Current Clinical Urology
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Advanced Male Urethral and Genital Reconstructive Surgery

2nd Edition

Humana Press

Current Clinical Urology

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Editors

Advanced Male Urethral and Genital Reconstructive Surgery

Second Edition

Foreword by Guido Barbagli

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Foreword

This book by Brandes and Morey, I have here the honor to introduce, is an updated text on advanced male urethral and genital reconstructive surgery. Out of 50 chapters, 37 are dedicated to male urethral stricture repair, 10 to complex reconstruction of the male genitalia, and 3 to male urinary incontinence surgery. I was greatly impressed by the list of prestigious authors involved in this project and the number and quality of the topics included in the text. The impact of this textbook on the urological community will be great and important. At the urological meetings and congresses that I have participated in, many requests from an update on urethral and genital reconstructive surgery, prosthesis implants, and more were received. Unfortunately, to date, the urologist's "bread and butter" is based primarily on prostatic cancer and robotic surgery, and, until now, it did not look as if the future offered much of change to this scenario. We need to thank Brandes and Morey who, with this textbook, fill a gap in our scientific knowledge and, more importantly, provide us with the cultural and technical instruments to apply to our daily professional practice, which also includes patients suffering from urethral diseases, genital anomalies, urinary incontinence, or a scarred bladder neck following prostatectomy, robotic also.

Reconstructive urethral surgery can be likened to a fan that ladies of old used to cool themselves: the wider the fan, the greater the effect. With urethral surgery, the wider the choice of techniques, the more stricture disease can be treated. Of course, in our daily practice, we use a standard choice of surgical techniques, but sometimes we are requested to use a nonstandard approach. Urethral stricture is not a homogeneous disease but includes a wide spectrum of different anatomical, pathological, and surgical conditions: from a simple meatal stenosis in patients with failed hypospadias repair, to panurethral disease in patients with genital lichen sclerosus, to complex posterior urethral stricture with a false passage in patients with pelvic trauma. Today, we are able to repair the majority of penile and bulbar urethral strictures using one-stage techniques with oral graft transplants. However, we also sometimes need to rediscover old techniques and old solutions to treat complex cases. Thus the two-stage or staged urethroplasty should not be banished to the attic. Today, oral mucosa is the most popular substitute material used for urethroplasty, but in some patients, the use of genital or extragenital skin should be the preferred choice.

This is the main point of the textbook from Brandes and Morey. This book like the wide open fan presents a wide spectrum of techniques to repair all types of the stricture diseases that the surgeon might confront in daily practice. The textbook is fully illustrated and the techniques are presented step by step. The book clearly shows what the various urethral strictures look like and the surgical techniques to use for repair of these strictures. What approach to take will be determined by you, your experience, your surgical background, and your patient's expectations. Each day, as I enter the operating room, I remember the words of my friend and teacher in surgery and in life, George Webster from the Duke University Medical Center: "No single technique is appropriate for all situations and the successful surgeon will have a repertoire of operations to choose from. While the surgeon's goal is to create a urethral lumen of even caliber, this must not be accomplished at the expense of continence and sexual dysfunction."

These wise words say all that needs to be said.

Arezzo, Italy Guido Barbagli, MD

Preface

We are extremely pleased with the completed version of this unique textbook on advanced male urethral and genital reconstruction. The discipline of male reconstructive urology has expanded beyond merely urethroplasty and penile and scrotal reconstruction; other important related topics include surgery for urinary incontinence, erectile dysfunction, urinary fistulas, priapism, tissue engineering, regenerative medicine, cancer survivorship, and wound healing. The chapters in this book have been contributed by internationally recognized experts, to whom we are most grateful. With their input, our hope has been to create a comprehensive resource which may help to codify, under one cover, the spectrum of surgical challenges faced in a contemporary male reconstructive urologic clinical practice.

As reconstructive urologists, we are fortunate to perform quality of life surgeries that relieve patient suffering. This is truly a privileged and humbling craft which often provides transformative benefits for our patients. Many people see their profession as just a means to pay the bills. For us, it is more of a calling. In the words of Steve Jobs, founder of the Apple computer company:

> You've got to find what you love. And this is as true for your work as it is for your lovers. Your work is going to fill a large part of your life; and the only way to be truly satisfied is to do what you believe is great work. And the only way to do great work is to love what you do. If you have not found it yet, keep looking. Don't settle.

We agree – don't settle – strive for greatness and do what you love.

Reconstructive urology is an evolving field with an international flavor; important innovations have been introduced from all corners of the globe. Many of the procedures highlighted in this book did not exist 10 years ago. We embrace these innovations and encourage an open, reflective mindset – take chances when necessary and do not be afraid to make adjustments as needed for continual improvement, on the wards, clinics, and operating theaters and in your personal life.

One of the chapters in the textbook deals with complications of urethroplasty. While failures are unwanted, we grow by learning from our mistakes, and by making changes, so as not to repeat the same errors in the future. In reconstructive urology, making changes in patient selection, surgical technique, and decision making is an ongoing process.

We are grateful to our families, friends, mentors, colleagues, and trainees for their support and inspiration in the completion of this compendium. In the words of James Joyce from the Dubliners, "[it is far] better to pass boldly into that otherworld in the full glory of some passion, than fade and wither dismally with age." We hope our textbook has helped solidify and strengthen your passion for the craft of male urethral and external genital reconstructive surgery. Enjoy!

St Louis, MO Steven B. Brandes
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1 Decision Making and Surgical Technique in Urethroplasty

Steven B. Brandes

Summary

Surgical technical skills necessary for urethroplasty can be learned fairly quickly by the trainee. The difficult skill to acquire, which often requires years of experience, is proper pre- and intraoperative decision making. Herein we detail how to accurately evaluate urethral strictures by imaging, cystourethroscopy, and physical examination. Operative tricks and tips, patient selection, timing of surgery, patient positioning, and surgical technique specifics are elaborated. Key aspects of anterior and posterior urethroplasty are also detailed.

Introduction

The open surgical repair of urethral strictures has dramatically changed during the last 50 or so years. Today, nearly all urethral strictures, regardless of length, can be reconstructed in a one-stage operation. In patients with a normal penis, the penile skin, urethral plate, corpus spongiosum, and dartos fascia are available for urethral reconstruction. Only a small proportion of patients, who have severely scarred or insufficient local tissues, associated skin infections (or disease), or complex strictures and/or fistula, require a multistaged approach.

The length and location of the urethral stricture, the etiology of the stricture, and the history of previous urethral surgery or instrumentation help one to decide which urethroplasty method to use. Before undertaking urethroplasty surgery, the urologist must be familiar with the use of numerous surgical reconstructive techniques to address any condition of the urethra that might surface at the time of surgery. Oftentimes, the preoperative surgical plan needs to be modified intraoperatively when faced with unexpected findings. Urethroplasty should not be withheld on the basis of age. Elderly men tolerate urethroplasty well and with similarly low complication rates.

Management of urethral strictures should not be considered a reconstructive ladder. The practice of repeat dilations and urethrotomies before considering urethroplasty is antiquated thinking and should be abandoned. The goal of stricture management should be for cure and not just temporary management. Open surgical urethroplasty has excellent long-term success and should be considered the gold standard that all other methods should be judged.

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Preoperative Assessment

The first important step to performing urethroplasty surgery is obtaining accurate preoperative information about the anatomy of the urethral stricture. It is key to know the number of strictures, the location and length of each stricture, etiology and the lumen diameter of each stricture. It is also important to know the functional significance of the stricture and degree of the resulting voiding dysfunction.

Urethral stricture evaluation starts with a flow rate measuring Q_{max} and voided volume. For accurate readings a voided volume of at least 150 mL is preferred. Examine the shape of the tracings. Uroflow tracings that look like a flat mesa are typical of a urethral stricture. A stricture cannot stretch with increasing flow and thus does not give the typical bell-like shape of the normal unobstructed urethra. In the office, we also obtain a postvoid residual by bladder scan and an international prostate symptom score (IPSS) on each patient. A formal ultrasound of the bladder taken to examine bladder wall thickness will help determine the chronicity of the outlet obstruction. In other words, long-standing stricture and outlet obstruction will result in bladder muscle hypertrophy.

Another important means to evaluate the urethral stricture is flexible cystoscopy. A flexible ureteroscope or a pediatric cystoscope is also useful when there is a tight distal stricture and the proximal urethra needs evaluating. We encourage a liberal use of endoscopy to better define confusing urethrography results and to evaluate the pallor of the epithelium and the elasticity or rigidity of the stricture. In general, the worse the spongiofibrosis, the less the distensibility.

Stricture Versus Stricture Disease

A key concept when it comes to managing urethral stenoses is categorizing the stenoses into either “urethral stricture” or “urethral stricture disease.” The two processes of stenoses have different characteristics, extent, and etiology. “Strictures” are typically short, focal, and of an acute nature, such as from an external blow or iatrogenic instrumentation. Here, the injury to the urethra is limited, and thus, the vascularity and general condition of the remaining urethra and spongiosum are typically normal. “Stricture disease” stenoses are typically long, involve broad areas of varying spongiofibrosis, and are typically the result of inflammation or infection, rather than trauma. “Urethral stricture,” therefore, is typically managed by an anastomotic urethroplasty while “stricture disease” by substitution urethroplasty.

Imaging and Cystoscopy Evaluation

Imaging with *both* a retrograde urethrogram and a voiding cystourethrogram is essential. Proper positioning of the patient is vital, so that if the patient is not placed oblique enough, the overall stricture length will be underestimated. When the patient is positioned in the oblique position, sufficiently on his side, the proper image shows only one obturator fossa. We encourage the reader to perform the urethral imaging of one’s patients under fluoroscopy himself, to assure good quality images. We like to use a suction device with an injection port in its center that is placed on the glans penis to perform the retrograde under fluoroscopy. This typically works better than a small Foley catheter in the fossa or a Brodney clamp.

Once the patient’s bladder is full, a voiding study is performed. The retrograde is an anatomical study, while the voiding study is functional. *Both* are needed to adequately assess a stricture. If the stricture is too tight to fill the bladder, a small pediatric feeding or ureteral catheter can be placed to fill the bladder. If a feeding tube cannot be placed, intravenous contrast at roughly 2 mL per kilo is given, the patient forces fluids, and the bladder is allowed to fill over the next hour or so.

From a technical viewpoint, a false stricture at the penoscrotal junction may appear, as the result of external compression from the urinal. This is usually observed in the patient with a short phallus or the obese patient. When measuring the length of a stricture, measure from normal urethral lumen diameter to normal lumen to predict the actual length of graft or flap needed. Most imaging today is digital. Hard copies are usually not produced and, when they are, they are small and not actual size. A useful trick to measuring strictures is to first measure the pubic ramus width, which is typically 2 cm. This distance can then be used as a ruler to estimate stricture length. The other trick is to place a 1-cm radiopaque marker next to the urethra during the actual imaging. It will show up on the final images and can be used as a scale to properly measure stricture length.

When the imaging remains confusing, intraoperative examination under anesthesia with a rigid cystoscope (retrograde) and/or flexible cystoscopy (antegrade) can be very helpful to making an accurate diagnosis and a surgical plan. Cystoscopy is particularly helpful in decision making, as it helps tell if the stricture is near obliterative (usually select an EPA for the urethroplasty), non-obliterative (usually select a substitution urethroplasty), or functionally significant (urethra may be narrow on RUG, but if it accepts a flexible cystoscope, it's *not* functionally significant then). Cystoscopy further helps determine/confirm stricture location, by simultaneously manually compressing the urethra externally and looking with the cystoscope for lumen compression. It is oftentimes difficult to tell a mid- from a distal bulbar stricture on a RUG. For mid-bulbar strictures, we usually perform an EPA or graft (ventral or dorsal), while for a distal bulbar we place the graft dorsal.

We have found urethral evaluation with a pediatric cystoscope particularly useful, especially when stricture length and location are confusing on imaging or when only a RUG and no VCUG could be performed. We have two flexible pediatric cystoscopes by Storz in our outpatient clinic, and as long as the stricture is >8 Fr in diameter, the scope can be passed into the bladder and, under direct vision, determine an accurate measurement of all the white and narrow portions.

Timing of Surgery

Before any urethroplasty is performed, the patient's scar (stricture) should be stable and no longer contracting. Thus, we prefer that the urethra not be instrumented for 3 months before any planned surgery. If the stricture patient goes into urinary retention or requires frequent intermittent self-catheterization, then we typically place a percutaneous suprapubic tube. Proximal urinary diversion will allow for resolution of acute urethral inflammation and allow narrowed areas to declare themselves (urethral rest).

After a previous failed urethroplasty, we generally wait at least 6 months before attempting another open repair. The long time interval is needed for the tissues to soften and become pliable and for the tissue planes to reform. "Redo" surgery at an earlier interval is often very difficult and prone to failure. For the long stricture, it is important that the genital skin is not infected with candidiasis or similar skin disease because it is penile skin that is often used as an onlay flap for long strictures. Here, contemplated urethral reconstruction needs to be postponed until the skin infection resolves.

Positioning

Patient Positioning

To prevent sacral nerve stretch, we use a folded blanket and egg crate mattress to rotate the pelvis in the cephalad direction while in the "social" lithotomy position. Commercially available special tables are also available for this purpose. The patient's legs should be liberally and carefully padded, especially the lateral thigh, to prevent perineal nerve injury and palsy. At all costs, we try to minimize the time our patients are in the exaggerated lithotomy position. We strongly try to limit surgery time to *less than 5 h*, because this seems to be the upper limit for developing severe positioning complications. In general, it takes us roughly 2–3 h for an anastomotic urethroplasty and 3–4 h for a substitution urethroplasty.

Fig. 1.1 Positioning the scrub nurse at the head of table, with the Mayo stand over the chest, facilitates passage of instruments to the surgeon

To hold the legs, we prefer the Yellofin stirrups (Allen Medical, Acton, MA) because of the superb leg support and overall padding, as well as its ability to move the legs up or down during the surgery with ease. Thus, if a buccal graft needs to be harvested, the legs can be taken down during graft harvest, without redraping or prepping.

Scrub Tech Positioning

The scrub nurse should be positioned in front of the surgeon with the Mayo stand over the chest of the patient (Fig. 1.1). The instruments can be passed to the surgeon in this position with ease and so facilitates the overall speed of the operation. If the scrub nurse stands behind the surgeon, it is difficult for the scrub nurse to pass instruments and she cannot assist you in the surgery.

Anterior Urethroplasty

General Concepts

Lighting

A head lamp is very useful to illuminate the deep hole that the perineum can be, particularly for proximal bulbar urethral strictures. Loupe magnification glasses are very useful. I have had a pair of 2.5 power glasses for years and have found that they provide sufficient visualization. We strongly encourage anyone who performs urethroplasty surgery to purchase a pair of surgical loupes, even if one's eyesight is "perfect." It is a worthy investment that you can use throughout one's career. I even use such loupes for my open abdominal reconstructive surgery cases.

Incision

A midline perineal incision and the Lone Star retractor (Cooper Surgical, Trumbull, CT) provide excellent exposure of the bulbar urethra. We have not found the lambda incision or extravagant retractors to be necessary for excellent exposure. For posterior urethroplasty, however, we prefer the Jordan perineal retractor system (C&S Surgical, Slidell, LA) for the Bookwalter. As to length of perineal incision, I have been liberal with the length and typically make the incision from the inferior aspect of the scrotum to roughly 1–2 cm above the anus. In rare circumstances of poor proximal exposure hampered by the incision size, I have extended the incision posteriorly and around the anus.

Intraoperative Endoscopy

With the liberal use of a pediatric cystoscope or flexible ureteroscope, the degree of urethral lumen elasticity and inflammation can be assessed. In general, the worse the spongiofibrosis, the worse the distensibility. Endoscopy is useful for confirming or clarifying urethrography findings and can visually assess urethral mucosa and associated scarring. We perform flexible cystoscopy during every urethroplasty (Fig. 1.2). After the bulbar urethra has been initially exposed, at times it is difficult to determine the location and/or full extent (proximal as well as distal) of the stricture. Oftentimes you can see the urethra transilluminated by the cystoscope light at the distal extent of the stricture. If unclear about the proximal extent of the stricture, a useful trick is to fill the bladder retrograde and percutaneously place a peel-away sheath into the bladder (we prefer the Chiou suprapubic tube kit, Cook Urological (USA)).

Fig. 1.2 Liberal use of intraoperative cystoscopy is essential to urethroplasty success

Antegrade cystoscopy can then be performed. If the scope is too short to reach the proximal stricture, a guidewire can be placed retrograde into the bladder and then grasped with the cystoscope and brought out the SP tract. With thru-and-thru access, a council-tip Foley can then be placed antegrade and retrograde. Palpating the ends of each of the catheters will give you the true length and extent of the stricture.

Other reasons we do intraop cystoscopy are to look for a secondary stricture, radiolucent bladder stone and to assess the quality and color of the remaining urethra – or in confusing anatomical situations, such as a urethral false passage or diverticulum. If the urethral epithelium is white and blanched, we will typically extend the urethrotomy until healthy-appearing pink epithelium is reached. Another important trick is that if we plan on doing a substitution urethroplasty, before performing the urethrotomy (ventral or dorsal, no matter), we routinely cystoscope the urethra and place a guidewire into the bladder. With the guidewire in place, you can guarantee that you can find the urethral plate (by palpation) and that it is being opened like a book, in the proper plane.

Urethral Mucosal Staining

Urethral injection of relatively pure methylene blue to stain the mucosa can be a very useful tool to facilitate proper suturing of mucosa to mucosa. Technically, we inject the blue dye with a catheter tip syringe into the penis and place a penile clamp to prevent leakage of the dye. Upon performing the urethrotomy, the mucosa will be stained blue. The strictured mucosa typically takes up the dye less (less blue stained) than the normal mucosa and thus can occasionally be used as a way to distinguish the margins between scarred and totally normal mucosa. Moreover, since the spongiosum is white to pink, the same color as the urethral plate, the anatomical margins can be difficult to distinguish from each other. A blue mucosa facilitates proper placement of sutures.

Urethral Vascular Control

Oftentimes, when performing a urethral stricture excision and primary anastomosis, the cut ends of the nonscarred urethra bleed aggressively. A safe and effective way to control this bleeding is to place noncrushing straight "bulldog" vascular clamps on the proximal and distal aspects of the urethra. Only in a bloodless field can suturing be performed accurately and with leisure.

Bipolar Electrocautery

Dissection of the urethra off the corporal cavernosal bodies can be tricky. There are many perforating vessels between the urethra and corporal body every centimeter or so. Liberal use of bipolar cautery will provide good hemostasis. We like to use the bayonet style with wide blades. Do not use unipolar cautery. We feel it unduly risks nerve or vessel injury that may affect penile sensation or sexual function.

Urethral Mobilization

The penile urethra is typically fairly adherent to the corpora. The urethra can be best separated from the corpora by a "split-and-roll" dissection method. This method is similar to the dissection technique one uses for vena caval mobilization for a retroperitoneal lymph node dissection for testis cancer. This is why we jokingly refer to the urethra as the "pena cava." To mobilize the proximal bulb effectively, first the bulbospongiosus muscle fibers should be removed sharply and bluntly off the tunica of the bulb, from medial to lateral. Once the spongiosis muscle is opened "like a book," the attachments to the perineal body need to be divided. Typicality, we incise these attachments with scissors directly posteriorly, while holding anterior countertraction on the bulb with forceps. This method will avoid accidentally injuring the tunica of the spongiosum with resultant brisk bleeding. For a tension-free anastomosis, the urethra typically needs to be mobilized so that the cut edges overlap by 2 cm (1-cm spatulation each, for the proximal and distal ends).

Urethral Elasticity

In his seminal work on fresh cadavers, Francisco Sampaio and colleagues detailed the inherent elastic nature of the urethra and corpus spongiosum. With 25 fresh cadavers, penile extensibility was noted to be 51.1 ± 7 %, whereas mean urethral extensibility was 66.2 ± 7.2 %. Urethral extensibility was to the same degree for each urethral segment (namely, penile, bulbar, and membranous urethra). Maximal stretched urethral length without penile curvature with artificial erection was also calculated to a constant factor of 75.2 %. They further calculated that to bridge each gap of 1 cm of excised urethra, the remaining normal urethra would have to be mobilized at least 4 cm (4:1 ratio). This ratio of mobilization to bridge a gap changes with age, from a low of 1:3.2 for a 1-year-old child up to 1:6.6 for a 70-years-old man. In other words, penile and urethral extensibility reduces with advancing age (Fig. 1.3).

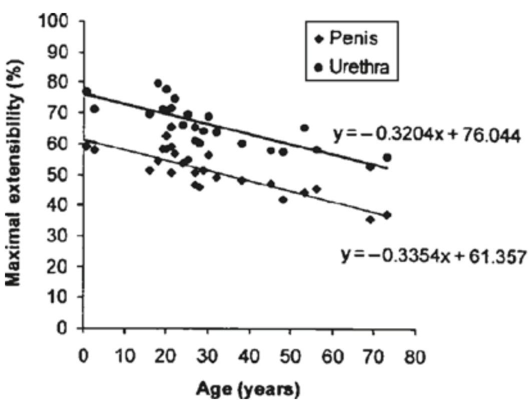

Fig. 1.3 Correlation of urethral and penile extensibility. Note that extensibility of the mobilized urethra is significantly longer than penile extensibility, as well as intervariability by patient age (From DaSilva and Sampaio [1])

Straightening the Urethra (Shortening the Gap)

Anatomically the urethra is "S" shaped and makes a natural curve in the bulb around the pubic bone and corpora of the penis. The shortest path between two points is obviously a straight line. By mobilizing the urethra and making the urethra lie into a straight line, the excised gap in the urethra can be bridged (Fig. 1.4). This technique of straightening out the urethra is the key principle used with the progressive approach to posterior urethroplasty. Here, the urethra is straightened by the sequential methods of splitting the corpora (developing the intercrural plane), performing an inferior pubectomy, or, in extreme cases, rerouting the urethra around the superior pubic ramus. Each step helps to make the urethra progressively straighter and thus progressively shortens the gap between the two ends of the urethra.

Urethral Calibration

Sound each of the cut ends of the urethra with bougie à boules to calibrate urethral size for proper and adequate spatulation, as well as to diagnose any secondary stricture up- or downstream from the main

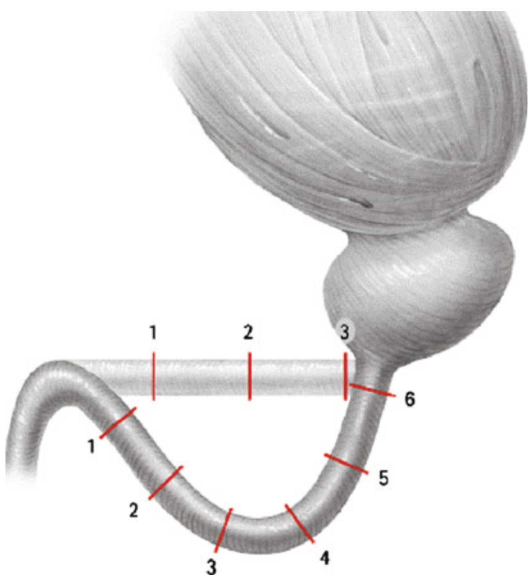

Fig. 1.4 Straightening of the natural curve of the bulbar urethra will help shorten the distance between the cut ends of the urethra by an additional 2–4 cm (From Mundy [2])

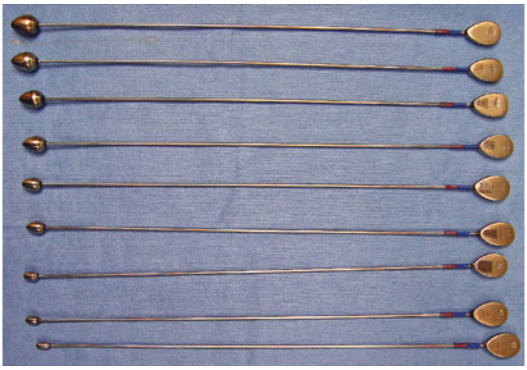

Fig. 1.5 Bougie à boules are essential to accurately calibrate and thus to adequately spatulate the urethra

stricture bougie to 24 French for the penile urethra and to 36 French for the bulbar urethra (Fig. 1.5).

Urethral Orientation

Once the urethra is mobilized and excised, place stay sutures at the 3 and 9 o'clock positions in each of the cut ends of the urethra. This will greatly facilitate urethra orientation for proper spatulation and for subsequent suturing. For proximal bulbar or posterior urethra anastomotic urethroplasty, we typically use numbered mosquitoes (1 through 12, which correspond to the same location on the clock). This helps prevent the sutures from being tangled (Fig. 1.10).

Specific Methods

Anastomotic Urethroplasty

Whenever possible, anastomotic urethroplasty is the preferred method of urethral reconstruction, because of its high success rate and durability. However, in young patients with bulbar urethral strictures that are of a nontraumatic etiology, I have been doing many more graft reconstructions lately, as I am concerned about potential sexual side effects as to erection and glans sensation.

The successful bridging of the gap of excised tissue and performance of a tension-free anastomotic urethroplasty are dependent on urethral mobilization and inherent tissue elasticity to increase the urethra's overall length. The other means to bring the two cut edges together is to shorten the distance between them, by straightening out the urethra. Generally, we perform anastomotic urethroplasty only for bulbar strictures proximal to the suspensory ligament and less than 3 cm in length.

In a brief urethral length study we conducted on US patients with non-strictured urethras (mean age 55 years), the normal anatomical dimensions of the male urethra are as follows:

Anatomical lengths of the male urethra

Urethral segment	Mean length ± 1 SD (cm)
Total length	25.5 ± 3.2
Penile	12.0 ± 1.6
Bulbar	7.5 ± 1.4
Membranous	2.5 ± 0.6
Prostatic	3.4 ± 1.1

The elasticity of the urethra has been shown to be on average up to 66 % in fresh cadavers. Thus, complete mobilization and stretch of the bulbar urethra (mean length 7.5 cm) should be able to bridge a maximum gap length of 5.0 ± 0.9 cm. Considering 1-cm urethral spatulation on each end, this results in a maximum stricture length of about 4 ± 0.9 cm for bulbar anastomotic urethroplasty. The more distal the stricture is in the bulbar urethra, the shorter the gap that can be bridged – and the corollary, the more proximal the stricture, the longer the gap that can be bridged.

Primary anastomosis for strictures of the penile urethra (distal to the suspensory ligament) typically risks bothersome chordee and should generally be avoided. Furthermore, extensive distal urethral dissection, beyond the suspensory ligament, risks penile tethering or urethral bowstringing of the penis. Degrees of penile tethering range from a minor, straight erection that points down to a more major, significant ventral chordee. To achieve a successful and durable urethroplasty result is a difficult undertaking, and thus, we would never entertain taking down the anastomosis to correct chordee. Instead, such ventral chordee can be corrected by taking down the suspensory ligament in a secondary operation. By dividing the fulcrum where the penis is

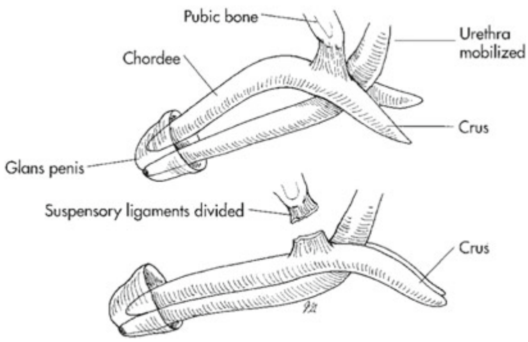

Fig. 1.6 Correction of iatrogenic chordee with suspensory ligament release (From Yu and Miller [3])

being held in position helps to straighten it (Fig. 1.6).

When the stricture is very proximal, depending on patient anatomy, strictures longer than 3 cm can often be bridged. Morey has suggested that the length of stenoses that can be bridged can be extended, based on whether the stricture is in the proximal or distal bulbar urethra and based on patient stretched penile length. The longer the patient's stretched penile urethral lengths (>15 cm) and stenoses in the proximal bulb, the longer the bulbar gap that can be bridged. Patients with short stretched penile lengths (<15 cm) and distal bulbar stenoses are often better managed by a substitution urethroplasty. This makes intuitive sense if urethral dissection is carried distal to the suspensory ligament. Overall, the true limitations to bridging the gap are the length of the bulbar urethra, its elasticity, and the location of the stricture.

