penile revascularization by either an arterioarterial or arteriovenous approach is an effective long-term therapeutic treatment option for arteriogenic erectile dysfunction in young men with pelvic, perineal, and penile trauma. It is able to restore normal erectile function subjectively and objectively. However, its success is dependent on selection of appropriate patients, careful diagnostic evaluation by specific erectile function studies, and use of an anatomically appropriate microsurgical approach.

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CHAPTER

78

Repair of Vesicovaginal Fistula

LARRY T. SIRLS
GARY E. LEACH

Development of a urinary fistula is one of the most devastating of postsurgical complications. It causes extreme emotional stress, and early aggressive surgical intervention should be considered. In the vast majority of patients, surgical correction is necessary. Adherence to meticulous surgical technique and liberal use of vascularized interposition flaps increase the success of any fistula repair.

ETIOLOGY

In developed countries, the most common cause of vesicovaginal fistula (VVF) is gynecologic surgery, with more than half of cases occurring secondary to abdominal hysterectomy.[1] VVF may be secondary to inadvertent suture placement between the vaginal cuff and bladder wall, resulting in tissue necrosis and fistula formation. Other causes include urologic surgery, radiation therapy, gastrointestinal surgery, and trauma. Factors that may increase the risk of VVF include ischemia, diabetes mellitus, pelvic inflammatory disease, tumor, and radiation therapy. In Goodwin and Scardino's series, 21% of VVF and ureterovaginal fistulas were either directly or indirectly related to previous radiation therapy.[2] In underdeveloped countries, obstetric trauma due to vaginal delivery remains the most common cause of VVF.

PRESENTATION AND DIAGNOSIS

The typical VVF presents as severe, continuous day and nighttime urinary incontinence. The history of a difficult hysterectomy or increased intraoperative bleeding may be associated with VVF. Excessive vaginal discharge after pelvic surgery may suggest a VVF. To confirm that vaginal discharge is urine, oral phenazopyridine (Pyridium) or intravenous indigo carmine may be administered after placing a tampon or gauze pack in the vagina. When the drainage is confirmed to be urine, the presence of a fistula must be differentiated from other causes of urinary incontinence. This may be accomplished by pelvic examination with a full bladder, cystoscopy, voiding cystourethrography, and bilateral retrograde ureterograms. Concurrent ureteral involvement may affect as many as 10% of patients with VVF. Retrograde pyelograms are essential to evaluate the ureters, because positive pressure may demonstrate a ureteral fistula not visualized on routine low-pressure intravenous urography. An easy first step is to fill the bladder with methylene blue–dyed saline. If blue fluid is identified per vaginam, then the fistula involves the bladder or proximal urethra. If clear urine continues to leak per vaginam, a ureteral or uterine fistula must be considered. Biopsy of the fistula site is mandatory in any patient with a history of pelvic malignancy. Urodynamic studies may be necessary to identify concurrent stress incontinence or factors such as reduced bladder capacity or poor compliance that may require augmentation cystoplasty.

TREATMENT

When the diagnosis of vesicovaginal fistula is confirmed, conservative therapies may be attempted, including uninterrupted catheter drainage of the bladder and cystoscopic fulguration of the fistula site.[3] In our experience, catheter drainage has usually failed before urologic referral. Fulguration may be attempted for a small VVF but may enlarge the fistula and should not delay definitive repair.

SELECTION OF SURGICAL PROCEDURE

A VVF may be repaired through an abdominal, vaginal, or combined approach, depending on the surgeon's experience. The vaginal approach avoids significant abdominal dissection and reduces postoperative patient morbidity. Reported results have been excellent.[4–7] We prefer the transvaginal approach for all VVF, with three exceptions. The first exception is a fistula that is high in the apex of a narrow vagina and that is difficult to expose; second is a fistula adjacent to or involving the ureter, requiring ureteral reimplantation; and third is a fistula requiring concurrent augmentation cystoplasty for small bladder capacity or poor compliance. Ultimately, the choice of an abdominal versus transvaginal approach is dependent on the surgeon's evaluation and experience. Regardless of the approach used, adherence to basic concepts of repair is critical: First, the initial attempt at fistula closure is the best opportunity for cure. Second, surgical success is dependent on a watertight multilayered closure that is free of tension and without overlapping suture lines. Debridement of necrotic tissue, excellent hemostasis without devascularization, uninterrupted bladder drainage, and control of infection are critical.

The use of vascularized tissue interposition is optional in uncomplicated VVF but should be strongly considered for a large fistula, after a failed fistula repair, in a patient with a history of radiation, or if the surrounding tissue is precarious. The interposition of well-vascularized tissue provides excellent blood supply, separates suture lines, and fills dead space. When using the transabdominal approach, omentum, peritoneum, even pericolic fat may be used. With the transvaginal approach, the Martius labial fat pad[8] is readily available; however, peritoneum from the pouch of Douglas or a muscle or myocutaneous flap, such as the gracilis, may be used. In our experience, the Martius labial fat pad is sufficient for all except the most extensive fistula or for vaginal vault reconstruction requiring a larger myocutaneous flap.

PREOPERATIVE CONSIDERATIONS

When atrophic vaginitis is a factor, preoperative estrogen replacement may increase vaginal tissue vascularity and aid postoperative healing. Because of local contamination, a povidone-iodine vaginal douche is used the night before and the morning of surgery. Preoperative culture-directed oral antibiotics are followed by perioperative intravenous broad-spectrum antibiotics.

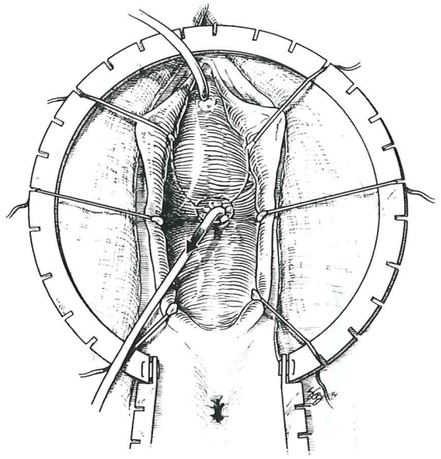


Figure 78–1
The anterior vaginal wall U incision extends to the border of the fistula. The fistula is then circumscribed. (From Zimmern PE, Leach GE: Vesicovaginal fistula repair. Urol Clin North Am 2:87–89, 1994.)

VESICOVAGINAL FISTULA: VAGINAL APPROACH

The patient is placed in the lithotomy position, and a Foley or Fogarty catheter may be positioned through the apical fistula from the vaginal side to improve exposure. The anterior vaginal wall incision line is infiltrated with saline below the vaginal mucosa. The apex of the U incision extends to the border of the fistula, and the fistula is circumscribed (Fig. 78–1). Lateral mobilization of the vaginal incision allows closure over a vascularized interposition flap if one is needed (Fig. 78–2). The vaginal wall mucosa cephalad to the fistula is excised to allow advancement of the anterior vaginal wall flap for closure (Fig. 78–3). The fistula margins are trimmed, but the fistula is not excised. Excision makes a small fistula large and may cause bleeding that requires fulguration, further devascularizing wound edges (Fig. 78–4). In addition, the fibrotic edge of the fistula may help anchor the closure sutures. The circumscribed fistula is closed with a running 3-0 or 4-0 Vicryl suture through full-thickness vaginal wall, including the adjacent bladder wall (Fig. 78–5). A second layer of interrupted 3-0 absorbable Lembert sutures is placed to reinforce the initial suture line (Fig. 78–6). At this point, the additional vascularized flap may be positioned.

The Martius labial fat pad graft is the simplest vascularized flap used to reinforce a fistula closure.[8] A vertical

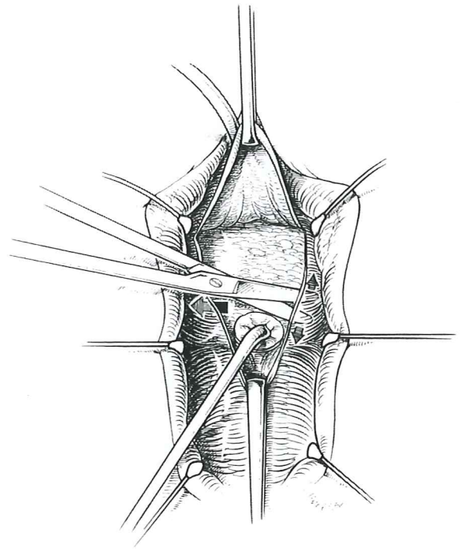


Figure 78–2
Lateral mobilization of the vaginal incision allows closure over an interposition flap if necessary. (From Zimmern PE, Leach GE: Vesicovaginal fistula repair. Urol Clin North Am 2:87–89, 1994.)

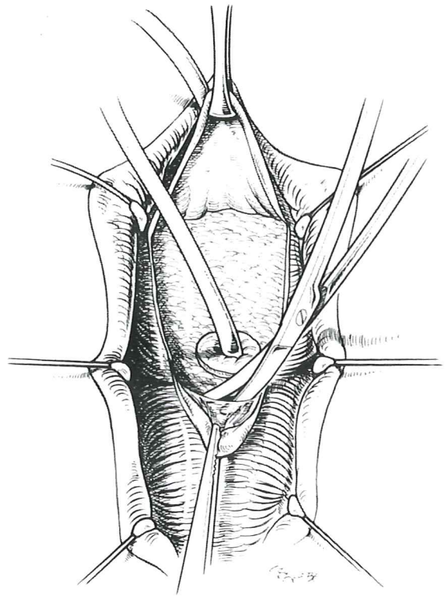


Figure 78–3
The vaginal wall mucosa cephalad to the fistula is excised to allow advancement of the anterior vaginal wall flap for closure. (From Zimmern PE, Leach GE: Vesicovaginal fistula repair. Urol Clin North Am 2:87–89, 1994.)

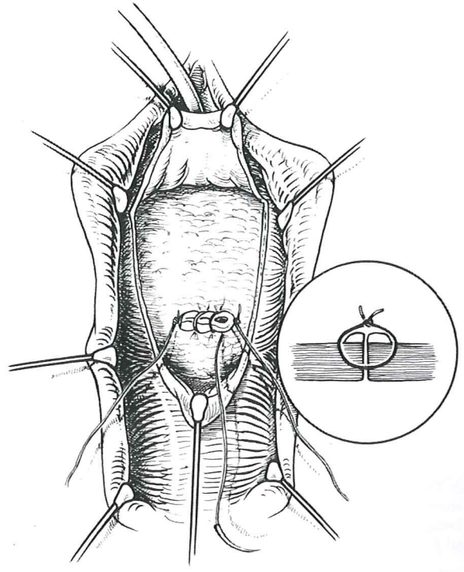


Figure 78–5
The fistula is closed with a running full-thickness synthetic absorbable suture. (From Zimmern PE, Leach GE: Vesicovaginal fistula repair. Urol Clin North Am 2:87–89, 1994.)

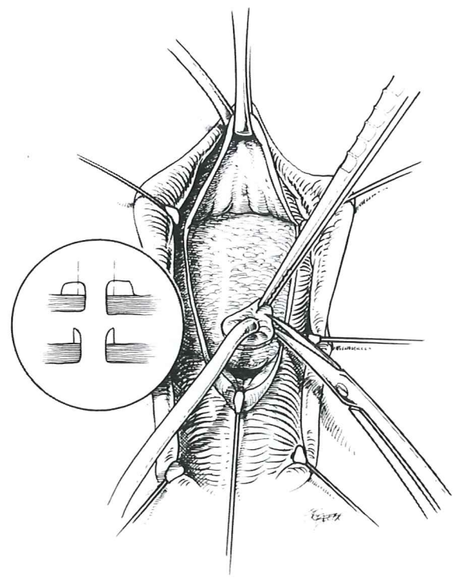


Figure 78–4
The fistula tract is trimmed but not excised. (From Zimmern PE, Leach GE: Vesicovaginal fistula repair. Urol Clin North Am 2:87–89, 1994.)

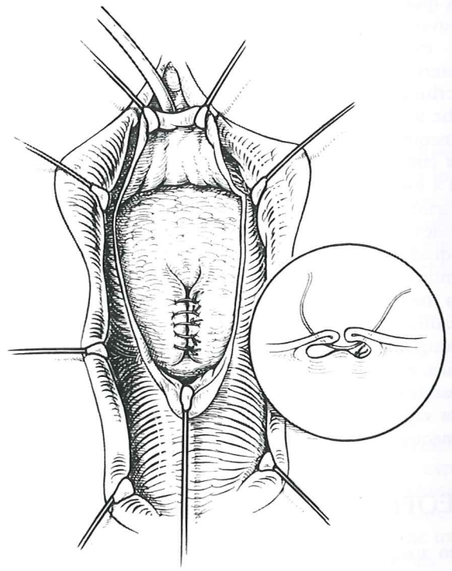


Figure 78–6
A second layer of Lembert sutures reinforce the first suture line. (From Zimmern PE, Leach GE: Vesicovaginal fistula repair. Urol Clin North Am 2:87–89, 1994.)

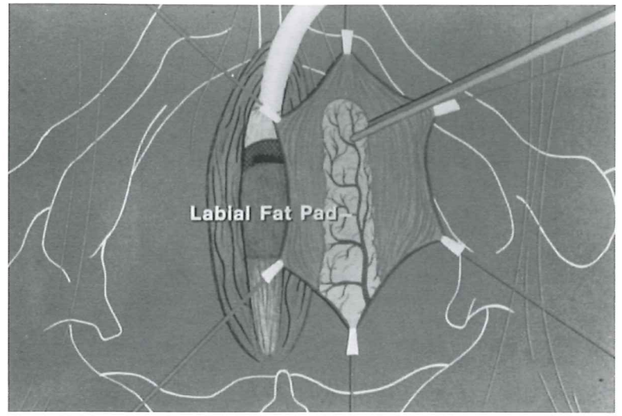


Figure 78–7
The Martius labial fat pad is found deeper than the subcutaneous tissue and is supplied by branches of the posterior-based pudendal artery. (From Zimmern PE, Leach GE: Vesicovaginal fistula repair. Urol Clin North Am 2:87–89, 1994.)

incision is made over the labia majora, and mobilization begins deep to the subcutaneous tissue, taking care to preserve the posterior-based pudendal arterial supply (Fig. 78–7). A tunnel is created medially from the inferior aspect of the labial incision toward the anterior vaginal wall fistula site. The fat pad is passed through this tunnel and secured over the fistula site with interrupted absorbable sutures (Fig. 78–8). The final layer of closure is the anterior vaginal wall flap, which is advanced over the fistula closure site and secured with a running 2-0 Vicryl suture.

MYOCUTANEOUS FLAPS

For large complex fistulas (such as after radiation therapy) or cases of vaginal vault obliteration in which vaginal reconstruction is required, muscle or myocutaneous flaps, especially the gracilis, may be required. The gracilis muscle is a flat, straplike muscle that is the most superficial muscle of the media thigh.[9] It is an accessory thigh adductor and knee flexor and can be sacrificed without impairing function or gait. The muscle alone can be used by interposing it between the bladder or urethra and vagina, thereby decreasing the possibility of fistula recurrence. This use requires enough vaginal mucosa to cover the muscle. Alternatively, the skin and subcutaneous muscle overlying the muscle can be retained to fill the vaginal defect (myocutaneous flap), or a split-thickness skin graft can be placed directly on the muscle if the subcutaneous tissue is too thick to allow a functional or aesthetic vagina.

Technique

In the modified lithotomy position, a straight line is drawn from the pubic tubercle (overlying the easily palpable adductor longus tendon) to the semitendinosus tendon at the medial condyle of the knee.[10] The gracilis flap is marked as an elliptic skin flap posterior to this line and centered over the muscle (Fig. 78–9). The usual reliable maximum skin island is 8 cm wide by 22 cm long. The skin flap should not overlie the distal third of the muscle unless a delay procedure is performed. The incision extends through the fascia until the muscle is identified. The distal tendon is divided, and the flap is developed proximally until the vascular pedicle is encountered (Fig. 78–10). The domi-

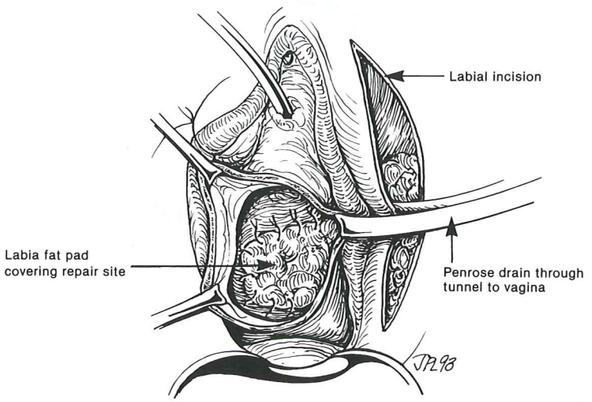


Figure 78–8
The mobilized Martius flap is passed into the vagina and secured over the fistula site with interrupted absorbable sutures. (From Zimmern PE, Leach GE: Vesicovaginal fistula repair. Urol Clin North Am 2:87–89, 1994.)

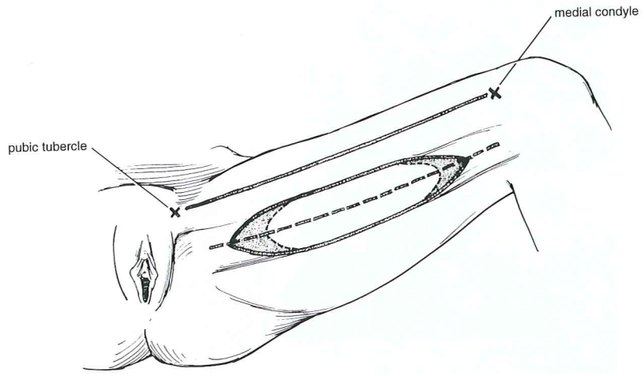


Figure 78–9
The gracilis muscle is located posterior to a line drawn from the medial condyle of the knee to the pubic tubercle. An elliptic incision is made, and the distal gracilis tendon is identified. (From Hinman F [ed]: Atlas of Urologic Surgery, Philadelphia, WB Saunders, 1989.)

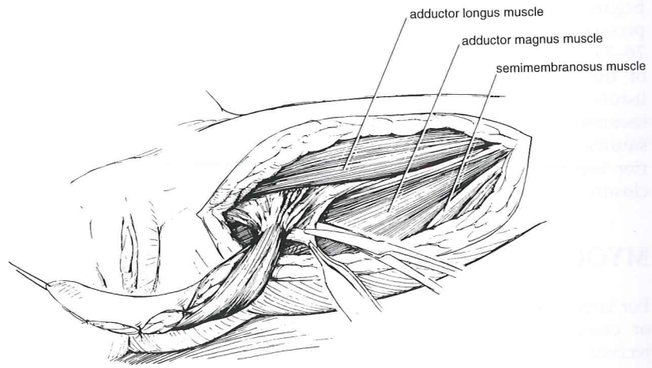


Figure 78–10
The distal tendon of the gracilis is divided, and the myocutaneous flap is mobilized proximally toward the vascular pedicle located 7 to 8 cm from the pubic tubercle. (From Hinman F [ed]: Atlas of Urologic Surgery, Philadelphia, WB Saunders, 1989.)

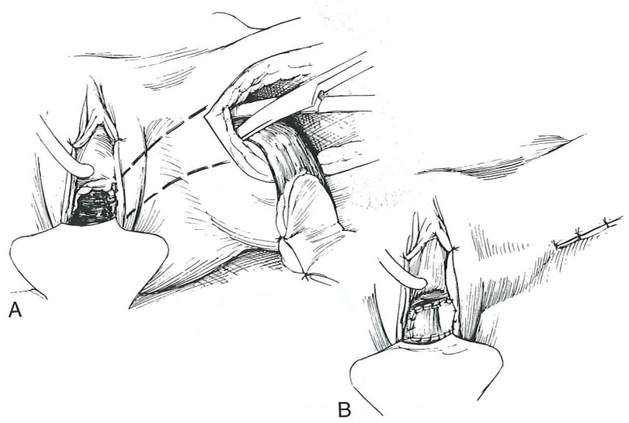


Figure 78–11
The gracilis myocutaneous flap is rotated posteriorly and tunneled under a skin bridge to the vaginal introitus. (From Hinman F [ed]: Atlas of Urologic Surgery, Philadelphia, WB Saunders, 1989.)

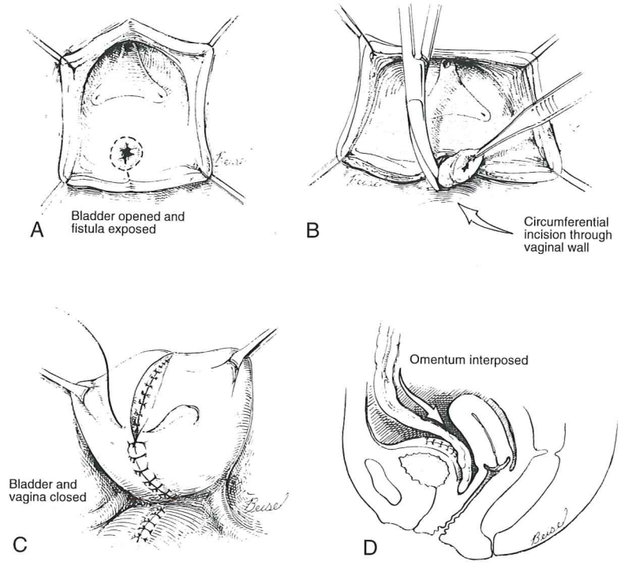


Figure 78–12
Transabdominal vesicovaginal fistula repair. *A*: The posterior aspect of the cystotomy is extended to and includes the fistula. *B*: The fistula is sharply circumscribed and excised, including the vaginal wall. *C*: The bladder is closed in two layers, and the vaginal wall is closed. *D*: Further mobilization may be necessary to allow interposition of a vascularized pedicle flap. (From Gillenwater JY, Grayhack JT, Howards SS, et al [eds]: Adult and Pediatric Urology, St. Louis, Mosby Year Book, 1991.)

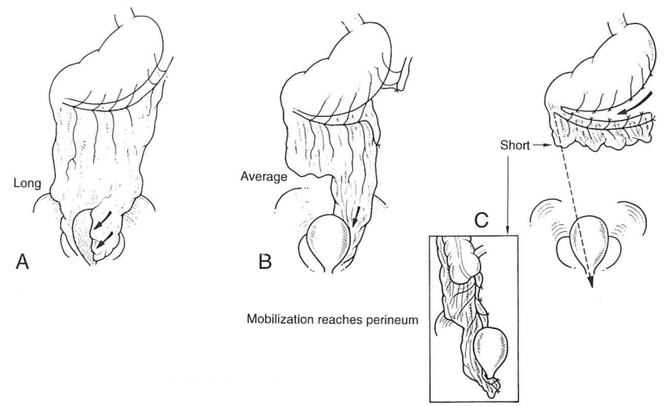


Figure 78–13
A: In about 30% of patients, the omentum reaches the pelvis without mobilization. *B*: In another 30% of patients, division of the left omental margin provides adequate length. *C*: In the remaining 40%, complete mobilization of the omentum on the right gastroepiploic artery is required. (From Webster G, Kirby R, King L, et al [eds]: Reconstructive Urology, Cambridge, MA, Blackwell Scientific Publications Inc, 1993.)

nant vascular pedicle, a branch of the profunda femoris or medial femoral circumflex artery, is consistently located between the adductor longus and brevis muscles about 8 to 10 cm distal to the pubic tubercle. The flap is rotated posteriorly through a tunnel under the skin bridge into the vaginal introitus (Fig. 78–11). If muscle alone is used, it is elevated alone without the skin or subcutaneous tissue. The donor site is closed primarily with suction drains.

TRANSABDOMINAL VESICOVAGINAL FISTULA APPROACH

The abdominal approach may be used for any VVF, depending on the surgeon's experience and preference. The abdominal approach is preferred over the vaginal approach in three situations: when an apical vaginal fistula is difficult to reach, when ureteral reimplantation is needed, or when augmentation cystoplasty is required. A simple fistula may be approached extraperitoneally, whereas a complex or large fistula usually requires a transperitoneal approach.

Technique

A low midline infraumbilical incision is preferred; it can be extended to the xiphoid process if necessary. The bladder is mobilized and exposed, and a vertical cystotomy made. The posterior extent of the cystotomy is extended to the fistula and includes it (Fig. 78–12). A Foley catheter placed through the fistula may aid exposure. A finger or blunt instrument in the vagina may aid in dissecting the bladder off of the vaginal wall. Wide mobilization is necessary to allow placement of an interposition flap and ensure separation of suture lines. The fistula tract is excised, the anterior vaginal wall is closed, and the bladder is closed with two layers of synthetic absorbable suture. At this point, vascularized tissue may be interposed between the vaginal and bladder suture lines (see Fig. 78–12).

Omental Mobilization

In about 30% of patients, the omentum reaches the pelvis without mobilization (Fig. 78–13).[11] In another 30%, division of the left gastroepiploic and left omental margin (lateral splenorenal ligaments) allows sufficient length to reach the pelvis. In 40%, however, complete mobilization of the omentum on the right gastroepiploic artery is necessary to reach the pelvis (see Fig. 78–13). Mobilization of an omental pedicle flap is performed by separating the attachments to the transverse colon and mesocolon (Fig. 78–14). Complete mobilization requires careful ligation of the short gastric arteries to avoid tension, possible avulsion, and bleeding.

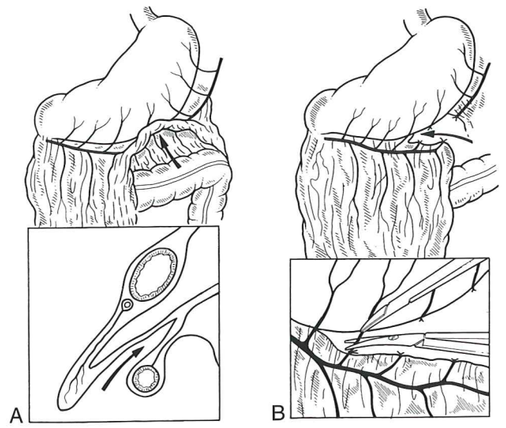


Figure 78–14
A: Complete omental mobilization requires division of the attachments to the transverse colon. *B*: Further mobilization of the omentum from the greater curvature of the stomach may be required to provide additional length. Note the correct plane leaving the gastroepiploic arcade intact in the omentum (inset). (From Webster G, Kirby R, King L, et al [eds]: Reconstructive Urology, Cambridge, MA, Blackwell Scientific Publications Inc, 1993.)

RESULTS

The reported success of VVF repair by the abdominal and vaginal routes varies from 65% to 100% (Table 78–1). Even with large or complex fistulas the use of vascularized tissue interposition results in cures approaching 90%. A rare patient requires ileal conduit or continent urinary diversion.

COMPLICATIONS

Other than failure, complications of vaginal VVF repair are rare. Vaginal stenosis or foreshortening may be noted. Preoperative urodynamic evaluation should minimize the risk of postoperative stress-urinary incontinence. Most patients experience urgency and frequency, which should be self-limited unless secondary to diminished bladder capacity. Complications of myocutaneous flaps include flap necrosis, sexual dysfunction, and leg scarring. Partial necrosis and skin slough may be seen in 10% to 30% of cases, whereas total flap loss occurs in fewer than 10%.[12, 13]

Table 78–1
Reported Success Rates After the First Attempt at Vesicovaginal Fistula Repair

Investigators	Number of Patients	Number of Patients Cured (%)
Persky (1979)	7	6 (86)
Goodwin and Scardino (1980)	43	28 (65)
Kettle and Laube (1982)	188	168 (89.5)
Blandy (1991)	23	23 (100)

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AESTHETIC GENITAL SURGERY

CHAPTER

79

Aesthetic Surgery of the Male Genitalia

GARY J. ALTER

Advanced techniques to enhance the appearance of the penis, scrotum, and escutcheon have been based primarily on improved reconstructive pediatric and adult surgical procedures. During the past several years, enhanced media and patient awareness has led to significant demand for aesthetic surgery of the male genitalia. Considerable improvement in the aesthetic appearance of the genitalia is now possible, although this surgery is challenging, requiring strict attention to detail and meticulous technique.

A man's identity is often related to the size and appearance of his genitalia, and thus his self-esteem can be impaired if he feels inadequate compared with a perceived ideal. Normal men therefore may desire genital enhancement, because they consider a larger penis to be more aesthetically pleasing or masculine. Such feelings arise from comparison with published photographs, from a sexual partner's ridicule, or from media bombardment describing the sexual benefits of a large penis. Such men may have a lifelong concern about their penis size, frequently relative to the flaccid length, especially in a locker-room setting. Erect length is usually not a primary concern unless sexual partners have made negative comments. Increased thickness is sought to improve appearance or to increase friction during intercourse, thereby enhancing pleasure for himself and his partner (rarely does a patient suggest a vagina-tightening procedure to his partner). Men seeking enlargement place greater importance on length but usually choose both length and girth enhancement. Moreover, a large penis may be a visual erogenous stimulant. It is obvious that size does not substitute for passionate, compatible lovemaking, but some women as well as gay men claim heightened sexual gratification. Although both heterosexual and homosexual men seek surgery, the gay community tends to be more concerned with genital aesthetics. Variations in glans size and shape, testicle and scrotal size, and the escutcheon and suprapubic region are more closely examined in the homosexual population. Although physicians should reassure a normal patient, they must not deny his perception. For example, a man with a normal penis may still be a candidate for penile enhancement just as a woman with normal breast size is considered for breast enlargement. Postoperatively, a healthier social and professional adjustment occurs owing to increased self-confidence when fear of intimacy and social maladjustment are overcome.

Aesthetic surgery improves the form of a normal organ for the purpose of enhancing a patient's self-esteem.[1] Many urologists have a bias against aesthetic surgery inasmuch as their training is geared to eliminating disease and treating deformities. However, aesthetic surgery is justified if the potential benefits are positive and the risks are minimal. Psychologic evaluation and treatment are frequently recommended, because surgery does not cure a general lack of self-esteem. Indeed, such surgery is contraindicated in psychologically unstable patients, even though aesthetic surgery can enhance self-esteem and can thus secondarily lead to an improved quality of life, both socially and professionally. Because aesthetic demands and expectations are greater, preoperative and postoperative follow-up is often more time consuming, even with an excellent result. Meticulous surgical technique with dedication to detail is imperative.

These patients are concerned with appearance, and therefore, complications, unrealistic expectations, or inadequate results can cause severe depression. Thus, a realistic understanding of the design and limitations as well as a patient's expectations of the surgery must be established to correct misconceptions and prevent dissatisfaction. Some patients may even become violent if dissatisfied and depressed, and thus honesty, clear communication, and compassion are mandatory for both patient and physician.

Each individual must be evaluated to determine the best methods to achieve his goals. Several procedures are available, depending on the patient's anatomy; both standing and supine examinations are carried out to determine variations that change with gravity. Penoscrotal webbing and extensive suprapubic fat are not usually presenting complaints, but the physician must describe these abnormalities and possible corrective surgery.

PENILE LENGTHENING

Demand for penile lengthening, which is greater than for girth, is achieved by combining release of the penile suspensory ligament with the postoperative use of penile weights. However, interpreting the results of penile lengthening is difficult owing to the lack of a standard measurement technique. Dorsal measurements are taken before and after operation from the pubic symphysis and from the suprapubic skin to the tip of the glans penis on full stretch at a 90-degree angle to the abdomen. Functional and visual penile length can be increased if thick suprapubic fat or subcutaneous tissue is removed by open lipectomy or liposuction. A pharmacologic erection may be performed to measure erect length gain and to document any penile curvature.

The suspensory ligament of the penis is a thick triangular band extending from the linea alba and the upper portion of the symphysis pubis and arcuate ligament to the dorsal midline of the penis.[2] It derives from the outer investing fascia of the abdomen and divides into a sling at the junction of the fixed and mobile portions of the penis. In addition, thickened bands of Scarpa's fascia, called the *fundiform ligaments,* firmly attach to the rectus fascia above the pubic symphysis and extend onto the dorsal and lateral penis, possibly restricting penile excursion.[3] Release of the suspensory ligament and restricting bands of Scarpa's fascia can provide slight length increase by inferior displacement of the penis. However, true length gain may be achieved by combining ligament release with the use of special penile weights that act as an external tissue expander. Releasing the ligament frees more of the penis to be stretched. Suprapubic skin is not advanced onto the proximal dorsal shaft of the penis unless the patient has a relative deficiency of shaft skin, usually resulting from overly aggressive circumcision.

Technique

A transverse low pubic incision of approximately 4 cm is preferred when skin advancement is unnecessary. Different incisions are used to advance skin onto the shaft and to incise the suspensory ligaments and restraining bands of Scarpa's fascia. Because advanced skin is thicker than normal shaft skin and is hair bearing, the base of the penis may have a hump or may appear thicker with hair-bearing skin. V-Y advancement flaps of various sizes are based either at the penopubic junction or several centimeters proximal to the penopubic junction. A large V-Y advancement flap based distally at the penopubic junction is not recommended because it often produces a deforming, dorsal hair-bearing hump at the base of the penis, large "dog-ears," and the appearance of penile shortening, especially in patients with a relative penoscrotal transposition or a thick suprapubic fat pad. Healing problems at the Y junction often occur because of a compromised blood supply. A double Z-plasty with the distal vertical limb ending at the penopubic junction advances skin, leaves a less noticeable scar, and causes no unsightly hump (Fig. 79–1). Moreover, Z-plasty flaps are more reliable than V-Y flaps in this region because they are based laterally. A 4-cm vertical limb with four flaps 2 cm long at an angle of 60 degrees advances the skin about 2 cm. A double Z-plasty incision is excellent for a minor suprapubic open lipectomy, but a large lipectomy may be more easily performed through a different incision.

The wound is opened, and Scarpa's fascia transversely incised. As the penis is pulled, blunt dissection on both sides of the midline defines the suspensory ligament of the penis, which is then incised in the midline off the pubic symphysis to the lower border of the symphysis (Fig. 79–2). The ligament is then released 1 cm on each side of the midline, and the deep dorsal vein is seen passing below the pubis. The dorsal neurovascular structures are not injured if the ligament is released directly on the periosteum of the pubis and if release is stopped at the lower border of the pubis. Once this ligament is released, more restraining bands of Scarpa's fascia are incised transversely with the penis on stretch. Care must be taken to prevent injury to the spermatic cords. Although bleeding is usually minimal, hemostasis must be meticulous.

The corporeal bodies then descend off the pubic bone, creating a dead space that should be filled because the ligament can reattach and possibly reduce length gain or

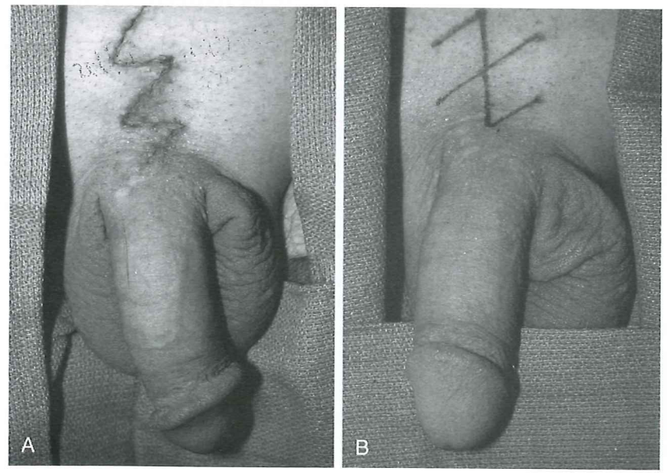


Figure 79–1
Double Z-plasty used only if the patient has a shortage of penile skin. *A:* Design. *B:* Closure.



Figure 79–2
Suspensory ligament of the penis in the midline and restraining bands of Scarpa's fascia bilaterally.

cause penile shortening. A roll of polytetrafluoroethylene (Gore-Tex; W.L. Gore and Associates, Flagstaff, AZ) fills the space despite the potential infection risks of alloplastic material, but dermal-fat grafts are occasionally used. A closed-system drain is inserted, and Scarpa's fascia is closed vertically. Buried intradermal absorbable sutures are placed, followed by a subcuticular suture of small absorbable or monofilament sutures. Atraumatic handling of the flap tips and meticulous wound closure are mandatory.

Results

The degree of length gain achieved is controversial. Ligament release alone may occasionally increase flaccid length 1 inch, but often no gain is achieved. An optical illusion of flaccid length gain may occasionally occur. Penile weight use is imperative to obtain length gain. The patient intermittently suspends these weights from the corona of the penis daily for a period of months to stretch the corporeal bodies. True length increases of several inches are rare but may occur if a suprapubic lipectomy is also performed on thick subcutaneous tissue. However, some compulsive weight users anecdotally report flaccid as well as erect gains of several inches. In fact, a 1-inch gain is considered successful even with weights. Even if no real length is gained, however, the flaccid penis may give the illusion of being longer, owing to greater convexity at the penile base. Because many patients desire the appearance of a longer flaccid penis, this illusion of increased length sufficiently reaches this goal. Erectile length is more difficult to discern, because most phalluses are not measured erect preoperatively and postoperatively. Minimal or even no increase in erectile length usually occurs unless the penis is stretched by weights. Length can be increased if a patient has a relative shortage of penile skin augmented by advancing infrapubic skin. Decreased length resulting from corporeal reattachment after ligament release is uncommon if a Gore-Tex roll is inserted into the space between the corpora and the pubis and if weights are used.

Simultaneous lengthening and girth enhancement procedures are no longer performed, because weight use needs to be delayed several weeks owing to penile swelling and discomfort, which risk premature ligament reattachment. In addition, stretching the dermal-fat grafts to achieve length decreases the girth. Once length is achieved after 6 to 12 months, dermal-fat graft augmentation is performed.

GIRTH INCREASE

Injection of large amounts of fat into the dartos fascia produces avascular fat pockets isolated from any potential blood supply. Lack of graft viability owing to an inadequate tissue bed, difficulty in immobilization, and fat cell trauma result in fat necrosis and reabsorption. Reabsorption or migration of fat in the relatively cylindric penis can cause severe deformities such as S-shaped curvatures or asymmetry. Nodules of necrotic or calcified fat develop if injected fat does not survive, deforming the appearance or texture of the penis. Injection of large amounts of fat increases the incidence of these complications, whereas small amounts of injected fat result in minimal girth gain owing to reabsorption of more than 50% of the fat.[4–7] Because of the high incidence of these complications, only dermal-fat grafts are recommended. A dermal-fat graft is a composite of deepithelialized skin and underlying fat. Dermis takes easily and provides support, enabling accurate graft placement.

Technique

The circumference of the penis can be increased by inserting strips of dermal-fat grafts into the dartos fascia or by wrapping a dermal-fat sheet around the penis (Fig. 79–3). The latter is preferred, inasmuch as exact graft positioning is possible and ridges do not develop. The graft is placed around three fourths of the circumference of the penis between Buck's fascia and dartos fascia, leaving the urethra uncovered. The graft is placed from the distal corona to the penopubic junction. The size of the graft needed is determined by measuring stretched penile length from the penopubic junction to the distal corona. The measured amount of donor tissue should be greater than the penile measurement, because the dermal-fat graft shrinks upon harvest. This elasticity should enable the graft to stretch during an erection. The dermal-fat grafts are obtained from bilateral donor sites at the inferior gluteal creases or vertical medial buttocks (Figs. 79–4 and 79–5) or rarely from the groin creases (see Fig. 79–9). Even when the grafts are centered on the gluteal creases, the scars can be unsightly. Although vertical medial buttock donor sites leave hidden scars, healing problems are more common (Fig. 79–5*C*). If escutcheon elevation or dermatolipectomy is performed, the lower abdomen is used as the donor site (see Fig. 79–7). Meticulous multilayered closure with subcuticular suturing is performed.

The penis is partially degloved through a 270-degree circumcision incision, revealing Buck's fascia overlying the corpora. Dissection raises the underlying dartos fascia on the shaft to the penopubic junction. The ventral skin is

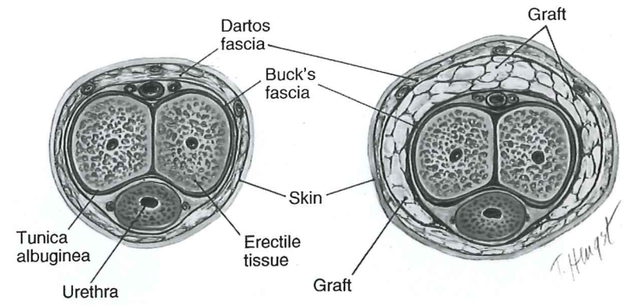


Figure 79–3
Penis cross section showing placement of the dermal-fat graft between Buck's fascia and dartos fascia.

not incised, and the ventral dartos fascia is not dissected off the spongiosum, thereby minimizing loss of blood supply. The thickness of the dermal-fat graft is less than 1 cm to ensure take and to prevent possible difficulty replacing the dartos fascia and skin. If two grafts are used, they are sutured together with darts to prevent ridges and scar contracture (Fig. 79–5*B*). The dermal side is superficial, lending a smooth texture to the penis. Stay sutures of Vicryl are placed in the medial and lateral proximal edges of the dermal-fat graft. Each of these sutures is separately threaded through a needle, and a Furlow inserter is used to pass the sutures into the medial and lateral penopubic region. The stay sutures are then pulled, positioning the dermal-fat graft in place (Fig. 79–6*A*). Leaving the ventral dartos fascia attached to dartos fascia also helps to position and stabilize the graft, preventing ventral displacement. The penis is stretched, and the graft is tailored distally and laterally to fit into the dissected pocket. The distal coronal skin is elevated. The most distal edge of the graft is thinned further to simulate the normal distal tapering of the penile shaft, and it is attached to the most distal corona with absorbable sutures, taking care not to injure the dorsal nerve branches. The lateral edge of the graft is sutured to Buck's fascia at the junction of the corpus and the urethra with several bilateral tacking sutures, but extensive fixation is unnecessary. The graft is placed loosely but without redundancy to prevent a restricted erection. The stay sutures are tied over dental-roll bolsters, stabilizing the proximal graft (Fig. 79–6*B*). Skin and dartos fascia are replaced over the graft, producing a symmetric, smooth girth enhancement. The skin must not be tight over the graft, or venous congestion and necrosis are possible.

The postoperative dressing is crucial to success. Extra-thin DuoDerm is lightly wrapped circumferentially around the penis. The dressing remains for about 6 days, allowing tissue ingrowth and graft take. It is easily removed by having the patient soak the dressing with baby oil, starting the day before removal. The bolsters are removed after the 10th postoperative day.

Results

Dermal-fat graft enhancement achieves a 1- to 2-inch circumference increase (Figs. 79–7 to 79–9). Although the procedure is far more invasive than fat injections and requires several hours of surgery, its permanent symmetric girth increase is definitely more reliable. Significant penile edema and induration persist for 6 weeks after operation, and relatively normal texture returns in 4 to 6 months. Decreased shaft sensation usually normalizes in several months when swelling resolves, but this is not problematic because most erogenous sensation is in the glans. Dermal-fat grafts placed as sheets instead of strips provide smooth texture with less risk of ridges and displacement. Nodules and fat reabsorption are less common with dermal-fat

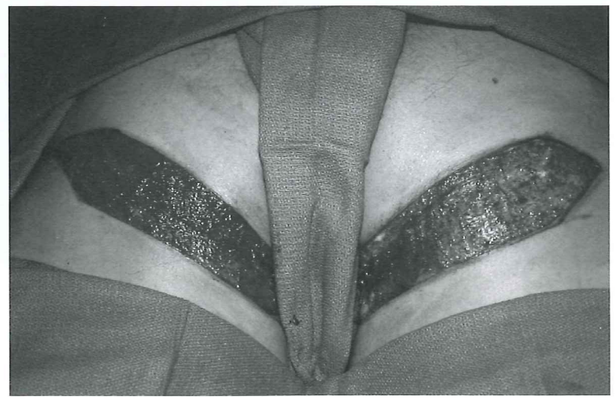


Figure 79–4
Deepithelialized dermal-fat graft donor sites centered in the gluteal creases.

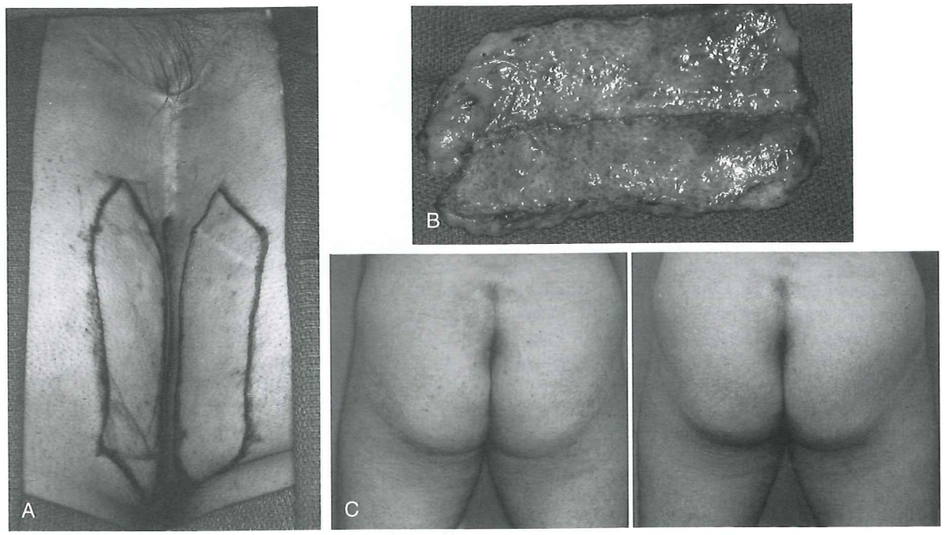


Figure 79–5
Dermal-fat graft donor sites from the medial buttocks (the midline scar is from a previous pilonidal cystectomy). *A:* Design. *B:* Dermal-fat grafts obtained from the medial buttocks. They will be thinned, sutured together, and tailored. *C:* Buttocks before removing dermal-fat grafts (left) and after removal of dermal-fat grafts (right), showing no distortion or visible scars.

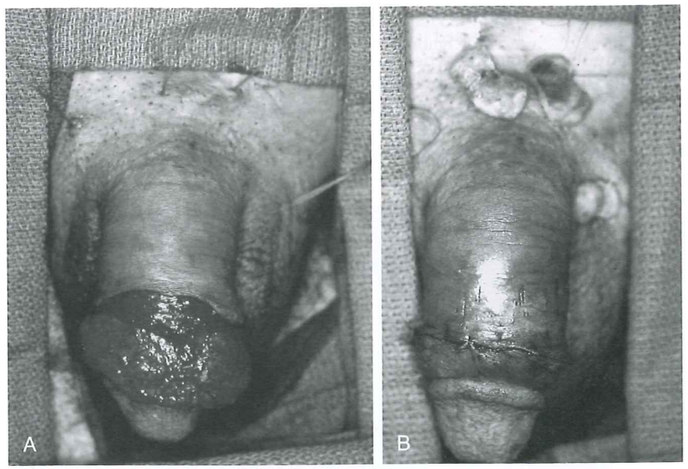


Figure 79–6
A: Skin and dartos fascia are dissected off Buck's fascia through a hemicircumcision incision. The dermal-fat graft is placed by pulling on stay sutures threaded into the suprapubic region and upper scrotum. The dermal side is superficial, resulting in a smooth texture of the penis. *B:* The dermal-fat graft is sutured distally to the corona and laterally to the corporo-urethral junction. The incision is closed with a subcuticular suture after the graft is placed. The stay sutures are tied over bolsters.

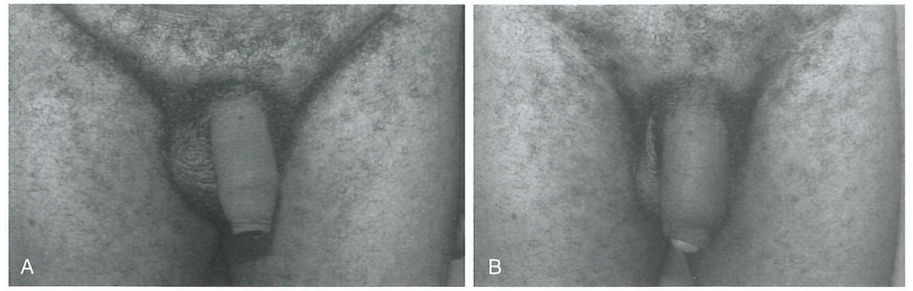


Figure 79–7
A 49-year-old patient who underwent dermal-fat graft wrap augmentation, conservative circumcision, and escutcheon elevation (the lower abdominal skin was used as the dermal-fat graft donor site). *A:* Preoperation. *B:* Postoperation. At 8 months, the patient had gained approximately 1¼ inch in proximal circumference and 1 inch in distal circumference. The escutcheon lift gave him a more youthful genital appearance. The dermal-fat grafts were obtained from the lower abdomen.

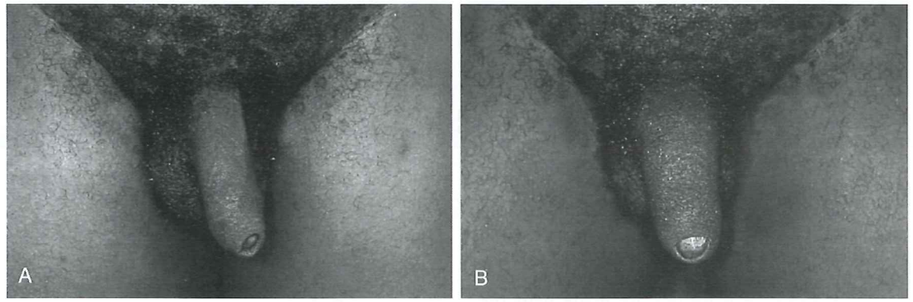


Figure 79–8
A 27-year-old patient who underwent dermal-fat graft wrap augmentation and conservative circumcision. *A:* Preoperation *B:* Postoperation. At 4 months, his proximal circumference had increased by 1¾ inches and distal circumference by 1⅜ inches. He is very pleased with the result.