Substitution Urethroplasty and "Stricture Disease"

When the stricture is too long for stricture excision and primary anastomosis, a patch or flap of substitute material is interposed. The characteristics of the urethra of the patient who needs to undergo urethral substitution surgery are very different from the urethra of anastomotic urethroplasty. Here, the stenoses are just a manifestation of "urethral stricture disease" where the majority of the urethra is potentially "diseased" and the

Table 1.1 Stricture rates after anastomotic and substitution urethroplasty

	1 year	5 years	10 years	15 years
Anastomotic (%)	7	12	13	14
Substitution (%)	12	21	30	42

Redrawn from Andrich et al. [4]

Table 1.2 Complications reported after substitution and anastomotic urethroplasty

	Substitution (%)	Anastomotic
Postvoid dribbling	28	–
Diverticulum/pouch	12	–
Urinary tract infection	5	–
Chordee	3	–
Urethrocutaneous fistula	3	–
Impotence	2	5 %
Total	33	5 %

Redrawn from Andrich et al. [4]

blood supply compromised in other areas of the urethra, proximal or distal to the obvious stricture. This distinction between "stricture" and "stricture disease" helps to explain the success and durability of anastomotic urethroplasty, whereas substitution urethroplasty, whatever material used, has consistent and progressive long-term recurrence.

As detailed in Table 1.1, it is evident that anastomotic urethroplasty is highly successful and durable. In contrast, substitution urethroplasty has progressive and ever-increasing rates of failure with time (even up to 15 years after surgery). The debate about the type, whether a flap or a graft should be used in the reconstruction, is thus often moot. Aside from having better and more durable success, anastomotic urethroplasty also has fewer complications than substitution urethroplasty. See chapter 21 in this text on Complications by Shenfeld, as well as Table 1.2, comparing the complication rates from a single institution in England.

Substitution urethroplasty entails three different surgical methods: (1) urethral stricture excision and missing segment replacement with an augmented anastomosis (a spatulated anastomosis on one side and on the other, a graft or flap),

(2) urethral stricture excision and missing segment replacement with a combination of a graft (dorsal) and a flap or graft (ventral), or (3) stricture incision (urethrotomy) either ventral or dorsal and patch the defect with an onlay graft or flap.

Flaps and Grafts

Penile skin flaps rely on the rich vascular collaterals within the tunica dartos for its blood supply. The anterior lamella of Buck's fascia is elevated to ensure taking the entire dartos. Elevation is basically along avascular planes and thus bloodless. Skin island flaps are versatile and can be mobilized to all areas of the anterior urethra. In general, make the flap at least 2 cm in width to insure that the final caliber of the reconstructed urethra is roughly 24 French, assuming the urethral plate is at least 0.5–1 cm in width, for a total circumference of 2.5–3 cm. When it comes to substitution urethroplasty, one-stage tube grafts or flaps should be avoided, due to their general lack of success and durability. Depending on the location and the length of the stricture, flaps can be ventral longitudinal (for the pendulous urethra), ventral transverse (for fossa strictures), or transverse circumferential (for all aspects of the anterior urethra) and rotated to reach the defect. Proper mobilization will not put the flap on tension or cause penile torsion. From a practical viewpoint, when suturing the flap or graft to the open urethral plate, it is essential to keep both the penis and the substitution material on stretch. Keeping the tissue stretched with traction and countertraction avoids the complications of sacculations and diverticula, which are prone to secondary infection and bothersome postvoid dribbling.

For substitution urethroplasty, there appears to be no advantage of using a flap over a graft when it comes to restricture rate. In fact, to date, there is no comparative, randomized prospective trial when it comes to comparing flaps or grafts. In general, grafts are quicker and easier to harvest and have less harvest donor site morbidity than flaps. For these reasons, buccal mucosa grafts are very popular and are the current substitution material of choice. In Wessells and McAninch's [5] review and meta-analysis of 26 urethroplasty series, the restricture rates for grafts and flaps were not significantly different (15.7 and 14.5 %, respectively). Urethral restricture rates seem to be highest for scrotal flaps and extragenital skin grafts and the lowest for posterior auricular grafts, buccal mucosa grafts, and penile skin flaps. Other distinct disadvantages of scrotal skin over penile skin are that it is more difficult to work with, tends to contact (more prone to sacculation), has a unilateral blood supply, and success rates are also worse. In cases of bulbar strictures where there is inadequate penile skin or graft material, we therefore highly discourage the temptation to use a local scrotal skin flap; instead, we prefer a staged urethroplasty in such rare situations.

Buccal mucosa is currently the most popular substitution tissue in urethroplasty surgery. Buccal mucosa is the current preferred graft material because it can be quickly and easily harvested; is readily available; is tough and resilient to handling; can be harvested from either cheek in large-sized grafts; contracts little and has a high degree of "take" (epithelium is thick and elastin rich, whereas the lamina propria is thin and highly vascular), minimal donor site morbidity, and concealed donor site scar; possesses antibacterial and anti-infective properties; thrives in a wet/moist environment; and is often resistant to skin diseases. It is clearly an ideal graft material and we employ it almost exclusively.

Does Location of Buccal Graft Placement (Dorsal or Ventral) Really Make Any Difference?

Theoretically, yes. In practice, not really. Admittedly, dorsal graft placement usually has less blood loss and avoids sacculations yet has the same relative long-term stricture-free rates and the same complication rates of postvoid dribbling (1 in 5) as ventral grafts. Ventral grafts, on the other hand, require less urethral dissection and mobilization and are thus technically easier. Ventral versus dorsal is more a matter of surgeon preference. For proximal bulbar strictures, we prefer ventral buccal graft placement because dorsal grafts are typically more technically difficult to sew in a deep and proximal wound. However, in all other areas of the urethra, we prefer dorsal buccal graft placement. For the distal bulbar urethra and penile urethra, the spongiosum is typically not sufficient (too small) to cover the graft and give it proper blood supply. We place our grafts here dorsally spread fixed and quilted to the vascular corpus as the urethra is progressively more dorsal within the corpus spongiosum, the more proximal. Regardless of where the graft is placed, many patients will have some postoperative minor postcoital semen pooling and postvoid dribbling. Clearly, the keys are proper tailoring, proper defatting and preparation of the graft, placing the graft in a vascular bed, and keeping the graft fixed and in apposition to the host bed. As to the harvest site, we prefer the inner cheek and strongly discourage the use of the inner lip. With lower lip harvest there is a greater likelihood for troublesome neurosensory complications, such as persistent pain and/or perioral numbness. The lip mucosa is also more flimsy and less robust than cheek mucosa.

Buccal Graft Harvest: Technique Specifics

Before surgery, we always examine the mouth for mucosal lesions like ulcerations or lichen planus. Patients with poor dentition or who use tobacco chew are more likely to have mucosal disease. Our only cases where the harvested buccal graft had no structural integrity and fell apart are those who chew or with lichen planus. We would exclude such patients from buccal mucosal harvest. As to the harvest technique, we first have the anesthetist tape the endotracheal tube to one side. Nasotracheal intubation is unnecessary and we have had many patients with nasal erosions and complaints of nasal pain after surgery, so we have stopped this practice. At first we wash the face and inner mouth with 1 % hydrogen peroxide. This type of prep is more than adequate, for when our ENT colleagues harvest the buccal mucosa, many of them do not use a skin preparation at all. As to preoperative antibiotics, at one time we were giving intravenous penicillin but are now giving just cefazolin, a first-generation cephalosporin. First, we pack the tongue medially with a 4×4 gauze, mark Stensen's duct with a marking pen, and place stay sutures of 2-0 Prolene, 2 cm lateral and 1 cm posterior from the vermillion of the mouth. We then place a Steinhauser buccal mucosal stretcher (Walter Lorenz, Florida (USA)) on the cheek. We have modified the Steinhauser with a weight on the end (as in the manner of a weighted vaginal speculum) so it further can self-hold the mouth open. We then place a mouth prop in the midline and mark a fusiform-shaped graft roughly 2×5 cm, careful to make the cephalad margin away from Stensen's duct. The anterior margin of the graft is roughly 1 cm from the vermillion, so as to avoid the possibility of skin retraction and esthetic problems. With a 22-gauge spinal needle, we inject 10–20 mL of 1:100,000 epinephrine solution as a submucosal wheel. Waiting a few minutes after injection before dissection allows for excellent hemostasis. Pesky bleeding can be easily controlled with bipolar electrocautery. Since the facial nerves are in proximity, it is unwise to use monopolar energy here. We place two stay sutures of 3-0 chromic on the corners of the graft and then use a no. 15 blade to harvest the graft superficial to the buccinator muscle. With the stay sutures giving traction, an index finger and a gauze soaked in epinephrine solution give countertraction. Once the graft is harvested, we pack the mouth with epinephrine-soaked gauze to facilitate hemostasis. On the back table, we defat the graft with the midportion of the Metzenbaum scissors and cut while pressing the blades against an index finger. This removes the bulk of fat. The graft is then pinned to a vein board or silicone block (alternative: the needle counter foam pad) and scraped with the edge of a no. 15 blade. This emulsifies any residual fat. The graft is sufficiently thinned when newsprint lettering can be visible through the graft. The graft is particularly resistant to infection and skin diseases. While it seems counterintuitive to take the "dirty" buccal graft and sew it in to a sterile penile or perineal wound, they all seem to do fine. In fact, we have accidentally dropped a buccal graft or two onto the operating room floor over the years. We implanted these grafts successfully and did they not develop a wound or urinary tract infection. As to the harvest site, many report today that they leave the mucosa open and allow it to heal by secondary intention.

Many claim that the oral and perioral side effects are less. The main disadvantage of not closing the mucosa is that it precludes future buccal graft re-harvest, for repeat urethroplasty. As an alternative to leaving the site open, some sew a graft of AlloDerm, an acellular dermal matrix to promote epithelialization. Instead, we prefer to reapproximate the mucosa with a few interrupted 3-0 chromic sutures, with a single skin hook giving traction at the distal end. The fusiform harvest shape of the graft and width of 2–2.5 cm facilitates closure. We harvest grafts >2.5 cm in width for a staged urethroplasty – such defects are typically too wide and under too much tension, so we leave these open and allow for secondary intention. Postoperatively, we have the patients swish and spit with a mouthwash four times a day. Although we typically use the prescription Peridex (chlorhexidine gluconate 0.12 % oral rinse), we have also had good success with over-the-counter mouthwashes.

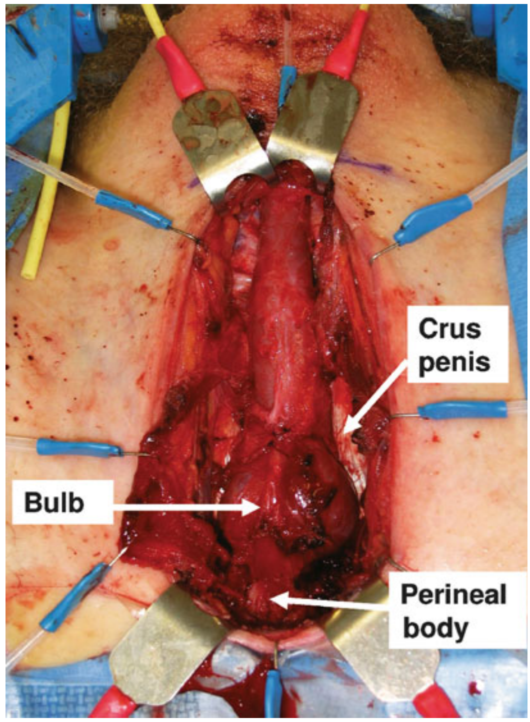

Fig. 1.7 Excellent exposure of the entire bulbar urethra via a midline incision and Lone Star retractor

Posterior Urethroplasty

Posterior urethral stenosis is not a true "stricture" but instead is scar tissue that fills the gap created by the distracted ends of the urethra. In contrast, anterior urethral stricture is an epithelial scar tissue that contracts in length and width, with varying degrees of spongiofibrosis. Posterior urethroplasty is "urethral flap advancement surgery" that relies on bipedal corpus spongiosal blood supply. With the stricture being so proximal, the length of the urethral flap can be relatively long, up to the suspensory ligament, being 6 cm or more. Detached from its proximal vascular supply, the urethra is solely dependent on distal retrograde blood flow. It is not surprising then that patients with compromised retrograde flow, such as can occur with the impotent (symptom of potential penile vascular insufficiency) or hypospadiac patient, or with excessive distal urethral mobilization have lower rates of anastomotic surgical success. Overall, the excellent efficacy and long-term durability rates reported for posterior urethral reconstruction are another example that stricture excision and primary anastomosis is always the preferred method, over a tissue "substitution" urethroplasty.

Technical and Surgical Specifics

First, we make a midline perineal incision from just anterior to the anus up to the scrotal margin. We can typically achieve excellent exposure of the urethra and do not consider a lambda incision necessary (Fig. 1.7). While we have had good success with just the Lone Star retractor system, the Jordan Perineal Retractor System for the Bookwalter provides excellent and superior exposure for posterior urethroplasty. When using this system, mobilize the urethra from the perineal membrane till the penoscrotal junction. Do not mobilize the urethra distal to suspensory ligament; otherwise, you risk creating iatrogenic chordee. Mobilize the entire bulb and separate the bulb from the perineal body and rectum posteriorly. We typically use bipolar electrocautery liberally here to control pesky bleeding from small perforating vessel branches or from the bulbospongiosus muscle.

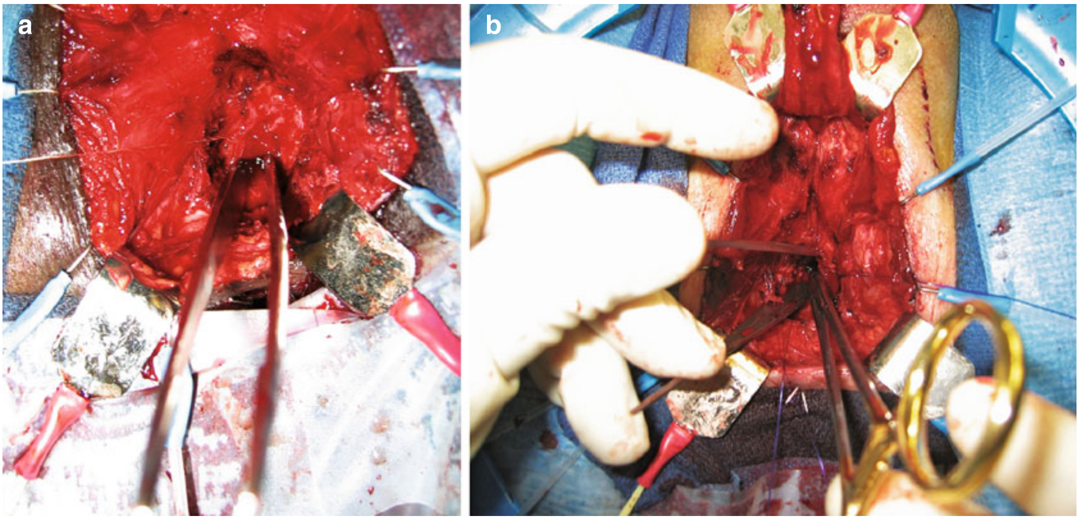

Fig. 1.8 (**a**, **b**) DeBakey forceps placed "backwards" into the prostatic urethra to facilitate suturing

We try to avoid using monopolar electrocautery out of concern of electrical scatter and potential injury to the nervous and vascular supply to the penis for tumescence. Then, place a hard 22-French Robnel catheter and palpate the proximal end of stricture. Transect the urethra just proximal to the palpable end of the Robnel with Mayo scissors. The urethra should not bleed too much if the cut is made through the scar. The bulbar arteries are usually obliterated already from the prior pelvic fracture. However, the bulbar urethra can bleed quite briskly, if the cut is not through the scar or if the bulbar arteries are intact. Once the urethra is transected, pack the fossa to temporarily control bleeding and then oversew any bleeding bulbar arteries. Place a 24-French Van Buren sound via the SP tract and into the prostatic fossa and incise onto the palpable end of sound (use a scalpel). If the sound cannot be felt confidently, we typically perform antegrade cystoscopy or open the bladder. A useful trick to confirm you are at the level of the veru is to blindly place a spinal needle through the scar and look antegrade to confirm its location – then use the needle as a guide for scar excision. When the sound cannot be felt, it generally suggests that the stricture is long or the prostate is displaced off the midline. We also typically inject methylene blue via the Robnel to stain the distal urethral mucosa prior to transection.

Scar tissue around the sound is then excised sharply until the tissue is palpably supple and the antegrade-placed sound can be easily rotated in all directions. Spatulate the prostatic/membranous urethra at 6 o'clock till the back handle of a DeBakey forceps or long nosed nasal speculum can fit easily into the urethra (Fig. 1.8a). The verumontanum can usually be easily seen at this time. To perform the anastomosis, we typically place eight sutures in the proximal urethra. Holding the end of the nasal speculum or the DeBakey forceps open will facilitate suture placement (Fig. 1.8b). We first place sutures at 12, 6, 3, and 9 o'clock and then place another four sutures in between. We prefer 4-0 PDS and usually bend the RB needle into a "ski" needle to facilitate suture placement (Fig. 1.9). We serially place numbered labeled mosquitoes on all the sutures to enable proper orientation (Fig. 1.10). We first place 1/2 the sutures into the distal urethra in numerical order, in clockwise fashion (e.g., start at 12 o'clock proximal and sew to 6 o'clock distal); place the 16 F silicone Foley; and then place the other 1/2 of sutures counterclockwise. The sutures are then serially tied in numerical order, in the same order they were placed. Turner-Warwick-isms we have not found useful are complex acronyms, 12-French fenestrated catheter, lambda-shaped perineal incision, and his "specialty" instruments and needle drivers.

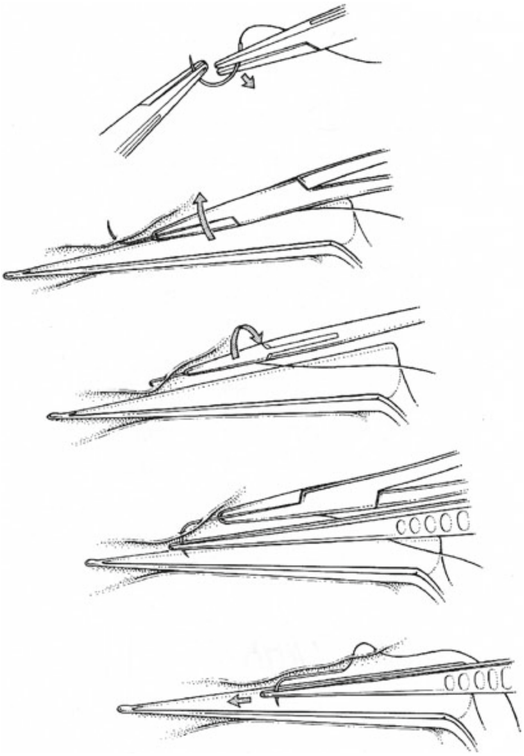

Fig. 1.9 The "ski" needle and DeBakey forceps (alternative, gorget) are useful to facilitate proximal sutures placement (From Mundy [6])

Fig. 1.10 Serially numbered mosquito clamps (1–12) to facilitate suture orientation

In 1983, Webster popularized an elaborated perineal approach for reconstruction of pelvic fracture-related urethral distraction injuries wherein urethral mobilization is augmented as needed by progressing through the additional steps of corporal splitting, inferior pubectomy, and urethral rerouting. We have found urethral rerouting to have a limited role and instead believe that liberal urethral mobilization and corporal splitting alone are usually sufficient to bridge the gap. Moreover, most posterior urethral strictures are typically no more than 2–3 cm in length and, thus, the limits of the progressive approach are usually not required. To split the corpora, we incise the ventral Buck's fascia overlying the pubic bone with a scalpel and then bluntly spread with a wide right angle to get in to the a vascular plane. We typically only split the corpora 1/2 to the top of the pubic bone, because any more distal, there are too many intercommunications and risks pesky bleeding and potential ED.

Informed Consent

An essential aspect of surgical planning is an informed consent discussion with the patient about the risks and benefits of the procedure. When it comes to posterior urethroplasty, we tell each of our patients that the potential surgical side effects are stress urinary incontinence (minor degree, relatively common [up to 36 %], whereas bothersome to more severe incontinence is rare [roughly 2 %], urgency to void is common [up to 66 %], temporary impotence is not uncommon [up to 26 %], permanent impotence is very rare [0–7 % depending on the series]) and positioning complications from being in lithotomy (such as perineal nerve palsy and sacral nerve stretch), also rare. We also quote to outpatients that long-term, durable success with posterior urethroplasty is roughly 85 %.

Preferred Surgical Instruments of SB Brandes

Instruments

1. Yellofin stirrups
2. 3M irrigation pouch, "Steri-Drape" #1016. Suction tubing to bottom of pouch
3. Bipolar, wide-tip cautery

4. Baby Yankauer-type suction, "Andrews" sucker
5. Bougie à boules from 10 to 32 F
6. Lone Star retractor, #3308 (large ring), and corresponding hook: blue ("dura") hooks, #3311 (5 mm)×6, and four-arm yellow hooks, #3334 (14×20 mm)×4 (Cooper Surgical, Trumbull, CT)
7. 18 F Robnel catheter
8. Stevens tenotomy scissors, 6"
9. 0.5 Castro toothed forceps×2
10. Jerold's forceps with teeth×2
11. Van Buren sounds 20–32 F
12. Steinhauser mouth retractor/mucosal stretcher (Walter Lorenz Surgical Instruments, #01- and mouth prop, and 1.5" Deaver retractor)
13. Foam pad from needle counter or vein board
14. Jogenson scissors (for proximal bulbar and membranous urethral dissection)
15. Jordan Perineal Bookwalter Retractor
16. Long nosed nasal speculum
17. Flexible cystoscope and Benson guidewire
18. Methylene blue
19. 12 numbered mosquito clamps

Suture
1. 2-0 Prolene (polypropylene), SH needle, tapered (for glans penis traction or vermillion of mouth)
2. 4-0 chromic, RB-1, tapered
3. 4-0 PDS, tapered, single armed, RB-1 (purple dyed)
4. 16 F silicone Foley for bulbar urethroplasty and 12 F for penile urethroplasty
5. 2-0 Vicryl (polyglactin), SH needle, tapered; 3-0 Vicryl (polyglactin), SH needle, tapered; and 3-0 chromic, SH needle, tapered

Editorial Comment

One of the enjoyable aspects of urethral reconstruction surgery is the creative nature of the process. Each patient presents a unique history, anatomy, and nature of disease. Excellent success rates can be achieved with careful technique, clinical acumen, and adherence to several basic principles. While we recognize the regional variation intrinsic to urethroplasty centers around the world, our take-home messages are as humbly offered as follows:

1. Many patients referred in for treatment have indwelling catheters, are self-catheterizing, or are recovering from some other recent endoscopic intervention. We believe it is critical to "prepare the battlefield" by allowing for at least 2 months of urethral rest prior to urethral reconstruction. Only then can severe or synchronous strictures be manifested and addressed accurately.
2. The first step of every urethroplasty should be cystourethroscopy. We do not routinely perform endoscopy on stricture patients in the office because of the time and discomfort involved. But looking in at the beginning of the case is a very good habit to ensure that the anatomy matches the films, to assess the stricture severity and verify the need for open surgery, to direct the location of the incision, and to avoid unnecessary trauma to the urethra.
3. We prefer stricture excision over grafting when possible. While no operation has the same level of success as excision with primary anastomosis, consideration of stricture location is paramount. EPA can be safely applied for short (≤1 cm) traumatic strictures in the penoscrotal area or long strictures (2–4 cm) of the proximal bulb in the vast majority of men. These patients are always happy when you tell them that you did not need to cut into their cheek for tissue and that the success rate is over 95 %. Anything in between and you should probably employ a limit of 2 cm for what you can safely excise.
4. Penile skin grafts are as good as, and often more convenient than, buccal mucosa grafts. If we only need 1–3 cm of tissue for an onlay graft, we prefer to use a small elliptical "mini-patch" of lateral distal penile shaft skin. The results are equivalent and the harvesting process is much easier. Buccal grafts are preferred when ≥3 cm is needed due to their superior handling characteristics.
5. We do not subscribe to the classic "elaborated" approach for posterior urethroplasty – nearly all can be successfully reconstructed by EPA with

liberal urethral mobilization. We have simply not needed to divide the corpora and/or reroute the urethra, and we prefer avoiding these steps due to the additional time and trauma they entail. Having said that, for reconstruction of deep bulbomembranous stenosis (usually after pelvic fracture), a deep "12 o'clock cut" between the corpora directly onto the inferior pubis is often critical to provide the proximal exposure one needs to excise the scar adequately. For deep proximal cases, we prefer the precision of smaller needles such as RB-2 or TF needles rather than longer RB-1 "ski" needles.

–Allen F. Morey, MD

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2 Male Urethra and External Genitalia Anatomy

Peter A. Humphrey

Summary

An intimate knowledge of male external genitalia and urethral anatomy is essential for successful surgical management of male urethral strictures, fistulas, and other anomalies. Of particular importance for urethral reconstruction is the prepuce, a mixture of skin and mucosa and anatomically divided into five layers – epidermis, dermis, dartos, lamina propria, and epithelium. The urethra is divided into the anterior (bulbar, pendulous, and fossa navicularis) and the posterior (membranous and prostatic). Urethral epithelium transitions from urothelial (transitional cell) (proximal) to pseudostratified or stratified columnar (distal), and then onto squamous (meatus). Location of the urethra within the spongiosum is also clinically important, where the more proximal (bulbar) the more eccentric and ventral.

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Male Urethra

The male urethra may be divided into proximal (posterior) and distal (anterior) segments [1–6]. The proximal segment is comprised of prostatic and membranous portions, while the distal segment is made up of bulbous and penile (pendulous) segments (Fig. 2.1). The prostatic urethra is 3–4 cm in length, is formed at the bladder neck, turns anteriorly 35° at its midpoint (the urethral angle), and exits the prostate at the apex, where it is continuous with the membranous urethra. The urethral angle divides the prostatic urethra into proximal (so-called preprostatic) and distal (so-called prostatic) segments. The transition zone of the prostate wraps around the proximal urethra. The main prostatic ducts from this zone drain into posterolateral recesses of the urethra at a point just proximal to the urethral angle. Beyond the angle, ejaculatory ducts and ducts from the central prostatic zone empty at the posterior urethral protuberance known as the verumontanum. At the apex of the verumontanum, the slit-like orifice of the prostatic utricle, a 6 mm Müllerian remnant that is a saclike structure, may be found. Ducts from the peripheral zone of the prostate empty into posterior urethral recesses in grooves in a double row from the verumontanum to the prostatic apex. Histologically, the surface epithelial lining of the prostatic urethra is predominately urothelial

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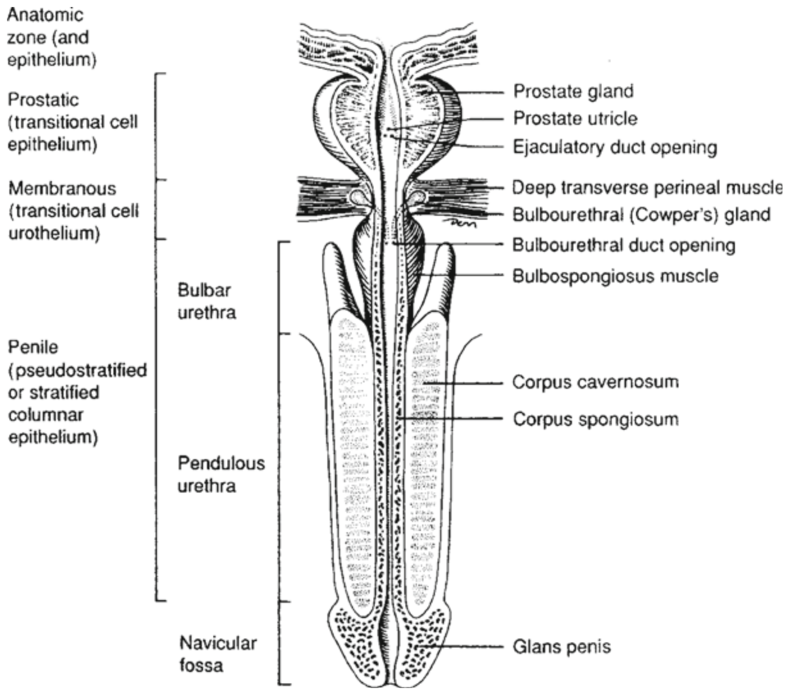


Fig. 2.1 Anatomy of the male urethra (From Carroll and Dixon [12])

(transitional cell), although prostatic epithelium may also be found.