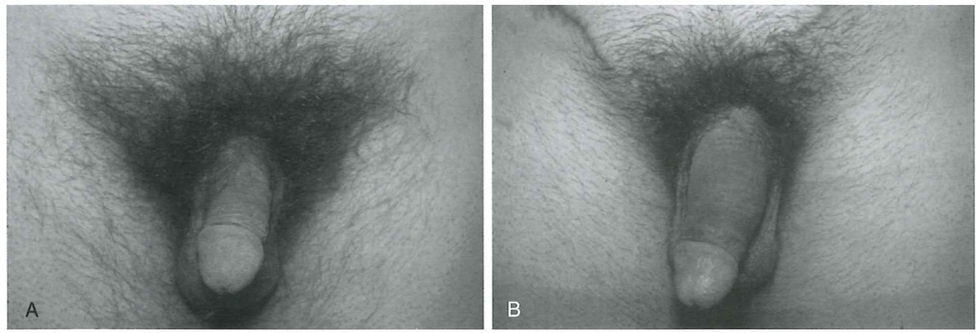


Figure 79–9
A 30-year-old who underwent release of the suspensory ligament and dermal-fat graft wrap augmentation (no longer performed simultaneously). *A:* Preoperation. *B:* Postoperation. At 3 months, the patient had gained approximately 1¾ inch in proximal circumference and 1¼ inch in distal circumference. No stretched length gain occurred, but the penis appears longer in the flaccid state owing to the dermal-fat graft. Donor sites were obtained from the groin creases.

grafts than fat injections. Rarely, inadequate graft take, infection, and asymmetry occur with dermal-fat grafts, resulting in penile shortening and curvature due to fibrosis. Dermal-fat grafts that are too thick (>1 cm) or an overly tight dressing can produce venous congestion of the surrounding dartos and skin, with possible skin injury or necrosis.

SURGERY FOR THE AGING OR CONCEALED PENIS

Some men have large suprapubic fat pads that bury and conceal the functional and visual penile length. Other causes of concealed penis are a shortage of penile shaft skin due to overly aggressive circumcision, a congenital buried penis, or a small phallus.[8–11] Surgery is derived from the principles and techniques used to correct the pediatric buried penis (see Chapter 71). In these cases, excess fat is excised and restricting bands of Scarpa's fascia are released to increase the visual and functional length of the penis. The suspensory ligament is partially or completely released. Moreover, aging causes suprapubic skin and fat to descend and to conceal the penis when the patient is standing. Combining fat and skin excision in an aging man provides a more attractive and youthful appearance to the escutcheon while increasing visual and often actual penile length (see Fig. 79–7). Examining patients in the standing position is therefore required for an accurate diagnosis.

A low transverse incision is made in the pubic hair if subcutaneous fat only is removed and if skin advancement onto the penis is unnecessary. If excess skin is excised to raise the escutcheon and give a more youthful appearance to an aging patient, the incision is made above the level of the pubic hair. Preoperative markings are made with the patient standing to determine the amount of skin to be resected. Suprapubic fat is widely resected down to the rectus fascia, freeing the hidden penile shaft from the deep subcutaneous tissue. Fat around the spermatic cords and some scrotal fat are removed, but overly aggressive fat removal in the inguinal regions can cause genital edema and injury to the superficial sensory nerves of the genitalia. Excessive thinning of the skin flaps can cause skin loss. Fat removed from the suprapubic region is tapered to minimize a potential concavity. The suspensory ligament is often partially or completely released. Despite lipectomy, the corporeal bodies still have a tendency to retract under the penile skin into the scrotum and pubis, and thus tacking sutures of 0 polyester (Ethibond, Ti-Cron, or Mersilene) are placed (Fig. 79–10). Tacking the subdermal tissue of the suprapubic skin to the rectus fascia maintains the upward position of the escutcheon. Tacking the tunica albuginea at both sides of the urethra to the subdermal tissue of the penoscrotal junction with 00 polyester sutures maintains the penile skin on the shaft of the penis, preventing retraction into fat or the scrotum. The periurethral sutures are placed through the suprapubic incision or through a separate incision just inferior to the penoscrotal junction. Care must be taken not to cause skin dimpling due to the tacking sutures or to include the dorsal nerves. Closed suction drains are placed until drainage stops.

Surgery on a concealed or aging penis achieves marked aesthetic and often functional improvement (Fig. 79–11).

PENOSCROTAL WEBBING

The ventral penile shaft can be visibly obscured if the scrotum extends onto the penis, causing a penoscrotal web or improperly defined penoscrotal junction. A well-defined penoscrotal junction gives the penis a longer appearance. This deformity is congenital or may result from overresection of ventral skin during circumcision. A single or double Z-plasty with the vertical limb centered along the penoscrotal junction sharpens the junction, giving the appearance of more ventral length.[12] Excision of scrotal skin to eliminate the web is contraindicated because it may cause skin shortage and scar contracture with eventual worsening of the web. This relatively simple procedure can be performed under local anesthesia.

RECONSTRUCTION

Because no standardized techniques exist, a wide variety of penis enlargement procedures have been performed with

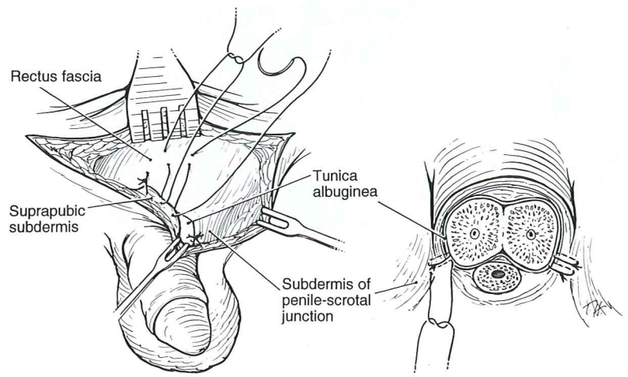


Figure 79–10
Technique of tacking the suprapubic subdermis to the rectus fascia and bilateral tacking of the penoscrotal subdermis to the tunica albuginea.

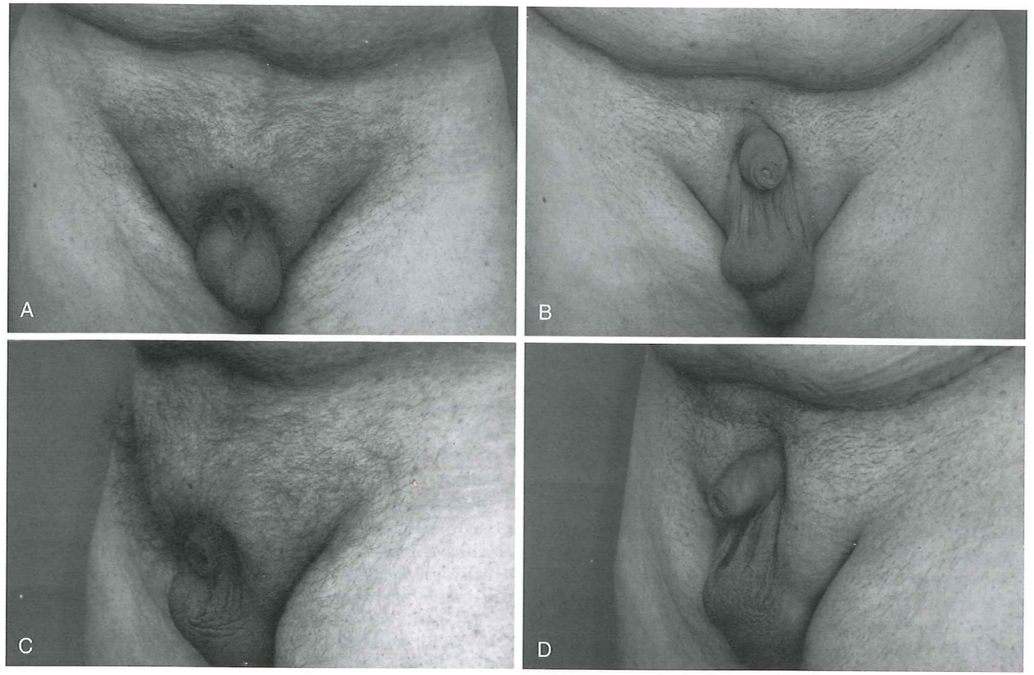


Figure 79–11
This 35-year-old with buried penis underwent suprapubic dermatolipectomy with elevation of the escutcheon, partial release of the suspensory ligament, tacking of the suprapubic subdermis to the rectus fascia, and bilateral tacking of the penoscrotal subdermis to the periurethral tunica albuginea. *A* and *C:* Preoperation. *B* and *D:* Postoperation.

differing results. Faulty theoretic or anatomic designs have often predisposed to significant complications and deformities, especially if the surgeon is not technically meticulous (Fig. 79–12).

Specific complaints related to the lengthening procedure with large V-Y advancement flaps include wide, thick scars; a hairless depression in the pubic area; decreased penile length; a hump deformity at the base of the penis due to thick, hair-bearing V-Y flaps; a low-hanging penis; scrotal "dog-ears"; and loss of sensitivity on the shaft or glans of the penis (Figs. 79–13*A* and 79–14*A*). The most severe deformity occurred when the soft penis was surrounded by the scrotum (scrotalization) and the penis retracted under a thick V-Y flap and pubic fat pad. Complications

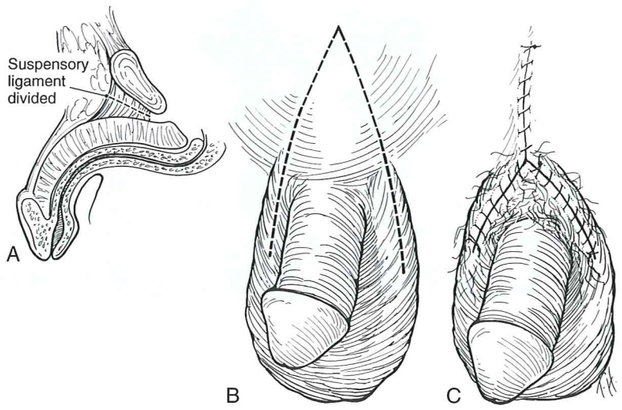


Figure 79–12
Method often used for penile lengthening frequently resulting in the need for reconstruction. *A:* The suspensory ligament is released. *B:* A large V-Y advancement flap is designed. *C:* The flap is advanced, resulting in hair on the proximal shaft of the penis, bilateral "dog-ears," and a lower-hanging penis.

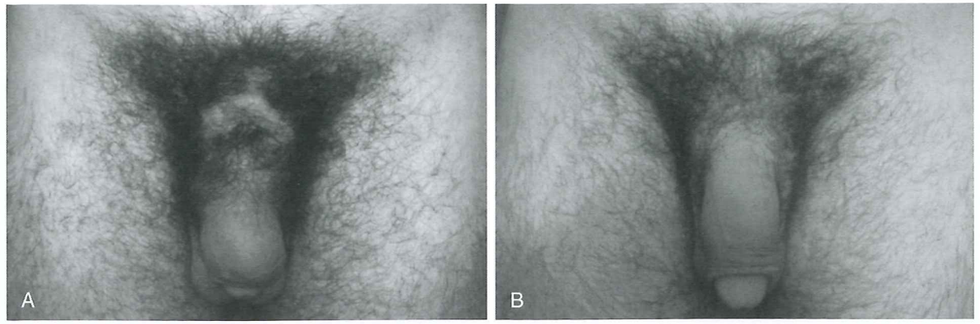


Figure 79–13
A 20-year-old patient who underwent release of the suspensory ligament, a large V-Y advancement flap, and multiple fat injections. *A:* Deformity showing a low-lying penis, hair on the proximal shaft, bilateral "dog-ears" at the penoscrotal junction, a shorter-appearing penis, wide pubic scars, and a large amount of fat in the shaft. *B:* Correction of V-Y "dog-ears," scar revision, selective removal of fat nodules, and contouring of the left side of the penis.

relating to fat injections involved disappearance of fat, penile lumps and nodules, shaft asymmetry and distortion, excess penile skin near the glans, and inadequate rigidity due to excessive fat and an overly large base (usually when combined with the V-Y flap). Other complaints include impotence, urinary leakage, and persistent penile pain. Complaints relating to dermal or dermal-fat grafts include penile distortion and asymmetry, hard strips or nodules, restricted erections with penile shortening, and penile curvature.

An unhappy patient is usually depressed and often desperate. He distrusts physicians because an earlier surgeon may have inadequately informed him of possible complications and deceived him. This first or an ensuing surgeon may have performed one or more subsequent operations without improvement or may even have worsened his situation. Therefore, the first appointment concentrates on regaining a patient's trust.

A patient is evaluated while standing and supine. He must prioritize his reconstructive goals, because complete correction of all the deformities may not be possible at one operation, if at all. He may want only limited fat removal, partial or no V-Y flap reversal, or minimal scar revisions. Realistic expectations must be emphasized. The operative plan, goals, and possible result are carefully explained and shown to the patient in front of a mirror.

The most common repair is partial or complete reversal of the V-Y advancement flap with excision of the wide scars (Figs. 79–13*B* and 79–14*B*). Extensive pubic, penile, and scrotal scars are excised, and the V flap is reelevated to near its previous location. It is frequently impossible or undesirable to reverse the V-Y flap completely, because either real or illusory penile shortening can occur. A patient may have a relative skin shortage restricting his erection if he had partial flap loss after the first procedure or if part of the flap must be excised at revision, especially if he has had many previous circumcisions. Partial V-Y reversal results in a Y-shaped scar with a shorter vertical limb. The V flap is advanced without significantly undermining or thinning its base, thereby protecting its blood supply.

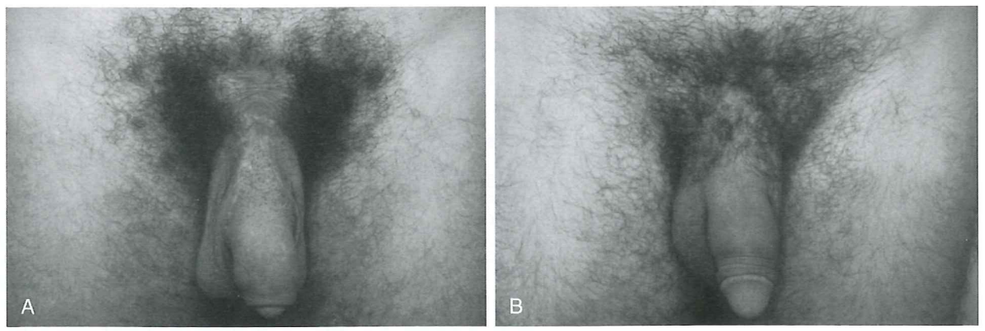


Figure 79–14
A 25-year-old patient who underwent release of the suspensory ligament, a large V-Y advancement flap, and fat injections. *A:* Deformity showing a low-lying penis, hair on the proximal shaft, bilateral "dog-ears" at the penoscrotal junction, a shorter-appearing penis, wide pubic scars, and fat in the shaft. *B:* Reconstruction after partial reversal of V-Y advancement flap, correction of V-Y "dog-ears," scar revision, and selective removal of fat. Complete reversal of the V-Y flap was not possible owing to previous partial loss of a portion of the flap.

By redraping the penis with the normal shaft skin and elevating the penis to its normal position, the reversal eliminates the suprapubic concavity and eradicates the unsightly dorsal penile hump and proximal hair-bearing tissue.

Prolonged lymphedema or potential skin loss can occur if the skin and dartos fascia at the penile base are completely circumcised while repairing scars and "dog-ears." The design of the skin closure must be carefully performed with the penis on full stretch to ensure that no restriction of erection is created. If a discrepancy of skin occurs on the scrotal side from reversal of the V flap, the "dog-ear" is excised from the midportion on the scrotal side of the incision, creating a lateral dart instead of following the "dog-ear" around the penile base. Alternatively, the "dog-ear" can be excised by following it along the lateral aspect of the scrotum.

The skin, subcutaneous tissue, and Scarpa's fascia are undermined and closed in layers over a suction drain. Meticulous skin closure without tension using buried intradermal 4-0 or 5-0 absorbable Vicryl or monofilament sutures and a running subcuticular suture decreases the potential for developing hypertrophic scars. If the upper limb of the vertical incision pulls (especially if the scar is revised without complete reversal of the V-Y flap), one or several small Z-plasties relieve tension and reduce the risk of a restrictive hypertrophic scar contracture. Despite careful wound closure, minor healing problems often occur at the common junction of the V flap with the vertical closure.

Erections and skin adequacy must be evaluated before surgery to determine flap reversal possibilities and reconstruction options. If flap reversal is impossible, the dorsal penile hump is reduced by excising the subcutaneous fat on the V flap, taking care not to devascularize the flap. Liposuction of this fat has not been successful. Although the aesthetic appearance is improved, the difference in skin texture and hair growth continues. If the patient complains of penile shortening, the suspensory ligament is rereleased, often placing a Gore-Tex roll between the corpora and the pubis to prevent reattachment of the corpora in a shortened position.

Removal of fat nodules or penile contouring is performed through limited or complete circumcising incisions, a medial raphe incision, or part of a previous V-Y incision. No new shaft incisions are necessary. Deforming or firm fat deposits are removed first, followed by contouring of the residual fat. Overresection of fat can create unsightly concavities. Large, diffuse areas of injected fat are usually removed through a circumcision incision, but aggressive removal is discouraged owing to possible deformities, lymphedema, or skin necrosis. As much dartos fascia as possible should be preserved.

If V-Y flap reversal is performed, simultaneous removal of fat nodules or deforming fat deposits is limited. Simultaneous removal of a large amount of fat with reversal of the V-Y advancement flap can cause injury to the tip of the V flap or prolonged swelling of the penis. The flap is usually reversed first, along with removal of a limited amount of fat. Fat is removed through a 1- to 2-cm tunnel on one or both sides of the most distal aspect of the V-Y incisions without undermining the V flap or through a limited circumcision incision. One side of the penis must be kept relatively unviolated to ensure adequate lymphatic and blood drainage. Six months after V-Y flap reversal, more aggressive fat removal can be performed through a portion of the previous V-Y incision or through a circumcision or median raphe incision. However, a proximal medial raphe incision in a patient with a large V-Y flap reversal can injure the remaining untraumatized proximal dartos fascia.

Dermal or dermal-fat grafts causing problems can be totally removed through a circumcision incision, a longitudinal incision on the underside of the penis, or a low pubic incision. The dissection can be difficult owing to graft adherence to Buck's fascia, and thus care is taken not to injure the dorsal neurovascular structures. Removal of the scarred dermal graft usually eliminates the deformity, curvature, or penile restriction.

CONCLUSION

Girth enhancement with dermal-fat grafts is an effective procedure, whereas lengthening by release of the suspensory ligament is controversial and requires more objective data. Lengthening followed by penile weight use and subsequent dermal-fat graft augmentation probably ensures maximal length and girth enhancement. If patients desire additional length and girth, the lengthening operation is performed first, followed by months of weight use. If girth enlargement were performed first or simultaneously, stretching the penis would cause thinning of the graft. Suprapubic lipectomy or dermatolipectomy associated with skin tacking is highly successful in enhancing penile appearance. Elimination of penoscrotal webbing is an easy, effective procedure.

A physician must not use a routine approach; each patient should be evaluated according to his anatomy and desires, and surgical recommendations are therefore individualized. Knowledge and understanding of plastic surgical principles and techniques are mandatory to obtain satisfactory results, and meticulous surgical technique must be used. Patients must understand that penile lengthening and augmentation are investigational and that definitive results cannot yet be determined. Honesty is required inasmuch as overoptimism creates a dissatisfied and potentially hostile patient. Penile enhancement techniques will continue to evolve with more data and experience. Many patients achieve substantially improved self-esteem, justifying the continued exploration of new and better methods of penile enhancement.

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CHAPTER

80

Female Aesthetic Genital Surgery

PART I

DAVID A. GILBERT

Aesthetic surgery of the female genitalia remains a surgical challenge despite the perceived simplicity of the female genital anatomy, particularly when compared with the male counterpart. This perception is often emphasized in medical decision-making. For example, a majority of physicians opt to convert children with genital ambiguity to the female gender because it is understood that it is easier to construct the female genitalia. Even in utero development suggests that the female phenotype is the rudimentary progenitor of both sexes and is the "sex by default" if virilization is incomplete. Female genitourinary functions are perceived as basic, and the associated anatomy simplistic. However, the anatomic variants involved during a woman's reproductive period, the repetitive nature of these functions, and the dependent anatomic location lead to acquired deformities and accentuate anomalies that often result in requests for aesthetic refinements.

ANATOMY

The female external genitalia extend from the mons pubis anteriorly to the perineal body posteriorly and to the medial groin creases laterally (Fig. 80–1). The genitalia are divided into the outer vulva (mons, pubis, and labia majora) and the inner vestibule (clitoris, labia minora, introitus, urethral meatus, and hymen). The vulva is located at the border of the lower abdomen and the anterior perineum as a mound over the pubis. The vulvar margins are defined by the pubic mons anteriorly, which separates into sagittal cushions that pass posteriorly to surround the vestibule as the labia majora. The vulva is covered externally with hair and contains well-vascularized adipose and connective tissue.

The vestibule is composed of two parts: an outer funnel—made up of the clitoris and its prepuce, the labia minora, and the urethral meatus—and a deeper tube, the introitus, which is the beginning of the vaginal canal. All of the vestibular tissues are hairless and retain secretory cells and nerve endings.

The external genitalia are closely adherent to the underlying superficial fascial system, a loose arrangement of collagen sheets that lie between nests of adipose tissue and belie its tenacious strength. The superficial fascial system extends as an organized system between the dermis, the underlying premuscular fascia, and the pubic periosteum. In the lower abdomen, the superficial fascial system is most prominently portrayed as Scarpa's fascia and the ill-defined Camper's fascia. Over the pubis, Scarpa's fascia becomes Colles' (dartos) fascia, which incorporates all of the female external genitalia from the mons anteriorly to the perineal body posteriorly and laterally from one ischiopubic ramus to the other (Fig. 80–2). Over the thigh reflections, Colles' and Scarpa's fasciae become the fascia lata of the thigh. Colles' fascia thus maintains the superficial integrity of the female external genitalia. Deep to the superficial fascial system, the gynecoid female pelvis widens through the pelvic outlet, and perineal competence is thus maintained through tight fascial layers (the urogenital diaphragm) and a well-developed levator muscle sling within the pelvis.

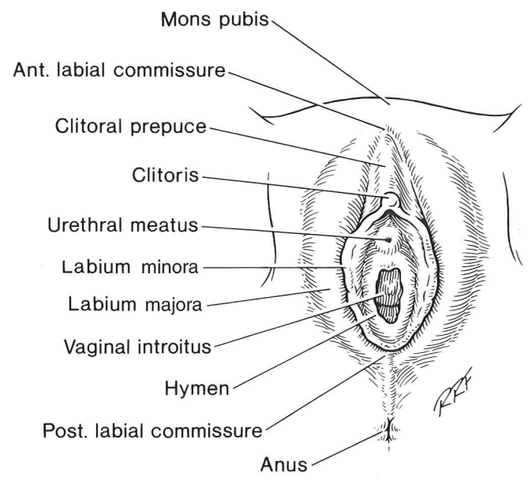


Figure 80–1

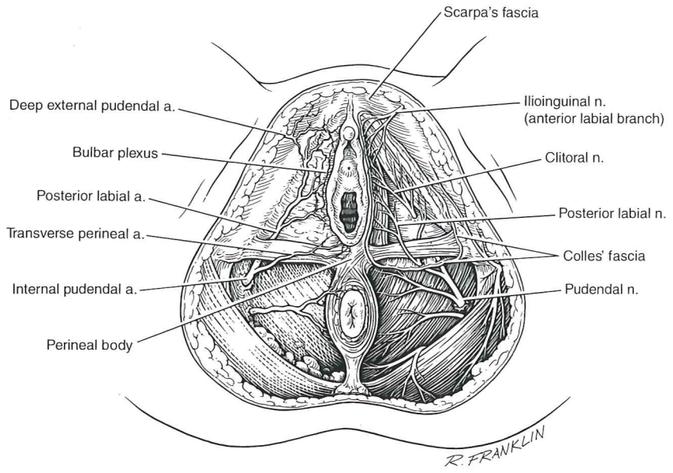


Figure 80–2

The external genitalia are vascularized mainly through the internal and external pudendal artery systems, with small contributions emanating from the abdominal wall system. Branches of the internal pudendal artery include the internal, external, and transverse superficial perineal arteries, which arise from the internal pudendal artery in the perineum and course across the posterior genitalia to anastomose with branches of the deep external pudendal system. The deep external pudendal artery arises from the profunda femoris, pierces the fascia lata of the medial thigh, and separates into the abdominal and perineal arteries and their associated anterior bulbar plexuses.

Perineal sensory nerve innervation arises from the tactile and erogenous branches of the internal pudendal nerve (which supplies erogenous sensibility to the glans clitoris) and tactile branches of the external pudendal nerve. Sensory branches of the ilioinguinal, iliofemoral, and posterior genitofemoral cutaneous nerves also contribute.

AGING

In preadolescents, the pubic mons and labia majora are closely attached to the underlying periosteum through the Scarpa's, Colles', and Buck's fasciae by the strong septa of the superficial fascial system. The vestibular clitoris and prepuce are smooth and small, surrounded by pink labia minora hidden by the labia majora. The labia minora are loosely located to either side of the vagina and border the introitus. They extend anteriorly to drape over the clitoris as a hood and diffuse posteriorly to the perineal body. At puberty, the labia minora begin to protrude between the majora and take on a darker pigmentation. At the same time, the clitoral prepuce becomes more wrinkled and covers the clitoris.