The membranous urethra, at 2–2.5 cm in length, is the shortest segment of the male urethra. It is lined by stratified/pseudostratified columnar epithelium and is surrounded by skeletal muscle fibers of the urogenital diaphragm (external urethral sphincter).

The bulbous urethra is 3–4 cm in length, has a larger luminal caliber than the prostatic or membranous urethra, and extends in the root of the penis within the bulb of the corpus spongiosum from the distal margin of the urogenital diaphragm to the penile urethra (Fig. 2.2). The lining epithelium is identical to that of the membranous urethra, being of a stratified/pseudostratified type. The ducts of Cowper's (bulbourethral) glands, which are embedded in the urogenital diaphragm, open into the posterior aspect of the bulbous urethra. Mucin-secreting Littre's glands can also be found in the walls of the bulbous urethra (Fig. 2.3).

The penile urethra is of about 15 cm in length and extends to the tip of the glans penis at the urethral meatus. It is surrounded in its entire length by the corpus spongiosum. The distal 4–6 cm of the prostatic urethra is a saccular dilatation termed the fossa navicularis that terminates at the urethral meatus. Recesses called lacunae of Morgagni that extend into Littre's glands are found in the lateral walls of the penile urethra.

There are five anatomical levels of the distal (anterior) urethra (Fig. 2.4): urethral epithelium, lamina propria, corpus spongiosum, tunica albuginea, and Buck's fascia [1, 2]. Most of the penile urethral lining is a stratified/pseudostratified columnar epithelium, whereas the distal penile urethra, including the fossa navicularis, is lined by ciliated stratified columnar epithelium or stratified nonkeratinizing squamous epithelium. The lamina propria of the penile urethra is a fibroconnective tissue with elastic fibers and scattered, longitudinally oriented smooth muscle.

Lymphatic drainage of the prostate and bulbomembranous urethra is into the obturator and external iliac nodes, while the drainage from the penile urethra is into the superficial inguinal

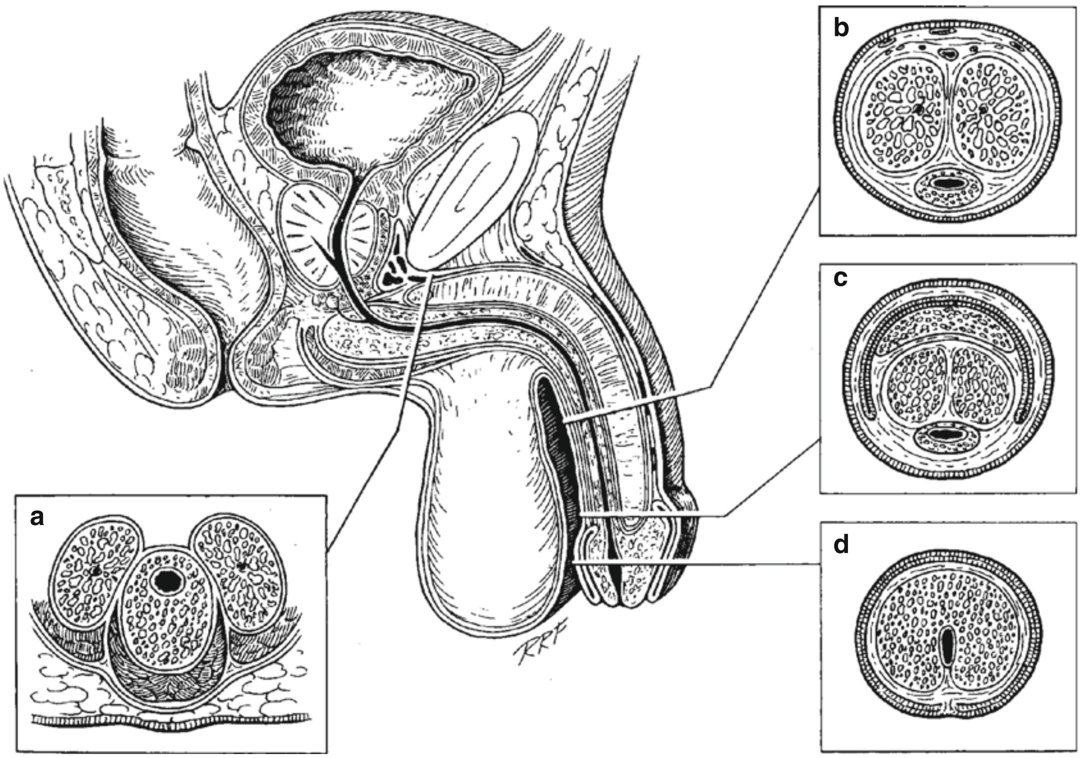


Fig. 2.2 Cross sections of the anterior urethra. (**a**) The bulbous urethra. (**b**) Penile shaft. (**c**) Coronal margin. (**d**) Glans (From Carson [13])

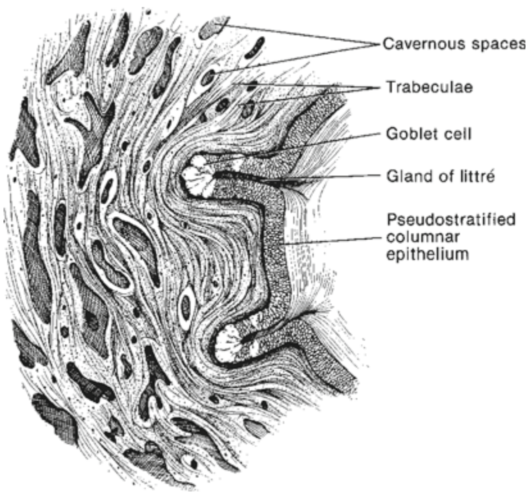


Fig. 2.3 Anatomy of the epithelium and glands of the penile urethra (From Hinman [14])

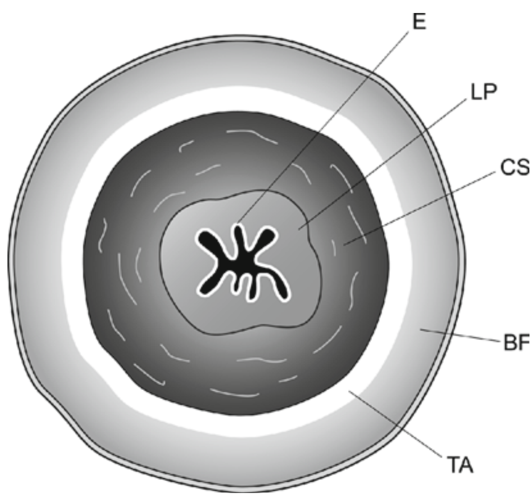


Fig. 2.4 Cross section of penile urethra and periurethral tissues. Diagrammatic cross section. *E* epithelium, *LP* lamina propria, *CS* corpus spongiosum, *TA* tunica albuginea, *BF* Buck's fascia

nodes. Urethral innervation is mainly by the dorsal nerve of the penis [7]. Branches of the perineal nerve can supply the periurethral area in some men [1].

Penis

The penis is anatomically composed of three parts: posterior (root), central body or shaft (Fig. 2.5), and anterior portion composed of glans, coronal sulcus, and foreskin (prepuce) (Figs. 2.5 and 2.6) [1–3, 5, 8]. The posterior penis is comprised of erectile tissue that is deeply embedded in the perineum and fixed to the anterior wall of the pelvis by the suspensory penile ligament, which is a dense connective tissue band [3]. In the shaft there are three cylinders of erectile tissues: a ventral corpus spongiosum surrounding the urethra and two corpora cavernosa (Fig. 2.1). Histologically, the erectile tissues are characterized by numerous vascular spaces with surrounding smooth muscle fibers (Fig. 2.7). The vascular walls in the corpora cavernosa are thicker and the architecture is more complex compared to the corpus spongiosum. The tunica albuginea, a sheath of hyalinized collagen, encases the corpora cavernosa. All three corpora are surrounded by Buck's fascia, adipose tissue, dartos muscle, dermis, and a thin epidermis (Fig. 2.8). Distally, the corpus spongiosum forms the conical glans (Figs. 2.5 and 2.6), which is also composed of a stratified squamous epithelium, lamina propria, tunica albuginea, and corpora cavernosa. The coronal sulcus is a cul-de-sac just below the glans corona (Fig. 2.5).

The microanatomy of the penile skin can be discussed based upon consideration of distal anatomy, including glans, coronal sulcus, and foreskin, and of a proximal portion, the corpus or shaft (Fig. 2.6) [1, 2]. The glans and coronal sulcus are covered by a thin, partially keratinized squamous epithelium. The glans and coronal sulcus surface is actually a mucosa, rather than skin, since no adnexal or glandular structures are present. The glans lamina propria separates the corpus spongiosum from the epithelium. Its thickness varies from 1 mm (at the corona) to 2.5 mm (near the meatus). Histologically, the lamina propria is comprised of fibrous and vascular tissue, with the vascularity being less prominent compared to the underlying corpus spongiosum. The coronal sulcus lamina propria is essentially a prolongation of the foreskin and glans lamina propria.

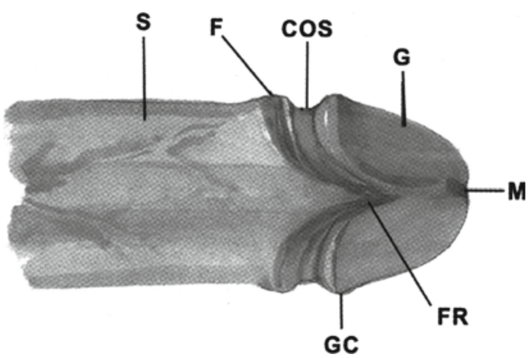


Fig. 2.5 Penile anatomy: Distal portion includes glans (*G*), coronal sulcus (*COS*), and foreskin, whereas proximal portion includes corpus or shaft (*S*), (*M*) urethral meatus, (*GC*) glans corona, and (*FR*) frenulum (From Mills [15], chapter 38)

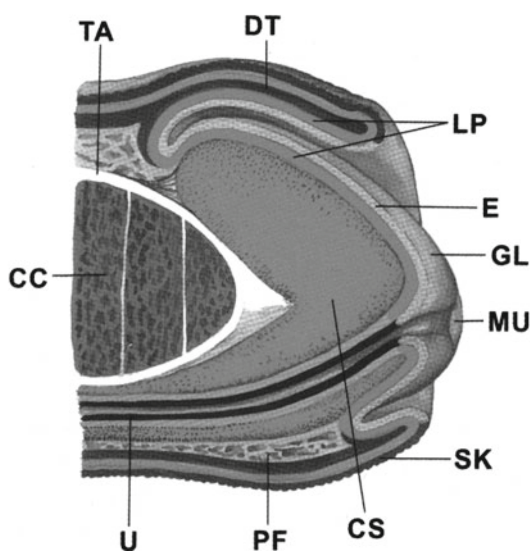
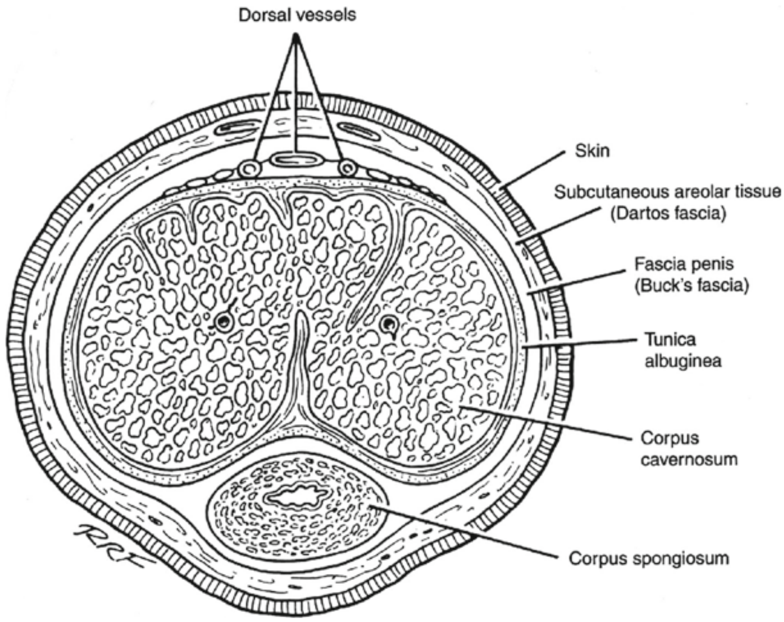


Fig. 2.6 Distal portion of penis including glans (*GL*), coronal sulcus, and foreskin (*E* epithelium, *LP* lamina propria, *CS* corpus spongiosum, *TA* tunica albuginea, *CC* corpus cavernosum, *DT* dartos, *SK* skin, *U* urethra, *MU* meatus urethralis, *PF* penile or Buck's fascia) (From Mills [15], chapter 38)

Fig. 2.7 Cross section of the penis (From Quartey [16])



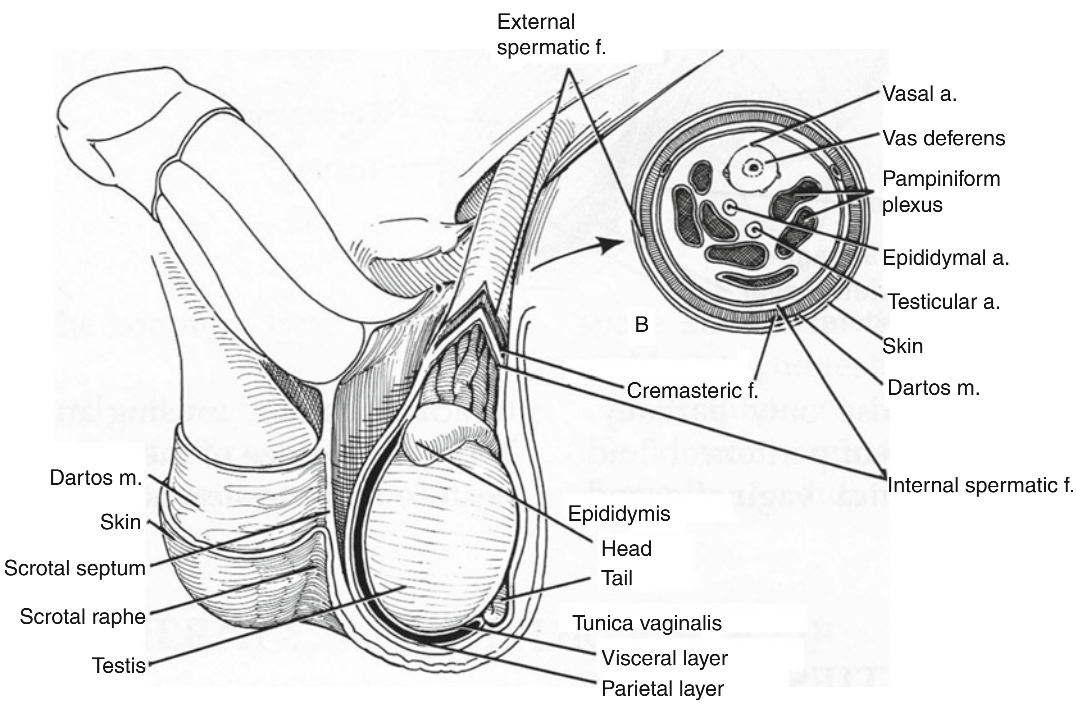


Fig. 2.8 Fascial layers of the scrotum and testis (From Hinman [14])

The foreskin, or prepuce, is a mixture of skin and mucosa that is basically an extension of the skin of the shaft and normally covers most of the glans, with an inner mucosal surface of the foreskin covering the coronal sulcus and glans surface [1–3]. Grossly, the skin surface is dark and wrinkled while the opposite mucosal lining exhibits a pink to tan coloration. Histologically, there are five layers to the foreskin – the epidermis, dermis, dartos, lamina propria, and epithelium. The skin is made up of epidermis with keratinized stratified squamous epithelium and dermis with connective tissue containing blood vessels, nerve endings, Meissner (touch) and Vater-Panini (deep pressure and vibration) corpuscles, a few hair structures, and sebaceous and sweat glands. The dartos is the middle component of the foreskin and has smooth muscle fibers surrounded by elastic fibers, with numerous nerve endings. The lamina propria is a loose fibrovascular and connective tissue with free nerve endings and genital corpuscles. The squamous epithelium of the mucosa surface of the foreskin is in continuity with the glands and coronal sulcus mucosal epithelium and is the same structurally. The skin of the penile shaft overlies the dartos, Buck's fascia, tunica albuginea, corpora cavernosa, and corpus spongiosum (Fig. 2.7). It is rugged and elastic and comprised of an epidermis and dermis. The epidermis is thin, with slight keratinization and basal layer pigmentation. Hair follicles are present and are more frequent in the proximal shaft. Only a few sebaceous and sweat glands can be found.

Lymphatics of the glans and corpora cavernosa drain into superficial and deep inguinal lymph nodes, while lymphatics of the foreskin and skin of the shaft drain into superficial inguinal nodes [2, 3]. Innervation of the glans and foreskin is by the terminal branches of the dorsal nerve of the penis [1]. These nerves are located along the dorsal arteries. Two groups of nerves from the pelvic (inferior hypogastric) plexus innervate the penile erectile tissues [3]. Lesser cavernous nerves supply the corpus spongiosum and penile urethra, while greater cavernous nerves supply the corpora cavernosa and corpus spongiosum. The pudendal nerve also contributes some branches to the cavernous nerves.

Scrotum

The scrotum is a cutaneous fibromuscular sac that contains the testes and lower spermatic cords [5, 9]. It consists of skin that covers the dartos smooth muscle, fibers of the cremasteric muscle, and several layers of fascia. The skin of the scrotum is pigmented, hair bearing, and loose with numerous sebaceous and sweat

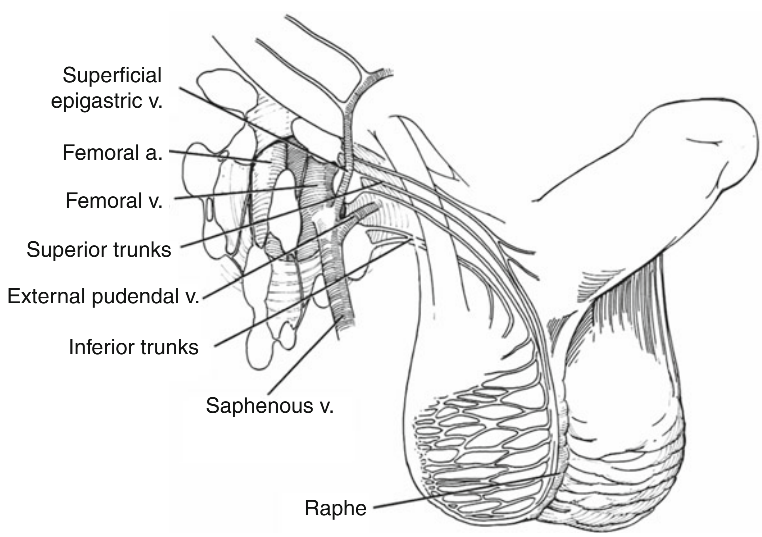


Fig. 2.9 Lymphatics of the scrotum (From Hinman [14])

glands. Depending on patient age and tone of the underlying smooth muscle, the surface is smooth to highly folded and wrinkled with transverse rugae. The epidermis is thin and, along with the dermis, overlies the dartos layer of smooth muscle. A subcutaneous fat (adipose) layer is lacking. The external spermatic fascia is continuous with the abdominal external oblique aponeurosis. The underlying cremasteric skeletal muscle bundles form the upper portion of the scrotal wall. It is a continuation of the abdominal internal oblique muscle. The internal spermatic fascia is in continuity with the transversalis fascia and is separated in the midline by a fibrous septum (Fig. 2.8). Attached to this fascial layer is the flat mesothelial lining of the parietal tunica vaginalis. Lymphatic drainage is to ipsilateral superficial inguinal lymph nodes. There is lymphatic anastomosis across the midline raphe [10] (Fig. 2.9). The scrotum has a complex pattern of innervation [11]. The main supply is via scrotal branches of the perineal nerve, a branch of the pudendal nerve. Other contributions come from the inferior pudendal branch of the femoral cutaneous nerve and the genital branch of genitofemoral nerve and anterior cutaneous branches of the iliohypogastric and ilioinguinal nerves [11].

Editorial Comment

An intimate knowledge and familiarity with urethral and external genital gross anatomy is essential in order to be able to perform reconstructive surgery of these structures. Our urology trainees often struggle with our urethroplasties and genital reconstructive cases because they are not familiar with the anatomy and the blood supply and do not know how to properly expose and dissect out the tissues. I urge all trainees who read this text to go to the cadaver lab with an experienced surgeon on a regular basis. You will be amazed how your surgical skills will improve.

–Steven B. Brandes

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Vascular Anatomy of Genital Skin and the Urethra: Implications for Urethral Reconstruction

3

Steven B. Brandes

Summary

An intimate knowledge of the penile skin blood supply is essential to successfully mobilize and construct a fasciocutaneous onlay flap for "substitution" urethral reconstruction. For successful anastomotic urethroplasty, an intact and adequate dual urethral arterial blood supply is essential. The key vascular feature of the urethra and the reason that it can be mobilized extensively and divided is its unique bipedal blood supply. The proximal and distal ends of the urethra are supplied by two arterial blood supplies, the proximal urethra in an antegrade fashion and the distal, retrograde. The common penile artery, a branch of the internal pudendal, first branches into the bulbar and circumflex cavernosal arteries (supplying the proximal corpus spongiosum) and then bifurcates into the central cavernosal arteries and into the dorsal artery of the penis. The dorsal artery arborizes and penetrates into the glans penis and then flows retrograde into the spongiosum. Thus, the corpus spongiosum has two blood supplies, proximally, the bulbar and circumflex arteries and distally, arborizations of the dorsal penile artery.

Penile Anatomy: Gross

The penis is covered with an elastic layer of skin that has no subcuticular adipose layer. Beneath the penile skin is the dartos fascia, a layer of loose areolar subcutaneous tissue. The dartos is devoid of fat and slides freely over the underlying Buck's fascia. The dartos of the penis is contiguous with Scarpa's fascia of the abdominal wall, in which run the superficial nerves, lymphatics, and blood vessels. Beneath the dartos fascia lies the superficial lamina (or lamella) of Buck's fascia. Buck's fascia covers in one envelope the tunica albuginea (outer longitudinal fibers) of the two corpora cavernosa and the tunica of the corpus spongiosum. In the scrotum, the embryologic equivalent of Buck's fascia is the external spermatic fascia.

When one develops a fasciocutaneous penile skin island flap of genital skin, as one does with an Orandi (vertical flap) or a McAninch/Quartey (circular transverse) flap, we take advantage of the natural anatomical cleavage planes of the superficial layers of the penis. The main two distinct cleavage (relatively avascular) planes

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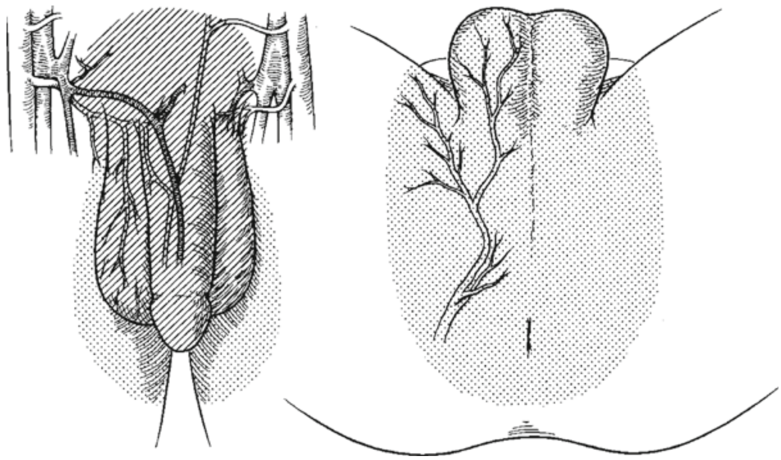

Fig. 3.1 The relative areas of arborization of the superficial external pudendal artery and the perineal/labial–scrotal arborization. Crosshatched area is based predominantly on the superficial external pudendal artery. The dotted area is based primarily on the perineal/labial–scrotal arterial blood supply. There are areas of overlap on the scrotum (From Jordan [3])

are between the skin and the dartos fascia, whereas the other is between the dartos fascia and Buck's fascia. Buck's fascia is fairly adherent to the underlying longitudinal fibers of the tunica albuginea and much more difficult to separate. In Peyronie's disease surgery, tunica plaque incision and grafting demands developing that difficult plane between the outer longitudinal layer of tunica albuginea and the overlying Buck's fascia.

Penile Skin Arterial Blood Supply

The blood supply to the skin of the penis and the anterior scrotal wall is from the external pudendal arteries. The blood supply to the posterior aspects of the scrotum is from the posterior scrotal arteries, which is a branch of the perineal artery, which is a further branch of the internal pudendal arteries [7] (Fig. 3.1).

Branching off the medial aspect of the femoral artery are the superficial/superior branches and the deep/inferior branches of the external pudendal artery. These superficial external pudendal branches pass from lateral to medial, in a variable pattern, across the femoral triangle and within Scarpa's fascia (a loose membrane of superficial fascia; Fig. 3.2).

After giving off scrotal branches to the anterior scrotum, the superficial external pudendal artery crosses the spermatic cord and enters the base of the penis as posterolateral and anterolateral axial branches. Together with interconnecting, perforating branches, they form an arterial network within the dartos fascia. The dartos fascia is not really the blood supply; it is more accurate to visualize the fascia as a trellis and the blood supply as the vine entwined on the trellis. At the base of the penis, branches from the axial penile arteries form a subdermal plexus which supplies the distal penile skin and prepuce (Fig. 3.3). There are perforating connections between the subcutaneous and subdermal arterial plexuses. These connections typically are minimal and very fine, and thus, a relatively avascular plane can be developed between the dartos and Buck's fascia. Because the fascial plexus is the true blood supply to the penile skin flaps that we use in urethral reconstruction, the flaps are considered axial, penile skin island flaps that therefore can be mobilized widely and transposed aggressively. When developing a penile skin island flaps, it is often important to preserve the lateral and base aspects of the flap pedicle, because the arborizations of the superficial external pudendal arteries pass onto the penile shaft from lateral to medial. The pedicles can be kept large and mobilized extensively and reliably, enough so to even reach the perineum and proximal urethra. Occasionally, between the two layers,

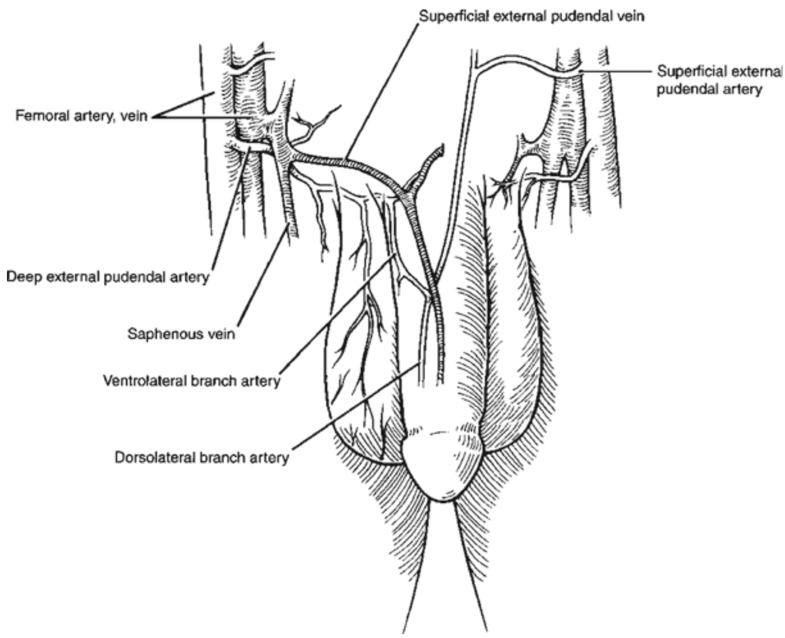

Fig. 3.2 The superficial external pudendal blood supply (to penile and anterior scrotal skin) (From Jordan [3])

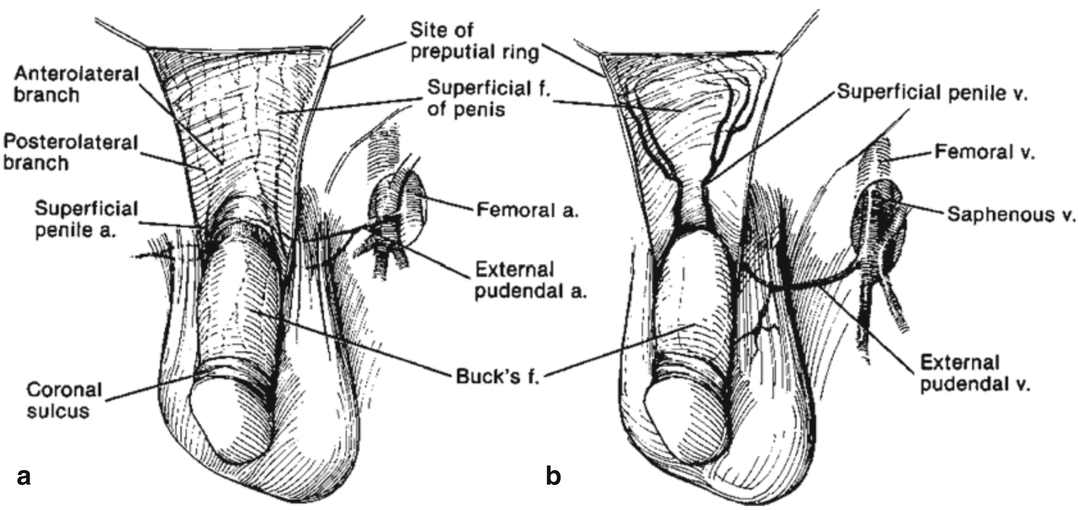

Fig. 3.3 Preputial blood supply. (**a**) Arterial supply. (**b**) Venous drainage (From Hinman [2])

there is a large communication or perforating branch that needs to be ligated and divided. At the subcorona, the axial penile arteries continue onto the foreskin as preputial arteries, as well as send perforating arterial branches which pierce Buck's fascia to anastomose with the dorsal arteries [7] (Fig. 3.4).