Pregnancy and weight gain give rise to increased fat accumulation and relaxation of the superficial fascial system, which results in perineal ptosis. Likewise, medial thigh lipodystrophy is often associated with fascial laxity and attenuation. If the labia minora hypertrophy excessively or become lax because of their dependent position, the hypertrophy may create a wrinkled appearance with an increase in size, pigmentation, nerves and organs, and sebaceous glands. These changes may generate problems with hygiene, pain on intercourse, inflammation, occasional infection with exercise, and, in some exaggerated situations, difficulty sitting. The labia droop in redundancy, making it difficult to sit or wear tight pants. Histopathology and surgical specimens often reveal small neuromas that may exaggerate the pain and discomfort.

As aging continues, the perineal ptosis progresses. The external genitalia begin to atrophy, with a progressive loss of subcutaneous fat, increased descensus, drying of the vulvar and vestibular tissues, and mucosal atrophy.

Clinical Findings

The aging external genitalia lead to aesthetic requests that include prepubic fat reduction, trimming of the labia minora, and occasional tightening of the vaginal introitus. These aesthetic considerations are often associated with functional demands related to the need to live a complete, fully functional lifestyle. Many requests arise among active middle-aged women who begin to show signs of external genital changes after pregnancy, weight gain, and the efforts to regain shape and fitness after childbirth. Women of today indulge in strenuous exercise programs that include running, weight training, aerobics, and riding bicycles—all of which increase stress on the perineum. This same subset of women often wear small bikinis, tight-fitting pants, and leotards, which tend to irritate the hypertrophied perineal tissues (Fig. 80–3).

Interest in voiding dysfunction, transvaginal delivery after cesarean section surgery, and functional repair of the female perineal anatomy has been revived. Requests for external genital rejuvenation are born out of embarrassment and a question of self-esteem, particularly if the patient feels that her complaints are frivolous. In fact, most requests are relatively straightforward and are attended to

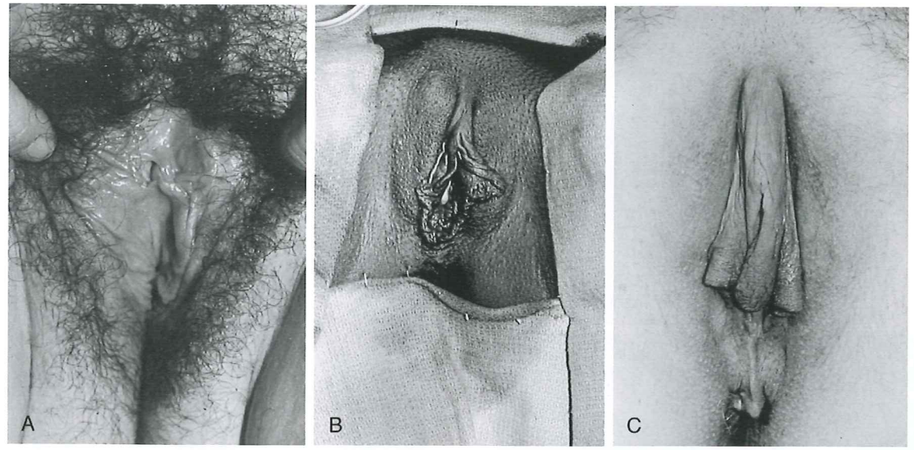


Figure 80–3
Women complain of enlarged labia minora that restrict physical activities (e.g., riding a stationary bicycle, *A*), limit occupational opportunities (e.g., exotic dancing, *B*), and hamper sitting (e.g., cannot wear tight jeans and cannot sit because of vestibulitis due to labial pressure, *C*).

quite simply. The largest number of requests are for pubic liposuction, labial reduction, and tightening of the vaginal introitus. Patients are often very specific in their request that care be taken not to overcorrect perceived genital deformities.

SURGERY

Pubic Liposuction

Attenuation of the superficial fascial system and associated increase in fat deposits occur in the vulva over time. This relaxation makes it easier to proceed with liposuction of the prepubic mons. Pubic ptosis is separate from abdominal ptosis but is often treated at the same time either with liposuction, as a combined abdominoplasty-liposculpture, or as a thigh lift. Liposuction of the mons and labia majora should be confined to the vulva (Fig. 80–4). No attempt should be made to expose the clitoris or increase clitoral sensitivity by liposuction of the surrounding tissues. Liposuction is usually restricted to an average of less than 100 g of fibrofatty tissue from the pubic areas. The Mercedes and Rosenberg gynecomastia cannulas are often the most successful in removing prepubic and perineal fat.

Vaginal Tightening (Perineorrhaphy)

A patulous vaginal introitus often accompanies multiparous vaginal deliveries, weight gain, and perineal ptosis. These result in levator (pubococcygeal) muscle diastasis,

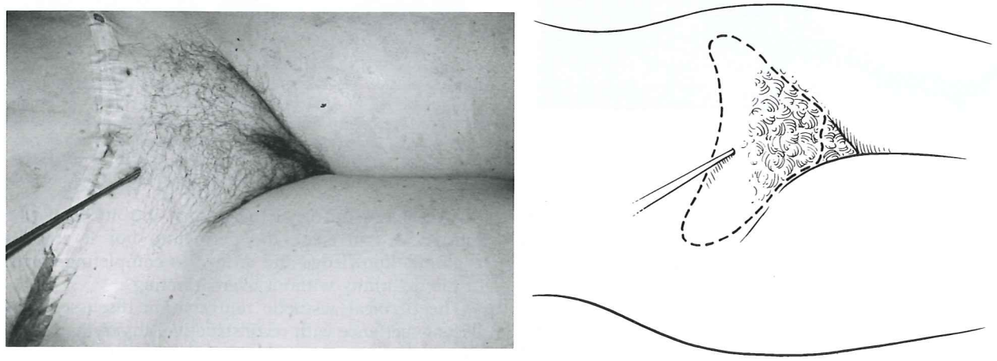


Figure 80–4
Pubic ptosis is separate from abdominal ptosis but is often treated in concert with an abdominoplasty and liposuction. An average of less than 100 g of fat, subcutaneous tissues, blood products, and tumescent solution is liposuctioned from the pubic mons. Care must be taken not to liposuction subcutaneous tissue from around the clitoris because that would expose the clitoris to irritation.

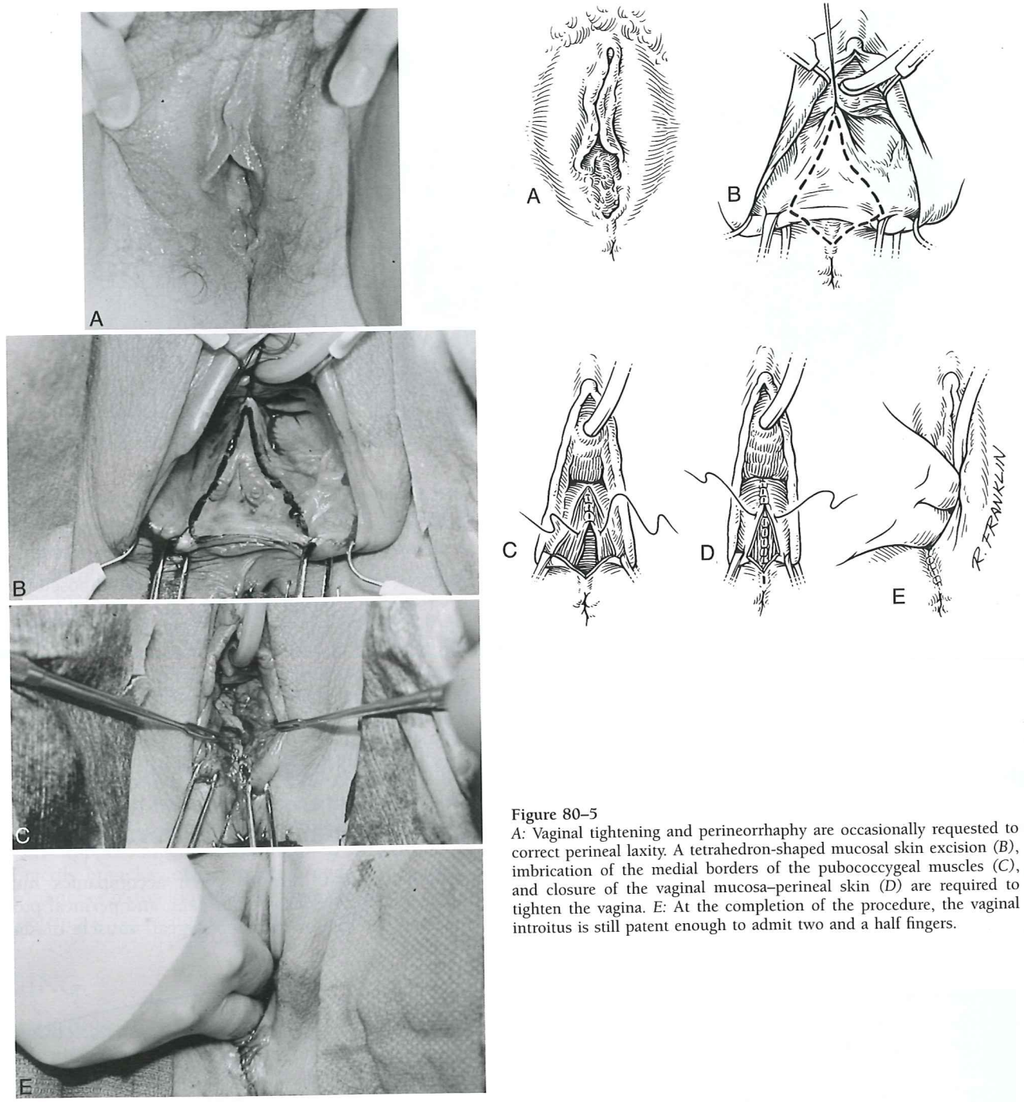


Figure 80–5
A: Vaginal tightening and perineorrhaphy are occasionally requested to correct perineal laxity. A tetrahedron-shaped mucosal skin excision (*B*), imbrication of the medial borders of the pubococcygeal muscles (*C*), and closure of the vaginal mucosa–perineal skin (*D*) are required to tighten the vagina. *E:* At the completion of the procedure, the vaginal introitus is still patent enough to admit two and a half fingers.

laxity of the perineal body, attenuation of the superficial perineal tissues, and associated rectoceles and cystoceles with stress incontinence. Surgical correction of these findings is beyond the scope of this chapter; however, firm introital tone is part of the aesthetics of female genital anatomy. Increasing vaginal tone requires coaptation of the levator muscle dehiscence and excision of excess skin and mucosa. This includes elliptic excision of excess posterior vaginal mucosa, identification and imbrication of the medial levator muscles (the pubococcygeal muscles), re-creation of the perineal body, and excision of skin tags (Fig. 80–5). Restructuring of the vaginal introitus must be definitive to rejuvenate the perineum, but it requires an anatomic knowledge and an eye to completing correction of the deformity without overcorrecting.

The perineal aesthetic rejuvenation discussed here reflects experience with reconstructive surgery performed on patients with congenital anomalies or intersex problems, patients who have undergone cancer ablation, and male-to-female transsexuals (Fig. 80–6). All of these groups have required innovative techniques to reconstruct functionally competent and aesthetically acceptable external genitalia.

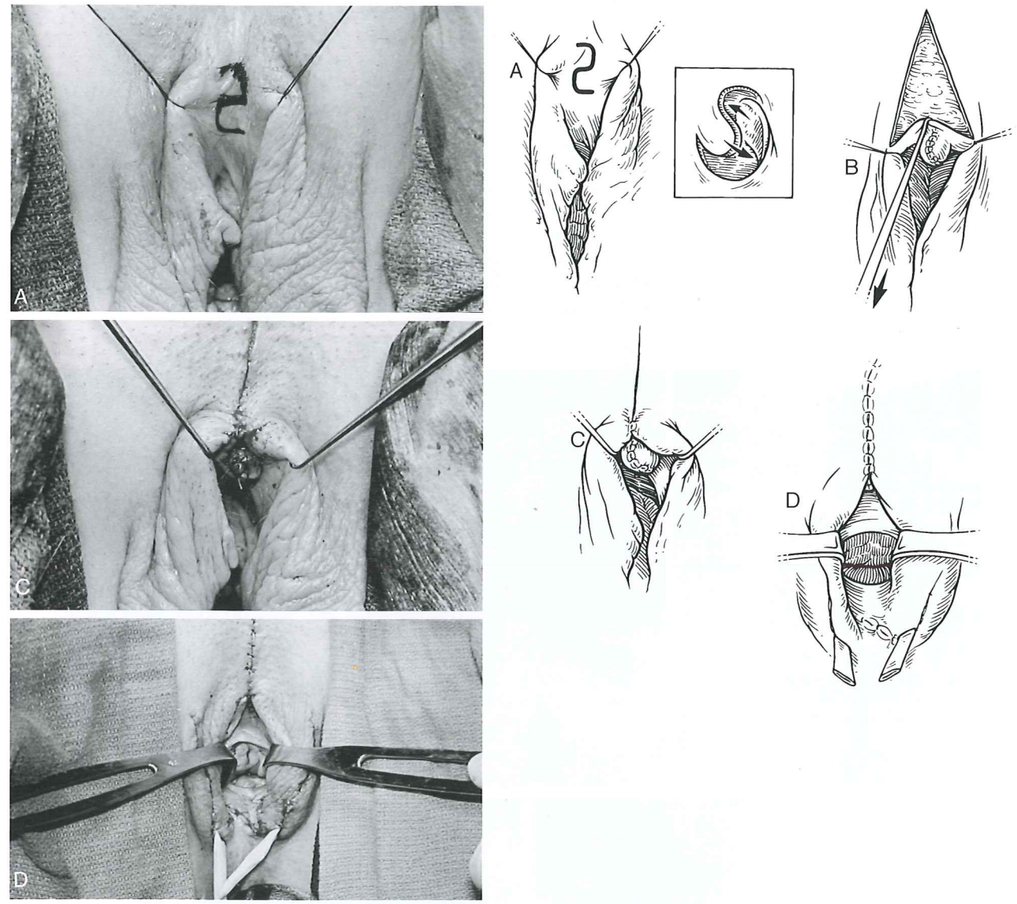


Figure 80–6
Clitoral reconstruction is occasionally required to complete aesthetic external genital reconstruction. *A:* An incomplete female perineum with posterior fourchette tethering and absence of the clitoris and labia minora in a male-to-female transgendered patient. Initially, the posterior fourchette is released with a four-flap Z-plasty. A neoclitoris is constructed by first locating the normal anatomic position and then marking with an S flap. *B:* The S flap is then incised, and the two flaps are then elevated, transposed, and sutured together. The anterior tip of the flap is incised and transposed over the neoclitoris in a clitoral hood advancement technique (much like a meatal advancement glansplasty for glanular hypospadias). The anterior flap tip is advanced posteriorly and maintained in its new position by suturing the lateral borders of the flap together in the midline. *C:* The labia majora are then advanced together medially to enclose the clitoris. *D:* The completed reconstruction of the vestibule.

PART II
AESTHETIC LABIA MINORA REDUCTION

GARY J. ALTER

Enlargement or asymmetry of the labia minora increasingly concerns women. Despite the wide range of normal anatomy of the labia minora, many women feel that they are abnormal and then lose self-confidence, causing sexual inhibition and self-consciousness when wearing tight pants.[1]

Judgment concerning the aesthetics of the labia minora is determined individually. Most patients do not want their labia minora to protrude past the labia majora, and thus a length of about 1 cm is considered ideal.[1] Friedrich classified enlarged labia minora as being more than 5 cm when measured horizontally from the midline when placed on mild lateral traction.[2]

Labia minora enlargement and asymmetry are usually congenital.[3, 4] However, more extensive enlargement can be due to chronic inflammation, pulling or traction on the labia, and exogenous androgenic hormones.[5–7] Significant

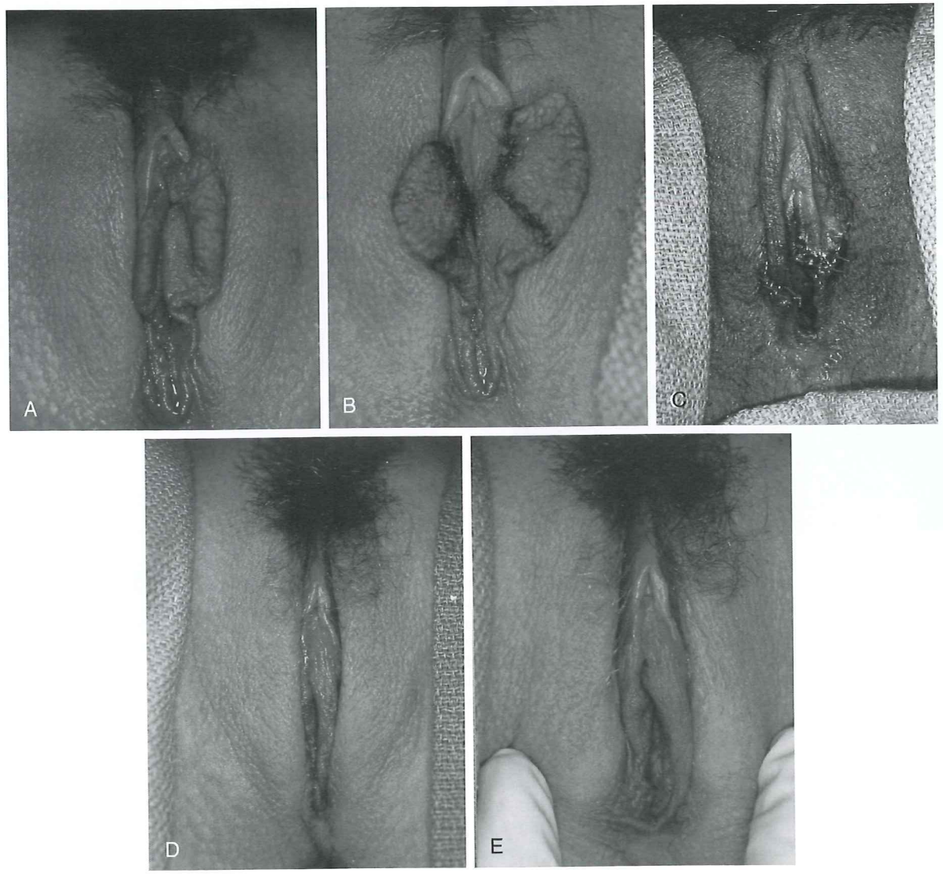


Figure 80–7
A 24-year-old woman who was self-conscious about her enlarged, asymmetrica labia minora since childhood. Her left labium is much larger than her right. *A:* Preoperation without lateral tension. *B:* The markings of the wedge resections bilaterally. *C:* The result at the conclusion of the procedure. Notice the small transverse suture line on each labium. *D:* Postoperation at 3 months without lateral tension. *E:* Postoperation at 3 months with lateral tension.

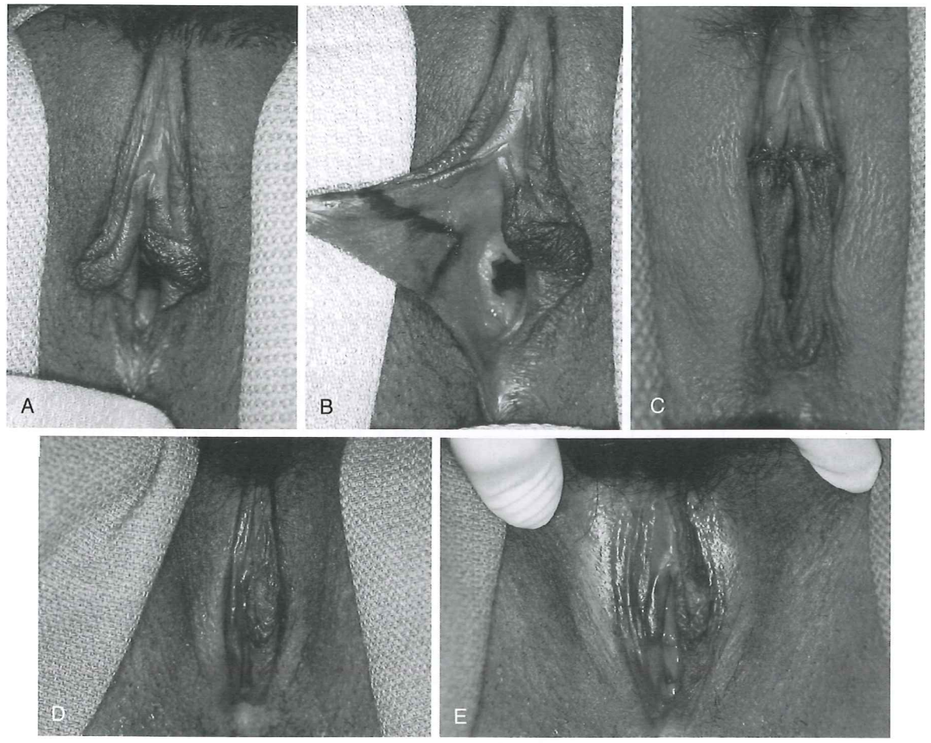


Figure 80–8
A 24-year-old woman with enlarged asymmetrica labia minora. Her clitoral hood and prepuce are more prominent than those shown in Figure 80–7. The anterior portion of the left labium has a thicker double edge. The labia are more prominent anteriorly than posteriorly. *A:* Preoperation without lateral tension. *B:* The markings of the right labial wedge resection. The wedge is centered with a more posterior angle to eliminate the anterior prominence. *C:* The result at the conclusion of the procedure. Notice the small transverse suture line on each labium. A small vertical wedge was also removed from the left anterior labial edge to improve symmetry. *D:* Postoperation at 3 months without lateral tension. *E:* Postoperation at 3 months with lateral tension.

enlargement can cause difficulties with hygiene, self-catheterization, sexual intercourse, and infection. Surgery to correct the enlargement is performed for aesthetic or reconstructive reasons.

The previously reported technique of labia minora reduction is amputation of the enlarged labia and oversewing of the edge.[1–7] This procedure is not ideal, because it removes the normal labial edge with its unique contour and color. The new labial edge is composed of lighter labial tissue with a suture line running along its length. Because normal appearance is the goal, an improved technique was developed to preserve the normal labial edge and color: A wedge of protuberant labial tissue is removed, and the edges are reapproximated.[8]

The blood supply of the labia minora is extensive, as outlined by Hwang and colleagues.[9] The posterior labial artery anastomoses with the superficial external pudendal artery in the labia majora, with contributions from the internal circumflex artery. Multiple arterial arches in the labia minora arise from this initial arch, creating a rich blood supply that enables a more tailored labia minora reduction.

Because female genital anatomy varies greatly, the operation must be individualized. A patient is examined in the office in the lithotomy position with her head elevated. Holding a mirror, she is able to indicate her concerns and is then shown the expected result and method of surgery.

Surgical Technique

In the lithotomy position under general or regional anesthesia, a patient is reevaluated and asymmetry noted (Figs. 80–7*A* and 80–8*A*). The smaller labium is usually corrected first, and the other labium matched as closely as possible, marking the most protuberant area of each labium with a V-shaped wedge (Figs. 80–7*B* and 80–8*B*). The amount of resected tissue is determined by placing several fingers inside the vagina, because overresection can produce an overly tight introitus or pulling during sexual intercourse. The most anterior marking does not extend to the fourchette, which must not be violated. The angle of the wedge resection varies (Fig. 80–8*B*). The labium may be too protuberant in the anterior half or throughout their entire course. If a deficiency of posterior labium minora is pres-

ent, the anterior labium is advanced posteriorly, possibly making a longitudinal incision on the posterior labial edge. If the resected wedge is inadequate to make the labial length about 1 cm, an anterior or posterior wedge can also be excised, creating anterior and posterior labial edge flaps.

The subcutaneous tissue of the labia minora is reapproximated with 4-0 Vicryl suture, and the skin is closed with 4-0 and 5-0 Vicryl. The transverse reapproximation of the labial edges is the only suture line seen on the labial edge; the other suture lines are on the medial or lateral labial sides (Figs. 80–7*C* and 80–8*C*). This transverse suture line is sometimes closed with a small V to prevent notching during scar contracture. Internal dog-ears can easily be excised. The labial edges may vary in thickness as well as protuberance. Smaller vertical excisions can be used to tailor the double edge (Fig. 80–8*C*).

Local antibiotic ointment is applied to the repair. No urinary catheter or vaginal packing is needed. The Vicryl sutures dissolve in several weeks or can be removed after 1 week if local irritation occurs. Patients usually heal well without any noticeable deformity (Figs. 80–7*D* and *E* and 80–8*D* and *E*).

CONCLUSION

Labia minora reduction using a wedge-shaped excision is easily performed in about 1 hour, with minimal complications. If a patient is not concerned with aesthetics, simple amputation of the protuberant tissue and oversewing the labial edge suffice. However, for those who are concerned with appearance, the most natural result possible must be achieved. Aesthetic labia minora reduction should not be withheld from these patients, because it engenders markedly improved self-confidence.

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PEYRONIE'S DISEASE

CHAPTER

81

Correction of Penile Curvature Using Tunica Albuginea Plication, Flaps, and Expansion with Fascial Grafts

MARTIN K. GELBARD

Penile curvature is caused by Peyronie's disease in most cases, although in a few patients it is the result of congenital corporeal disproportion. The surgical approach to these related problems consists of changing the configuration of carefully selected regions of the tunica albuginea. Tissue expansion by grafting into relaxing incisions and reconfiguration of the tunica by plication or the use of flaps are independently effective means of changing the shape of the erect corpora.

Each of these techniques has its own strengths and weaknesses, and each finds its best application in certain specific clinical situations. The goal of this chapter is to show how these three tools—expansion, reconfiguration, and plication—offer complementary methods and how together they provide sufficient versatility to approach a wide variety of clinical problems.

THE ROLE OF SURGERY IN THE MANAGEMENT OF PENILE CURVATURE

Surgery offers the only treatment for congenital curvature and the only effective method for restoring sexual function in men with severe, disabling, and long-standing deformity due to Peyronie's disease. Surgery should not be considered for patients with minimal amounts of bending, regardless of the etiology. The hallmark of an appropriate surgical candidate is functional difficulty due to curvature. Considerable individual variation exists, but angulation of greater than 45 degrees dorsally or greater than 30 degrees ventrally generally makes intercourse physically difficult. Of course this complex problem has other dimensions. Young men with congenital curvature may feel so self-conscious that they wish to consider surgery for less significant deformity.

An in-depth discussion of Peyronie's disease is beyond the scope of this chapter, but the question of which patients with this disorder will benefit from surgery has to be addressed. The early stages of Peyronie's disease are characterized by changes in the effect and extent of inelastic scar; therefore, surgery is generally not considered until the process has had 12 to 18 months to stabilize. Although much has been made of "spontaneous remission" of this disease, functionally significant deformity rarely resolves.[1] Despite the advisability of deferring surgery for the initial 12 to 18 months, cases with severe bending (>45 degrees), with Dupuytren contractures, or with dystrophic calcification are unlikely to improve during this period. Finally, patients with Peyronie's disease must be carefully counseled on the risks involved in surgery, and they must understand the compromise inherent in reconstructive surgery for a condition that irreversibly destroys the elasticity of an expansile organ. In patients sexually incapacitated by this disorder, surgery can successfully restore function even if it cannot restore the penis to its original condition. A patient's expectations must be in line with the surgeon's clinical goals—to reestablish a satisfactory sex life, not to build the perfect penis.

PREOPERATIVE EVALUATION

Disease persistence and sexual dysfunction, two of the key criteria in opting for intervention, can be determined only by a carefully taken history. Moreover, this is the best time to establish with patients a relationship that fosters effective communication. Open and honest interchange is essential for patients to learn about treatment options and risks. For a physician, it is critical to understanding patients' deficits and, more importantly, their expectations.

Certain complaints can be particularly helpful in revealing the effects or extent of corporeal distortion. A tendency

for the apparently erect penis to buckle or fold up with attempted insertion is usually associated with segmental diameter reduction in the penile shaft (hourglass deformity). Inhomogeneous rigidity during erection is another important sign of damaging loss of transverse tunica expansion. Patients who complain that the erection is firm up to the region of a palpable plaque, then soft distally, have a penis that is difficult to reconstruct successfully. Distal flaccidity is a relative contraindication to plication or graft-based tunica expansion.

Surgical rearrangement of the tunica albuginea can correct penile deformity and improve sexual function only in men who have no major problems with erection. If a reliable history of firm, well-maintained (albeit bent) erections can be obtained, there is no compelling clinical reason to test or document erectile function. If a patient's history is otherwise, or if he is at risk owing to diabetes or hypertension, or if medicolegal reasons are a factor, further investigation with duplex Doppler studies or Rigiscanning is warranted.

Jordan has shown how dynamic infusion corpus cavernosometry can predict the results of reconstructive surgery for Peyronie's disease, and it is certain that further studies with this meticulous dedication to precision will give us a better understanding of what we can accomplish.[2] Does every potential candidate for a non–prosthesis-based Peyronie's operation need to be studied this way? Probably not. In general, patients with Peyronie's disease and a history of serious difficulty obtaining or maintaining an erection are not candidates for plication or tunica expansion. A man with erectile dysfunction who responds well to intercavernous injection or a vacuum erection device occasionally prefers to continue with these methods after straightening by plication rather than undergo implantation of a penile prosthesis.

Deformity must be documented in any patient considered for surgery. Tracings of the erect penis can be used, although photography is preferable. Pictures can be obtained by the patient at home or in the office, after the use of intercavernous injections or a vacuum chamber.[3] If possible, two views should be obtained—dorsal and lateral (Fig. 81–1).

A number of methods have been described for imaging plaques, including low-kilovoltage radiography, xeroradiography, ultrasonography, computed tomography scanning, and magnetic resonance imaging.[4] The key imaging issue for the surgeon is whether plaque calcification is present, because this affects (in graft expansion technique) the placement of relaxing incisions. Fortunately, this information is readily available through low-kilovoltage plain films.[5] This is the only plaque-imaging study that I routinely perform.

SURGICAL ANATOMY OF THE TUNICA ALBUGINEA

The tunica albuginea is a collagenous fascial sheet that covers the sinusoid erectile tissue of the corpora cavernosa. It is a tough but elastic material, containing elastic fibers that are oriented transversely, sandwiched as stacked hoops between an inner layer of transverse collagen fibers and an outer longitudinal layer of collagen fibers.[6, 7] The outer longitudinal layer contributes most to tunica thickness, reaching a maximum of slightly more than 2 mm in the dorsal position. The tunica is thinnest in the urethral groove, where the longitudinal layer is absent. Immediately lateral to the groove are the paraurethral ridges, heavy bands of longitudinal fibers that are second only to the dorsal region in thickness.[7]

When stretched to its normal physiologic limit, the tunica albuginea reaches a point where further sinusoid filling can cause no additional expansion. This mechanical behavior causes a sharp rise in wall tension at maximum stretch, when it attains fiber lock displacement. The tunica becomes rigid at this point and determines the shape of the erect penis. To a lesser degree, penile shape is affected by intercorporeal connective tissue struts, fibers of the intercorporeal septum, and by the collagenous skeleton of the cavernosal sinusoids. Plication, expansion, and flap surgery can alter the surface area or planar quantity of the tunica albuginea but not the contributing structural influences of these secondary factors.

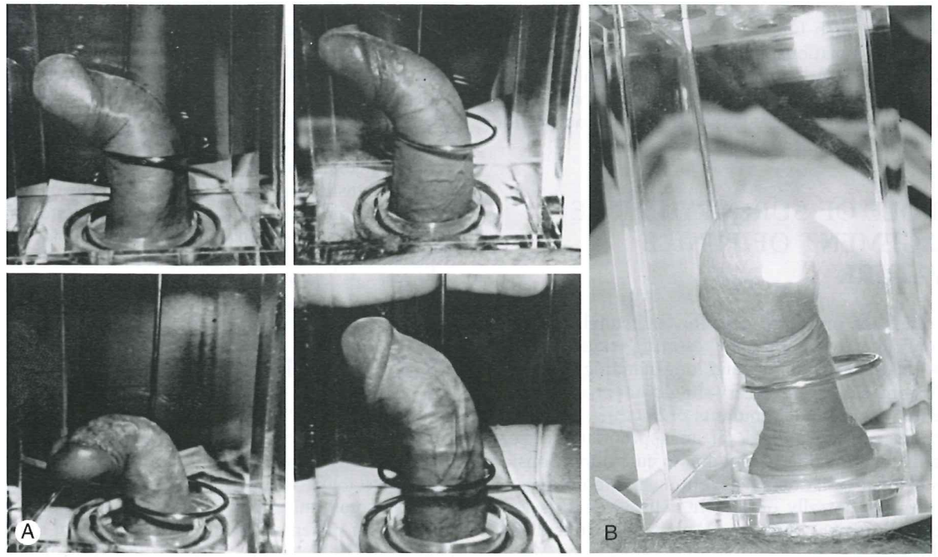


Figure 81–1
Documentation of bending in vacuum chamber. *A:* Various degrees of lateral bending. *B:* Hourglass deformity. (*A* from Gelbard MK: Peyronie's disease. In Das S, Hashmat IH [eds]: The Penis. Philadelphia, Lea & Febiger, 1993.)

SURGICAL TECHNIQUE

Artificial Erection and the Use of Tourniquets

In order to identify the areas of abnormal tunica responsible for penile distortion and to confirm the effects of surgical correction, the corpora must be filled with normal saline until a rigid erection is obtained. A number 21 butterfly needle with a pair of 20-ml syringes works well initially, although a slightly larger-gauge needle may be necessary later in the case to overcome the leakage that can occur after a procedure involving multiple grafts. The proximal portion of the corpora must be occluded, and this is accomplished with a 1/4-inch Penrose drain secured under stretch by a hemostat or by manual compression of the proximal corpora against the pubic bone. Encircling occlusion of the penis by an elastic Penrose drain should remain for a period of minutes only, during which curvature is assessed. Prolonged use of tourniquets for hemostasis is unnecessary and should be avoided.

Plication

Tunica albuginea plication was first described by Reed Nesbit in 1965, as a means of correcting congenital curvature of the penis.[8] It remains the best way to correct congenital bending, but since Nesbit's initial report, this technique has been adapted to correct acquired curvature due to Peyronie's disease. In addition to Nesbit's method of excising small ellipses of tunica, plication can be accomplished without resecting tunica—either by suture imbrication[9] or by transverse closure of small longitudinal incisions.[10]

The best candidate for this approach is a potent man with moderate curvature well localized to one region. Correction of compound or multiple bends can emphasize the shortening that is a consequence of this procedure, although when it is used to straighten an isolated bend of 60 degrees or less, the actual loss of length is slight and barely noticeable (Fig. 81–2). Plication corrects curvature with less effect on erection than grafting procedures, and it thus deserves particular consideration in patients who have borderline erectile competence and who prefer postoperative injection or vacuum therapy to prosthesis implantation.

Exposure

The choice of incision depends on the orientation of the bend, because exposure must be gained on the convex side. For ventral bending, the dorsal tunica is best exposed by a circumcising incision and proximal mobilization of the skin. Ventral or lateral tunica is easily reached via a ventral incision in the raphe for correction of dorsal or lateral curvature.

When the skin has been incised, a relatively avascular region of the corpora can be selected for insertion of the butterfly needle. Insufflation to the point of rigidity then allows the surgeon to identify the region of tunica in the most convex position of the curvature. Exposure of the tunica in this area is gained by mobilizing all or part of the neurovascular bundle, or the urethra, or by longitudinally

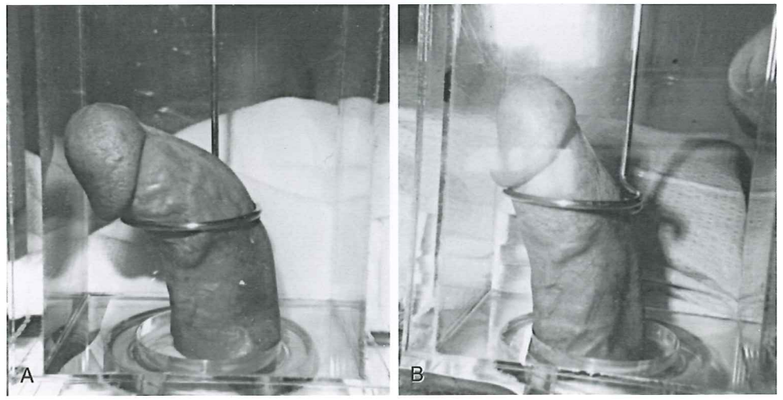


Figure 81–2
Before and after Nesbit operation.

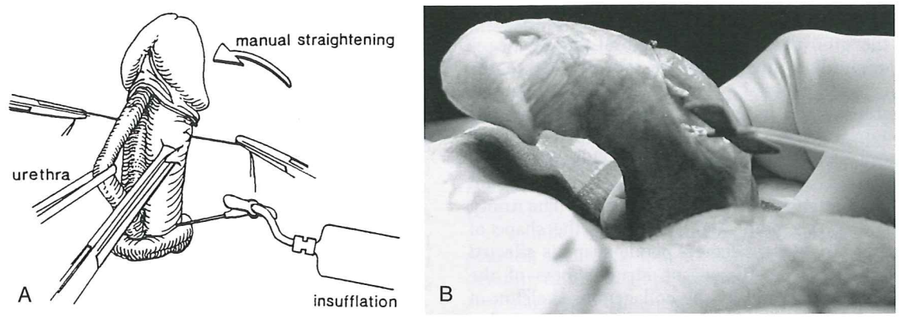


Figure 81–3
Preparation for plication procedure. *A:* Effect of corporeal insufflation. *B:* Holding sutures and Allis clamps applied.

splitting the lateral aspect of Buck's fascia, depending on the orientation of curvature.

Marking the Tunica

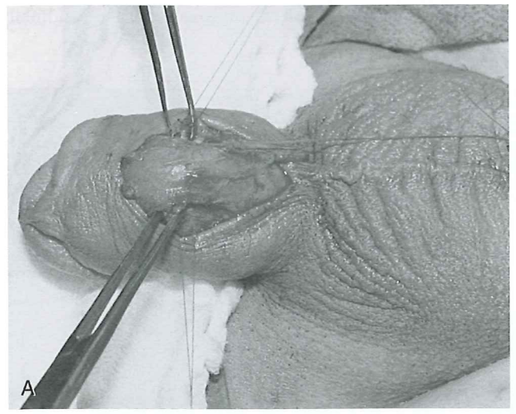
The orientation of the curvature also determines how the corpora are best plicated to achieve straightening. In the case of ventral bending, the dorsal midline must be plicated. For dorsal bending, a *pair* of plications (one on each paraurethral ridge) is required for effective correction.

Placing a pair of 3-0 Prolene holding sutures at the point along the shaft where curvature is most prominent is an aid to accurate plication. The sutures should be placed to define a line that is both perpendicular to the long axis of the penis and perpendicular to the plane defined by the curvature. With these sutures under mild traction during a repeat saline artificial erection, manual straightening of the penile shaft tends to buckle out a fold of tunica on the convex side (Fig. 81–3). This fold is grasped with a pair of Allis forceps to effect preliminary plication. Continued saline inflation demonstrates whether the clamps have grasped the appropriate amount of tunica in the proper position to correct the curvature. If this is not the case, the Allis clamps are repositioned until the correction is satisfactory.

When straightening has been achieved, the tunica must be marked for permanent plication. This is done by removing the Allis clamps and applying a small line of methylene blue dye (with a sharpened cotton swab stick) to the teeth marks in the tunica left by the clamps (Fig. 81–4). After the experimentation with repeat Allis clamp application and artificial erection has been translated into a pair of these blue lines, all that remains is to permanently close the gap between them.

Closure

Three techniques are used for securing the measured tucks: excision of elliptic patches of tunica and closure, transverse closure of longitudinal incisions, and suture imbrication of intact tunica (Fig. 81–5). Nesbit's original technique of ellipse incision and closure ultimately provides the smoothest and most natural contour. A transversely oriented ellipse is marked out, with proximal and distal margins coincident with the pair of lines described earlier. The ellipse is scored with a number 15 blade and then removed with fine scissors, taking care not to injure or resect the underlying erectile tissue. An absorbable material such as Vicryl or Dexon can be used, because the strength of the closure does not rely on the suture material once healing has taken place. However, stretching of the closure may occur with time. For this reason it is my practice to use also a pair of inverted 3-0 Tevdek sutures in each closure for additional reinforcement. The defect is closed with running 3-0, after a single inverted 2-0 stitch is placed in the middle of the ellipse to ensure that it is pulled together without distortion. Nesbit's technique is not as useful in the presence of hourglass deformity, when concomitant widening is desired.



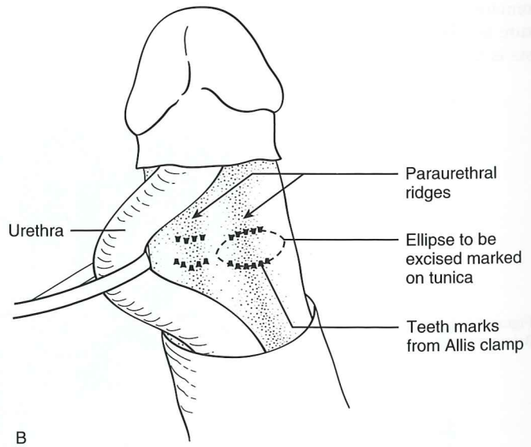
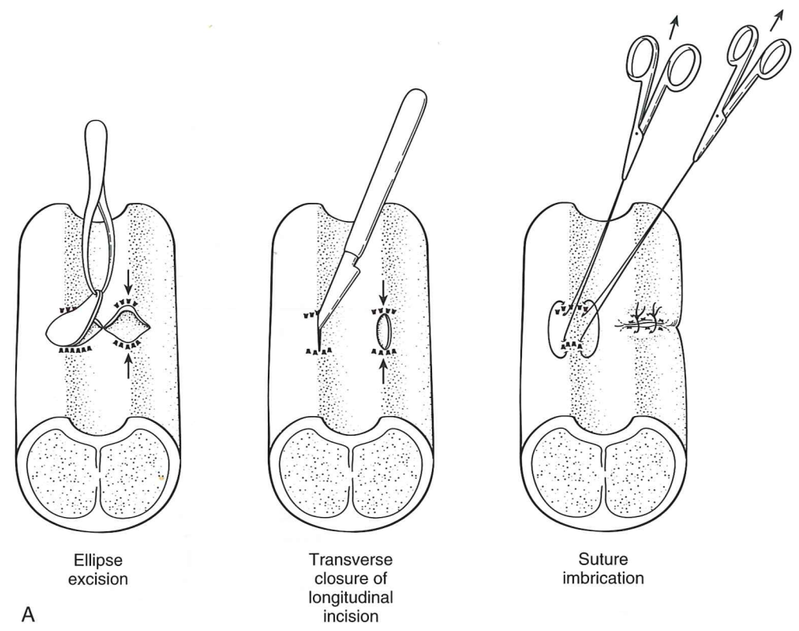


Figure 81–4
Preliminary plication. *A:* Allis clamps applied to the corpora ventrally, on either side of the urethra. *B:* Marking the tunica in the impressions made by the teeth of the clamps.

Absorbable suture material can also be used to close longitudinal incisions transversely. When dorsal bending is associated with narrowing of the shaft, this technique effects concomitant widening, although only a few millimeters can be achieved in most cases. A number 11 pointed blade is used, edge up, to create a longitudinal incision extending between the pair of lines marked by the Allis clamps. While the assistant grasps the midpoints of



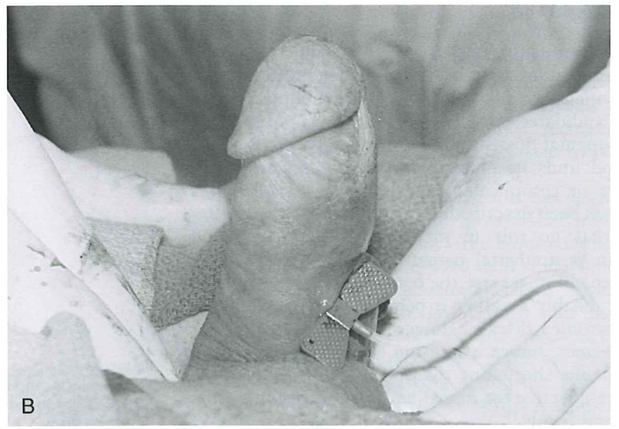


Figure 81–5
Permanent plication. *A:* Three methods for plication of marked tunica. *B:* Reinsufflation of the corpora after closure.

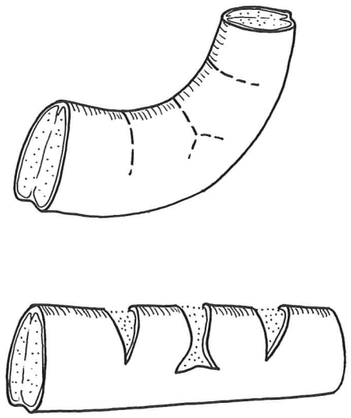


Figure 81–6
Dorsal relaxing incisions. (From Gelbard MK: Relaxing incisions in the correction of penile deformity due to Peyronie's disease. J Urol 154:1457, 1995.)

this incision with a pair of Adson pickups and pulls them apart transversely, the surgeon places a single inverted stitch of 2-0 to bring the proximal and distal ends of the incision into apposition. If widening is desired, it is best to close the remainder of the incision with interrupted sutures, because these cause less gathering of the tunica than does a running suture line.

Suture imbrication of the intact tunica is the simplest means of plication. Because this closure permanently relies on the strength and integrity of the sutures, a nonabsorbable material is required. Soft braided suture (such as Ti-Cron or Tevdek) is preferred over monofilament, because the permanent nodules created are less irritating to the patient. The chief advantage of this method is the ease with which sutures can be cut out and replaced to revise the amount of correction.

FASCIAL EXPANSION WITH GRAFTS

Tunica expansion with grafts is a more versatile technique for the alteration of corporeal shape than plication but has a potentially greater effect on postoperative erectile function. Candidates must be potent, with uniform shaft rigidity; segmental or distal flaccidity cannot be corrected. This method finds its chief application in patients with more severe or complicated deformity due to Peyronie's disease. It has been described as an adjunct to hypospadias repair but has no role in the correction of congenital curvature in postpubertal patients. Despite its appealing ability to expand or reverse the contracture due to plaque, it does not reliably lengthen a penis that has been shortened by Peyronie's disease. However, when curvature exceeds 60 degrees, tunica expansion by grafting appears to cause less penile shortening than plication. Tunica expansion is more effective for dorsal and ventral bending than it is for lateral bends.[11]

Relaxing Incisions

The use of artificial erection to identify the regions of deformity and the surgical exposure of the abnormal tunica is similar to that described earlier; however, when expansion is the goal rather than plication, the concave part of the bend (usually corresponding to the palpable plaque) must be exposed. The offending region of restrictive scarring in the tunica must be marked with the goal of expansion in mind. Relaxing incisions are marked with methylene blue and generally spaced about 1 cm apart. When calcified plaques are present, one or more of these incisions should cross the involved area to facilitate enucleation of the dystrophic calcification. In most cases, this allows preservation of the overlying tunica and minimizes the amount of grafting necessary to relax the associated contracture.

As in plication, the technique for dorsal expansion of the tunica is slightly different from that for ventral expansion. To correct dorsal curvature, a series of transverse full-thickness relaxing incisions that are centered on the dorsal midline suffice (Fig. 81–6). When ventral curvature is present, relaxing incisions must be made in pairs to equally divide the right and left paraurethral ridges transversely in the area of greatest curvature (Fig. 81–7). To achieve the smoothest possible correction, three relaxing incisions are superior to one or two. Substantial bends

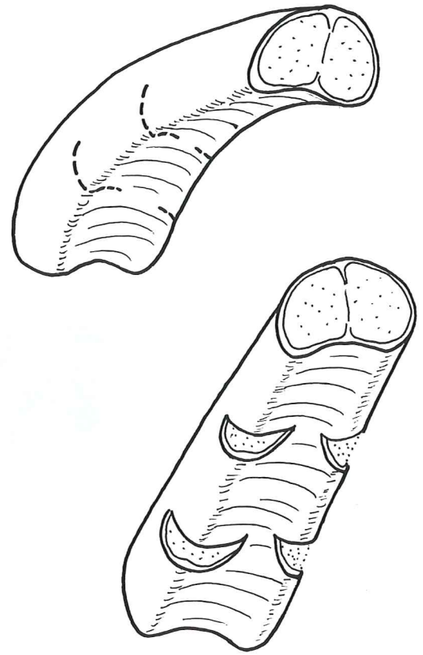


Figure 81–7
Ventral relaxing incisions through the paraurethral ridges. (From Gelbard MK: Relaxing incisions in the correction of penile deformity due to Peyronie's disease. J Urol 154:1457, 1995.)

(>60 degrees) involve the loss of 3 to 6 cm of penile expansion in the scarred area.[4] A single relaxing incision simply cannot be made to open this widely, no matter how large a graft is used.

To afford the maximum protection to the underlying erectile tissue, fine scissors are used to cut the relaxing incisions, after scoring the tunica with a number 15 blade. Once all the planned incisions have been made, the penis is stretched to evaluate their effect. They should gape open evenly, with no remaining palpably tense bands of tunica. When a relaxing incision crosses an area of calcification, a Freur ENT periosteal elevator is used to separate and lift the tunica off the calcium, which is then gently dissected free from the erectile tissue and removed (Fig. 81–8). A substantial amount of tunica, surprisingly pliable when free of calcification, can usually be preserved. By remaining intact to bridge the space between relaxing incisions, it reduces the amount of grafting required.

Diameter Reduction and Tunica Flaps

Longitudinal expansion of transverse relaxing incisions overcomes bending at the cost of a slight diameter reduction. If there is no appreciable narrowing of the penis at the area of curvature, this side effect can be disregarded. If the penis is narrowed slightly in the curved region, it is best to laterally dart at least one of the three relaxing incisions to preserve maximal diameter. In the case of severe hourglass narrowing at the site of bending, one or both adjacent relaxing incisions can be converted to a pair of oblique flaps. By advancing these flaps apart, additional widening can be gained (Fig. 81–9).