Scrotal Skin Blood Supply

The anterior aspect of the scrotum is supplied by anterior scrotal arteries, which are branches of the external pudendal artery. At the cephalad end (top) of the scrotum, they give off branches superficially to form a subdermal plexus that

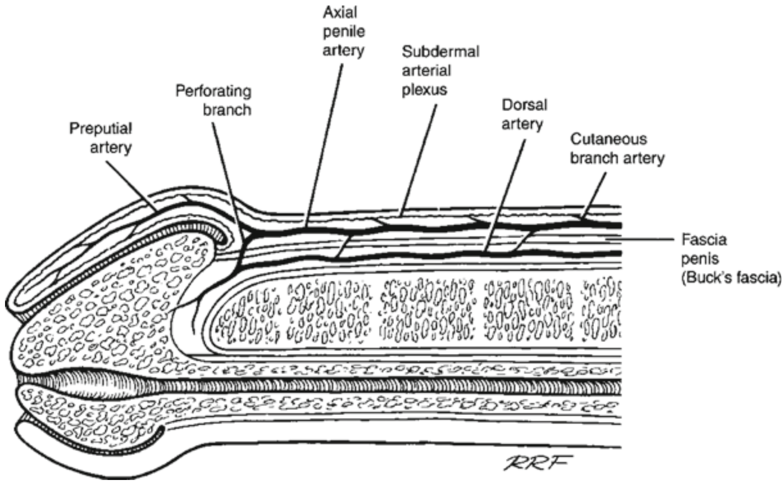

Fig. 3.4 Cross-sectional view of penile skin arterial plexuses; subdermal, subcutaneous, and dorsal arterial (From Jordan [3])

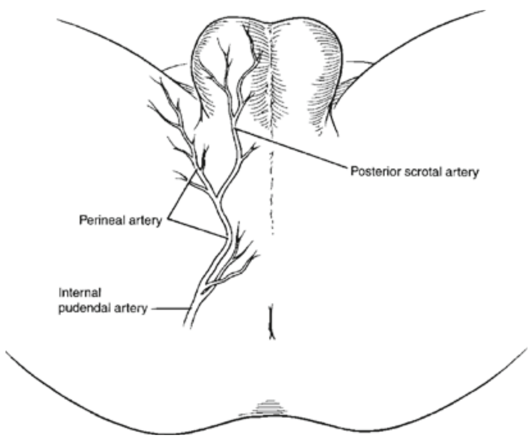

Fig. 3.5 The perineal artery/labial–scrotal blood supply (From Jordan [3])

continue along the caudal aspect of the anterior scrotum to anastomose with the posterior scrotal arteries.

The blood supply to the posterior aspect of the scrotum is from several scrotal arteries, which are branches of the perineal artery, which is a superficial terminal branch of the internal pudendal artery (Fig. 3.5). The perineal artery emanates from Alcock's canal to pierce the posterolateral corner of the perineal membrane and then runs anteriorly, along the superficial fascia, in a groove between the bulbospongiosus and ischiocavernosus muscles. The scrotal arteries also give off branches to form a subdermal arterial plexus that anastomose at the apex of the scrotum with anterior scrotal arteries from the other side (Fig. 3.1). Furthermore, along the central scrotal septum, there are additional intercommunications between the anterior and posterior scrotal arteries.

Scrotal skin island flaps, based on a fascial flap of tunica dartos, can be efficient for mobilizing skin island to the bulbar urethra; the pedicle is often too short to reach the anterior urethra. The facial pedicle can also be oriented posteriorly by extending an "∩"-shaped incision onto the perineum (as in the Blandy flap for perineal urethrostomy).

Venous Drainage of the Penile Skin

Between the proximal–posterior aspects of the glans penis and the distal ends of the corpora cavernosal bodies is the retrobalanic venous plexus. From this venous plexus arise two branches of veins, the deep dorsal median and the superficial dorsal median (Fig. 3.6). The deep dorsal median vein runs posterior to Buck's fascia, while the superficial dorsal median vein pierces Buck's fascia subcoronally to run in the superficial layer of the dartos fascia. Typically, there are no large connections between the deep (subdermal) venous plexus and the superficial (subcutaneous) veins (Fig. 3.6). However, occasionally the circumflex or deep dorsal median veins connect

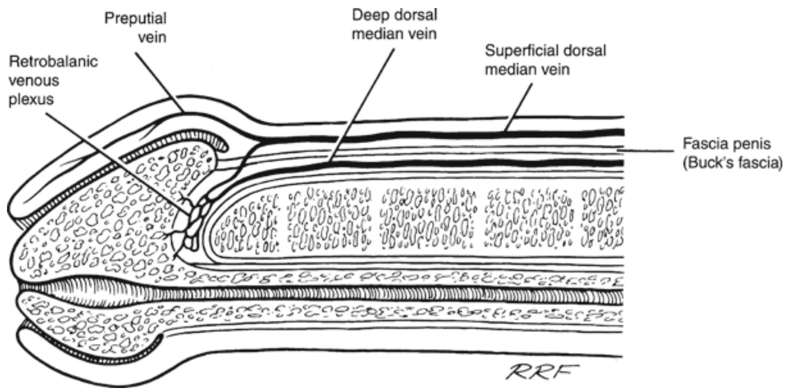

Fig. 3.6 Deep and superficial dorsal median veins arising from the retrobalanic venous plexus (From Jordan [3])

to the superficial veins in the subcutaneous tissue, or the superficial dorsal median vein branches off directly from the deep dorsal median vein, instead of the more typical origin in the retrobalanic venous plexus.

The superficial veins can also run dorsolateral, lateral, and/or ventrolateral. Running with the axial dorsal penile arteries are venae comitantes. The veins in the prepuce, however, are small and multiple and are distributed without particular orientation. These veins then join together to drain into one or two of the large superficial veins or continue independently to the base of the penis that drain through the inferior external pudendal vein into the saphenous vein (Fig. 3.3b). At the base of the penis, the large communicating veins, the venae comitantes, and the subdermal venous plexuses all combine in variable patterns to form the external pudendal veins, which further empty into the long saphenous veins or directly into the femoral vein.

Venous Drainage of the Scrotum

The anterior scrotal veins and the veins that drain the anterior scrotal subdermal venous plexus coalesce at the base of the scrotum to drain into the external pudendal vein. The posterior scrotal veins combine with the veins of the subdermal venous plexus of the posterior scrotal wall and drain into the perineal vein. The perineal vein then pierces the posterolateral corners of the perineal membrane to join the internal pudendal vein within Alcock's canal.

Genital Flap Selection

Genital skin island flaps are versatile for anterior urethral reconstruction. A thorough knowledge of the anatomy and specific tissue characteristics and adhering to the surgical principles of tissue transfer can result in long-term success. The specific skin island flap that is selected should be based on specific physical characteristics. Sought-after characteristics for such island flaps are as follows: (1) skin for harvest is from an area of natural skin redundancy, (2) the skin at the donor site is elastic or redundant enough to be closed, (3) the skin island is thin and hairless, (4) the island of skin is long and wide enough to bridge the entire stricture, and (5) the vascular pedicle to the skin island is reliable, long, and robust.

Blood Supply of the Urethra (Corpus Spongiosum)

A detailed knowledge of the arterial blood supply of the corpus spongiosum is essential to perform stricture excision and primary anastomosis urethral surgery.

Arterial Blood Supply

The key feature and the reason that the urethra can be mobilized extensively, divided, and then sewn back together is that it has a unique dual blood supply. The distal and proximal ends of the

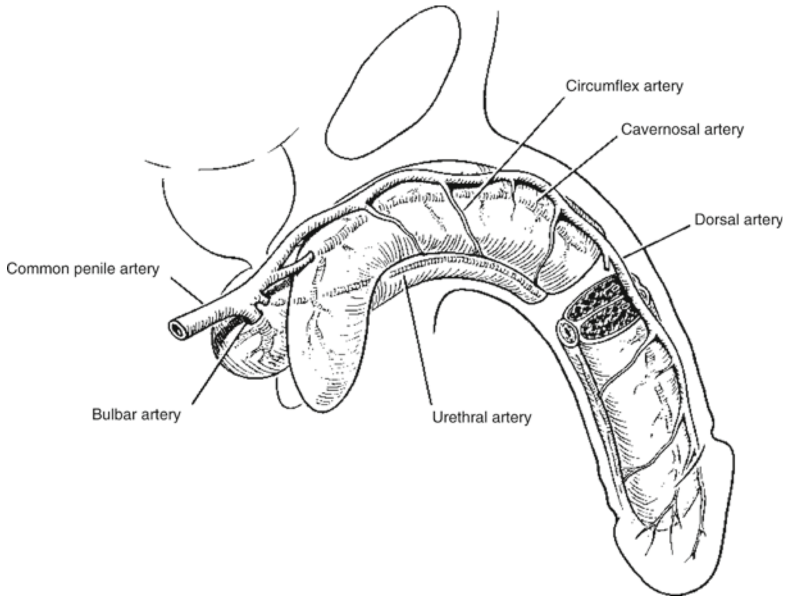

Fig. 3.7 Urethral and penile arterial blood supply (From Jordan [3])

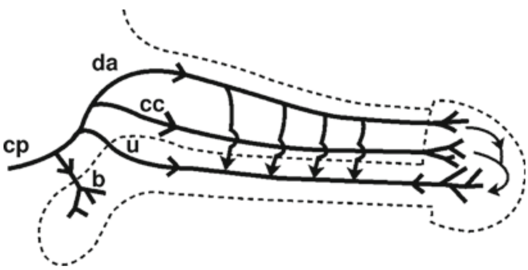

Fig. 3.8 Bipedal arterial blood supply of the urethra (*cp* common penile, *da* dorsal artery of the penis, *cc* central cavernosal, *u* urethral, *b* bulbar artery)

urethra are supplied by two arterial blood supplies, the proximal urethra in an antegrade fashion and the distal urethra in a retrograde fashion. The internal pudendal artery branches into the perineal artery and posterior scrotal artery and then continues distally as the common penile artery (Fig. 3.7). The common penile artery branches into the bulbar arteries and circumflex cavernosal arteries (which both supply the proximal corpus spongiosum). The common penile artery then bifurcates into the central cavernosal arteries (also known as the deep artery of the corpus cavernosum) and into the dorsal artery of the penis (Fig. 3.8). The dorsal artery of the penis arborizes and penetrates into the spongy tissue of the glans penis. From the glans penis, the blood flows retrograde into the corpus spongiosum. The corpus spongiosum thus has two blood supplies, proximally by the bulbar and circumflex cavernosal arteries and distally by arborizations of the dorsal penile artery. There are also perforators between the ventral corpora cavernosa and the corpus spongiosum. These perforators, however, are neither constant nor reliable in their distribution. When the urethra is mobilized and transected for anastomotic urethroplasty, adequate distal blood supply and retrograde flow is essential. Within the corpus spongiosum there are typically two or three urethral arteries. Based on recent ultrasonography studies, contrary to common belief, the urethral arteries are not typically located at the 3 or 9 o'clock positions [1]. Urethral arteries, in contrast, have a variable position, and the location varies with near equal distribution around the clock, among patients (Fig. 3.9). The arteries can be close to the urethral lumen epithelium, especially in patients who have undergone prior urethral procedures. Although researchers suggest that urethral stricture patients undergo urethrotomy, the direction for the incision can be determined by the preoperative ultrasound artery location; we have not found this to be particularly helpful. Rather, urethrotomy location probably does not matter so much as it is not too deep into the spongiosum

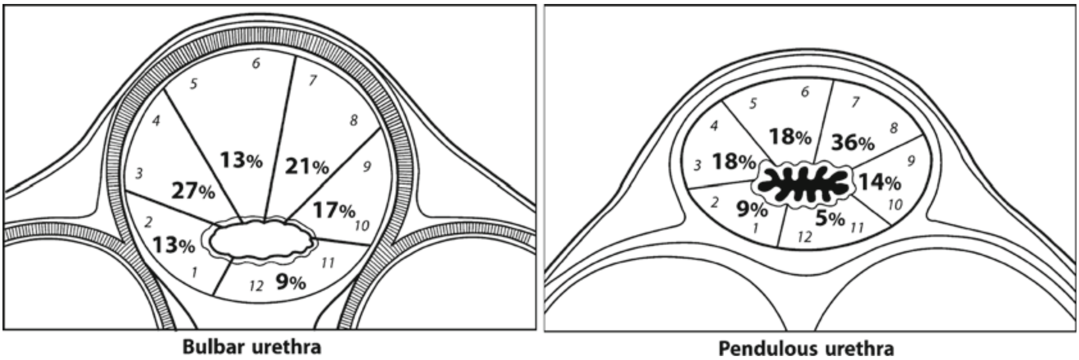

Fig. 3.9 Distribution of the location of the urethral arteries in the bulbar and pendulous urethra (Redrawn after Ref. [1])

yet deep enough to allow the epithelium open up and re-scar in an open position.

If the urethra is overly mobilized distally or the patient has a known severe hypospadias, retrograde distal blood flow can be severely compromised. Here, anastomotic urethroplasty can result in proximal urethral ischemia and re-stricture. Such patients with compromised dual blood supply are thus often better served with substitution urethroplasty (Fig. 3.10). The other situation where the proximal urethra is at risk for ischemic necrosis with excision and primary anastomosis (EPA) surgery is the unusual situation where the bulbar arteries, as well as the common penile circulation, have been disrupted and, thus, bipedal blood flow is inadequate (Fig. 3.11).

Urethral ischemic necrosis or ischemia refers to recurrence of stricture of the anterior and proximal urethra after excision and primary anastomosis (EPA) urethral surgery. Such ischemic strictures are particularly difficult to manage because often they are very long and have either a very narrow caliber or completely obliterate the proximal anterior urethra. In contrast, technical error strictures are typically short, annular, and easily amenable to internal urethrotomy. Jordan and Colen [4], upon reviewing all their failed posterior urethroplasties after pelvic fracture, observed that patients who developed the severe complication of proximal urethral necrosis all seemed to have one or more of the same characteristics; namely, previous histories of pelvic fracture associated with vascular injuries were children, were elderly, had a cold or decreased sensate glans penis, had decreased erections, or had failed prior posterior urethroplasty. They further studied these patients with nocturnal penile tumescence and, if abnormal, with penile ultrasound and Doppler and of those, if abnormal, with pudendal angiography. They concluded that ischemic urethral necrosis was most likely, when on angiography, there was bilateral injury to the deep internal pudendal artery–common penile arterial system, without distal reconstitution. In other words, because the bulbar arteries and the common penile circulation are disrupted in this situation, there is inadequate retrograde and antegrade urethral blood flow for anastomotic urethroplasty. Such extreme vascular injuries after pelvic fracture are exceedingly rare [6].

Jordan and Colen [4] suggest that patients who lack adequate bipedal blood supply of the urethra should be considered for penile revascularization before posterior urethroplasty. An algorithm for evaluating and managing patients at risk for ischemic necrosis is detailed in Fig. 3.12. When possible, a bilateral end-to-side anastomosis of the inferior epigastric artery to dorsal penile artery should be performed (Fig. 3.13). Impotent patients with bilateral pudendal complex injury with distal reconstitution also may have insufficient blood flow not allowing for normal erections [6]. In our experience with penile revascularization and refractory impotence after pelvic fracture, in young patients with few comorbidities, revascularization helps to resolve penile numbness and "coldness" and enables erection with intracavernosal injections

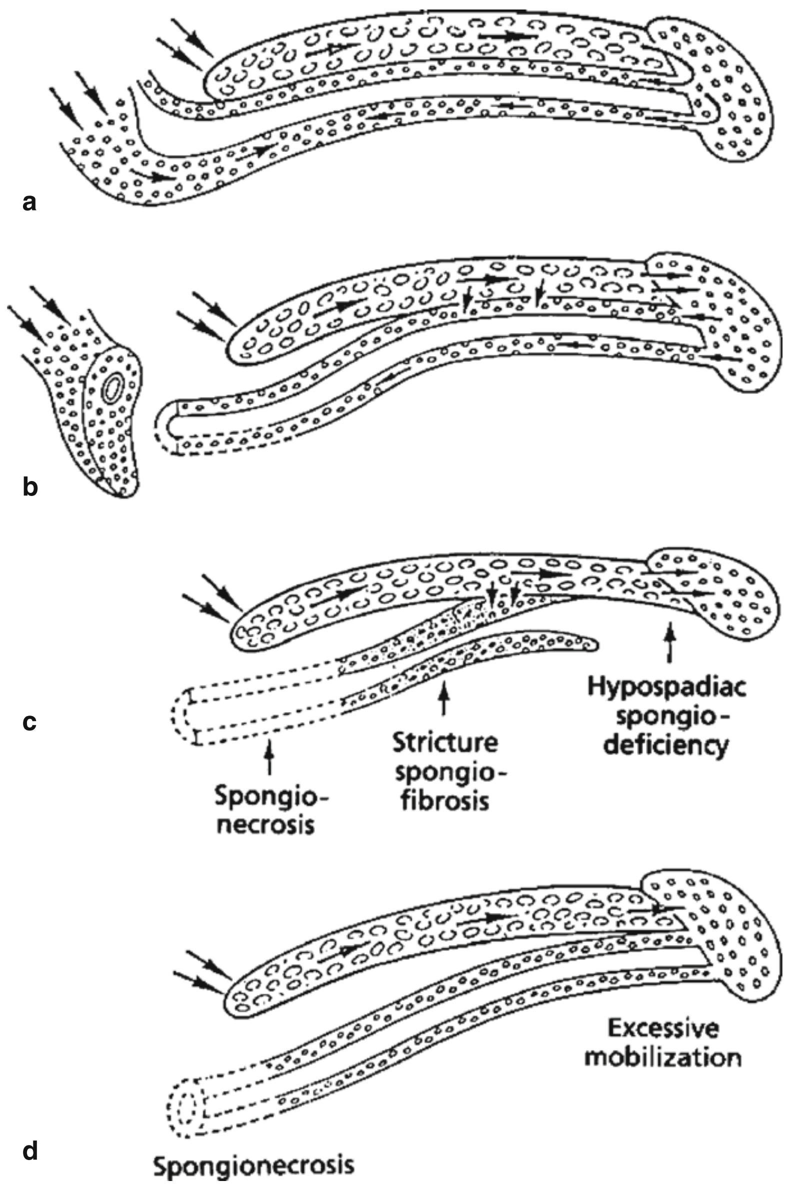

Fig. 3.10 Vascular principles of anastomotic urethroplasty. After division of the bulbar arteries, blood supply of the proximal bulbar urethra relies on the retrograde blood supply along its spongy tissue (**a**) and (**b**). Ischemic necrosis of the proximal mobilized urethra can result when the retrograde blood supply is compromised, such as occurs with hypospadias (**c**), incidental spongiofibrosis, or division of distal collateral vessels by excessive mobilization of the penile urethra (**d**) (From Yu and Miller [8])

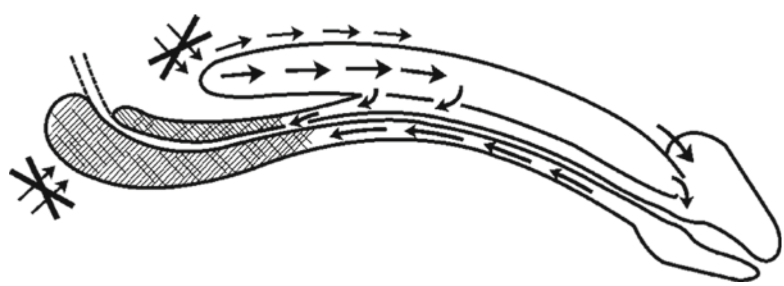

Fig. 3.11 The illustration shows that, in bilateral internal pudendal complex obliteration ("*X*" *marks*), there can be insufficient blood supply to the proximal urethra with an anastomotic urethroplasty. Hatched marks demonstrate "ischemic necrosis" of the proximal urethra after EPA surgery

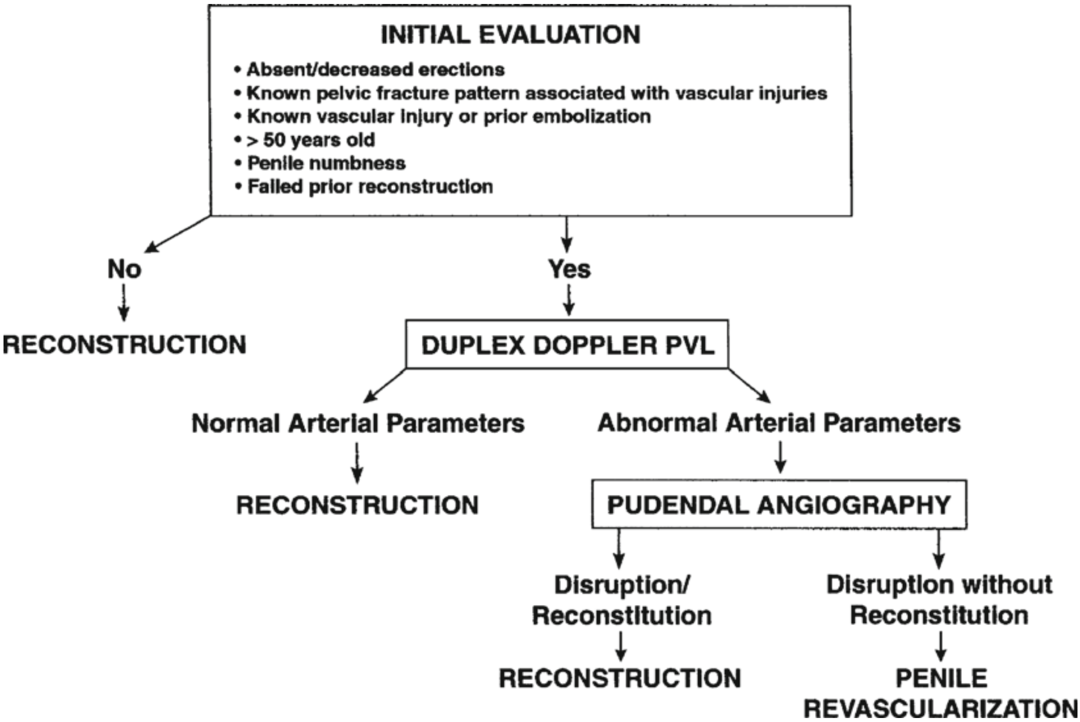

Fig. 3.12 Algorithm for identifying patients for potential urethral ischemic stenosis after posterior urethroplasty and after urethral disruption injury (From Jordan [3])

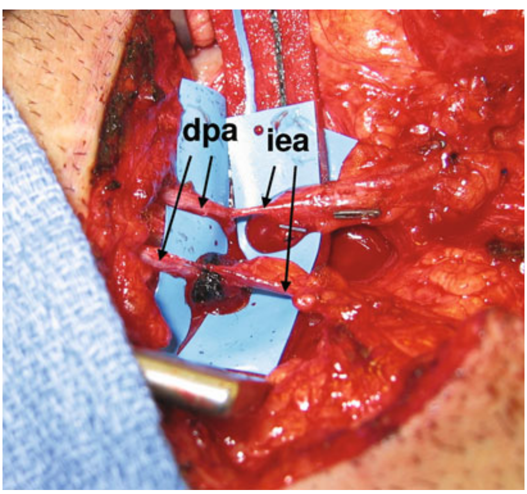

Fig. 3.13 Revascularization of the penis with bilateral end-to-side inferior epigastric artery (*iea*) to the dorsal penile artery (*dpa*)

or intraurethral alprostadil. In general, after pelvic fracture, aside from neurologic or venous problems, for normal erectile function or a normal response to pharmacotherapy, patients need at least one intact internal pudendal complex. According to Jordan and Colen [4], all patients with risk factors for urethral ischemic necrosis who undergo successful penile revascularization before anastomotic urethroplasty have successful urethral reconstructions. Successful penile revascularization means here that at 3–6 months after revascularization, peak systolic arterial blood flows are in the normal range. In summary, all patients with ischemic urethral necrosis, when studied, have bilateral injuries to the pudendals without reconstitution. Lack of reconstitution, however, only predisposes, not guarantees, that the urethra will experience necrosis after EPA.

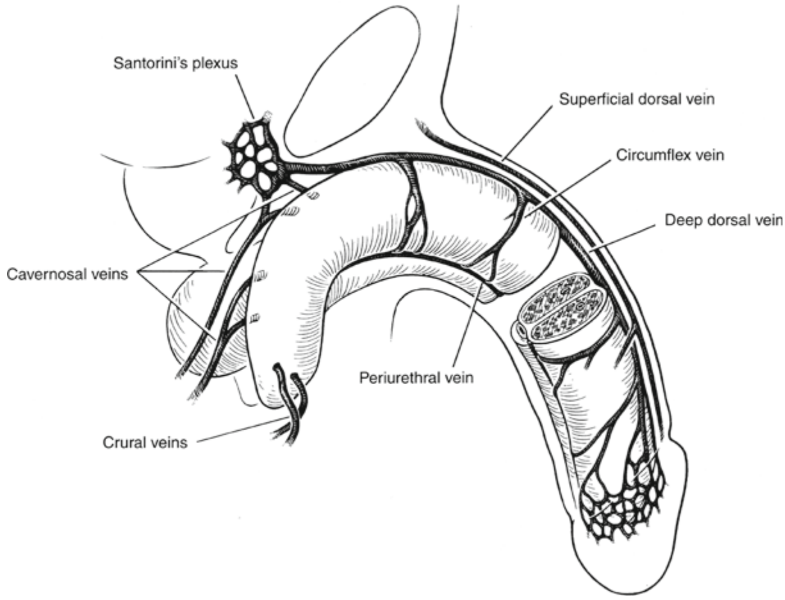

Fig. 3.14 The venous drainage of the urethra and penis (From Jordan [3])

The other place where antegrade and retrograde blood flow preservation with EPA urethroplasty is important is the postprostatectomy incontinent patient who also has a urethral stricture. When stress incontinence is severe, it often is treated with an artificial urinary sphincter, where a cuff is placed around the urethra and compresses it circumferentially. In our experience, the cuff erosion rate is high after anastomotic urethroplasty. Perseveration of the bulbar arteries, however, can help maintain the blood supply of the urethra proximal to the cuff, which might otherwise be compromised by cuff compression and occlusion of retrograde urethral blood flow. In maintaining the bulbar arteries, there should be adequate antegrade blood flow to the urethra proximal to the cuff. It seems logical that a vessel-sparing technique could improve spongiosal vascularity and bulk underneath the cuff and thus possibly decrease the risk of cuff erosion. Jordan et al. [5] have described an elaborate technique for sparing these vessels. See Chap. 34 by Kulkari for details.