Corporeal narrowing is not a part of every dorsal or ventral bend, but it is a constant feature of lateral deformity. In true lateral bends, curvature occurs in the plane perpendicular to the vertically oriented urethral meatus. Patients' complaint of "sideways bending" is often dorsal

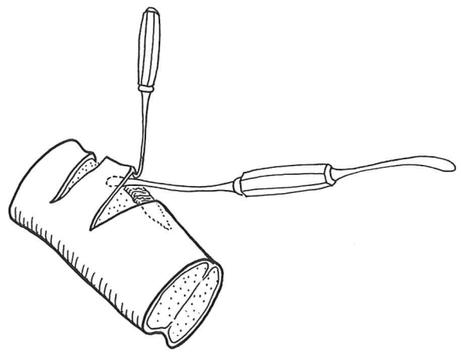


Figure 81–8
Use of Freur ENT periosteal elevator to remove dystrophic calcification and preserve the overlying tunica. (From Gelbard MK: Relaxing incisions in the correction of penile deformity due to Peyronie's disease. J Urol 154:1457, 1995.)

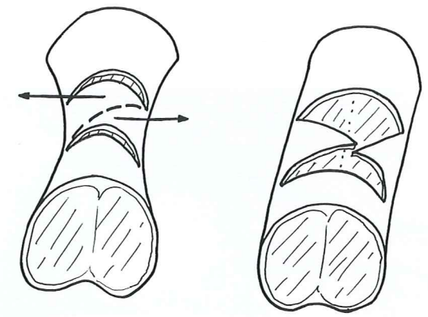


Figure 81–9
Oblique advancement flaps for widening of hourglass deformity. (From Gelbard MK: Relaxing incisions in the correction of penile deformity due to Peyronie's disease. J Urol 154:1457, 1995.)

curvature (with respect to the vertical plane of the meatus), associated with enough rotation of the shaft to allow the bend to "tip over." This is to be distinguished from true lateral bending, for which the surgical approach is considerably different. Because grafting alone has not been effective in correcting true lateral bends of greater than 40 degrees and plication alone can accentuate the narrowing, these cases should be managed with a combination of contracture expansion and contralateral plication. Relaxing incisions must produce both longitudinal *and* diameter expansion, recognizing that tunica flaps do not widen the laterally bent corpora as effectively as they do in dorsal deformity.[11] After grafting and repeat artificial erection, plication is used to eliminate any remaining bend.

Graft Materials

Experience has shown temporalis fascia to be an excellent graft material for use in this technique. The surgical goal of tunica expansion (rather than tunica replacement) is achieved because of its limited contraction as a graft. It is harvested by a head-and-neck or plastic surgeon, through either a vertical temporal or posterior auricular incision.[12] A patch of about 7 by 8 cm is obtained and is flattened onto a Teflon block. Dermis has been used for fascial expansion as well, harvested as described elsewhere through an oblique lower abdominal incision.[2] Dermal grafts should be cut about 50% oversize owing to their tendency to contract with maturation.

When the largest relaxing incision has been stretched open both longitudinally and transversely, measurements are taken and are used to draw the required outline on the fascia. Darted incisions are filled with square-ended grafts, whereas simple linear relaxing incisions require elliptic patches. Attention must be given to the sum total of grafts required and how they will be cut from the amount of fascia available. Temporalis fascia grafts are tailored to the size of each defect, receiving at most a 10% overage to allow space for suturing. Graft outlines are painted with methylene blue so that they retain painted edges after

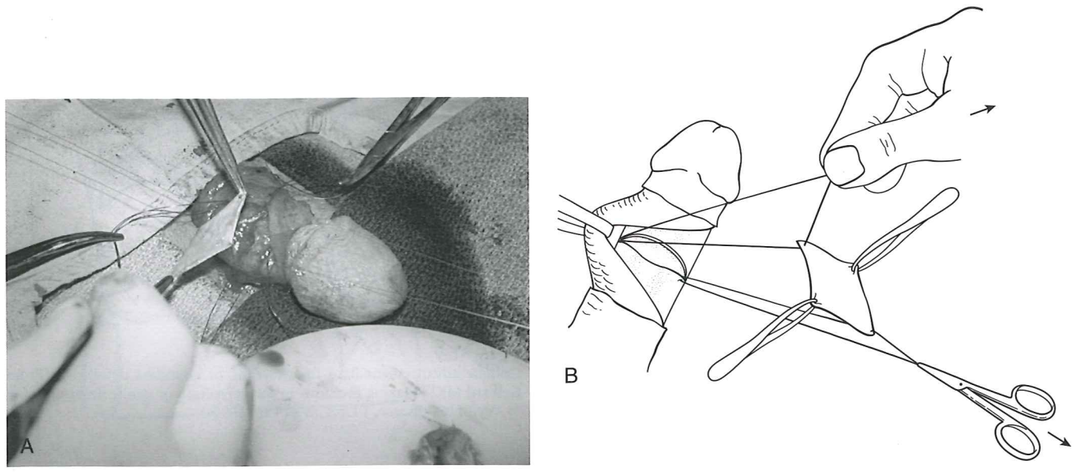


Figure 81–10
Transferring temporalis fascia grafts. *A:* Photo. *B:* Line drawing.

being cut on the Teflon block with a number 10 blade. Colored edges facilitate the subsequent suture anastomosis.

Anastomosis, Testing, and Revision

A graft is transferred from the Teflon block by placing two corner sutures of 5-0 polydioxanone or Maxon through the apices of the incision and the points of the corresponding graft, then carefully guiding it over as the sutures are pulled up and tied (Fig. 81–10). When the two remaining corners have been tacked with lengths of the same material, fine running technique is used for each anastomotic quadrant.

Watertight closure should be obtained to facilitate repeat artificial erection (Fig. 81–11). Even so, it is best to use a slightly larger-gauge butterfly needle than was used before grafting, because this permits the higher flow rate necessary to achieve rigidity in the presence of a few small leaks.

If the correction appears satisfactory, Buck's fascia and skin are closed with fine absorbable material in the usual fashion. If a substantial amount of curvature remains, additional grafting should be considered, even if this means harvesting the remaining contralateral temporalis fascia. If three grafts have been placed initially, this is unusual.

More commonly, postanastomotic artificial erection discloses minor (10 to 20 degrees) residual curvature. In the case of dorsal deformity, this can be the persistence of slight glans tilt. By placing grafts at least 1 cm proximal to the corona, the shaft can be straightened with a low incidence of glanular sensory loss. If this leaves the distal tip

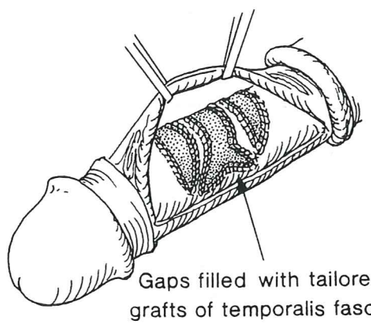


Figure 81–11
Watertight running anastomosis of grafts. (From Gelbard MK: Peyronie's disease. In Hashmat A, Das S [eds]: The Penis. Philadelphia, Lea & Febiger, 1993.)

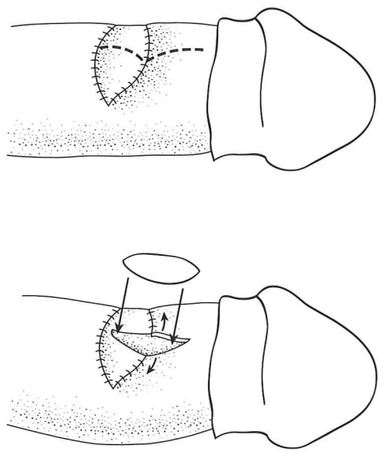


Figure 81–12
Correcting an indentation by perpendicular inlay of a secondary graft.

of the corpora tilting upward, a pair of small (2 to 3 mm) ventral plications are safer and just as effective as grafting under the glans.

If the grafts are undersized, notching or indentation may be seen at the suture line with saline insufflation. If this is severe enough to allow the inflated corpora to buckle under stress, it should be corrected. A longitudinal relaxing incision is marked across the offending anastomosis, which is then resewn to leave a gap at the marked line. This relaxing incision through graft and tunica is cut and grafted with additional fascia in the manner described earlier (Fig. 81–12).

POSTOPERATIVE CARE

Surgical drains are not used with any of the foregoing procedures, although a Foley catheter assists in temporary immobilization. After plication, a 2-inch Kling dressing is lightly wrapped, without compression. In the afternoon after surgery, the catheter is removed and the dressing changed to a single strip cut from a 4×4 gauze. These patients are then discharged, usually about 4 or 5 hours postoperatively. Patients with a fascial graft are kept at bed rest overnight, then discharged the morning after surgery. The penis is bandaged with a slightly more complex dressing that is kept in place (along with the Foley catheter) for approximately 24 hours. Before the Kling bandage is applied, the penis is stretched to elongate the grafts. As described earlier, it is not used to apply compression but only to maintain the penis at the reduced diameter achieved by elongation. A folded ABD pad is then placed to keep the penis upright, supported by a pair of rolled towel bolsters. The patient is examined 4 to 6 hours postoperatively for signs of reduced capillary fill, loss of sensation in the glans, or undue pain. If these are noted, the dressing is removed and replaced with a single strip cut from a 4×4. If all is well, the initial dressing is removed and changed in this manner the next morning, the catheter is removed, and the patient is discharged home.

Patients with grafts are maintained on broad-spectrum antibiotic coverage during their hospitalization and discharged with a week's course of oral therapy. All patients are encouraged to spend at least one half of each of the first 5 postoperative days off their feet. Patients with plication may return to work in 2 days, and patients with a graft in 1 week. Although they are discouraged from engaging in sexual activity for 6 weeks postoperatively, patients are reassured that erections will have no adverse effect (with the exception of modest pain for the first 5 to 7 days) and require no avoidance or suppressive medications.

Grafts undergo a prolonged maturation process that affects their pliability. Patients should be warned that they will see the results of this in the relatively protracted course of recovery. Most patients report that erections appear straight in the first week or two postoperatively and then begin to display a minor amount of apparently recurrent curvature. This parallels the palpable induration that grafts develop in this time period, as they begin the evolution that will lead to capillary ingrowth and eventual integration into the host site vascular network. Grafts lose their induration and blend impalpably into the surrounding tunica in 8 to 10 months, and patients need to know that optimal cosmetic results may be this long in appearing. Fortunately, by 6 weeks postoperatively, most patients have dramatic improvement over their preoperative condition and can resume sexual activity at that point.

RESULTS AND CONCLUSIONS

Success rates with plication for curvature due to Peyronie's disease have been reported to be from 72% to greater than 94%, with very few complications.[4] Shortening is not usually a problem, unless this technique is used to correct bending in excess of 60 degrees. Because of the relatively small disturbance that plication creates in the relationship between tunica and erectile tissue, it is unlikely to produce postoperative erectile deficits.[13] Among 36 cases that I have treated, patients have had no need for postoperative injection or vacuum therapy due to impotence.

As a group, the patients undergoing temporalis fascial grafting had the most severe curvature, compounded more

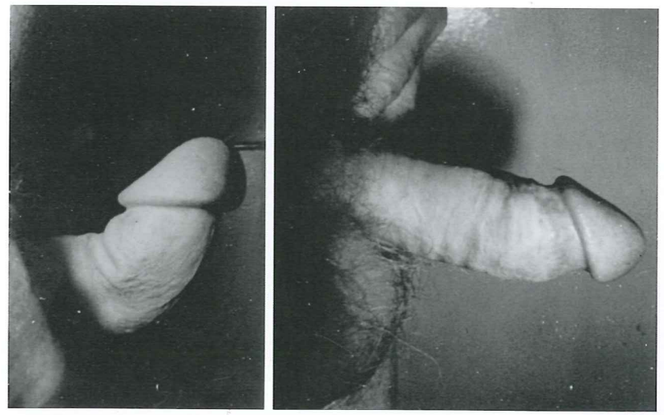


Figure 81–13
Before and after temporalis fascia graft.

commonly with diameter constriction. Nonetheless, the results of this procedure for correcting dorsal and ventral bending are quite good (Fig. 81–13). As detailed in a recent report, most patients have fared well.[11] Among 70 cases, 84% experienced straightening, 11% had improvement but persistence of residual curvature, and 5% were unchanged. Postoperative erectile deficit requiring the use of injection or vacuum therapy ranged from 15% to 26% in two different series. Only one case, involving true lateral deformity, eventually required implant surgery.

Plication and grafting into relaxing incisions, whether used alone or in combination, offer effective correction of penile deformity in properly selected patients. For patients whose curvature physically precludes intercourse, they are the two most reliable methods for restoring function without implantation of a penile prosthesis.

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CHAPTER

82

Treatment of Peyronie's Disease with Plaque Incision or Excision and Dermal Graft

GERALD H. JORDAN

The principal complaint of men affected with Peyronie's disease is curvature of the penis. In addition, many also note significant foreshortening of their penis and induration of the corporal bodies particularly noted with erection. The disease is characterized by the formation of a scar in the tunica albuginea of the corpora cavernosa. It is believed that this scar is caused by coital trauma to the penis at the point of the insertions of the midline septal fibers of the corpora cavernosa.[1, 2]

Once the penile tissues have been traumatized, a waiting period is needed to allow the natural healing process to take its course. During the healing process, injury with resultant curvature may resolve, improve, or worsen. In some cases, the injury totally resolves and "true" Peyronie's disease may not occur. In predisposed patients, however (many of the causes of predisposition not yet determined), patients develop the rather virulent scar that is recognized as Peyronie's disease. It is important, therefore, to defer definitive surgical treatment until the disease is mature.

A patient becomes a surgical candidate when a number of criteria are met: (1) The disease has reached maturity, with a period of at least 18 months from the initial onset of symptoms and the curvature stable for at least 6 months. (2) The patient has failed to improve using conservative modalities. (3) The curvature precludes intercourse, or erectile function deteriorates to the point that intercourse is precluded. (4) The patient and his partner understand the benefits and limitations of surgery and are willing to undergo the procedure.

COUNSELING THE SURGICAL CANDIDATE

Before a patient undergoes surgery, it is important to counsel both him and his partner about their expectations for surgical outcome. A good surgical result is defined as a penis that is sufficiently straightened such that residual curvature, if any, does not interfere with intercourse. Surgery does not restore a penis to its original appearance or function. Using the techniques currently available, penile length is not restored, nor is the penis, in all cases, perfectly straight after correction. In cases in which it is applicable, the second component of a good result is that erectile function will be preserved such that patients can resume intercourse with natural erections. Resumption or continuation of sexual activity is a reasonable goal of surgical treatment for Peyronie's disease. All patients at our center are therefore screened by our sex therapy colleague and counseled about their expectations for surgery. We do not undertake corrective surgery until we believe that the patient and his partner have realistic expectations about the surgical outcome.

EVALUATION OF ERECTILE FUNCTION

Because Peyronie's disease is intimately involved with erectile dysfunction in many patients, at this center we evaluate the erectile function of all surgical candidates preoperatively, using duplex sonography peripheral vascular laboratory studies and, in some patients, dynamic infusion pharmacocavernosography-cavernosometry. We have found that accumulated intracorporeal pressures in response to pharmacologic injection are a good indicator of the adequacy of a patient's erection for intercourse. Furthermore, a study performed by Angermeier at this center revealed a linear association between preoperative erectile function and postoperative results.[3] In this study, it was found that patients who had normal or nearly normal erectile functional parameters and good accumulated intracavernosal pressures almost uniformly had good surgical results; patients who had markedly abnormal vascular erectile parameters and poor accumulated intracavernosal pressures after injection uniformly had poor surgical results; and patients with minimal vascular parameter abnormalities and reasonable accumulated intracavernosal pressures had a surgical success rate of approximately 70%.

Our recommendations for surgical treatment are therefore based on this preoperative evaluation. If a patient demonstrates adequate erectile function on complex erec-

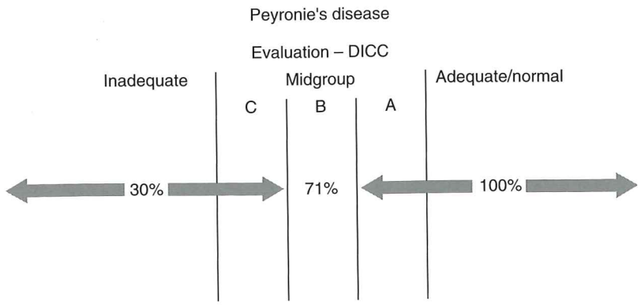


Figure 82–1
Diagrammatic representation of the study findings of Jordan and Angermeier. The group's "inadequate, midgroup, and adequate" were determined by retrospective study. The cutoff between inadequate and midgroup was 30 mm Hg accumulated intracoporal pressure. The cutoff between midgroup and adequate was 70 mm Hg accumulated intracorporal pressure. Jordan and Angermeier's study validated the cutoffs; in addition, it showed the linear relationship between preoperative erectile function and a successful result of surgery (excision of Peyronie's plaque with dermal grafting).

tile function testing (defined as an accumulated intracorporeal pressure of ≥70 mm Hg in response to pharmacologic injection, normal veno-occlusive function, and normal inflow parameters), he is considered to have a greater than 90% chance of having a satisfactory result from penile straightening alone. Patients whose evaluation results fall in the middle (accumulated intracorporeal pressure of >30 mm Hg and <70 mm Hg) are offered surgery to straighten their penis, with the understanding that they have only a 70% chance of a satisfactory result or a 30% to 35% chance that they will be left with a penis that is straight but has inadequate rigidity for vaginal penetration and intercourse. These patients may respond to a pharmacologic erection protocol or may return for placement of a prosthesis, if necessary. Patients who have obviously inadequate erectile function preoperatively (defined as accumulated intracorporeal pressures of <30 mm Hg associated with significant veno-occlusive and/or inflow dysfunction) are unlikely to demonstrate adequate erectile function postoperatively and are offered primary placement of a prosthesis with penile straightening (Fig. 82–1). Duplex Doppler penile examination is currently used as the initial step in evaluating all patients. Figure 82–2 shows the current protocol for perioperative evaluation of patients with Peyronie's disease.

SURGICAL PROCEDURE FOR PLAQUE EXCISION OR INCISION WITH DERMAL GRAFTING

The treatment approach for patients with Peyronie's disease varies according to disease presentation. In general, those patients who present with a ventral lesion are offered a plication technique. In patients with dorsal curvature and normal or minimally abnormal erectile parameters, a technique that incorporates either incision or excision of the Peyronie's plaque is used, with placement of a dermal graft. Most patients are currently treated with plaque incisions, and the entire plaque is excised only in those patients with extensive calcification. For those patients who have markedly abnormal erectile parameters on preoperative testing, correction of the curvature via incision and dermal grafting or corporal remodeling with primary placement of a prosthetic device is advised.

Plaque Exposure

In a circumcised patient, surgical exposure is through the patient's prior circumcising incision (Fig. 82–3). The incision is carried sharply to the superficial lamina of Buck's fascia, and the shaft of the penis is degloved.

In an uncircumcised patient, a circumcising incision may be used and the patient offered circumcision. If he refuses circumcision, he must be cautioned that after surgery, the redundant skin may develop chronic edema that necessitates subsequent circumcision. In an uncircumcised patient who refuses circumcision or a patient with an exceptionally proximal plaque, a parapenile/parascrotal counterincision can be made.

The degloved shaft of the penis is delivered through this incision, and the skin of the shaft is laid aside. Alternatively, a midline scrotal incision can be made, precluding the need for undue retraction on the redundant penile skin

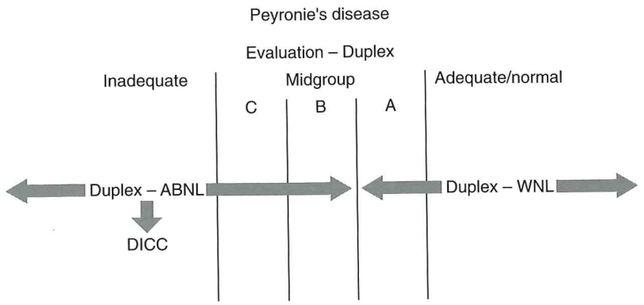


Figure 82–2
The currently used protocol combining duplex evaluation and dynamic infusion pharmacocavernosography-cavernostomy (DICC). Per Jordan and Angermier's study, the groups indicated would, by definition, be duplex normal. The other groups would be duplex abnormal, and DICC is used to separate those in midgroup B from midgroup C and inadequate.

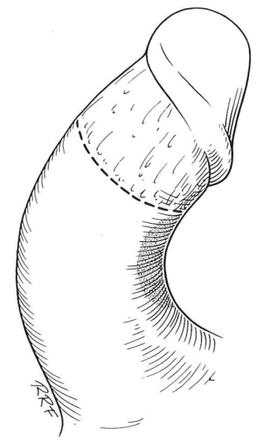


Figure 82–3
Diagrammatic representation of Peyronie's disease with a dorsal plaque. Incision is made through the patient's prior circumcision scar.

or, in the case of a proximal plaque, undue retraction to allow proximal exposure. Again, the shaft of the penis is delivered through the incision and the penile skin is laid aside.

After degloving, the dorsal midline is identified and the superficial lamina of Buck's fascia is opened, revealing the underlying deep dorsal vein (Fig. 82–4). The deep dorsal vein is excised on the pendulous portion of the penis (Fig. 82–5). No effort is made to take down the suspensory ligaments and accomplish a proximal dissection; rather, the dissection is carried distally to the point where the deep dorsal vein branches to become the retrocoronal plexus. The prominent circumferential veins are ligated, and in many cases a portion is excised (Fig. 82–6). When prominent periurethral veins are found, they are also excised. After the abbreviated vein dissection, ligation, and excision, the deep lamina of Buck's fascia is opened in the dorsal midline, exposing the midline tunica albuginea of the corpora cavernosa.

An occasional patient, rather than having a prominent deep dorsal vein, has deep dorsal veins that are paired and found lateral to the arteries. In these cases, the dorsolateral veins are not excised from their bed. Rather, the midline

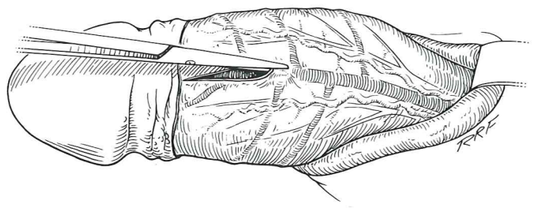


Figure 82–4
The penis has been degloved in the plane immediately superficial to the superficial lamina of Buck's fascia. The superficial lamina of Buck's fascia is opened over the deep dorsal vein.

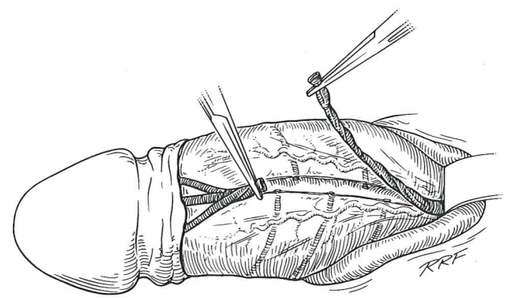


Figure 82–5
The dorsal vein is dissected and excised from the level of the retrocoronal plexus to the penopubic junction.

of Buck's fascia is opened down to the tunica albuginea of the corpora cavernosa, and exposure of the dorsal corpora and plaque is begun.

In both cases, Buck's fascia is dissected in concert with the dorsal neurovascular structures (Fig. 82–7). To avoid undue tension on the dorsal nerves, this dissection is carried widely around the ventral aspect and both proximally and distally. The distal dissection should not be taken any farther than is absolutely necessary because of the possibility of interfering with necessary enervation. In the case of distal plaques, however, the dissection can be carried beneath Buck's fascia distally and beneath the spongy tissues of the glans to the tips of the corporeal bodies. To accomplish this distal dissection, Buck's fascia is grasped distally, using a skin hook to retract the tunica albuginea, and the dorsal penile erectile bodies are everted from beneath Buck's fascia. Throughout the entire dissection in the region of the dorsal neurovascular bundle, hemostasis is achieved with suture ligation or bipolar electrocautery or both.

Incision/Excision of Plaque

After the dorsal plaque is exposed, artificial erection is achieved using a high-volume pump that distends the corpora with normal saline, allowing the limits of the plaque to be marked with Prolene stay sutures (Fig. 82–8). Most dorsal plaques are treated by creating multiple inci-

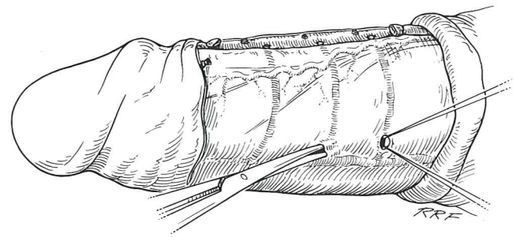


Figure 82–6
The circumferential veins are segmentally ligated and excised. The periurethral veins are ligated and excised.

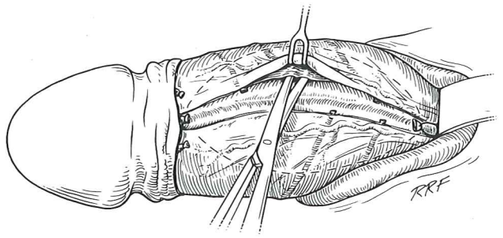


Figure 82–7
Buck's fascia is elevated, and thus the dorsal neurovascular structures are elevated. The fascia is widely elevated to diminish the potential for stretch injury to the dorsal neurovascular bundle.

sions through the plaque. The incisions are carried across the area of the Peyronie's scar, with the ends darted to create two Y shapes at the base. A small amount of the plaque is excised for submission to histology, usually from the point of most extreme curvature (Fig. 82–9).

In those few patients in whom the plaque is extensively calcified, the entire plaque is excised rather than incised (Fig. 82–10). The ovoid corporotomy defect is then converted to stellate by placing darting incisions, and the entire plaque is submitted to histology (Fig. 82–11). The corporotomy defect is then measured so that an appropriate-sized graft can be harvested.

It is important to note that the scarring process involves only the tunica albuginea and not the underlying spongy erectile tissue of the corpora cavernosa, and it is not necessary to carry the dissection into the substance of the erectile bodies. In addition, although it is not uncommon to see some involvement of the midline septal fibers, because the septal fibers are detached from the scar dorsally, the tethering is relieved and dissection of the scarred septal fiber, per se, is not necessary.

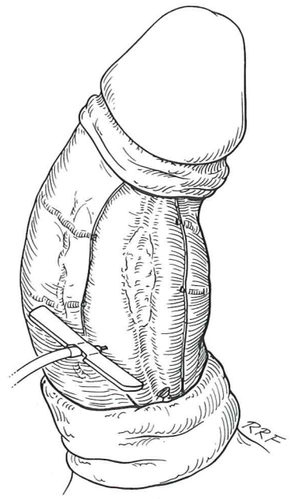


Figure 82–8
Artificial erection is performed to define the area of curvature.

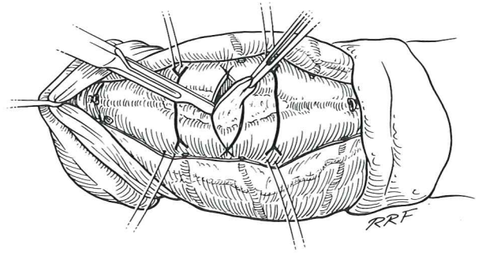


Figure 82–9
In using an incisional/dermal graft technique, prospective incisions are marked. An excisional/incisional corporotomy defect is created at the site of maximal curvature.

Dermal Graft Placement

The dermal graft donor site preferred at our institution is over the anterior iliac crest, where many men have an area of redundant tissue (Fig. 82–12). The graft is taken lateral to the midline abdominal hairline and not extended too far posteriorly (where the dermis becomes quite thick as the skin approaches the back). In the case of an incisional technique, a "generic" dermal graft is harvested that measures approximately 10 cm or 3×4 cm, depending on the degree of curvature and the redundancy of the dermal graft donor site tissue. For an excisional technique, the dermal graft is harvested to measure approximately 30% larger in all dimensions than the corporotomy defect.

The dermal graft is meticulously prepared. It is first deepithelialized either by hand or using a drum dermatome. I prefer to perform deepithelialization by hand under 2 1/2 or 3 1/2 magnification. After it is deepithelialized, it is elevated from the underlying adipose tissue and carefully defatted. The donor site is ensured to be hemostatic and is closed per primam. Closure can be accomplished using deep Vicryl subcutaneous sutures and either a running subcuticular Monocryl suture or polydioxanone (PDS) suture or a running continuous pull-out Prolene subcuticular suture.

If an incisional technique is used, dermal graft inlays are used to fill multiple corporotomy defects (Fig. 82–13).

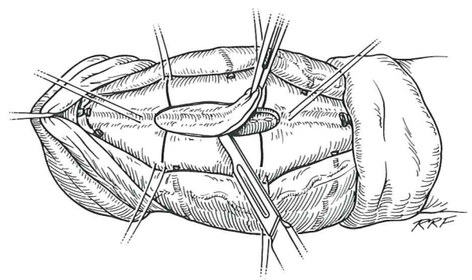


Figure 82–10
Diagrammatic representation of excisional technique. The plaque is excised. The darting incisions are marked.

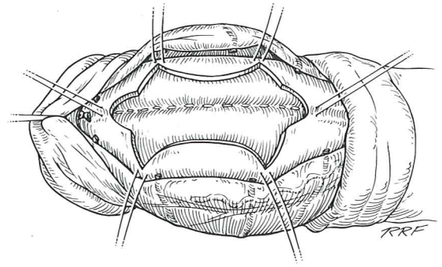


Figure 82–11
With the darting incisions created, the corporotomy defect becomes stellate.

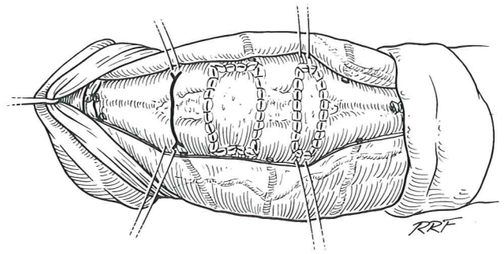


Figure 82–13
In using an incisional technique, the dermal grafts have been inset in two of the three incisional defects. Notice that the darting at the end of each incision creates a square inset. After each graft inlay, artificial erection is performed to assess the result.

After the first incision is complete, artificial erection is performed and subsequent incision and grafts are planned, with the artificial erection repeated after each, until a satisfactory result is achieved. The majority of patients require three incisions, although some need up to four to five to yield the desired result.

If an excisional technique has been used, after the graft is prepared, it is set into the corporotomy defect and tailored to fit (Fig. 82–14). It is then sutured in place using a combination of interrupted 4-0 PDS with continuous locked 5-0 sutures and sutured to the dorsal midline fibers. After the closure is completed, an artificial erection is performed to ensure that the penis is straight and the suture lines are watertight (Fig. 82–15). If leaks are found, they are oversewn with another PDS. If the curvature persists, modifications are performed until the desired result is achieved. These modifications can consist of either contralateral plication, incision of the graft with added graft inlays, or an additional incision with dermal graft.

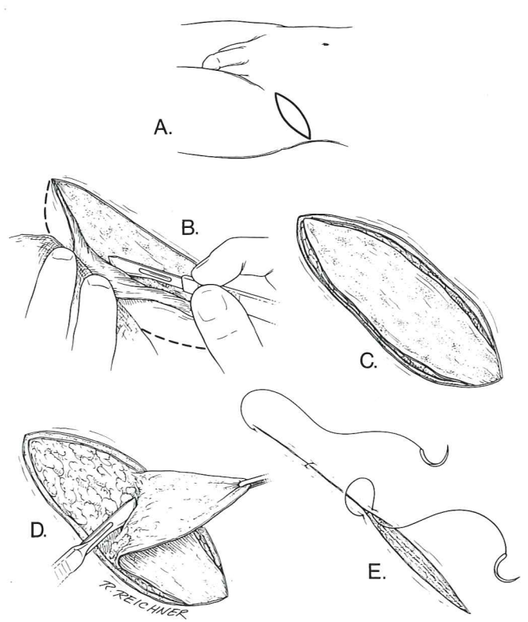


Figure 82–12
The dermal graft is harvested from the area over the anterior iliac crest. *A:* The graft donor site is situated lateral to the midline abdominal hairline. *B:* The graft is hand deepithelialized. *C:* The incision is deepened. *D:* The undersurface of the graft is elevated and meticulously defatted. *E:* The dermal graft donor site is closed per primam.

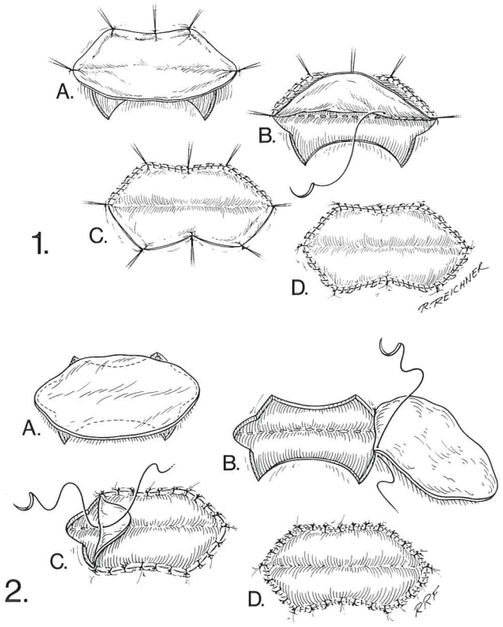


Figure 82–14
If an excisional technique is used, the dermal graft is meticulously tailored to the corporotomy defect. The graft is then inset using one of two techniques illustrated. The graft is initially tacked in place and tacked to the midline septal fibers, and then the inlay is completed with a watertight running locked suture line.

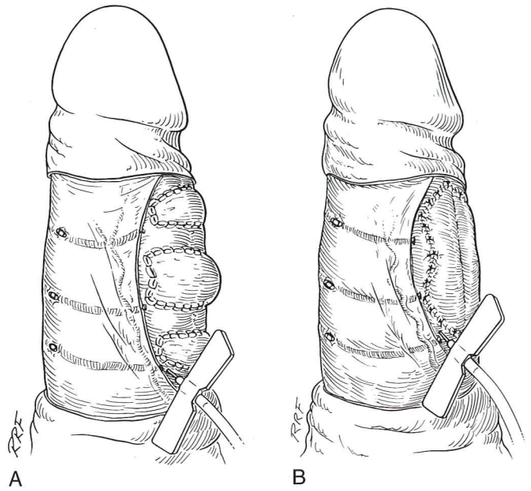


Figure 82–15
The appearance of the final artificial erection after an incisional dermal grafting technique (*A*) and after an excisional dermal grafting technique (*B*).

Closure

Buck's fascia is reapposed over the graft using interrupted sutures. Not intended to be watertight, this closure is planned so that any secretions that accumulate under Buck's fascia can escape and reach suction drains that are placed deep to the dartos fascia and superficial to Buck's fascia. In cases in which exposure was achieved by passing the penis through a small counterincision, the shaft is returned to the sleeve of the penile or preputial skin. In cases in which the patient has accepted circumcision, the redundant preputial and penile skin is excised.

Hemostasis is assured, the suction drains are brought out through separate stab wounds at the penopubic junction, and the skin is opposed using 6-0 Vicryl suture. A Bioclusive dressing is placed over the shaft of the penis, from the midglans to the base. In most cases, a loosely applied Kling dressing is applied over the Bioclusive dressing.

Recovery

While the Kling dressing is in place (approximately 4 hours postoperatively), the nursing staff checks the glans for adequate profusion every 30 minutes. After the Kling dressing is removed at 4 hours, the frequency of glans checks is reduced to every 1 to 2 hours. A small Foley catheter is placed and attached to gravity drainage.

Patients are kept at bed rest on the day of surgery. On the next day, the Foley catheter is removed and they are encouraged to ambulate. Drains are removed as drainage allows. This is usually late on the first postoperative day or early on the second postoperative day. Depending on the patient's progress and swelling, most patients are discharged from the hospital on the second postoperative day and given a detailed instruction sheet.

In the early postoperative period, erections are suppressed using oral diazepam and amyl nitrite capulets. It is my belief, however, that erections are a necessary part of achieving good graft maturity and compliance. The discharge instructions include a regimen of stimulated erection, massaging the penis with a lubricant. Patients are asked to have their partners massage the penis and gently straighten the graft. They are instructed to resume intercourse as the situation allows and are cautioned against marking the calendar. Although they are advised to refrain from intercourse for at least 8 weeks postoperatively, most patients do not resume intercourse before 12 weeks.

The goal of surgery for Peyronie's disease is a penis that is sufficiently straightened to allow intercourse with preservation of natural erections. We have found that when patients have realistic preoperative expectations of surgery, the vast majority are happy with the result.

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CHAPTER

83

Correction of Peyronie's Curvature Using Vein Grafts and Plaque Incision

JOHN M. DEIRMENJIAN
TOM LUE

Peyronie's disease was first described by Francois Gigot de la Peyronie in 1743 as a fibrous thickening of the penile shaft associated with pain and curvature.[1] A Peyronie's plaque, characterized by a fibrous scar in the tunica albuginea of the corpus cavernosum, restricts the elasticity of the penis and causes abnormal curvature on erection. Patients usually present between the fourth and sixth decades of life, although the disease has been reported to occur in adolescents to 80-year-olds.[2, 3] As much as 1% of the male population is affected by Peyronie's disease, and most patients are Caucasians.[4, 5] The pathophysiology of Peyronie's disease has perplexed urologists for more than 250 years, and the treatment remains a dilemma because of the unclear cause. The purpose of this chapter is to review the theories about the etiology of Peyronie's disease and its treatment and to emphasize surgical correction of Peyronie's curvature with plaque incision and venous grafts.

DIAGNOSIS

Because Peyronie's disease may be manifested by a spectrum of symptoms, a patient's complaints, including erectile dysfunction, may be multifactorial, ranging from a psychogenic etiology to pain, penile distortion, or performance anxiety.[6, 7] Therefore, evaluation of Peyronie's disease must begin with a thorough history and physical examination, including a detailed sexual history. The history must include the duration and progression of symptoms, any change in libido, evidence of penile trauma, prior or current medical illnesses, medication or illicit drug use, and a detailed surgical history.

Physical examination consists of an examination of the lesion while the penis is stretched. A patient is asked to provide photographs of his erect penis, assuming that he is able to elicit an erection and has access to a camera. A side-view photograph also provides information about the degree of angulation of the penis with erection. Plain radiographs or ultrasonography may be useful in identifying calcifications within the plaque.

FUNCTIONAL EVALUATION

The chief indication for hemodynamic evaluation in patients with erectile dysfunction and Peyronie's disease is to assess vascular compromise.[8] Duplex ultrasonography is used to measure the diameter and the flow of the cavernous arteries before and after intracavernous injection of a vasodilator. Patients are given 10 μg of prostaglandin E_1 (PGE_1), allowing for vascular evaluation of the penis in the flaccid and erect states. The location, degree of curvature, extent of the plaque, and degree of tumescence are assessed.

Patients who respond with an erection and good arterial flow become candidates for multiple parallel suture plication (MPSP) or venous graft with plaque incision. In patients with no demonstrable rigidity despite excellent flow, pharmacocavernosography and cavernosometry may be performed if indicated. If a venous leak is found, patients are given the option to undergo simultaneous venous graft and venous surgery. If a patient fails to achieve a completely rigid erection, combined intracavernous injection with self-stimulation is performed and a Doppler analysis is carried out. Patients with poor arterial flow on Doppler ultrasonography but with good erectile response to intracavernosal therapy can also be candidates for treatment with venous graft or MPSP. Self-injection therapy or a vacuum constriction device may be acceptable for management of their impotence after surgery. Those with poor arterial blood flow and no erection are advised to have a penile prosthesis with or without plaque incision (Fig. 83–1).

OPERATIVE MANAGEMENT

Operative management of Peyronie's disease has been the subject of great debate. The goal of surgical treatment of

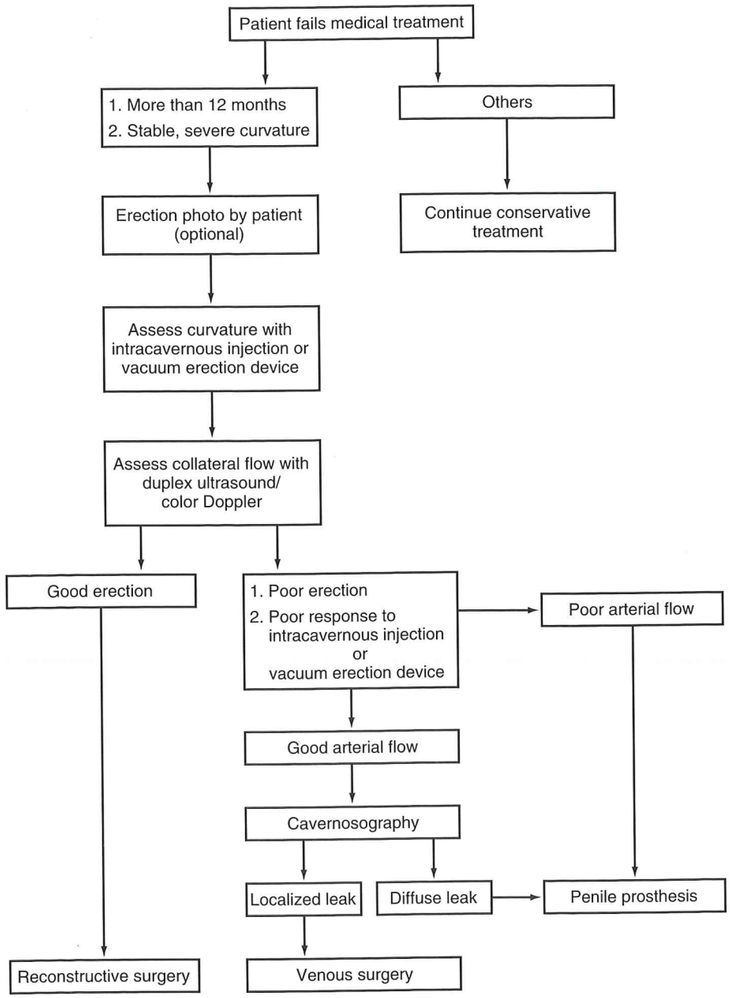


Figure 83–1
Algorithm depicting the management of Peyronie's disease.

Peyronie's disease is to straighten the penis, hence allowing resumption of intercourse. In addition, the penile deformity must be stable — that is, no change in its caliber or in symptoms associated with it must have occurred within 3 months, and the symptoms must have persisted for at least 12 months. Surgical correction of Peyronie's disease is not indicated for the resolution of pain. Moreover, patients are also counseled not to expect improvement of penile rigidity. A vascular evaluation with high-resolution ultrasonography and pulsed Doppler analysis before and after intracavernosal PGE_1 injection is performed on all candidates before any surgery involving dissection of the neurovascular bundle in order to assess collateral arterial blood flow. Interruption of communications between the cavernous and dorsal arteries may result in impotence in patients with borderline erectile function.

Multiple Parallel Suture Plication

Plication of the tunica albuginea is indicated in patients with good erectile response to PGE_1. We have abandoned the Nesbit operation, in which one or more ellipses of the tunica albuginea are made on the side opposite the curvature, despite prior reports of success in correcting the penile deformity.[9] We have found a greater incidence of recurrent curvature and bulging at the site of excision with the Nesbit procedure. Hence, we perform plication of the tunica albuginea. Plication is a relatively simple procedure, lasting approximately 30 minutes, and it can be performed under local anesthesia on an outpatient basis. Candidates for penile plication, however, must be informed that their penile length may decrease by 2 to 3 cm as a result of the plication.

The patient is brought to the operating room, where his genitalia are prepared and draped in a sterile fashion. A local penile block is achieved with 10 ml of 0.25% bupivacaine at the base of his penis. An artifical erection is induced with 10 μg intracavernosal injection of PGE_1 or 30 mg of papaverine with a 28-gauge needle. For dorsal curvature, a longitudinal ventral incision is made down to Buck's fascia. The corpus spongiosum is then identified. Deep parallel plicating sutures (usually four to six) are placed onto the tunica albuginea at the center of the curvature, 2 to 3 mm from the spongiosum on both sides, with 2-0 Ti-Cron (Tevdek) nonabsorbable braided suture.

For ventral curvature, a circumcision incision is made. The skin and subcutaneous tissues are subsequently dissected and reflected to the base of the penis. The urethra and neurovascular bundle need not be dissected for this procedure. Deep plication sutures are placed onto the tunica albuginea at the center of the curvature between the deep dorsal vein and the arteries. The 2-0 Ti-Cron sutures are then tied with surgical knots, and the deformity is reassessed. Two to three sutures on each side are usually required. The first node of the sutures is tied gradually until the curvature is corrected; thus, overcorrection can be avoided. On reassessment, if the curvature is overcorrected, the sutures can be removed and placed closer to one another. If lateral curvature is noted, lateral sutures may be placed. If the penis remains erect at the conclusion of the plication, a 21-gauge scalp vein needle may be inserted and corporeal blood may be aspirated to achieve detumescence. If the penis remains rigid after aspiration, 250 to 500 μg of a phenylephrine hydrochloride solution may be injected every 3 to 5 minutes until detumescence is achieved. The skin is then reapproximated with 4-0 chromic absorbable sutures. The penis is wrapped with a lightly compressive dressing, being careful to allow adequate blood flow to the glans. The dressing is changed on the following morning. The patient is then instructed to abstain from sexual intercourse for 4 to 6 weeks.

Plaque Incision and Venous Graft

Many reports in the literature describe excision of Peyronie's plaques and placement of an autograft (dermis, dura mater, or tunica vaginalis.[10–14] Gelbard and Hayden reported a technique in which multiple plaque incisions were made with insertion of small patch grafts using temporal fascia.[15] Inert substances, such as Dacron (Gore-Tex) or Dexon mesh, have also been used.[15, 16] Our experience shows that plaque excision results in excessive reaction and weakening of the tunica as well as impotence. Animal studies have shown that the dorsal vein is an excellent substitute for the tunica albuginea.[17] Therefore, in patients with severe curvature of the penis resulting in a shortened penis, we have modified our procedure to include a plaque incision with the use of either a dorsal vein graft or lower saphenous vein graft. The lowest portion of the saphenous vein has been used because of its few branches and the minimal dissection involved in its isolation.

The procedure is performed under general, epidural, or spinal anesthesia. The genitalia are prepared and draped in a sterile manner. An artificial erection is induced with normal saline through a 21-gauge scalp vein needle into the corpus cavernosum with compression of the crura. A circumcision incision is then made. The skin and subcutaneous tissue are dissected and reflected back to the base of the penis. For dorsal curvature, the deep dorsal vein, arteries, and nerves are identified and dissected off the tunica albuginea of the corpus cavernosum. The most critical portion of the operation is careful dissection of the neurovascular bundle. Surgical loupes and a Doppler device are used to dissect the bundle free from any fibrous extensions from the plaque. For ventral curvature, the corpus spongiosum is dissected off the tunica albuginea.

The dorsal vein of the penis is suture ligated with 2-0 silk suture distally and proximally, and all the branches are tied with 4-0 silk suture. The dorsal vein is then harvested and placed in normal saline solution. The plaque is then incised, the ends of the incision are extended in an H-shaped fashion (Fig. 83–2*A*), and the defect is measured to determine the appropriate size of graft. If the harvested dorsal vein is of sufficient length, a saphenous vein graft may not be needed. However, if the plaque size exceeds the amount of dorsal vein harvested, the saphenous vein is harvested. A 3- to 4-cm incision is made near the ankle along the course of the saphenous vein (Fig. 83–2*B*). The choice of right or left leg can depend on whether the patient will be driving a vehicle in the postoperative period. If so, then the left ankle is preferred. The incision at the ankle may be extended if a greater length is necessary. The saphenous vein is harvested and suture ligated distally. The harvested saphenous vein is divided into several segments. A relaxation incision is made in the plaque transversely for penile curvature and longitudinally for an hourglass deformity. First, the opened venous segments are approximated with a 5-0 Maxon suture. The opened saphenous vein patch with the endothelial side down is sutured to the defects with continuous 4-0 Maxon sutures (see Fig. 83–2*B*). If necessary, another plaque incision can be made and the procedure repeated. Normal saline is then injected into the corpus cavernosum to reassess the deformity. If necessary, a 2-0 Ti-Cron plicating suture may be used to compensate for over- or undercorrection.

The ankle incision is subcutaneously reapproximated with a 3-0 Dexon suture in an interrupted fashion. A Foley catheter is then placed. The skin is then reapproximated with a 4-0 Dexon suture subcuticularly. A sterile dressing is placed over the incision. The penile skin is then reapproximated with an interrupted absorbable 4-0 chromic suture circumferentially. The penis is wrapped with a lightly compressive circular dressing, which is reexamined 1 hour later to ensure adequate blood flow to the glans. A scrotal support is then placed over the dressing. The following day, the penile dressing and the Foley catheter are removed. The patient is discharged home with instructions to change the dressing once a day for 10 days and to abstain from sexual intercourse for 6 weeks. The dressing on the ankle is removed on postoperative day 2.