The other place where maximizing the bipedal blood supply of the urethra is important is when a bulbar or membranous urethral stricture is associated with a distal urethra with compromised blood supply (such is the case with patients with hypospadias, distal urethral spongiofibrosis). Because the retrograde blood flow is compromised with such distal urethral conditions, it is important to try to isolate and preserve the antegrade blood flow of the bulbar arteries and consider either a pedicle skin island flap for the distal urethral stricture or a staged approach.

Venous Drainage

The venous drainage of the corpus spongiosum is predominantly the venous drainage of the glans penis and the other deep structures, namely, via the periurethral veins, the circumflex veins, and the deep and superficial dorsal veins (Fig. 3.14).

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4 Lichen Sclerosus

Ramón Virasoro and Gerald H. Jordan

Summary

Lichen sclerosus (LS) is a chronic inflammatory disorder of the skin. The incidence in the Western world is underreported. In men, LS peaks between the ages of 30 and 60 years. Both genders can be affected, although genital involvement is much more common in women. Possible etiologies for LS are the Koebner phenomenon, genetic susceptibility and autoimmunity, oxidative stress, and infection. The clinical presentation is as white patches that seem to coalesce into "plaques" that can affect the prepuce and glans. It is not clear whether LS spreads by direct extension into the fossa navicularis and a portion of the anterior urethra or if urethral involvement is secondary to LS-induced meatal stenosis and subsequent inflammation of the glands of Littré. The classic radiographic appearance of LS anterior urethral stricture is a saw-toothed pattern. Surgical management of LS is primarily by staged urethroplasty.

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Introduction and Epidemiology

Lichen sclerosus is a chronic inflammatory disorder of the skin of unknown origin. No specific mechanism of disease has been elucidated, although substantial advances in characterizing the immunological basis of other disease processes may eventually characterize the pathogenesis of LS. There are several acquired scarring disorders of the skin associated with pathology of the basement membrane, such as mucous-membrane pemphigoid, that may be shown to be related [1]. There is a possibility that the disease mechanism in lichen sclerosus involves development of autoantibodies to a specific structure in the skin [2].

The traditionally reported incidence of LS in the Western population is 1/300–1/1,000, with a peak in males between the ages of 30 and 50 years [3, 4]. However, LS has been described in people of all ages, from infants to the elderly [3]. The peak ages of recognition in women are bimodal, with many cases noted before puberty, but another peak presenting in postmenopausal women [3].

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In the United States the prevalence of lichen sclerosus among white subjects and other ethnicities is unclear. In 2003 Morey and colleagues reported an incidence, in a regionally based population, of 7.04/10.000 (108/153,432) patients [5]. They found that the incidence in the age group 21–30 years doubled the incidence of the other groups. Also interestingly, they reported a double incidence of LS in black and Hispanic ethnicities when compared to Caucasians (10.6/10.000–5.07/10.000, respectively) [5]. A recent publication, by Peterson and colleagues, reviewed the Department of Defense Medical Database, providing a nationwide prevalence of lichen sclerosus in a larger group [6]. The retrospective review of 42.648.923 unique visits entered with ICD-9 codes 701.0 (LS) and 607.81 (BXO) found an overall rate of 1.4 LS diagnoses per 100.00 visits, with an equal age distribution, except for the fourth through sixth decades, where the prevalence doubled. The race distribution in this study showed a highest rate within Caucasian, with 2.1 diagnoses per 100.000 visits, followed by "others" with 1.1/100.000 visits, blacks with 1.4/100.000 visits, and Asian at 0.9/100.000 visits [6]. The worldwide prevalence may be substantially different. LS has been described in Africans [7, 8], Asians [9], and other dark-skinned races, which may bias the prevalence because of the analyzed population. Most current publications come from Europe and the United States.

Both genders have been affected, although genital involvement is far more frequent in women, with a female to male ratio with genital involvement of 6: 1–10:1 [4, 10].

In the past, the male genital involvement with lichen sclerosus was called balanitis xerotica obliterans (BXO), and much of the older literature reflects that previous designation. Any area of the skin may be involved; however, the prevalence of involvement of the genitalia in the male and female is estimated to be 85–98 % of total cases [11]. LS is believed to possibly be premalignant. The incidence of squamous cell carcinoma associated with vulvar lichen sclerosus averages between 4 and 6 % [12]. In men, the association between LS and penile cancer ranges from 2.3 to 9.3 % [13–16]. The true risk of malignancy remains to be determined. The problem is that few studies analyze the complete population followed with lichen sclerosus versus those that develop squamous cell carcinoma in previously determined lesions.

Historical Aspects

The term BXO was first applied by Stühmer in 1928 [17] and, as mentioned, is now considered to be just the genital manifestation of LS. Freeman and Laymon showed that BXO and LS were probably the same process [18, 19]. The first report of what was probably LS was published by Weir in 1875, where he described a case of vulvar and oral "ichthyosis" [20]. Hallopeau reported in 1887 a case of trunk, forearm, and vulvar lichenification consistent with LS and suggested the name of "lichen plans atrophique" [21]. Darier in 1892 described the typical histologic characteristics of what he called lichen planus scleréux, which later was renamed lichen sclerosus et atrophicus [22]. Since those initial reports, a number of names were then proposed to the entity we recognize as LS: Kartenblattförmige sklerodermie ("playing card" or "cardboard-like" scleroderma [23]), Weissflecken Dermatose ("white spot disease" [24]), lichen albus [25], lichen planus sclerosus et atrophicus [26], dermatitis lichenoides chronica atrophicans [27], and kraurosis vulvae [28]. Histologically, not all cases of LS are atrophic and, thus, Friedrich suggested that the term atrophicus was not accurate [29]. In 1976, the International Society for the Study of Vulvar Disease unified the nomenclature devising a new classification system and proposed the term lichen sclerosus [30].

Etiology

As mentioned previously, the cause of LS is not known. A number of various mechanisms have been proposed. The Koebner phenomenon relates the development of LS to trauma to the involved area. It has been proposed that the etiology may be that of an autoimmune disease [2]. There is evidence of both humoral and cell-mediated autoimmunogenic mechanisms in LS [31, 32]. Sanders hypothesized that reactive oxidative stress contributes to the sclerotic, immunologic, and carcinogenic processes in LS [33]. An infectious cause with the organism Borrelia burgdorferi implicated has been proposed. That has been called into question as the organism has not been able to be uniformly demonstrated in the lesions.

Koebner Phenomenon

Stühmer originally described LS as a post-circumcision phenomenon [17] and, clearly, LS has appeared in scars, both in the genitalia and other sites [34]. Patients have been described to develop lesions in areas exposed to radiotherapy [35], ultraviolet (sunburn [36]), or thermal injury. These associations have led to the proposal that LS is a manifestation of the isomorphic or Koebner phenomenon, in which a patient with latent dermatoses, because of histologic and immunologic alterations, may then develop the disease as the result of a stimulus. In this case, trauma would cause a lesion to develop in what would appear to be a clinically unaffected area.

Genetic Susceptibility and Autoimmunity

The theory that LS has a genetic origin is based on the observation of a familial distribution of cases, being reported in identical twins [37, 38] and nonidentical twins [39] with coexistence of dermatoses. Concomitant appearance of the disease in mothers and daughters has also been published [40].

Studies on the human leukocyte antigen (HLA) have suggested a genetic component in patients afflicted with LS. The major histocompatibility complex (MHC), a group of genes located in the short arm of chromosome 6, codes for the HLA antigens that influence cellular and humoral responses, determining an individual's susceptibility to inflammatory diseases. There are two isotypes of HLA molecules: HLA class I (A, B, C) and HLA class II (DR, DQ, DP). Class I and class II HLA gene clusters are located in different loci of the MHC, and between them are found several other genes with relevance to immune functions, such as tumor necrosis factors α and β (TNF-α, TNF-β). The major histocompatibility antigen complex determines an individual's susceptibility to inflammatory diseases by influencing cellular and humoral responses. Reports have described a disease association of LS with HLA class II antigens, specifically DQ7, an immunogenetic association also found in mucous-membrane pemphigoid [41].

Mucous-membrane pemphigoid is an acquired skin scarring disorder associated with autoantibodies to the 180 kDa bullous pemphigoid antigen (BP 180), a type XVII collagen present in the epithelial basement membrane. There is evidence of antibodies and T-cell responses to BP 180 [31, 32].

Men with LS have been found to have significantly greater incidences of autoimmune-related disorders and autoantibodies than control populations [42, 43]. Azurdia et al. found two cases (3 %) with another autoimmune disease (alopecia areata and vitiligo) in more than 58 men with clinically (33 %) or histologically proven (67 %) lichen sclerosus [44]. Ten percent of the same population had a first-degree relative with an autoimmune disease. A not statistically significant increased frequency of DR11, DR12, and DR7 was also found in the same cohort [44].

The association with various autoimmune disorders, which would include diabetes mellitus, alopecia areata, vitiligo, thyroid disease, and pernicious anemia, might suggest an immunologic component to the development of LS [45–47].

Other entities presumed to be of autoimmune origin, such as psoriasis, eczema, primary biliary cirrhosis, mystic, lupus erythematosus, and rheumatic polymyalgia, have all been described in association with LS [46–51]. The finding of thyroid antimicrosomal antibodies and gastric parietal cell antibodies has also been shown to be more frequent in patients with LS [52, 53].

Sanders speculates that a specific humoral immune response of circulating autoantibodies in

LS could be the result of DNA damage by reactive oxygen species (ROS), causing changes at a macromolecular level [33]. Thus, defective apoptosis and delayed apoptotic cell clearance would lead to an interaction of apoptotic cells and ROS resulting in neoepitope formation and subsequent autoimmunity [33].

Oyama and colleagues described a specific autoantibody response to extracellular matrix protein 1 (ECM-1) both in females and males affected with lichen sclerosus [2, 54]. ECM1 is an 85 kDa glycoprotein with important functions in skin physiology and homeostasis, which is located between the dermis and the epidermis. The mechanism of synthesis of these autoantibodies is not understood. It has been proposed that there is defective apoptosis with a delay in apoptotic cell clearance [23]. ECM1 has a role in epidermal differentiation and, at the dermis level, it binds to perlecan, the major heparan sulfate proteoglycan, acting as "biological glue" [55]. Mutation of the ECM1 gene results in lipoid proteinosis (Urbach-Wiethe disease), a rare autosomal-recessive genodermatosis that shares both clinical and histologic features with lichen sclerosus [56]. It is characterized by papules/nodules, indurated plaques, and sometimes ulcerated lesions involving primarily the skin and mucous membranes. However, there is no genital involvement in lipoid proteinosis, which also does not carry the potential for malignant conversion; therefore, the presence of ECM1 autoantibodies cannot explain all the pathophysiological features of LS [54].

It has been suggested that genital lichen sclerosus would be the result of chronic, intermittent exposure of susceptible epithelium to urine by Koebnerization under occlusion [57].

ECM1 autoimmunity may not be the initial manifestation but rather a consequence of the clinical manifestations of lichen sclerosus. Anti-ECM1 antibodies are not the causative mechanism but represent an epiphenomenon in genital LS [54].

Extracellular matrix protein 1 may also have a role in other acquired skin disorders and physiological skin changes including aging, wound healing, and scarring, although this remains to be determined [55].

Oxidative Stress

As we mentioned previously, the mechanism of synthesis of autoantibodies to structural molecules of the skin is unknown. One hypothesis is that autoantibodies might be the result of DNA damage induced by reactive oxygen species (ROS). Sanders et al. [33] hypothesize that oxidative stress contributes to the sclerotic, immunological, and carcinogenic processes in LS. A physiological balance between free radicals and antioxidant substances is maintained by cell antioxidant enzyme systems: copper-zinc superoxide dismutase (CuZnSOD), manganese superoxide dismutase (MnSOD), and catalase. Both CuZnSOD and MnSOD convert superoxide anions (O_2^-) into peroxide (H_2O_2), using O_2 and hydrogen as substrate. H_2O_2 is then divided into water and O_2 by catalase. ROS occurs when this equilibrium is altered; thus, there is augmentation of free radical formation, or antioxidant deficiency, or both. The resultant production of ROS causes oxidative injury of structural lipids and proteins at the cell membrane level, as well as at the DNA and sulfur-containing enzyme level. There are very sensitive markers of DNA damage, and Sanders demonstrated an increase in these markers and epidermal keratinocytes and dermal fibroblasts in the LS patient group when compared with controls [33].

Infectious

Acrodermatitis chronica atrophicans (ACA) is a dermatosis associated with *Borrelia burgdorferi*. A coexistence of ACA and morphea (localized scleroderma) has been published in 10 % of cases [58]. Associations of morphea with LS, as well as transition between the two entities, have been described [58, 59]. Aberer et al. [60] were the first to propose *B. burgdorferi* as the cause of morphea. Several articles followed their work with controversial results about the possible association of *B. burgdorferi* and morphea and LS.

In a review of the English, French, and German literature from 1983 to 2000, Weide et al. [61] investigated the role of *B. burgdorferi* in the pathogenesis of morphea and LS by serology, immunohistology, culture, lymphocyte stimulation, and DNA detection with polymerase chain reaction. They concluded that *B. burgdorferi* does not play a part in the pathogenesis of morphea or LS. In a recent communication, Edmonds et al. evaluated the sera of 30 adult males with biopsy-proven LS with ELISA. All samples were negative for Borrelia. The samples were also tested with IgG Western blotting. One sample was weakly positive, 9 samples were equivocal, and 53 samples were negative. To date this is the largest sample of patients with male genital lichen sclerosus tested for *B. burgdorferi* with validated techniques. They conclude that this pathogen is not to be considered the cause of LS [62].

LS and Squamous Cell Carcinoma (SCC)

Although extragenital LS does not carry a risk for malignant transformation, the relationship of anogenital LS and SCC is more controversial. The association between LS and malignant lesions on the genitoanal skin has been well established in women and has been reported in 3–6 % of patients with vulvar involvement [12]. In men this association is more controversial. Nasca et al. [14] presented 5 (5.8 %) cases of penile malignant lesions in 86 uncircumcised white patients with a long-standing diagnosis of lichen sclerosus. Three patients had SCC, 1 patient developed erythroplasia of Queyrat (CIS), and the other verrucous carcinoma (VC). Interestingly, 4 of the 5 patients tested positive for HPV 16 with protein chain reaction, which is contrary to reports from other authors, who report a lack of association with HPV-induced SCC and lichen sclerosus [16]. In a subsequent report, Nasca et al. [15] presented three additional cases that developed squamous cell carcinoma in the same series, making a total of 8 penile malignancies in 86 patients with LS (9.3 %), which suggests a considerable risk to develop epithelial malignancy in patients with long-standing LS [15].

Depasquale et al. [13] reported an incidence of 2.3 % of SCC in a series with long-term follow-up of men with genital lichen sclerosus. Twelve patients, of 522 with genital LS, developed squamous cell carcinoma; 5 were uncircumcised and the other 7 had undergone circumcision [13]. Barbagli and associates [16] presented their experience with 130 patients with long-standing LS diagnosis. They reported 11 cases (8.4 %) of penile carcinoma arising from previous lichen sclerosus lesions.

Although malignant changes are an accepted complication of other dermatoses, there is no consensus as to whether LS represents a premalignant condition or just appears concomitantly with squamous cell carcinoma. There is, on the other hand, general agreement that close surveillance should be done in patients with long-standing LS, advising prompt biopsies of any suspicious lesions, as early treatment of penile carcinoma carries a high success rate. The recommendation of the International Consultation of Urologic Disease (ICUD) on urethral stricture is to establish a long-term follow-up in patients with persistent lichen sclerosus to evaluate the possible malignant transformation [63].

Histology

The histology of LS is not one of pathognomonic features, but rather one of global histologic appearance (Fig. 4.1a, b). There are clearly other entities, with potential malignant significance, which share many of these features. The histologic features can vary within the stages of the LS process, the severity of lesions, and after effective treatment [64, 65].

At the epithelial level, there is an effacement of the crests with epidermal thinning. Hydropic degeneration (vacuolization) of the basal keratinocytes and inflammation and disruption of the basal membrane are common findings. When vacuolization is intense, there is disruption at the level of the dermis or the epidermis with consequent bulla formation, usually associated with mechanical trauma (e.g., scratching). There is also edema and homogenization of the collagen of the superficial dermis, with reduction of the elastic fibers, vascular stasis, and the deposition of glycosaminoglycans. Additionally,

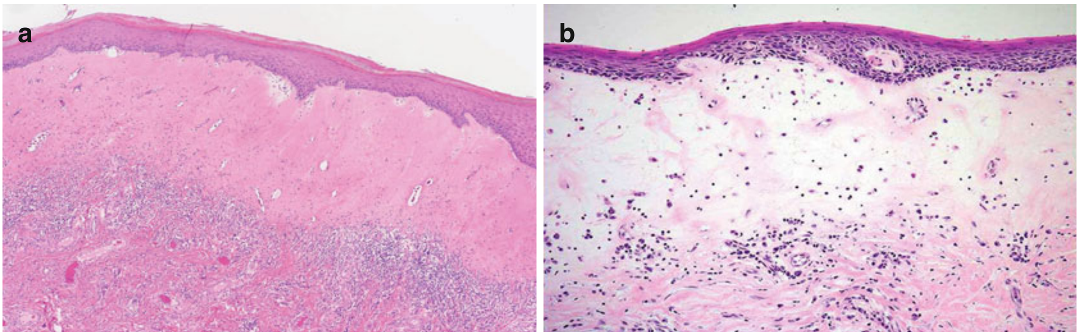

Fig. 4.1 (**a**) LS with hyperkeratosis, atrophic epidermis, edema, and homogenization of the papillary dermis with band-like mononuclear inflammatory infiltrate immediately beneath (hematoxylin and eosin, magnification 100×). (**b**) High-power view with thick hyperkeratotic layer, focal interface changes, and pigment incontinence (hematoxylin and eosin, magnification 40×)

perivascular mononuclear infiltrates are noted and the absence of melanocytes is noteworthy. These histologic findings along with edema produce the typical "white-patch appearance" of the lesions which are recognized as lichen sclerosus. In quiescent cases, it is common to observe an alternation of atrophic areas with epidermal hyperplasia, and the edema of the acute phase is replaced by collagen sclerosus [65]. Thus, biopsies of the lesions are often reported as compatible with lichen sclerosus.

Fig. 4.2 LS affecting the glans in a young man with resultant meatal stenosis and difficulty voiding. Note a well-defined line between healthy penile skin and atrophic/discolored tissue

Clinical Presentation

As mentioned previously, the most commonly affected areas, in both males and females, are the genitalia and perineum [4]. In the female subjects the urethra is spared, whereas in the males perianal involvement has not been described [57].

The lesions start as white patches that seem to coalesce into "plaques" (Fig. 4.2). In men, this often affects the prepuce, forming a sclerotic white ring creating phimosis [66]. When the glans is involved, it may have a mottled appearance. It is, in the author's experience, not unusual for patients to sometimes present just with perimeatal involvement, and the perimeatal area will appear white and scarred.

With progression, the lesions tend to obliterate the coronal sulcus. The frenulum becomes retracted in the scarring process and eventually the meatus can be almost obliterated by the scar [64]. The external meatus is affected in 4–37 % and the urethra in 20 % of patients [13, 67].

It is not agreed upon as to whether LS progresses into the fossa navicularis and a portion of the anterior urethra or whether the involvement of the urethra may all be secondary to the initial involvement at the level of the meatus with the development of meatal stenosis and high-pressure voiding. It is not at all unusual for the process to

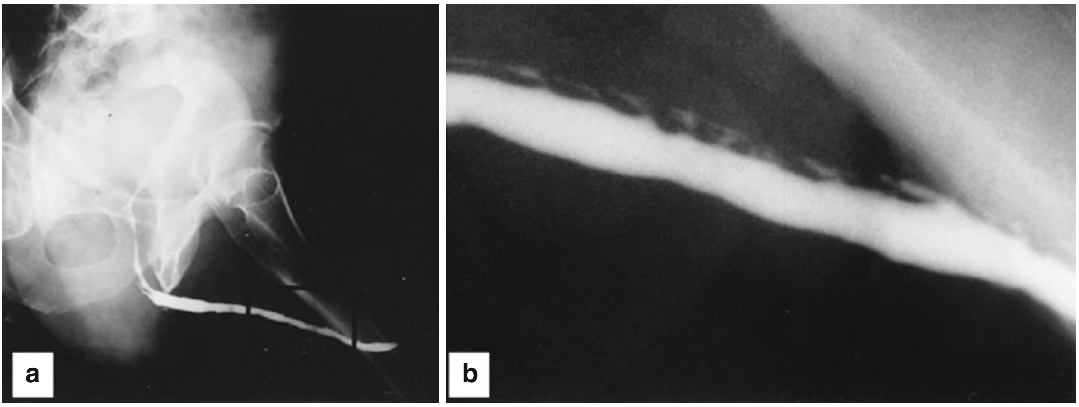

Fig. 4.3 (**a** and **b**) Retrograde urethrogram demonstrating the typical long and "saw-toothed" urethral stricture pattern of LS, along with dilation of the glands of Littré

involve only a portion of the anterior urethra and possibly may reflect the distribution of the glands of Littré in a given patient.

The classic appearance of male anterior urethral stricture associated with LS is that of a saw-toothed appearance throughout the involved area, with an area of perfectly normal anterior urethra proximally (Fig. 4.3). Patients present with both local and voiding symptoms. Itching is frequently reported, loss of glans sensation is likewise reported, and erections are often painful because of the scar limitation and limitation of the expansion of the penile skin due to scarring, particularly the area of the frenulum. Voiding complaints such as dysuria, urethral discharge, and obstructive lower urinary tract symptoms are frequent. With intercourse, patients often complain of tearing of the scarred frenulum.

At cystoscopy, the meatus is narrow, oftentimes displaced ventrally, even in patients who have not had meatotomy previously. The urethral epithelium appears whitish and the existence of filamentous white tissue which can be easily passed with the cystoscope is usual [64]. If one uses a pediatric cystoscope, usually the area of involvement can be traversed, with the sudden appearance of absolutely normal urethral epithelium and on contrast studies what appears to be normally compliant tissues. However, in the multiply instrumented patient, and the patient with urethral stricture secondary to LS, usually a multiply instrumented patient, the preservation of a normal proximal urethra is not a given.

Management

There is a recent guideline for the management of the patient with genital LS by the British Association of Dermatologists (BAD) [68]. The ICUD on urethral stricture has recently made recommendations also [63]. All management recommendations are based on nonrandomized series and local expert opinion.

The association with malignancy of the glans has been discussed previously. It is not the author's feelings, nor is it the recommendation of the 2010 ICUD on urethral stricture, that all patients need a biopsy. It is of paramount importance to rule out premalignant and malignant lesions that can be confused with lichen sclerosus, such as erythroplasia of Queyrat, lichen planus, and leukoplakia, all of them with distinctive histologic features [64]. What seems to be the hallmark with the suspicion of malignancy is the patient with "genital lichen sclerosus" that "behaves abnormally." In our experience, the vast majority of patients, even with significantly inflamed lichen sclerosus, can have their disease process quieted with the use of local application of superpotent steroids (Grade A recommendation by ICUD [63] and

Grade B recommendation by BAD [68]) and antibiotics. The use of antibiotics initially was done because of the proposed infectious etiology. Both doxycycline and the fluoroquinolones share the property of having excellent tissue accumulation of the antibiotic. Whether it is the antibiotic effect or an effect of the antibiotic being present in the skin is not clear. However, the experience of many who deal with LS would suggest that most cases can be treated with this combination. Thus, if the patient's inflamed status does not settle down with such a regimen, this raises a red flag that these patients should be biopsied. The problem with biopsy is that the findings of squamous cell carcinoma of the glans can be very elusive. We have had a number of patients who have been biopsied, with a biopsy read as benign, who continued to have problems, were rebiopsied, and eventually read as consistent with squamous cell carcinoma of the penis. We have also had other patients, where the biopsy has been consistently read as benign and later shifted to a therapy more compatible with the treatment of superficial squamous cell carcinoma of the glans (i.e., topical 5FU cream), where the process has responded. Again, concern should be about the patient who "doesn't act right." The opinions regarding urethral reconstruction are discussed below under Chap. 20, Staged Urethroplasty, in this text.

Medical Treatment

Nonsurgical management of these patients can certainly be undertaken. As mentioned, these patients are treated with a superpotent steroid and antibiotic. Our regimen consists of 0.05 % clobetasol propionate cream two to three times a day for 6–8 weeks with patients who present acutely and an initiation of antibiotic therapy at suppressive levels. The patient is reassessed at 6 weeks to 3 months. If the process has settled, the patient is voiding adequately and, his urinalysis reflects sufficient voiding, then the patient is followed.

Recently, the use of topical tacrolimus has been proposed in an effort to avoid late atrophy and further damage to an already thinned and fragile skin as a result of the inflammatory process of lichen sclerosus [69]. Luesley and Downey presented the first series of histologically confirmed LS treated with macrolactams. Sixteen women were enrolled; 60 % responded to treatment, and two patients had complete remission. They state that this observational study would justify a larger phase II study to accurately quantify the response to this topical alternative [69]. The BAD guidelines recommend that tacrolimus should not be used as first-line treatment for LS (Grade D recommendation) [68]. Bunker states that the use of an immunosuppressant drug with known neoplastic potential, in a dermatosis with malignant potency, could be detrimental [70].

Surgical Management

Surgical managements that are proposed are circumcision, repeated meatal dilation, meatotomy, meatoplasty, and obviously urethral reconstruction. Circumcision is no guarantee that the LS process will settle and not progress. Depasquale and Bracka [13] presented a high success rate with circumcision. Of 522 patients with LS diagnosis, they treated 287 with circumcision alone. Of the 287 patients who had been circumcised, 276 (92 %) needed no further treatment and were considered "cured."

Other surgeons have also reported good long-term results with circumcision in lichen sclerosus patients [71]. Kulkarni and colleagues published a multinational large series of males with LS. 34/215 patients underwent circumcision for histologically proven LS limited to the foreskin. All patients were cured with the circumcision [71].

Meatal dilation can certainly buy time; meatotomy is seldom a long-term fix. Morey et al. showed a success rate of 87 % (14/16 patients) with extended meatotomy in patients with refractory stenosis [72].

Malone described an innovative technique with a ventral/dorsal meatotomy and a relaxing V-shaped glans incision. They reported excellent functional and cosmetic results [73].

Whether it is the Koebner phenomenon that dooms meatotomy to failure or just the fact that LS is a "skin disease" is not clear. When there is meatal or perimeatal compromise, more aggressive therapy is required. Patients with meatal and perimeatal involvement frequently have developed panurethral stricture disease, probably the result of a combination of disease progression and high-pressure voiding against meatal stenosis. The trauma of repeated dilations cannot be underestimated.

Conservative methods to manage urethral strictures, such as internal urethrotomy and frequent dilations, have proven to achieve poor results in urethral strictures associated with lichen sclerosus. Several meatoplasty techniques have been proposed in the past, with variable functional and cosmetic results [74–79]. In a review of our series of strictures of the meatus and fossa navicularis, corrected with the ventral transverse skin island elevated on a dartos fascial flap, 12 patients (34 %) had LS. LS recurred at the fossa or meatus in 6 patients (50 %), with a mean follow-up of 8.9 years and a median of 8.3 years [80].

Early on, we applied this technique to every patient with a fossa stricture; in fact we believed it was the solution for those patients with a meatal stricture secondary to LS [81]. With better understanding of the pathophysiology of LS, we know that the process can recur in the flap. Venn and Mundy [82] published a 100 % recurrence of the inflammatory process when using genital skin for the repair of fossa navicularis stricture with LS/BXO. We had a 50 % flap recurrence in our series [80], and an explanation of this lower number could be that not all of them had true LS/BXO, as we did not biopsy all of the patients. After 2001 we stopped using this technique for LS/BXO, and since then, we have been treating LS fossa navicularis strictures with primary or staged buccal mucosa graft onlay; preliminary results are encouraging (data not published). Recent debate around the proper tissue for reconstruction of the meatus and fossa navicularis in patients with LS involvement needs to be clarified with long-term results of buccal mucosa procedures [83–85].

Anterior urethral reconstruction is considered when medical management fails or for complex strictures. It is the consensus of the ICUD on urethral strictures that skin should not be used for urethral reconstruction in patients with lichen sclerosus (Grade A recommendation) [63].