CONCLUSION

Peyronie's disease, a complex phenomenon whose etiology is unknown and whose treatment has traditionally been

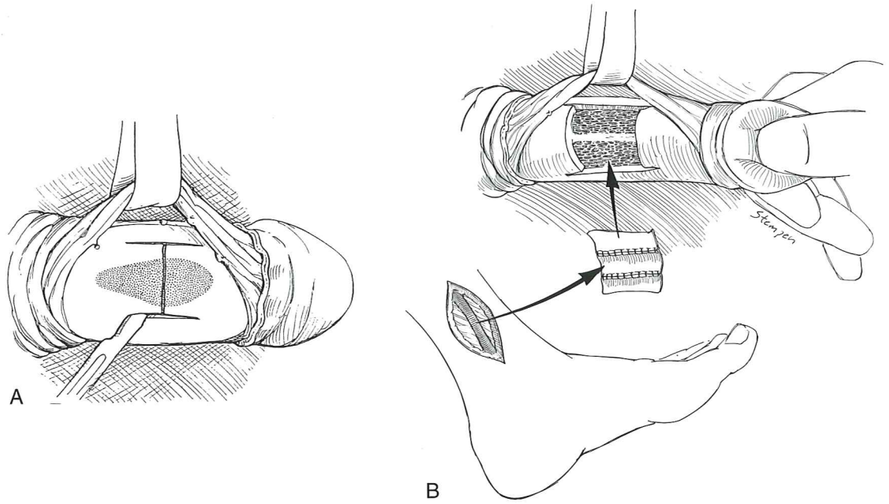


Figure 83–2
A: H-shaped incision of the Peyronie's plaque. *B*: Saphenous vein harvest and construction of a venous patch.

disputed, can affect as much as 1% of the population. Our approach to the management of Peyronie's disease has been conservative, with operative treatment reserved for patients in whom the disease has stabilized past the acute stage and in those who have failed to respond to medical management. Patients who present with erectile dysfunction in association with Peyronie's disease undergo a thorough vascular evaluation before an operation. In our experience, MPSP is a very useful technique if the patient does not object to shortening of penile length. We have found that plaque incision with venous graft (penile dorsal vein or saphenous vein) may lead to successful correction of the penile deformity without compromising penile length. This procedure requires overnight hospitalization but has no significant morbidity. To date, our patients have been pleased with the outcome of the surgical correction of Peyronie's disease.

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CHAPTER

84

Use of Inflatable Implants for Penile Straightening

IRVING J. FISHMAN

Penile angulation can be a physically and emotionally devastating condition. It may be a result of various conditions. These include congenital ventral angulation of the penis ("banana penis"), Peyronie's disease, trauma, and corporitis secondary to priapism or infection. In fact, any disease process that causes disproportionate development or scarring of the tunica albuginea or the corporeal tissues can result in tethering of the penis. The usual manifestation is erectile dysfunction that at the time of intercourse may be associated with pain to the patient, his partner, or both. The degree of penile deformity, which may be longitudinal or circumferential, is variable, ranging from severe curvature (120 degrees) and shortening of the penis to minor deformity, with complaints of inability to achieve or sustain an erection. This usually is an evolving process that may progress, regress to normal, or remain stable.

EVALUATION

The treatment of problems of erectile angulation must be individualized. It should be based on a thorough evaluation of penile function and anatomy and should be tempered by the patient's expectations and input. This evaluation should include a thorough history and physical examination, photographic documentation of the penile deformity, and documentation of the penile vasculature with duplex Doppler ultrasonography, after intracorporeal administration of vasodilating agents (prostaglandin E_1 [PGE_1] or Trimix. Sonographic examination also permits visualization of any significant scar tissue or calcification in the tunica albuginea or corpora. Soft tissue radiographs of the penis aid in documenting the presence or absence of calcifications. In addition, erectile function should be assessed with nocturnal penile tumescence or visual stimulation studies. In the absence of any significant nocturnal penile tumescence, implantation of a penile prosthesis in conjunction with a penile straightening procedure should definitely be recommended. In the presence of normal arterial flow with normal veno-occlusive function, penile straightening without implantation of a penile prosthesis is certainly an accepted alternative. In older patients (over 65), especially those with a history of peripheral vascular disease, the risk of erectile dysfunction postoperatively is greater. Implantation of a penile prosthesis is encouraged for those patients.

THERAPY

A multitude of medical therapies may be available to ameliorate the angulation caused by scar tissue due to Peyronie's disease or various other conditions contributing to penile scarring and associated angulation. Among these medications are potassium para-aminobenzoate (Potaba), colchicine, vitamin E, and tamoxifen. Steroid applications or injections, intralesional interferon and verapamil, and low-dose radiation therapy may also be tried. Despite these therapies, however, a significant number of patients require surgical intervention. Angulation due to corporeal fibrosis is seldom amenable to medical management and usually is considered a surgical problem at the outset. Implantation of a penile prosthesis is essential to restore erectile function.

Surgical Therapy

The surgical technique used to correct penile deformity requiring implantation of a penile prosthesis is determined by the cause of the problem—that is, whether the scarring is limited to the tunica albuginea or involves the corporeal tissues. In case of the former, correction of the angulation may be limited to plication, incision, or excision of the tunica albuginea. Plication of the corpora or a Nesbit procedure can lead to penile shortening, which is not desirable if the patient already has a short phallus. If the angulation is due to fibrosis of the spongy tissue, the latter will have to be either excised or transected to untether the penile tissues. The penile cylinders are then implanted in the space created by excision of the corporeal scar tissue. If excision is not feasible, the corpora can be filleted open to allow placement of the cylinders. The remaining defect in the tunica is closed with a graft. Alternatively, a space may be created within the corpora using a Rossello-Carrion instrument, which essentially drills a space for the cylinder.

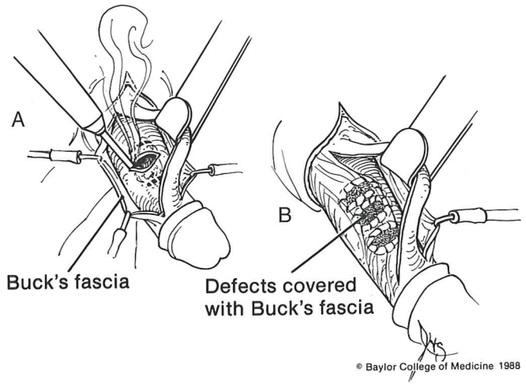


Figure 84–1
Buck's fascia patch for occlusion of a defect site in the tunica albuginea.

Before implantation of the prosthesis, the corporeal smooth muscles are relaxed by injecting a double dose of vasodilating agent, such as PGE_1 or a combination of papaverine, PGE_1, and Regitine. This usually results in relaxation of the corporeal smooth muscles, tumescence, and, at times, an erection. This allows us to assess the degree of penile erectile deformity and facilitates corporeal dilatation. If the penile response to the intracorporeal dilators is poor, an artificial erection can be induced by instilling normal saline via a butterfly needle and a tourniquet at the base of the shaft. The prosthesis is implanted via a penoscrotal or infrapubic approach. This technique has been described extensively elsewhere.[1] The cylinders that should be used under these circumstances are the American Medical Systems' CX type. Use of AMS Ultrex expansile cylinders may cause significant penile distortion as the cylinders stretch lengthwise on inflation. Others prefer to use the Mentor Bioflex cylinders, which are plastic and are more sensitive to heat and thus limit the use of cautery to incise the scar tissue of the tunica. Once the cylinders are in place, they are inflated to assess the functionality of the phallus. In a limited number of cases, this procedure is adequate to correct the deformity. In the presence of mild curvature, forceful modeling or counterbending of the erect penis may be adequate to break down residual contracture bands. Care should be taken to avoid exerting excessive force that could lead to disruption of the penile corporotomies. Nesbit plication may also be used if the penis is of adequate length and the deformity is minor. If the latter technique is used after inflatable prostheses have been implanted, great care must be directed to avoiding any injury to the cylinders.

If significant curvature persists, the point of maximal tethering in the tunica albuginea is incised via an extended penoscrotal incision or via a degloving circumcision incision, using an electrocautery knife to release the contracture. More than one incision is sometimes required. For dorsal curvature, to incise the scar tissue adequately, the neurovascular bundle must be elevated off the tunica albuginea. It is kept elevated with minimal traction and protected from the heat of the electrocautery with a malleable, narrow, silicon-covered brain retractor. The incision may have to extend into the septum to release the contracture. If the curvature is in a ventral direction, the urethra may have to be mobilized to provide access to the ventral plaque. If a patient has a circumferential band caused by scar tissue in the tunica albuginea; a longitudinal incision across the contractile band usually releases it. At times, if the plaque contains calcification, especially if an inflatable penile prosthesis is being used, the whole area of calcification should be excised to prevent damage to the prosthesis. Under these circumstances and in general, if the defect at the site of a tunica incision is greater than 50% of the corporeal circumference, it should be covered by either a Dacron or Gore-Tex graft, secured to the edges of tunica albuginea defects with either Tycron or Gore-Tex 3-0 suture. In most cases, however, the defect does not require a graft, and Buck's or Colles' fascia may be sutured loosely to the edges of the defect to help preclude hematoma of the shaft (Fig. 84–1). The circumcision skin incision is sutured in at least two layers with an absorbable suture, and a mildly compressive dressing is applied to the partially inflated erect phallus. In addition to 400 mg of Floxin or 80 mg of Garamycin and 1 g of vancomycin given intravenously 1 hour preoperatively, the operative site is irrigated with broad-spectrum antibiotics throughout surgery.

When significant corporeal fibrosis is encountered, the surgeon must decide whether it is feasible to achieve a satisfactory result by simply implanting a prosthesis into the fibrotic corpora or whether it would be better to excise the fibrotic corpora and implant the prosthesis in the resulting space. In the presence of severely fibrotic and relatively avascular corpora penile compliance, distensibility and stretchablity are very restricted. To improve the latter characteristics and to create a generous space for a prosthesis, excision of the fibrotic corpora is advocated. This procedure usually is quite challenging and is best

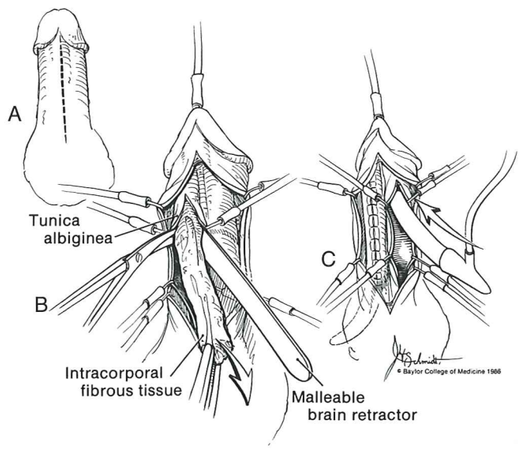


Figure 84–2
Excision of a fibrotic core of corporeal tissue via an extended penoscrotal incision. (From Fishman IJ: Complicated implantations of inflatable penile prostheses. Urol Clin North Am 14:217–239, 1987.)

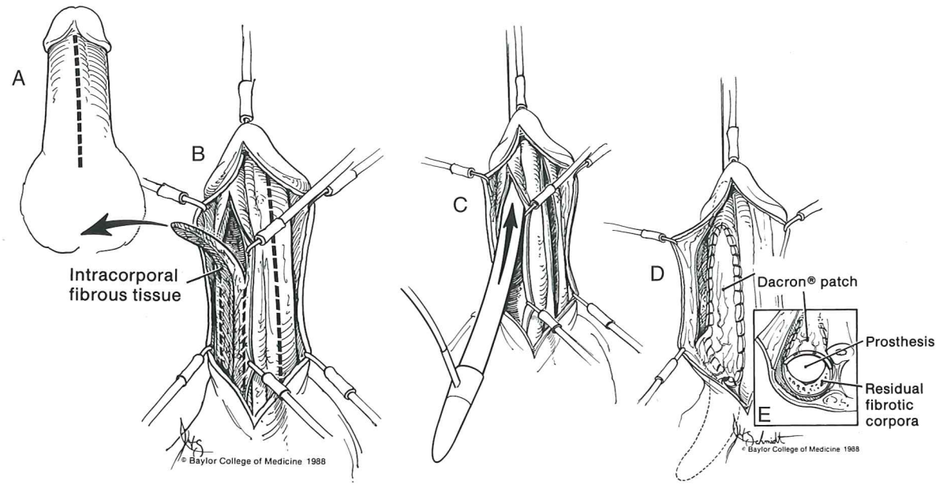


Figure 84–3
Dacron patch used to cover a corporeal defect.

performed via an extended penoscrotal and corporeal incision. Great care must be taken in dissecting the medial portion of the cavernosal tissues to avoid injury to the intercorporeal septum, which can usually be identified by its distinct radial fibers. Once the plane between the tunica albuginea and the corporeal tissues has been established, it is easily extended proximally and distally with blunt and sharp dissection. Once the core of fibrous tissue is freed from the tunica, it is grasped with a Kocher clamp, and the penis is evaginated as the distal fibrotic core is excised. The latter is transected as far distally as possible. A controlled distention cylinder is implanted in the newly created space. Once the cylinders are implanted and the corporotomies closed, they are inflated to assess the quality of erection. If significant angulation is evident, appropriate relaxing incisions can be made in the tunica (Fig. 84–2). On occasion, one is fortunate to create a channel in just the indurated corpora.

If it is not feasible to excise the corporeal tissue completely, an alternative is to create two longitudinal corporotomies by filleting the corpora and laying in the cylinders or rods after incising a furrow in the erectile tissue. The defect in the tunica is then closed with a synthetic patch that is sutured into the tunical defect (Fig. 84–3). Rasper dilators described by Rossello and Carrion and popularized by Wilson may at times be effective in creating a channel for the cylinders.[2] The space created is sometimes so small that placement of a small prosthesis is necessary. The AMS CXM inflatable penile prosthesis is very effective under these circumstances, because the girth of the device is smaller than the normal CX cylinders and it is easier to position within the newly created corporeal spaces. It nevertheless provides adequate rigidity and flaccidity.

At the conclusion of the procedure, the prosthesis is left partially inflated and a mildly compressive Coban dressing is applied. Postoperatively, the glans penis is checked periodically for penile sensation (the glans penis is pinched) and for capillary refill to ascertain that the neurovascular bundle is intact. The prosthesis cylinders are gradually deflated during the next 48 hours, while the compressive dressing is retained to prevent significant swelling or ecchymosis. Ice packs are used liberally to control pain and swelling. The sutures are removed on about the seventh day, and during the second week the patient is instructed in operation of the device but is asked to refrain from using it for approximately 6 weeks. Broad-spectrum antibiotics are administered for about 1 week postoperatively. The patient is encouraged to inflate his device fully for approximately 5 minutes daily to prevent the development of contractures. Recurrence of penile angulation after a phalloplasty has never been documented. The majority of patients and partners are extremely satisfied with the results of this type of surgery.

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CHAPTER

85

Procedures to Correct Penile Shortening

RICHARD E. BERGER

Peyronie's disease is a progressive idiopathic scarring of the tunica albuginea of the corpora cavernosa of the penis. Depending on the location of the scarring, a patient can experience lateral, dorsal, or ventral curvature. When scarring is bilateral or in the midline septum, shortening of the penis also occurs. In a few men, this shortening can be very distressing and can cause sexual dysfunction and marital discord. Men with infected penile implants requiring removal routinely experience corporeal fibrosis and penile shortening, which usually increases dissatisfaction with a complicated procedure. Finally, men who have a partial penectomy are often left with a penis that is too short to have intercourse and is inconvenient for urination.

To offer treatment to men with dysfunctional penile shortening we have developed two procedures that can significantly lengthen the functional length of the penile shaft in selected patients. We call these procedures the penile lengthening and surgical reconstruction (PLSR) and the finger trap procedure.[1, 2]

INDICATIONS AND PREOPERATIVE ASSESSMENT

Penile lengthening is a complicated procedure and should be performed on only the most motivated patients after extensive counseling. Rarely can a significantly shortened penis be restored to its predisease state. Support by both the surgeon and therapist should be provided both preoperatively and postoperatively. A program of sexual rehabilitation involving a sex therapist should be agreed on preoperatively, especially for patients who have significantly decreased the frequency of any type of sexual contacts. The patient's sexual partner must also be involved in the decision-making process. We inform patients that 1 to 1.5 inches can usually be gained but that this is variable. It is extremely important that the patient have realistic expectations about the outcome. We also carefully describe possible complications, including implant dysfunction, infection, skin sloughing, and loss of sensation. Preoperatively, an artificial erection is always created with intracorporeal injection of vasoactive substance, and careful length measurements are made. We also perform Doppler examinations of the dorsal arteries to make sure the distal penis is well vascularized because the cavernosal arteries are often injured during these procedures. After the procedure is explained and the patient understands the possible complications, he must believe that he has more to gain than lose if he is to undergo the surgery. Both the surgeon and the patient must be prepared for a physically and psychologically challenging postoperative course.

Because lengthening depends on mobility and stretchiness of the bundle, men who have had previous dissection of the neurovascular bundle are not good candidates for lengthening procedures. Furthermore, men with severe vascular disease are poor candidates because of the attenuation of blood supply caused by the lengthening procedure.

CHOICE OF PENILE IMPLANT

Corporeal lengthening procedures require placement of a penile implant. Lengthening can be performed over almost any type of semirigid or inflatable implant except the American Medical System's (AMS) Ultrex. Lengthening procedures create weaknesses in the tunica albuginea, which can result in aneurysms when the Ultrex expands. The AMS CX cylinder works much better. During lengthening procedures, the cutting current is used to incise the tunica albuginea over the implant. The silicone cylinders of the AMS inflatable implant are more resistant to heat than the Bioflex cylinder of the Mentor inflatable implants. Either may be used. Replace the cylinder if the Bioflex cylinder whitens during incision.

PENILE LENGTHENING AND SURGICAL RECONSTRUCTION PROCEDURE

A penoscrotal or infrapubic incision may be performed. Corporeal dilation is performed, and intracorporeal measurements taken. If a semirigid implant is chosen, it is placed into the distal corpora to put them on stretch. Final trimming of the implant or placement of rear tip extenders is deferred until lengthening and final corporeal length are achieved. If an inflatable implant is chosen, one should choose the implant length that will fit in the corpora without rear tip extenders so that the implant can later be lengthened. The penis is then degloved, either by inverting it out of the incision or by performing a circumcising incision and degloving it from distal to proximal (Fig. 85–1). Longitudinal incisions in Buck's fascia are then made bilaterally, and the dorsal neurovascular bundle is elevated distally to 2 cm from the glans and proximally as far as possible. The urethra is then carefully dissected off the corpora cavernosa to allow it to stretch in proportion to the stretch of the neurovascular bundle. A single circumferential incision is then made around both corpora cavernosa over the implant. Small tenotomy scissors are used to cut the midline septum. The distal end of the penis is then telescoped forward to the length that the dorsal bundle will allow, care being taken not to put excessive stretch on the dorsal bundle. Then, either the implant is trimmed to fit the new length or rear tip extenders are added to extend the implant to the new length. The corporotomy incisions used to place the implant are then closed. The midshaft incision is then closed with a circumferential patch of polytetrafluorethylene and sutured in place with continuous polytetrafluorethylene suture (Gore-Tex). The subcutaneous and skin incisions are then closed. A closed suction drain is placed subcutaneously in the penis and scrotum and brought out through a groin stab incision. A Foley catheter is placed at the end of the procedure. No pressure dressings are applied.

FINGER TRAP PROCEDURE FOR PEYRONIE'S DISEASE

The incision, exposure, and implant choice and placement are the same as for the penile lengthening and surgical reconstruction procedure. However, after the dorsal bundle and the urethra are dissected free from the corpora cavernosa, *multiple* incisions are made into the tunica albuginea over the implant with the cutting current of electrocautery (Fig. 85–2). These incisions are placed 150 degrees around the penis and centered in the median septum dorsally and ventrally. Between these dorsal and ventral incisions are placed 150-degree incisions centered laterally left and right. The midline septum is cut with small tenotomy scissors. After these incisions are placed, the penis telescopes out in the manner of a Chinese finger trap to the length allowed by stretching the dorsal neurovascular bundle. Either the implant is then trimmed or rear tip extenders are added to achieve the additional corporeal length. The lengthening incisions in the tunica albuginea do not require closure. Closed suction drains are placed under the penile skin and brought out through the groin. A Foley catheter is placed at the end of the procedure. No constricting dressings are placed.

FINGER TRAP LENGTHENING AFTER PARTIAL PENECTOMY

Penile lengthening after partial penectomy can be performed to restore sexual function or to facilitate urination. The ultimate length achieved depends greatly not on the length of the dorsal neurovascular bundle but on the amount of skin present after the penectomy. The penile shaft is exposed by inverting the penis out the penoscrotal or infrapubic incision (Fig. 85–3). The attachments of the urethra to the shaft skin are left intact. If lengthening is considered preoperatively, as much shaft skin as possible should be left in place as is consistent with adequate cancer surgery. A pubic skin advancement flap may be performed to cover the proximal dorsum of the penis if necessary. Because the dorsal neurovascular bundle mainly

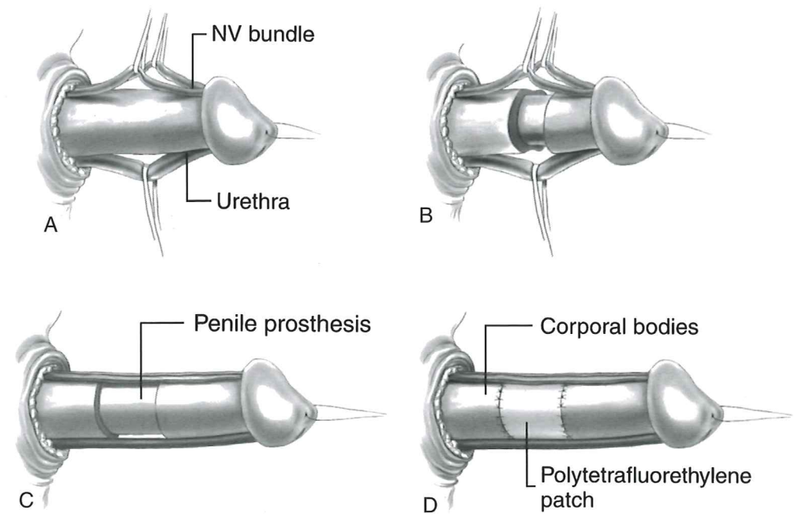


Figure 85–1
Penile lengthening and surgical reconstruction procedure. *A*: After placement of a penile implant, the skin of the penile shaft is degloved and the dorsal neurovascular bundle and urethra are dissected free. *B*: A circumferential incision is made around the tunica albuginea, and the midline septum is cut. *C*: The implant is fitted to the new extended penile length. *D*: A circumferential polytetrafluorethylene patch is placed in the corporeal defect.

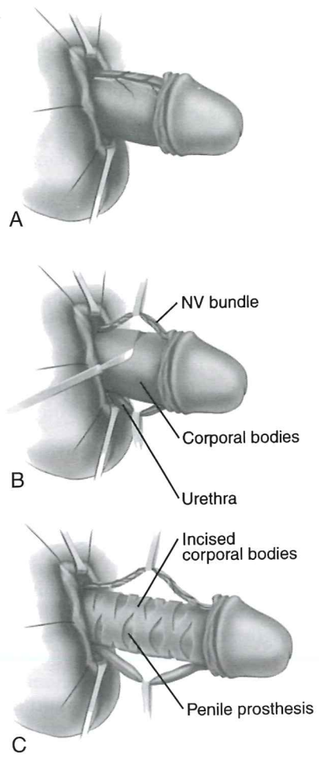


Figure 85–2
Finger trap procedure. *A*: After placement of the penile implant into the corpora, the penis is degloved. *B*: The neurovascular bundle and urethra are dissected free. *C*: Alternating dorsal/ventral and lateral incisions are made in the tunica albuginea, and the penis is telescoped.

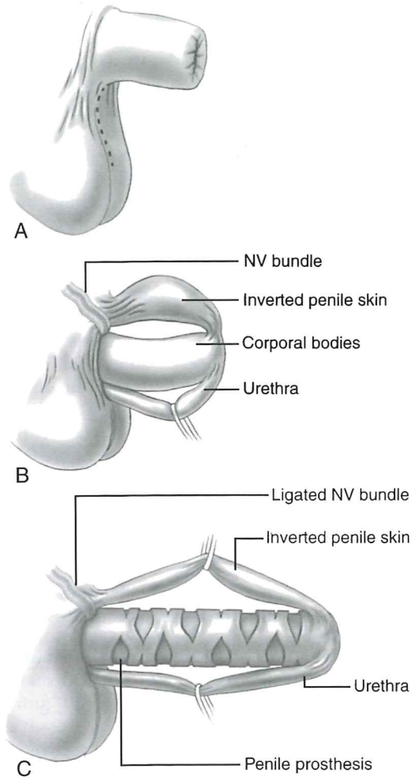


Figure 85–3
Finger trap procedure after partial penectomy. *A*: A scrotal incision is made and the implant placed. *B*: The penis is inverted out of the incision. The neurovascular bundle is dissected free and detached from the distal penectomy scar. The urethra is dissected free. *C*: Alternating dorsal/ventral and lateral incisions are made in the tunica albuginea, and the implant is extended to fit.

supplies the glans penis, which is no longer present, it may be detached distally from the penectomy scar and dissected proximally to give access to the corpora cavernosa. This allows for increased lengthening to the point that the corpora and skin allow.

COMPLICATIONS

Complications include infection, skin sloughing, and penile numbness. We administer preoperative and intraoperative vancomycin and gentamicin intravenously and irrigate generously with antibiotics during the procedure. We do not place a Foley catheter until the end of the procedure to avoid exposing the operative site to seeding of urethra bacteria that have been pulled onto the external Foley catheter. Neuropraxis due to dissection of the neurovascular bundle can last for as long as a year, and permanent numbness or dysesthesia is a risk. Unrealistic expectations on the part of the patient are the most frequent source of dissatisfaction.

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