The optimal tissue to replace the urethra has not yet been discovered, but buccal mucosal grafts, since first introduced in 1992 [86], have passed the proof of time and have become the tissue of choice in almost every reconstructive center around the world. In addition, other oral mucosal grafts, such as labial or lingual [87], have been utilized with excellent results.

Single- or multiple-stage techniques, with the use of buccal mucosa graft, have been used with optimal results [71, 88, 89].

The urethral reconstruction techniques are discussed elsewhere in this textbook.

Editorial Comment

While somewhat controversial, I feel that the natural history of urethral LS starts off as meatal stenosis and high-pressure voiding. Untreated or temporizing measures to treat the meatal stenosis lead to infection of the glands of Littré (littritis) and a posteriorly creeping stricture of multiple annular rings and segmental stenoses (Fig. 4.4a–c). With time, the process can involve the entire anterior urethra (Fig. 4.4d). It is for this reason and the potential for disease progression that I am fairly aggressive in treating meatal stenosis in these patients. Any failure at a urethrotomy or dilation, I quickly proceed to an extended meatotomy or a staged meatoplasty/urethroplasty (Fig. 4.5a, b).

On the basis of our clinical experience and reports by Mundy, Bracka, and others, our standard surgical practice for LS strictures is to avoid local genital skin, because in the long term, such surgeries progressively fail. We feel that foreskin or genital skin used for a flap may be involved by nonvisible LS and eventually lead to disease recurrence in the urethra. Although some authors do report good success with local genital skin flaps for LS, we feel this is more the

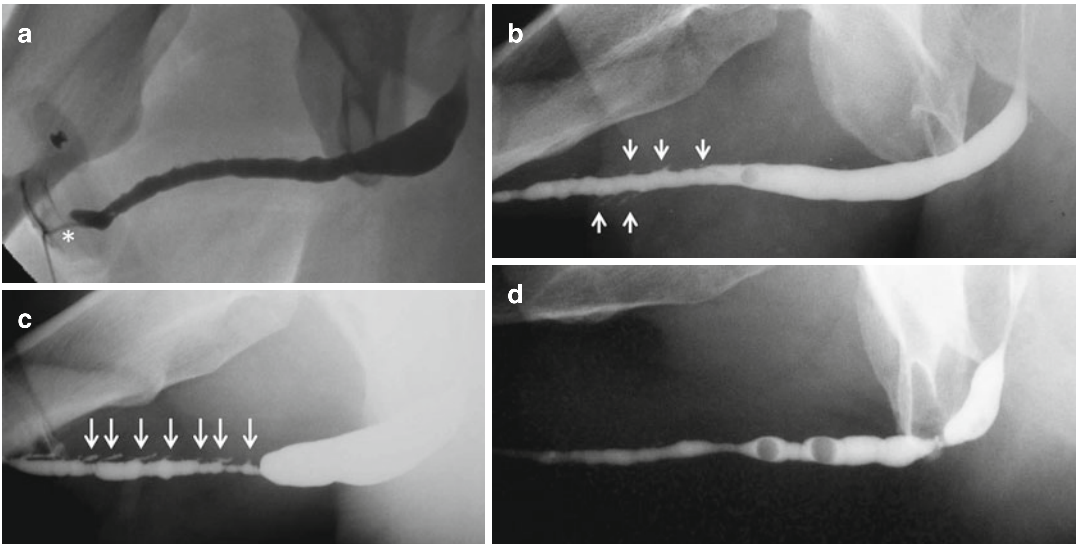

Fig. 4.4 Natural history and progression of LS and anterior urethral stricture disease. (**a**) "*" denotes the meatal stenosis. Also note the irregular penile urethral wall. (**b**) Prominent glands of Littré (*see arrows*) and distal urethral stenosis. (**c**) Prominent glands of Littré (*see arrows*) and long penile stricture. (**d**) Panurethral stricture from the meatus to the mid bulb (Images courtesy of E. Palminteri)

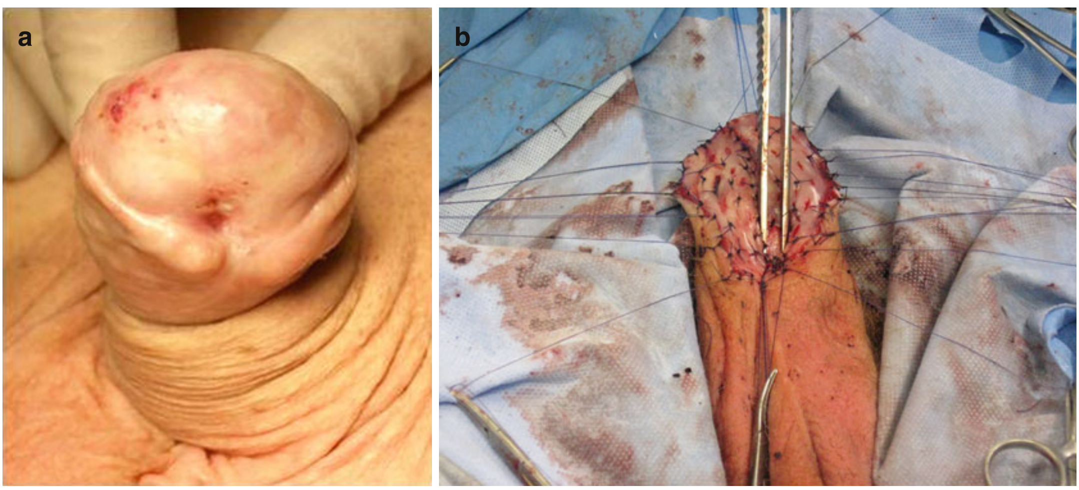

Fig. 4.5 (**a**) Typical appearance of glans penis and meatal stenosis from LS. (**b**) First-stage urethroplasty with buccal graft for the meatal and fossa urethral stricture (Image courtesy of G. Barbagli)

exception than the rule. Surgical therapy must be tailored to the site affected, the extent that the tissue is involved, and patient preference. For strictures that involve the urethral meatus, we usually perform a wide meatotomy, followed by long-term topical high-potency steroid or tacrolimus therapy. We manage strictures that involve the fossa navicularis or the penile urethra either by a staged urethroplasty (using buccal grafts) or a one-stage urethroplasty with dorsally placed buccal grafts. At the time of surgery, wide surgical margins are demanded in order to ensure that all involved LS tissue is removed.

Over the years, for so-called LS panurethral strictures, I have come to utilize less complex and aggressive urethroplasty. Although the urethrography may show narrowing of the entire urethra, most times it is only the meatus and fossa that is severely narrowed and the true functional culprit. To void with a relatively normal flow rate, the urethra just needs to be >14 Fr. So I evolved my approach to urethral reconstruction with the bias that everyone does not deserve, nor is it necessary, for the urethra to be 24FR. While this is an admirable goal, the functional result is what is important – so oftentimes the entire urethra does not have to be reconstructed – just the worst aspects. For this reason, if the distal urethra is pinpoint, but the rest of the urethra calibrates to >14 Fr, I will start off with just doing a distal BMG and leave the rest of the urethra alone. If the urethra is truly narrowed throughout, but the membranous urethra and proximal bulb is LS free and open, I have recently been utilizing more perineal urethrostomies rather than the typical extensive panurethral reconstructions.

In conclusion, all LS patients require long-term follow-up because the disease can progressively relapse and because of some rare, yet controversial, concerns for potential malignant transformation.

–Steven B. Brandes

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Imaging of the Male Urethra

5

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and Cary L. Siegel

Summary

The most common methods for imaging the male urethra are retrograde urethrography (RUG) and voiding cystourethrography (VCUG). In order to formulate a proper management plan, an accurate and well-executed study is essential to determine stricture presence, number, location, degree, and length. Conventional urethrography is performed under fluoroscopy with the hip tilted and the penis slightly stretched. Inadequate oblique images will underestimate "true" stricture length and the pubic bones may obscure the posterior urethra. VCUG is most valuable for assessing the posterior urethra, the proximal extent of stenoses, and their functional significance. Other modalities, such as MRI, CT, and sonourethrography, have an important yet limited role in urethral evaluation. MRI has particular value in evaluating the pelvic fracture patient with associated urethral disruption injury. Sonourethrography is particularly accurate at determining true bulbar urethral stricture length and extent of luminal narrowing. Detailed herein are such imaging techniques and the imaging characteristics of both the normal and abnormal male urethra.

Introduction

There are a number of different imaging techniques that may be used in imaging the male urethra. The most widespread methods include retrograde urethrography (RUG) and voiding cystourethrography (VCUG). However, other modalities, such as ultrasound, magnetic resonance imaging (MRI), and computed tomography, have been used as adjuncts.

Accurate diagnosis of stricture presence, number, location, and length is of paramount importance in planning appropriate treatment. Although RUG and VCUG are often sufficient for this purpose, ultrasound and MRI can be useful in certain situations, such as the evaluation of spongiofibrosis and the periurethral tissues.

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The purpose of this chapter is to review the different imaging modalities used in studying the male urethra, their techniques and indications. Normal and abnormal anatomy will be illustrated, with special attention to pre- and postoperative imaging of urethral stricture disease.

Conventional Urethrography

RUG and VCUG are the most commonly used techniques for male urethral imaging. They are readily available and can be safely and relatively quickly performed. The information they provide is usually sufficient to direct patient care. Serious complications are rare, and the procedure is usually well tolerated by patients.

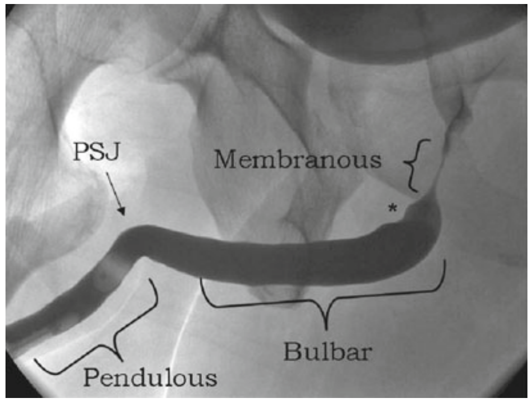

Fig. 5.1 Normal RUG. The tip of the Foley catheter can be seen in the fossa navicularis, as well as an air bubble which was introduced during the exam. The segments of the urethra are labeled. Note the natural bend in the urethra at the penoscrotal junction (*PSJ*), separating the pendulous and bulbar segments. Note the indentation in the anterior surface of the proximal bulbar urethra caused by the musculus compressor nuda (*asterisk*), composed of fibers of the bulbocavernosus muscle which wrap anterior to the urethra [1]

Normal Anatomy

The anterior urethra consists of a distal pendulous or penile segment and a proximal bulbar segment. The pendulous urethra is a smooth and featureless structure that widens focally near the meatus at the fossa navicularis. It is separated from the bulbar urethra at the penoscrotal junction, a natural bend that occurs in the urethra where it is bound superiorly by the suspensory ligament of the penis. The bulbar urethra is also smooth in contour and assumes a cone or funnel shape proximally at the bulbomembranous junction. Visualization of the bulbar cone is very important in the evaluation of a bulbomembranous junction abnormality, as an abnormal appearance of the cone is highly associated with membranous urethral involvement in disease (Fig. 5.1 [1]).

The posterior urethra consists of a distal membranous segment which, as it traverses the muscular urogenital diaphragm, becomes the narrowest portion of the normal urethra. More proximally, the prostatic urethra can be seen extending from the bladder neck to the membranous segment. A small longitudinally oriented mound of smooth muscle, the verumontanum, is present along the dorsal aspect of the prostatic urethra and can be seen as a filling defect during fluoroscopic studies. Its distal end marks the proximal aspect of the membranous urethra [2]. Useful anatomic landmarks to identify the membranous urethra are the inferior margins of the obturator foramina (Fig. 5.2 [3]). It is particularly important to identify the exact location of the membranous urethra, as this is where the urogenital diaphragm and external sphincter are located. In the trauma setting, injury to the external sphincter may affect urinary continence.

Retrograde Urethrography

The RUG is most useful for evaluation of the anterior urethra from the external meatus to the proximal bulbar portion. To perform the procedure, the patient is placed supine on the fluoroscopy table and then rolled up slightly onto one hip (approximately to a 45° angle), with the dependent thigh flexed so that an oblique view of the lengthened urethra can be obtained

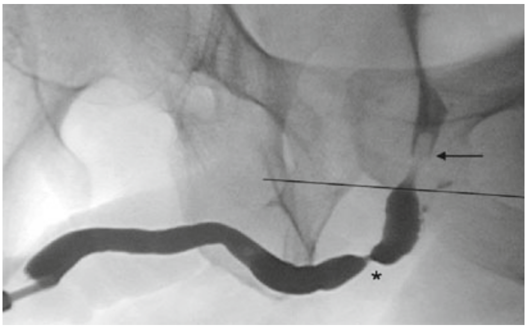

Fig. 5.2 Bony landmark for the membranous urethra. An *imaginary line* drawn near the inferior margin of the obturator foramina intersects the bulbomembranous junction of the urethra. This is most useful when urethral anatomy is distorted by trauma or stricture, precluding identification of the different portions of the urethra by morphology alone. Note the verumontanum (*arrow*), a filling defect in the posterior urethra whose distal end marks the proximal extent of the membranous urethra. There is a severe stricture of the bulbar urethra in this patient (*asterisk*). We also see Cowper's duct

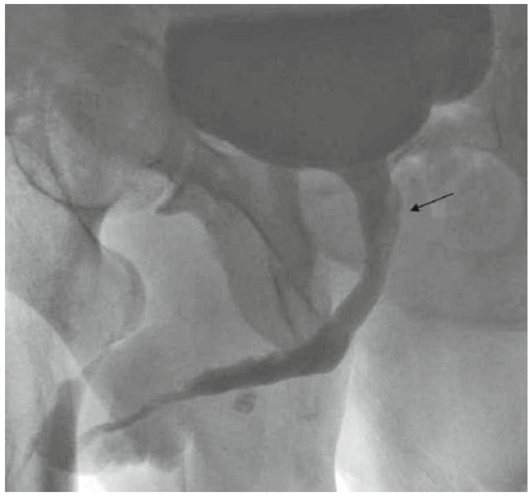

Fig. 5.4 VCUG. With voiding, the bladder neck opens and the prostatic urethra is distended. Note the faint filling defect posteriorly in the prostatic urethra due to the verumontanum (*arrow*)

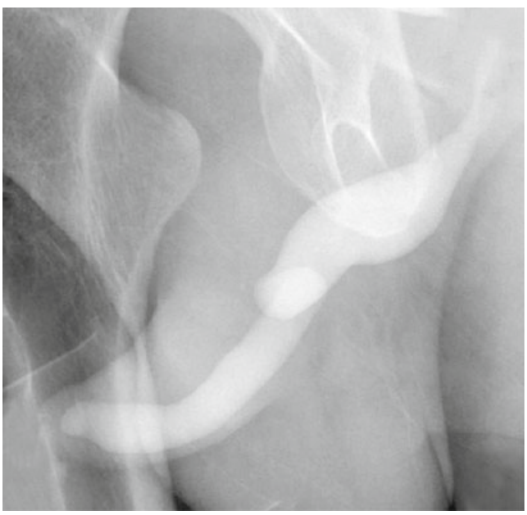

Fig. 5.3 Importance of proper patient positioning during RUG. In this patient who has not been placed in an oblique enough position, the distal bulbar and proximal pendulous urethrae overlap, thereby foreshortening and obscuring any strictures that may be present

(Fig. 5.3). Attention to proper patient positioning is extremely important to lengthen the urethra, to avoid overlap of the urethra and foreshortening of any strictures, and to view the posterior urethra separate from the pubic symphysis that may be present (Fig. 5.4).

The glans penis is cleansed with the use of a sterile technique, and a contrast administration device is inserted into the meatus. A small Foley catheter with the balloon gently inflated with 1–1.5 mL of air in the fossa navicularis until the catheter is secure generally serves this purpose well. Other devices include a suction catheter, a cone-tipped catheter, or a Brodney clamp. Sterile iodinated contrast is then injected into the urethra with the use of gentle pressure to avoid extravasation. In men with a patulous external meatus, a soft clamp or gauze tied around the external meatus may be used to stabilize the catheter in the fossa navicularis.

Because the anterior urethra is distended during the RUG, this examination is most useful for interrogation of the anterior segment. The number, location, and severity of strictures can be well delineated. Although the posterior urethra is opacified during most examinations, its distention is usually poor after contrast passes through the relatively narrow membranous urethra. To improve visualization of the posterior urethra, the patient can be instructed to void during the examination, distending the poste-

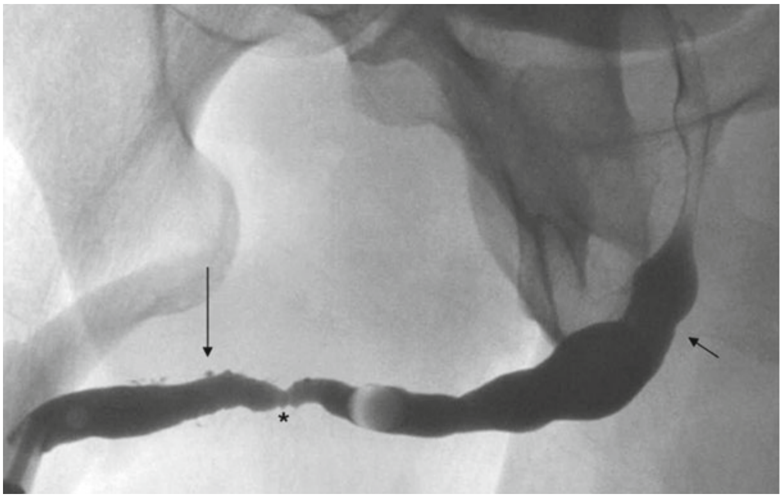

Fig. 5.5 Musculus compressor nuda and glands of Littre. The musculus compressor nuda that creates a normal muscular indentation along the anterior aspect of the proximal bulbar urethra is frequently seen during retrograde urethrography and should not be mistaken for a stricture (*arrow*). Note the true strictures in the pendulous urethra, immediately distal to an air bubble in the urethral lumen (*asterisk*). There is also filling of the glands of Littre (*long arrow*) in the pendulous urethra, commonly associated with prior episodes of urethral infection or inflammation

rior segment. Alternatively, autourethrography, where the patient injects the contrast himself after a catheter has been placed, has been shown to increase distention of the posterior urethra. It also may result in a less uncomfortable exam, with less risk of contrast intravasation [4].

Voiding Cystourethrography

The VCUG often is performed in conjunction with retrograde urethrography and is especially useful in assessing the posterior urethra. In contrast to the RUG, descent and opening of the bladder neck and distention of the posterior urethra are achieved during micturition [5]. During normal voiding, the membranous urethra distends slightly, while remaining the narrowest part of the urethra. As the membranous urethra widens, the cone of the bulbar urethra becomes less apparent and is infrequently seen [1].

To perform a VCUG, the bladder is filled with contrast either through the urethra in a retrograde fashion, an indwelling Foley catheter, or a suprapubic catheter. Rarely, a VCUG may be performed when contrast has been injected intravenously and the bladder has been allowed time to fill. The patient is positioned in much the same way as during a RUG and instructed to void into a canister. This is more easily accomplished if the fluoroscopy table is tilted upwards so that the patient is in a standing position. Images of the urethra are then obtained during voiding (Fig. 5.5).

Occasionally, normal anatomic structures are opacified during RUG or VCUG and should not be confused with areas of extravasation. Examples of such structures include the glands of Littre, the prostate gland, and the Cowper's glands and ducts. Opacification of the glands of Littre is often associated with urethral inflammation and stricture disease [3]. The musculus compressor nuda muscle may also be apparent and should not be confused with a stricture (Figs. 5.6, 5.7, and 5.8).

RUG and VCUG usually are safely and quickly performed, with little risk to the patient. Complications are extremely rare but may occur if there is venous intravasation of contrast either in a patient with a contrast allergy or in a patient with active infection, as a contrast reaction or bacteremia may result (Fig. 5.9).

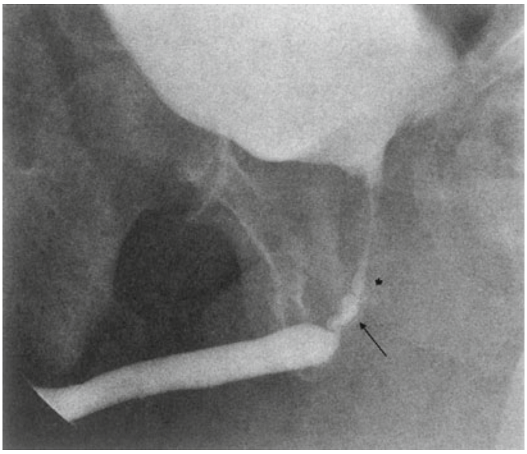

Fig. 5.6 Cowper's glands and ducts. Opacification of these structures is often, but not always, associated with urethral strictures or inflammation. In this case, a stricture of the bulbomembranous junction is present. Remembering that Cowper's glands (*asterisk*) are located in the urogenital diaphragm, at the same level as the membranous urethra, and that the ducts (*arrow*) empty into the proximal bulbar urethra can be useful anatomic landmarks, as in this case

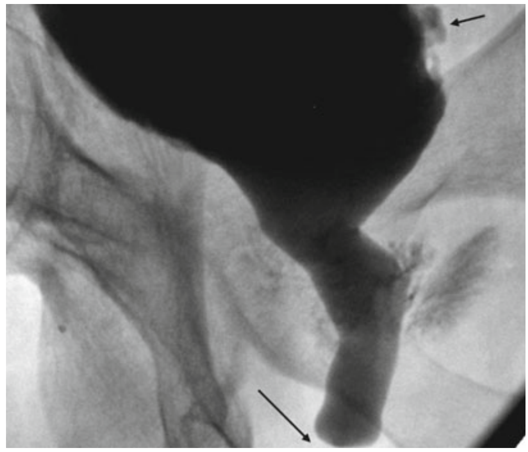

Fig. 5.7 Prostate gland. There are multiple tiny openings in the prostatic urethra from the prostatic ducts. These may become opacified during RUG, leading to visualization of the prostate gland itself. When this occurs, the pattern of glandular enhancement assumes a feathery appearance as illustrated above. There is a severe stricture of the membranous urethra (*long arrow*) causing dilatation of the prostatic urethra. Also note the bladder diverticula (*short arrow*), suggestive of long-standing bladder obstruction

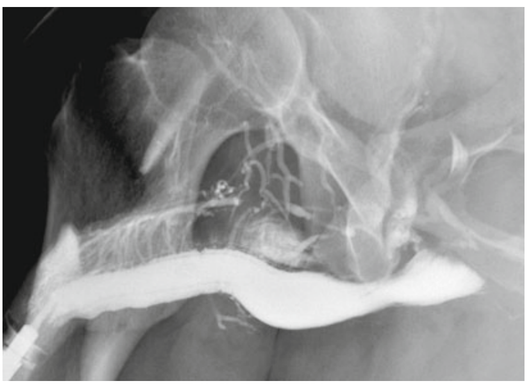

Fig. 5.8 Venous intravasation. If contrast is injected during RUG with excessive force or against a stricture that creates a pressure head, the urethral mucosa may be violated, leading to passage of contrast into the corpora spongiosum and the highly vascular corpora cavernosum [1, 13]. The contrast is then taken up by the penile venous system. This may predispose the patient to bacteremia or a contrast reaction, if the patient is allergic to iodinated contrast

Stricture Characteristics and Extent

Urethral strictures are most commonly the result of trauma, including iatrogenic injury. In the past, urethral strictures were most commonly caused by infection. However, as AIDS awareness has increased since the early 1980s, infectious strictures have become less frequent [3]. In nonindustrialized countries, chlamydia, gonorrhea, and tuberculosis are the most common agents to result in urethral stricture, whereas in the industrialized world, it is more commonly lichen sclerosus.

Strictures caused by instrumentation tend to occur at the membranous segment, because of its relatively narrow diameter, and the penoscrotal junction, where the urethra is fixed by the suspensory ligament of the penis. They are usually short in length and smooth in contour. Traumatic strictures are also typically short, focal, and smooth contoured but involve the bulbar urethra. In contrast, infectious strictures are irregular in contour, several centimeters in length, and often multifocal and involve the anterior urethra.

Not only is urethral imaging crucial in detailing the characteristics and extent of stricture disease before therapy, but it is also extremely useful in the evaluation of the postoperative

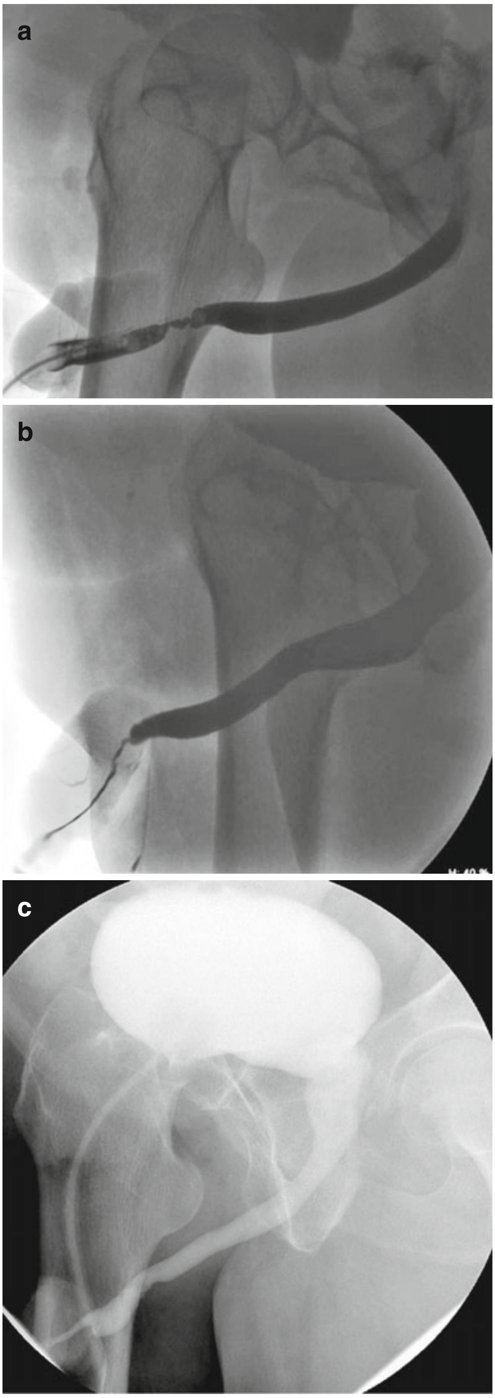

Fig. 5.9 Pendulous stricture. Preoperative RUG (**a**) and VCUG (**b**) demonstrate a proximal pendulous and distal bulbar urethral stricture with associated subtle filling of the glands of Littre. Note that the distal margin of the stricture is not defined during VCUG due to poor distention of the urethra distal to the stricture. A post-urethroplasty VCUG (**c**) shows only mild residual narrowing of the distal pendulous urethra with no leakage of contrast

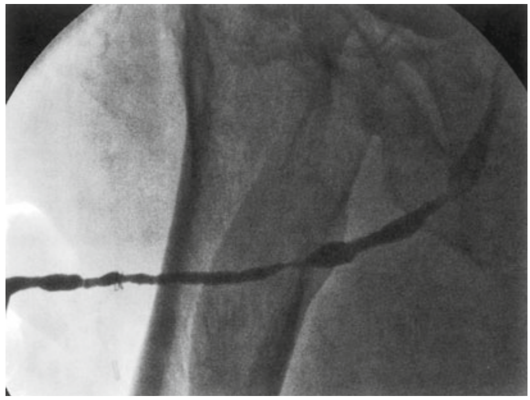

Fig. 5.10 Anterior urethral stricture. A long-segment stricture involves the entire course of the anterior urethra, which is diffusely irregularly narrowed

patient to assess response to therapy as well as possible complications (Figs. 5.10, 5.11, 5.12, 5.13, 5.14, 5.15, 5.16, and 5.17).

Ultrasound and Sonourethrography

Ultrasound has a limited role in evaluation of the male urethra. The preferred transducer is a linear high-frequency (7.5 MHz) transducer, and evaluation must be done in axial and longitudinal planes, while saline is injected retrograde (Figs. 5.18 and 5.19). In some cases a transperineal ultrasound may help in locating a reclusive calculus within the prostatic or the membranous urethra (Fig. 5.20). In cases of trauma, ultrasound can provide a quick estimate of soft tissue injury although a retrograde urethrogram would be required to assess the urethra itself. Incidental lesions, like Peyronie's plaques, can be seen in the corpora cavernosa with ease (Fig. 5.21).

A less frequently used method of imaging the urethra is sonourethrography. Introduced in the mid-1980s, it is an accurate tool for the diagnosis and characterization of strictures, particularly of the bulbar urethra. The examination is usually performed during the installation of sterile saline into the urethra in a retrograde fashion with the use of a small Foley catheter with its balloon inflated in the fossa navicularis or using a tipped syringe, much in the same way as a RUG.

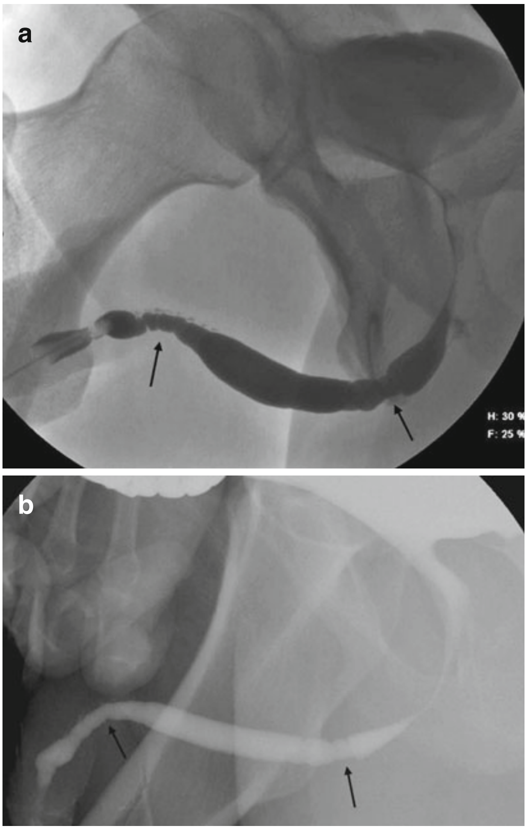

Fig. 5.11 Anterior urethral strictures. RUG (**a**) and VCUG (**b**) show strictures of both the pendulous and distal bulbar urethra (*arrows*) with associated filling of Cowper's glands and the glands of Littre. Note that the strictures are more apparent on the retrograde examination due to the superior distention of the anterior urethra that is attained during RUG

A high-frequency (7.5 MHz) linear transducer is then placed on the ventral surface of the penis and oriented along the course of the pendulous and bulbar urethra (Fig. 5.22). The probe may have to be repositioned more posteriorly onto the perineum to visualize the bulbar urethra. Although less frequently performed, transperineal scans may be obtained to image the posterior urethra. Some authors have advocated the use of an endorectal probe for imaging the posterior urethra, but this is seldom necessary (Figs. 5.23 and 5.24 [6]).

The advantage of sonourethrography lies in its ability to determine stricture length, espe-

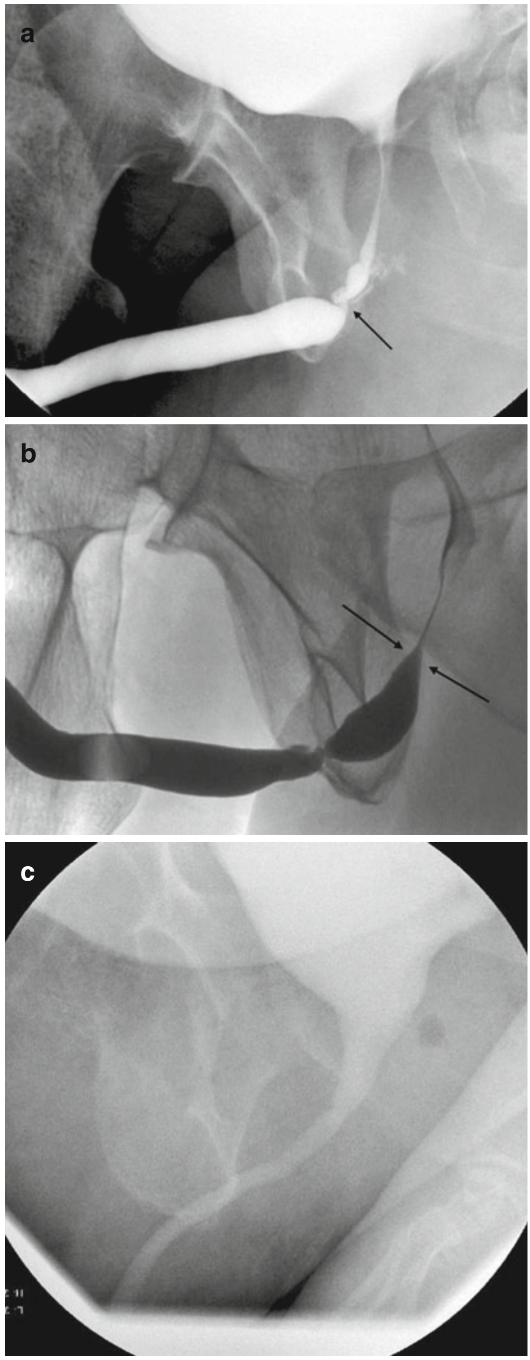

Fig. 5.12 Anterior urethral stricture. (**a**) RUG showing a severe stricture of the proximal bulbar urethra (*arrow*) with filling of Cowper's glands. Note the loss of the normal bulbar cone, shown in a different patient in (**b**) (*arrows*), indicating involvement of the bulbomembranous junction. Post-urethroplasty image (**c**) showing the normal postoperative appearance of the urethra

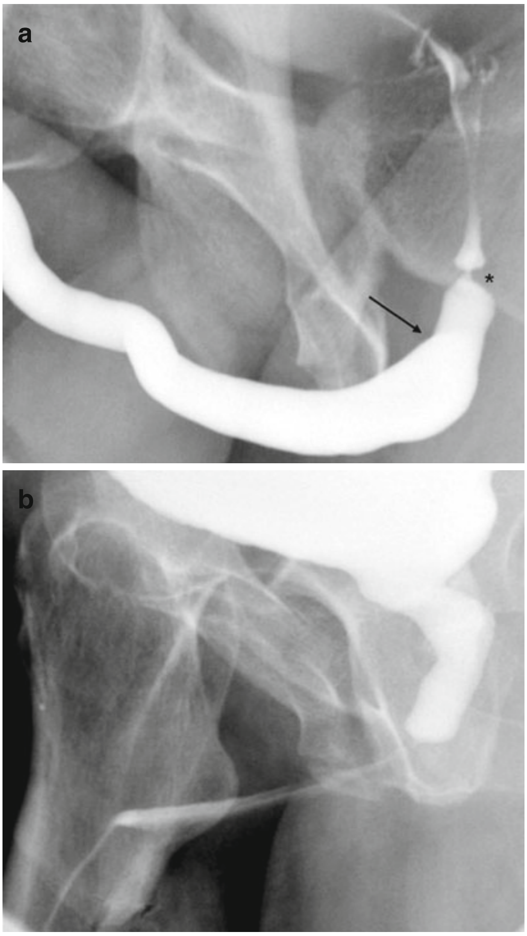

Fig. 5.13 Posterior urethral stricture. A focal stenosis of the membranous urethra is seen with both RUG (**a**) and VCUG (**b**) (*asterisk*). The cone of the bulbar urethra is preserved during the RUG (*arrow*), indicating that the proximal bulbar urethra is not involved in the stricture. There is distention of the prostatic urethra during voiding (**b**), due to the severe membranous urethral stricture

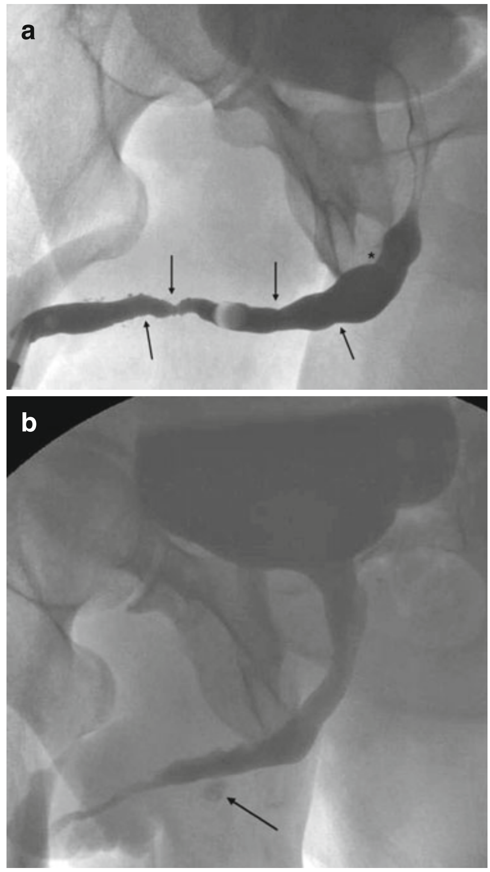

Fig. 5.14 Anterior urethral strictures. RUG (**a**) showing multiple strictures involving the pendulous and distal bulbar urethra (*arrows*). Note the normal appearance of the musculus compressor nuda (*asterisk*) and filling of the glands of Littre. A post-urethroplasty VCUG (**b**) demonstrates a small contrast leak at the operative site (*arrow*)

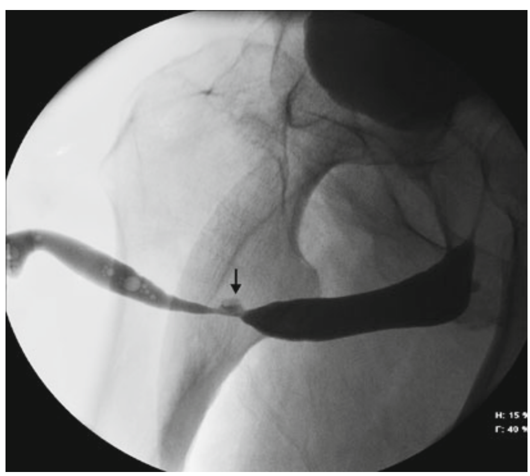

Fig. 5.15 Penile cancer. Long irregular stricture of the urethra, with ulceration (*arrow*) over the dorsal surface of the urethra due to penile cancer

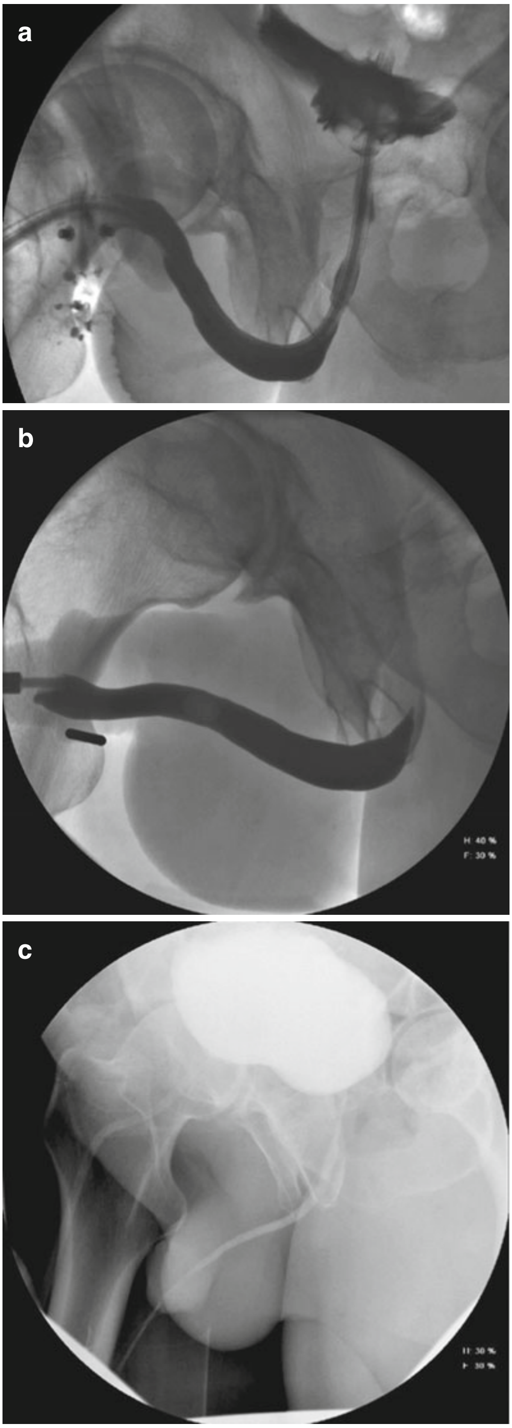

Fig. 5.16 Bulbomembranous disruption. Pericatheter RUG (**a**) in a patient with pelvic trauma reveals no gross abnormality. A standard retrograde exam performed 2 months later shows normal opacification of the anterior urethra but no filling of the posterior urethra (**b**). A voiding exam performed after urethroplasty shows resolution of the stricture and no leakage of contrast (**c**)

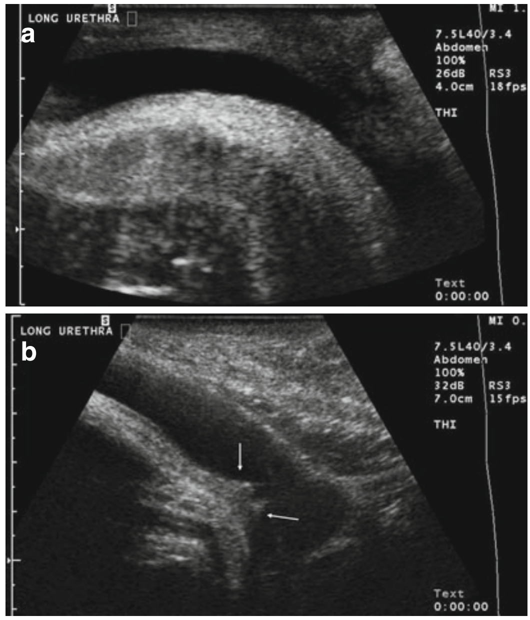

Fig. 5.17 Sonourethrogram. The pendulous urethra (**a**) is normal in caliber and distends uniformly after saline administration. However, there is a mound of tissue along the dorsal aspect of the bulbar urethra (*arrows* in **b**) causing a mild stricture. Note that the most superficial surface of the urethra closest to the transducer corresponds to the ventral surface

cially in the bulbar urethra, with a high degree of accuracy. Because the probe can be oriented along the course of the urethra, there is less tendency to foreshorten the length of a stricture than with RUG. Several authors have demonstrated the superiority of ultrasound in determining bulbar urethral stricture length, which is an important factor in treatment planning [7–10]. Short strictures may be amenable to excision and primary anastomosis, whereas longer strictures may necessitate urethroplasty. In addition, sonourethrography may provide information about the soft tissues surrounding the urethra including the degree of spongiofibrosis surrounding the stenotic portions of the lumen [8, 9, 11]. As fibrosis develops, the urethra becomes less distensible compared with the surrounding normal tissues, which is illustrated during the sonourethrogram [5, 10]. This information cannot be provided by conventional RUG/VCUG and is relevant as the severity of periurethral fibrosis is proportional to the frequency of stricture recur-

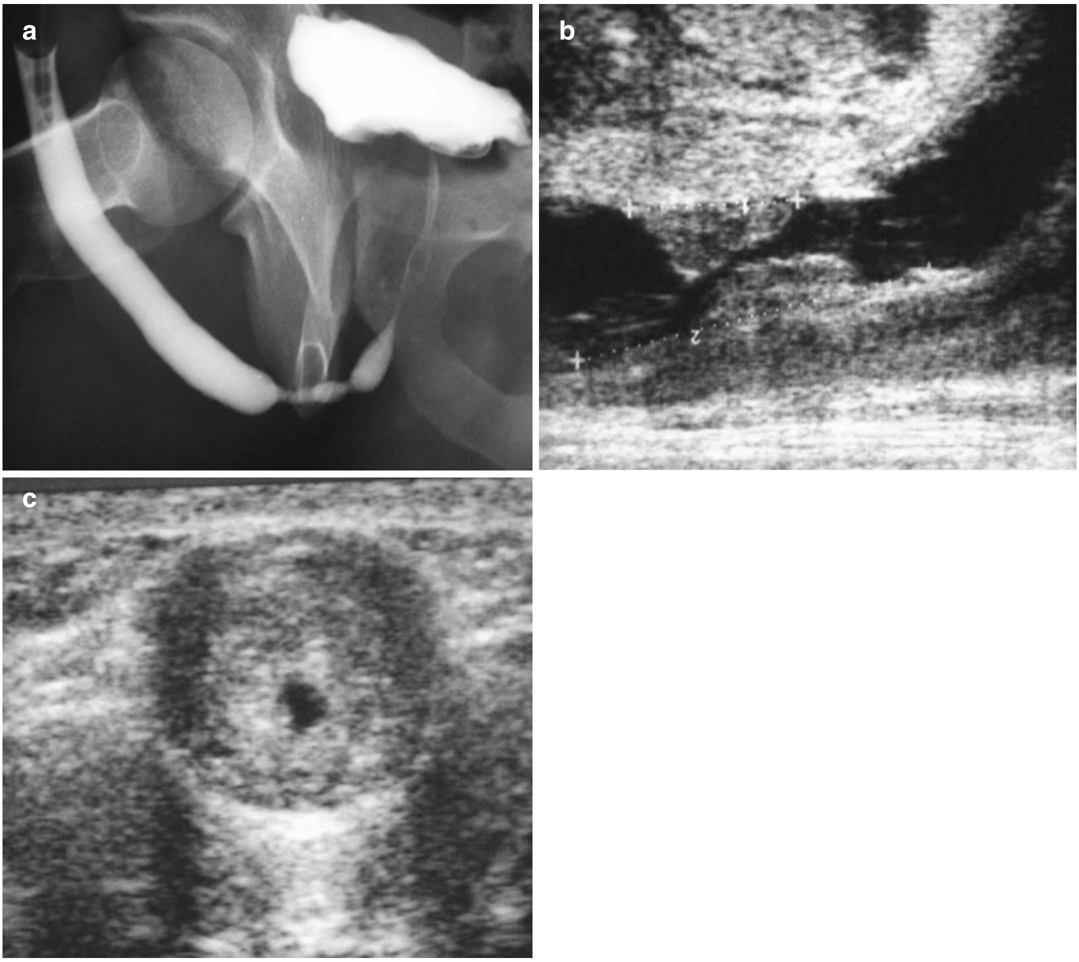

Fig. 5.18 Three centimeter dense mid-bulbar urethral stricture with severe degree of spongiofibrosis demonstrated on ultrasound. (**a**) Retrograde urethrogram. (**b**) Longitudinal sonourethrogram. (**c**) Transverse sonourethrogram (Images courtesy of E. Palminteri)

rence and may dictate treatment. Areas of periurethral fibrosis appear as hyperechogenicity of the tissues of the spongiosa surrounding the urethra [12]. The length and depth of fibrosis may also be measured with ultrasound. The disadvantages of sonourethrography include its limited availability, cost, limited evaluation of the posterior urethra, and the high level of technical expertise necessary to be able to perform and interpret the exam.

Magnetic Resonance Imaging

MRI is infrequently used in the evaluation of the male urethra. It is not widely available and is an expensive and technically difficult examination to perform. In most cases, little information is gained beyond that provided by more conventional imaging methods. However, MRI may provide useful information in certain clinical situations, particularly posterior urethral

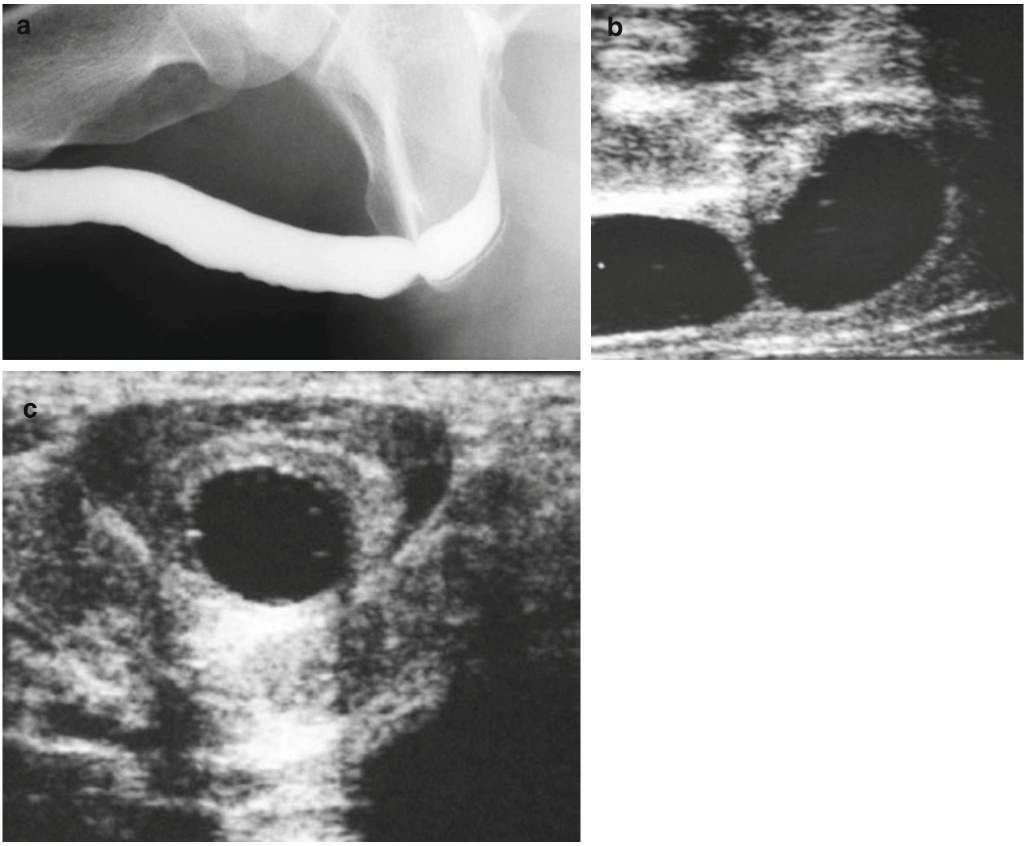

Fig. 5.19 Short annular bulbar urethral stricture amenable to urethrotomy. (**a**) Retrograde urethrogram. (**b**) Longitudinal sonourethrogram. (**c**) Transverse sonourethrogram (Images courtesy of E. Palminteri)

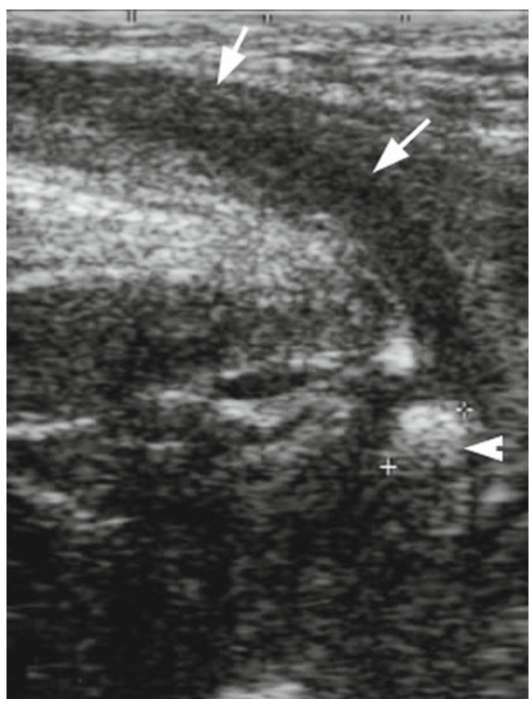

Fig. 5.20 Transperineal ultrasound. Bulbous urethra (*arrows*) traced proximally shows an echogenic calculus (*arrowhead*) impacted in the membranous portion of the urethra

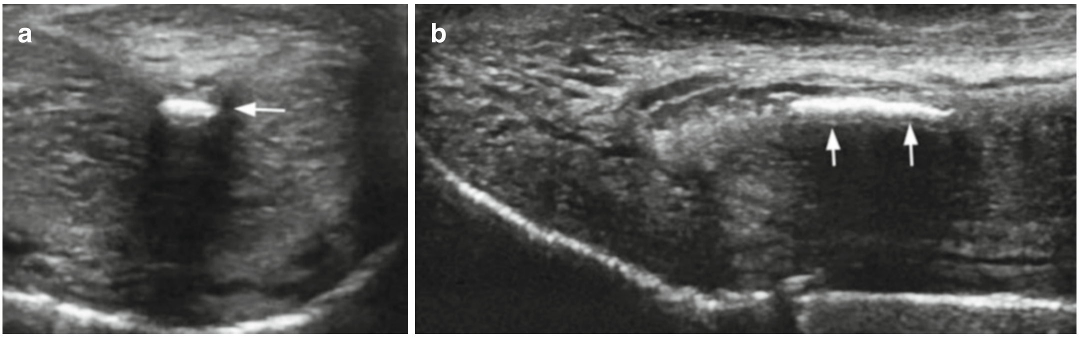

Fig. 5.21 Penile ultrasound. Longitudinal (**a**) and transverse (**b**) images of the penis. The linear echogenicity in the corpora cavernosa (*arrows*) with posterior shadowing represents the calcification of a Peyronie's plaque

Fig. 5.22 Transperineal sonography of the bulbar urethra with a 7.5 MHz probe, with simultaneous injection of saline per urethra. Note patient doing self injection of saline (Image courtesy of G. Barbagli)

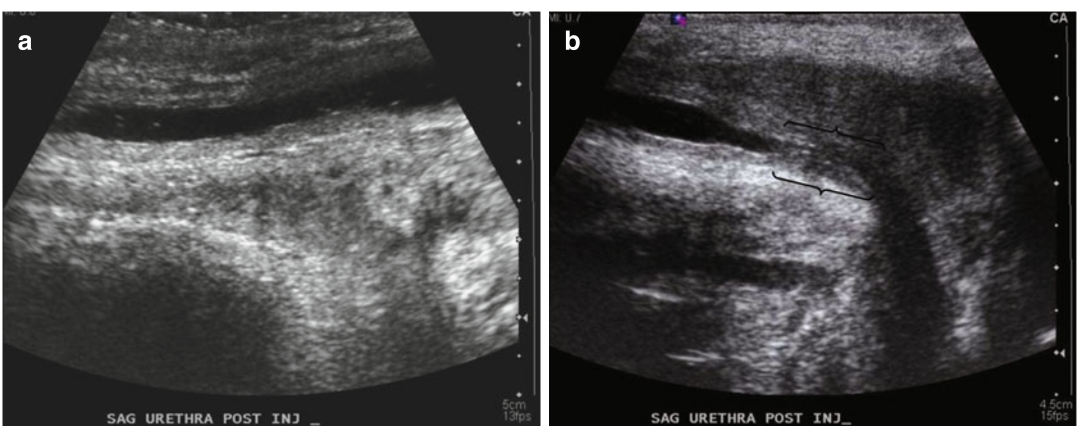

Fig. 5.23 Sonourethrogram. Normal distention of the pendulous urethra. (**a**). Long segment of the bulbar urethra which fails to distend (**b**), corresponding to the stricture seen during pericatheter retrograde urethrography (**c**)

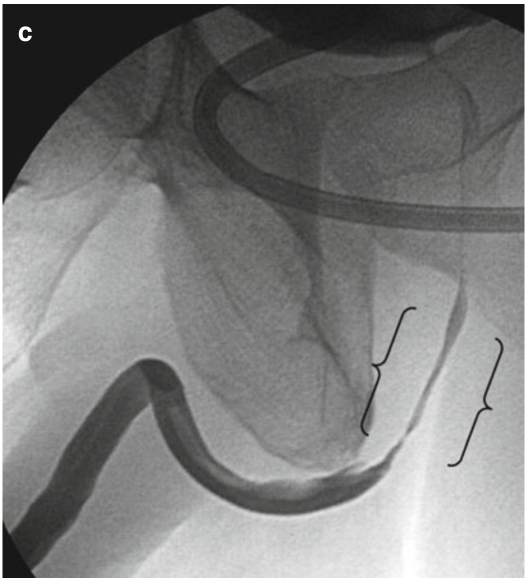

Fig. 5.23 (continued)

trauma, and in the evaluation of the periurethral soft tissues.

Techniques used vary from institution to institution and often depend on the preferences of the performing radiologist. Both T1- and T2-weighted sequences are necessary for full evaluation of the urethra. Intravenous contrast may be used and is useful in determining the amount of active periurethral inflammation which may be observed in patients with spongiofibrosis, because inflamed tissue tends to take up contrast material. Injection of sterile saline into the urethra is variably performed [13, 14].

In general, axial and coronal images are most useful for evaluation of the posterior urethra, whereas sagittally oriented images are most useful for the anterior urethra [15]. A phased array coil is placed over the perineum, and a small field of view is used.

If detailed urethral anatomic information is desired, contrast may be injected into the urethra prior to imaging. This may be performed

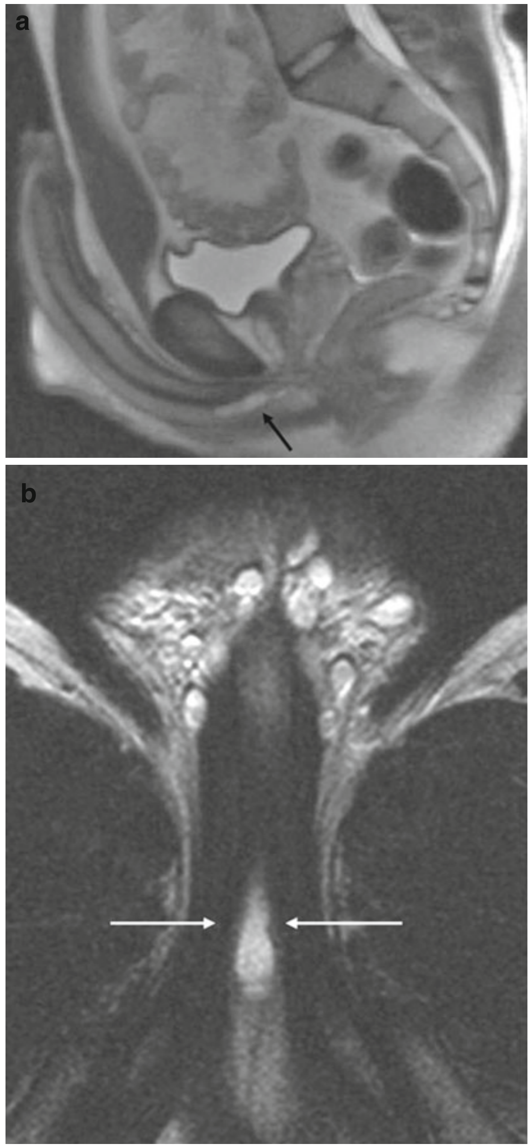

Fig. 5.24 Penile MRI. Sagittal (**a**), axial (**b**), and coronal (**c**) T2-weighted images of the penis in a patient with hematuria following penile trauma. There is a small T2 hyperintense fluid collection along the proximal corpora spongiosum (*arrows*). In this case, intraurethral contrast was not administered, making the distinction between contusion and a fluid-filled cavity communicating with the urethra difficult

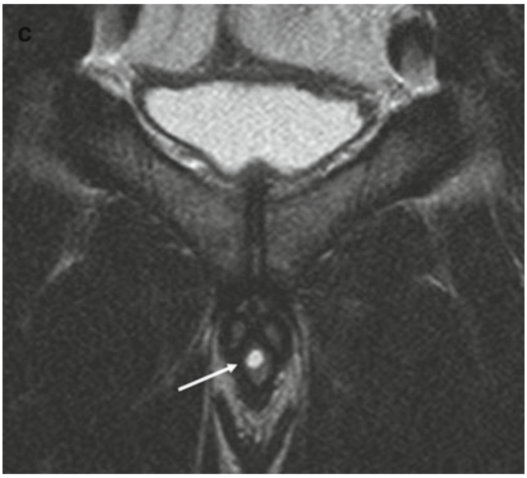

Fig. 5.24 (continued)

using a dilute gadolinium mixture (1:200 dilution yields good urethral opacification) which is injected into the urethra using a Foley catheter in the same manner as with a RUG or sonourethrogram. An MRI-compatible clamp is then placed on the distal end of the penis, and fat-saturated T1-weighted images are then acquired. This protocol has several advantages over simply injecting saline and obtaining T2-weighted images. First, fat-saturated T1-weighted sequences are usually faster to obtain than most high-resolution T2 sequences, thus minimizing scanning time and leakage of contrast from the urethra around the catheter. Also, any fluid-containing structure will appear hyperintense on T2-weighted images, which may be confound evaluation of periurethral fluid collections and make it impossible to differentiate collections which communicate with the urethra from those that do not. In contrast, only the urethra and collections or structures which communicate with the urethra will be hyperintense on fat-saturated T1 sequences (Figs. 5.25 and 5.26).

In addition to cases of possible active periurethral inflammation, MRI may also be useful in studying patients with traumatic posterior urethral injury [5]. The periurethral soft tissues are included in the imaging field, and information about the location of the prostate gland and pelvic hematoma may be obtained [1, 15].

Voiding CT Urethrography

Few centers have used multidetector CT for evaluation of the urethra. Benefits of CT include a very rapid scanning time and the ability to perform multiplanar reformatting to lengthen the urethra and determine stricture length and location accurately. For this examination to be performed, the bladder may be filled in an antegrade fashion by administering intravenous (IV) contrast in conjunction with oral or IV hydration and using an appropriately long scan delay time to allow distention of the bladder with contrast and urine. Alternatively, the bladder may be filled through a Foley catheter, which is then removed before scanning. The patient is then placed on the scanner table and instructed to signal when he is beginning to void. This then triggers the initiation of the scan [16].

There are several drawbacks to this seldom used technique. First, it is unlikely to provide information about the urethra that cannot be obtained using a less expensive and more conventional technique. Second, the anterior urethra may not be fully distended during voiding, which may limit evaluation of anterior urethral disease. There are also the standard risks when IV contrast is administered: nephrotoxicity and contrast allergy. If the patient triggers the scan but does not actually initiate a full voiding stream, then adequate opacification of the urethra will not be achieved, and the scan may have to be repeated, thus greatly increasing the gonadal radiation dose. Finally, the wait time for initiation of voiding while the patient is occupying the scanner may be impractical in centers with limited CT resources.

Editorial Comment

In formulating the reconstructive plan for any individual urethral stricture patient, the surgeon

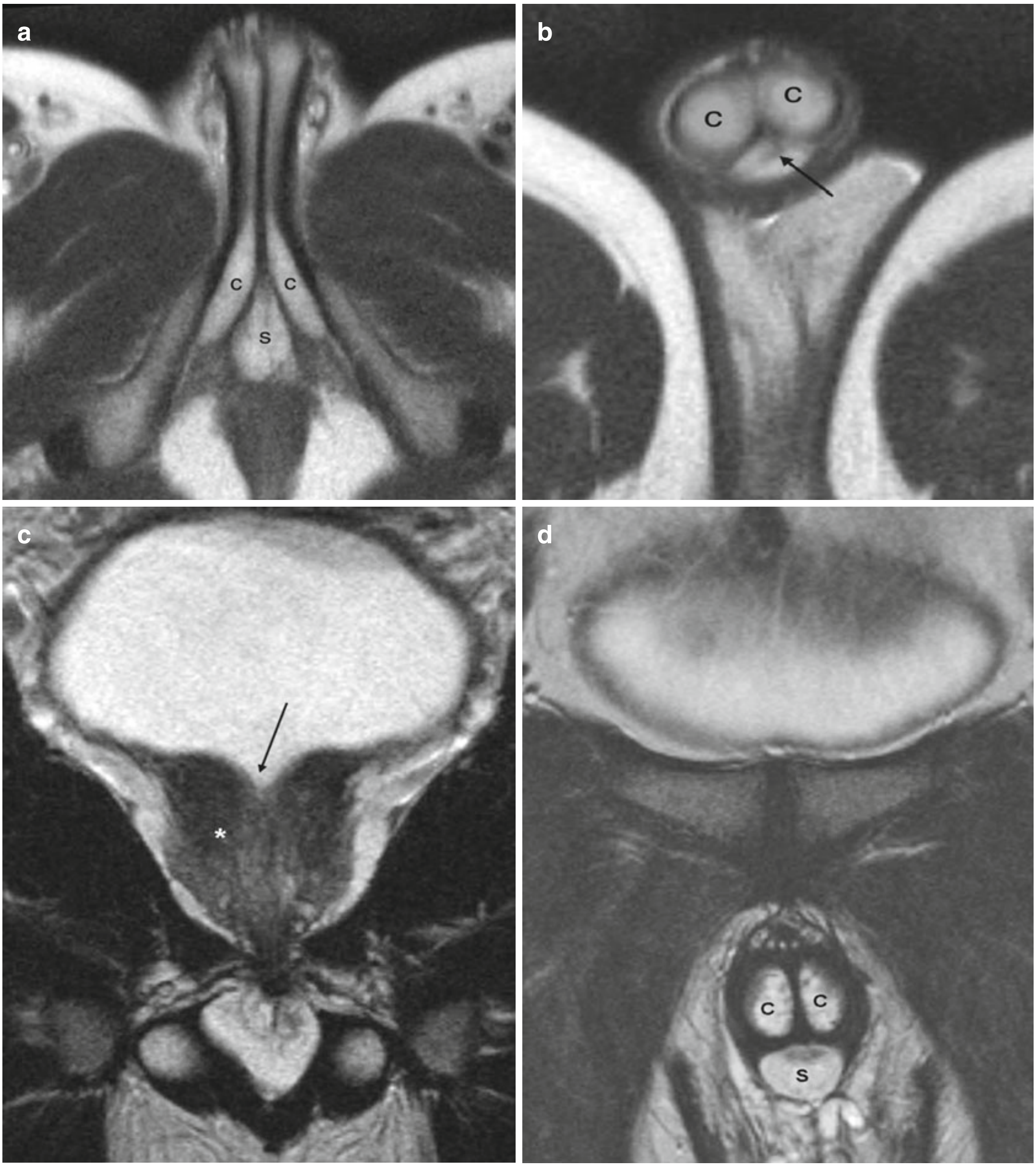

Fig. 5.25 Normal penile MRI. (**a**) Axial T1-weighted image through the base of the penis shows the proximal corpora spongiosum (*S*) flanked by the corpora cavernosa (*C*). (**b**) Slightly more caudally, the paired cavernosa and the spongiosa are seen in the penile shaft. A faintly hypointense structure, the urethra, is present within the spongiosum (*arrow*). (**c**, **d**) Coronal images demonstrate the bladder neck and prostate gland (*arrow* and *asterisk* in **c**) and the penile base with the central spongiosum (*S*) and paired cavernosa (*C*)

must have detailed radiographic road map, revealing the length, severity, and location of the obstructive lesions. A well-performed retrograde urethrogram will demonstrate the distal urethral anatomy, and a voiding cystourethrogram will highlight distension proximal to the stricture, as well as the functionality of the stenosis. The typical method for retrograde urethrography we employ is illustrated in Figs. 5.27 and 5.28. For tight meatal strictures, an Angiocath or

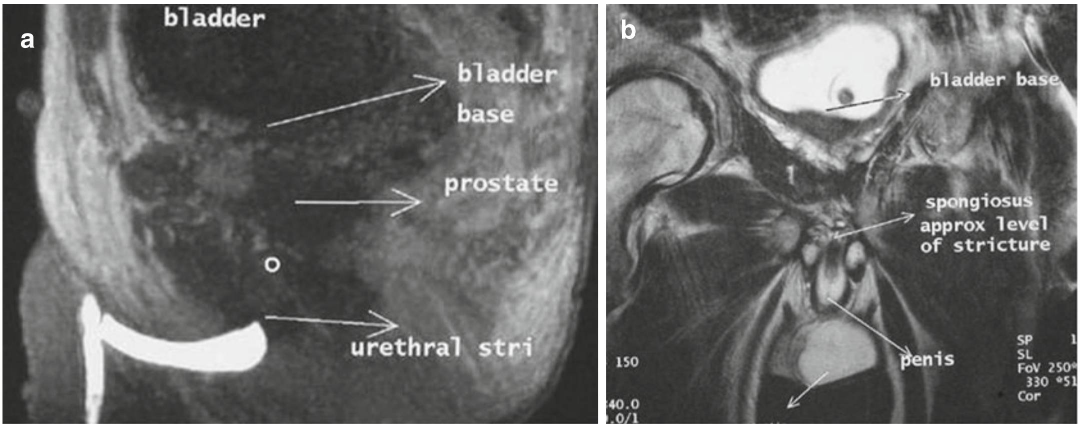

Fig. 5.26 MR urethrogram. Sagittal (**a**) and coronal (**b**) images obtained after intraurethral administration of gadolinium demonstrate an abrupt termination of the contrast column in the proximal bulbar urethra with widening of the space between the bulbar urethra and the bladder base in this patient with a post-traumatic urethral disruption (Images courtesy of SB Brandes)

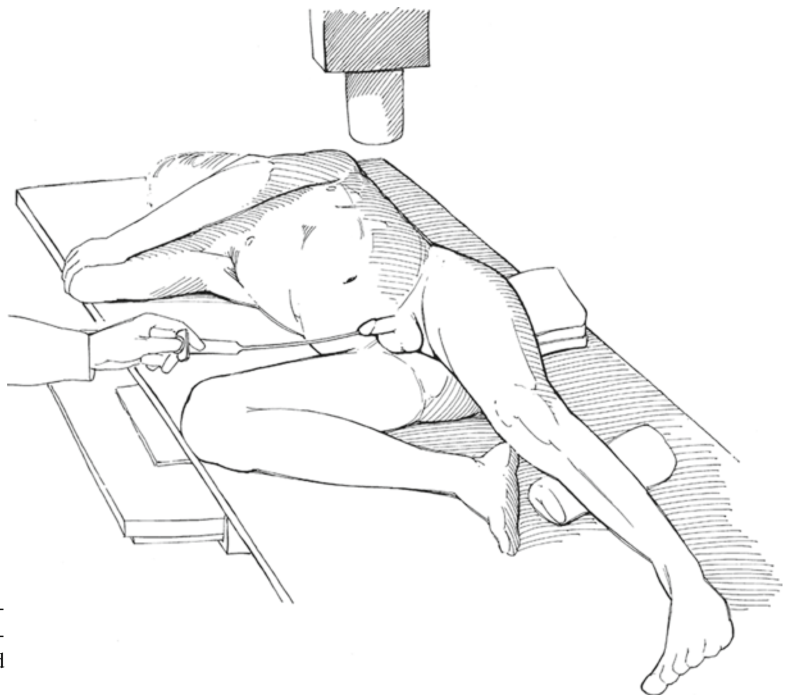

Fig. 5.27 Proper oblique positioning for retrograde urethrography (From Armenakas and McAninch [17])

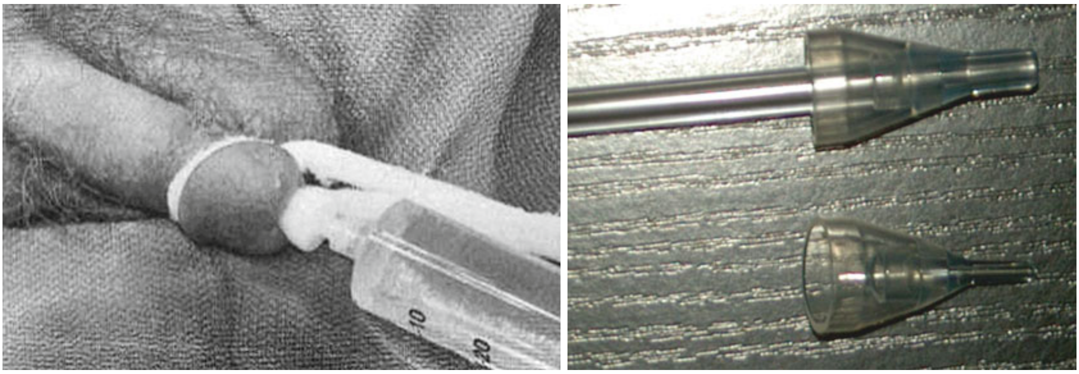

Fig. 5.28 RUG technique with cone-tipped catheter and penis on stretch (Images courtesy of E. Palminteri and J Gelman)

Fig. 5.29 RUG technique using an Angiocath for tight meatal stenosis induced by LSA (Image courtesy of E. Palminteri)

pediatric feeding tube is often needed to perform the urethrography (Fig. 5.29). Combining antegrade and retrograde imaging helps to determine stricture extent, location, caliber, and functional significance (Fig. 5.30). Dilated Cowper's ducts (Fig. 5.2) and prostatic ducts (Fig. 5.7) may be observed proximal to tight strictures due to chronic high-pressure voiding and tend to persist even after successful reconstruction. The lower quarter of the obturator foramen marks the position of the external sphincter mechanism, a helpful landmark to remember when evaluating patients with proximal bulbar pathology (Fig. 5.2).

Cystoscopy and transperineal urethral ultrasound can further complement the investigations. Although urethral ultrasound may help determine the true stricture length of some obliterative strictures, we now rarely utilize ultrasound, relying more on intraoperative endoscopic evaluation to elucidate both stricture length and degree of stenosis. Although not addressed in this chapter, strictures in the bulbar urethra that recur quickly after urethrotomy in the middle-aged or elderly patient or have an irregular, moth-eaten appearance on urethrography should be considered for urethral biopsy to rule out primary malignancy (Fig. 5.31). Close communication with a dedicated GU radiologist is recommended to insure good quality control urethral imaging.

–Allen F. Morey and Steven B. Brandes

Fig. 5.30 Combined retrograde urethrogram and voiding cystourethrogram in a patient with a pelvic fracture associated urethral injury (Image courtesy of E. Palminteri)

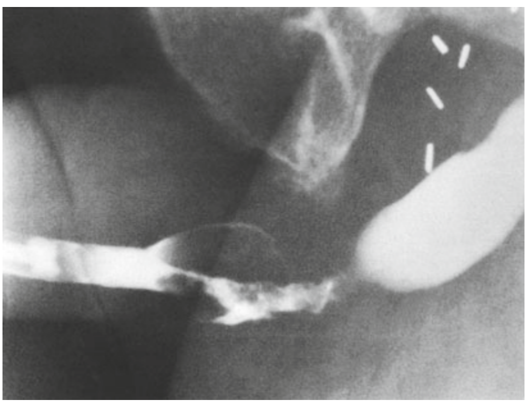

Fig. 5.31 Voiding urethrogram of bulbar urethral stricture due to primary squamous cell carcinoma

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6 Practical Plastic Surgery: Techniques for the Reconstructive Urologist

Hema J. Thakar and Daniel D. Dugi III

Summary

The success of any reconstructive surgeon is dependent on the tools in his or her armamentarium. Since the urethra consists of specialized tissue, advanced techniques are often required to provide an optimal outcome. In repairing the urethra, the goal is to create a watertight, mucosalized conduit. Reconstruction of the urethra can be guided by the reconstructive ladder which proposes an organized approach to wound repair, beginning with the simplest approach and progressively becoming more complex. While some reconstructive techniques are not widely used in urologic surgery, an understanding of their indications and principles is important in the repair of highly complex urethral defects.

Introduction

The success of any reconstructive surgeon is dependent on the tools in his or her armamentarium. In terms of urethral reconstruction, advanced techniques are often required to recreate a watertight, mucosalized conduit [1]. Generally, this requires identifying and repairing missing soft tissue in a creative manner.

Many techniques currently used in reconstructive urology are borrowed from the field of plastic surgery [2]. Over the last 60 years, plastic surgery methods that have translated into urethral reconstruction include techniques such as skin grafting, local flaps, pedicled flaps, and free tissue transfer. Innovations in tissue engineering, immune modulation, and transplantation promise to provide the reconstructive surgeon with even more options [3]. An understanding of the anatomy of the skin and basic wound healing is essential to comprehending how and when techniques of tissue transfer are indicated.

Anatomy of the Skin

The skin is the largest organ and has many roles including temperature regulation, homeostasis, and as a barrier to the outside world [4, 5]. The epidermis is primarily responsible for this function. The epidermis produces and maintains the stratum corneum, the waterproof outermost layer. The basal layer regenerates over a period of 50–60 days to create this layer. The epidermis also contains important specialized cells such as immune cells like Langerhans cells, sensory cells like Merkel cells, and melanocytes [5].

The boundary between the epidermis and the underlying dermis is called the dermal-epidermal

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junction. This interface is undulating, increasing the surface area of contact and transport between the two layers. In addition, it likely also decreases shear potential [4].

The dermis makes up the remaining 90 % of the total skin thickness. It functions to provide a collagen matrix to support the epidermis. The skin appendages, such as hair follicles, nail units, sweat glands, and sebaceous glands, are found in the dermis. Within the follicle is a multipotent "bulb cell" which is important in skin healing [5].

Two microvascular plexuses exist in the skin: a superficial plexus within the dermis and a deeper plexus between the dermis and the subcutaneous tissue layers. The two plexuses are connected by perforating vessels. This is clinically relevant because random pattern skin flaps are based on this interconnected blood supply. Importantly, this plexus is delicate and cannot withstand compression from forceps or other forms of undue tension [4].

Wound Healing

An understanding of wound healing is essential to affect the outcomes of urethral defects. The process of wound healing is separated into three phases: (1) inflammatory, (2) proliferative, and (3) remodeling. Usually, these three phases occur in an orderly fashion, but during disrupted wound healing, a wound may be in more than one phase concurrently [6]. The inflammatory phase begins with injury to the blood vessels, producing vasospasm and the release of thromboplastic tissue products from exposed endothelium. Platelets collect and create a plug at the site of the wound. The coagulation and complement cascades are activated, leading eventually to a fibrin clot. The clot releases growth factors and chemoattractants and is a scaffold for other cells [7]. After hemostasis is achieved, the vessels dilate and become more permeable due to histamine and bradykinin release [8]. The increased vascular permeability allows for additional inflammatory cells to migrate into the wound [9]. The first of these cells are neutrophils. Neutrophils provide nonspecific immunity and scavenge foreign bodies and cellular debris. Over the next 48–96 h, macrophages enter the wound and continue phagocytosis of bacterial debris and apoptotic neutrophils.

During the next 4–14 days, degradation of the fibrin plug and replacement with an extracellular matrix take place. This is the proliferative phase. During this phase, fibroblasts from the surrounding dermis enter the wound, proliferate, and synthesize collagen. Angiogenesis is also stimulated, inducing endothelial cell migration and capillary formation. Keratinocytes migrate into the wound and reform the epithelial layer [10].

Reepithelialization of a surgical incision is generally completed in 48 h. This is the rationale for maintaining immobilizing and protective dressings for 2 days after surgery. Analogously, some surgeons advocate early removal of a urinary catheter after urethroplasty [11]. This may be possible because reepithelialization has restored a watertight conduit. However, full wound strength has not yet been achieved at this early stage of wound healing.

The most important phase from a clinical standpoint is the final phase, remodeling. This starts at post-injury day 8 and continues for more than 1 year. The extracellular matrix is a dynamic structure that is always undergoing remodeling. Collagen is initially laid down in the wound, and for the first 4–5 weeks, there is a net increase in collagen. Over time, this collagen is replaced and deposited along the stress lines of the wound. The tensile strength improves as the collagen deposited becomes cross-linked. The tensile strength of the wound never returns to its pre-injury state, but by 3 months, it reaches a plateau of 80 % its pre-injury strength [12, 13].

Assessment of the Patient

The first step in the reconstruction of a defect is a careful assessment of the wound and the patient.

The urethral defect should be examined for what type of tissue is missing and what local tissue may be available. In considering the reconstructive options, remember the axiom: "Replace like with like."

In an elective situation, it is important to optimize medical conditions such as diabetes and poor nutrition. Of note, patients who are smokers are known to have an increased rate of wound complications postoperatively.

Tobacco smoke contains multiple toxins, including nicotine, carbon monoxide, and hydrogen cyanide, all of which compromise wound healing. Nicotine causes vasoconstriction and relative tissue hypoxia. Carbon monoxide binds strongly to hemoglobin, resulting in decreased oxygen delivery. Considering these factors and additional pulmonary risks with general anesthesia, it is our responsibility to advise patients to stop smoking before any elective reconstructive procedure. Primary care physicians have increasing access to pharmaceutical and social support resources to aid in smoking cessation. Nicotine substitutes such as gums and patches, although often used in smoking cessation, should be avoided in elective reconstruction to promote ideal wound healing.

There is no consensus on an optimal time for tobacco abstention before surgery, but recommendations usually range from 4 to 6 weeks preoperatively and to not resume tobacco use at all if possible, but at least for 6 weeks after surgery [14].

Reconstructive Ladder

The reconstructive ladder is a template used to describe an organized approach to wound repair. It begins with the simplest approach and progressively becomes more complex. In order of complexity, the options are secondary healing, primary closure, delayed primary closure, split-thickness skin grafts, full-thickness skin grafts, local flaps, regional pedicled flaps, and, lastly, free flaps [15].

Secondary Intention

The least invasive rung of the reconstructive ladder is healing by secondary intention. Secondary intention is the situation in which a wound is not closed and is allowed to heal by granulation. The applicability of this technique is less relevant in the sphere of urethral defects since extravasation of urine can lead to impaired healing, fistula formation, and strictures. Also, healing by secondary intention will lead to wound contraction which can result in recurrent stenosis.

Secondary intention has been an important concept in urethral repair historically. Johanson used secondary intention to complete epithelialization of the urethra in his buried intact epithelium technique [16]. Today, when an internal urethrotomy is performed in the treatment of urethral strictures, healing also occurs by secondary intention [17].

Negative-Pressure Wound Therapy

Over the past decade, negative-pressure wound therapy (NPWT) has become a new tool in reconstruction. Although perhaps not as applicable to urethral defects, an NPWT device can be used to temporarily cover a wound in patients who are not yet ready to undergo reconstruction. Most importantly in genital reconstruction, NPWT devices are excellent skin graft bolsters; they conform well to irregular surfaces and prevent shearing and fluid accumulation (Fig. 6.1) [18].

Primary Closure

The next rung on the reconstructive ladder is primary repair. In urethral reconstruction, the most obvious example is excision and primary anastomosis. When sufficient local tissue exists, cicatrix is excised, wound edges are mobilized, and the normal edges are then directly coapted to repair the defect. There is a fine line between making maximal use of the natural elasticity of the urethra to bridge a defect and putting undue tension on a repair. Attempts to reapproximate tissue under tension result in ischemia and necrosis, subsequently leading to wound breakdown, scar formation, or fistula [19, 20].

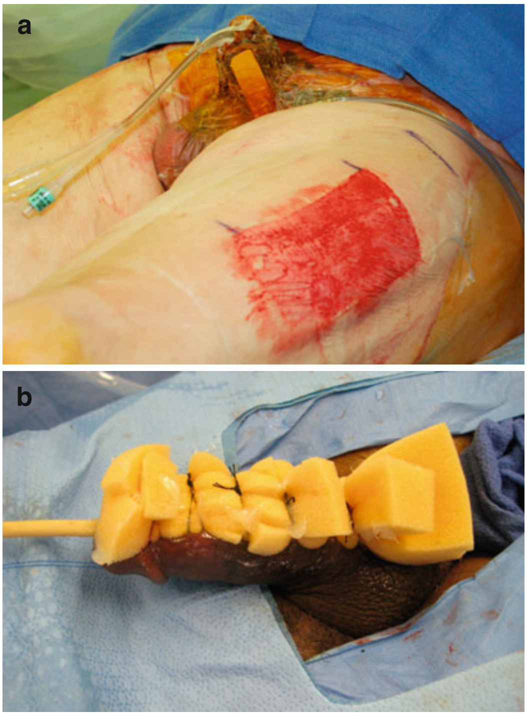

Fig. 6.1 (**a**) Negative-pressure wound therapy device used as a skin graft bolster. Tongue depressors are used to keep the penis at length. Note the split-thickness skin graft donor site in the foreground. (**b**) Tie-over sponge bolster using sterile scrub sponges

Tissue Grafts

Grafts are the next rung on the reconstructive ladder. Engraftment involves removing tissue (skin or mucosa) from its native location and blood supply and transferring it to a recipient bed, where the transplanted tissue undergoes revascularization (Fig. 6.2). Disruption of this process leads to graft failure.

The first phase of engraftment is known as plasmatic imbibition. During this time, diffusion of nutrients, oxygen, and metabolic waste occurs passively back and forth across the concentration gradient from the graft to the wound bed [21]. This process sustains the graft for approximately the first 48 h after grafting. The next stage, inosculation, involves the formation of anastomotic connections between host and graft vasculature. In conjunction with this process, capillary ingrowth also occurs from the host bed into the graft. Clinically, skin grafts begin to have capillary refill during this phase. New vessels within the graft establish the definitive vasculature that will ensure the long-term survival of the graft. Whether the preexisting vessels in the graft act as conduits for ingrowth and become re-endothelialized or

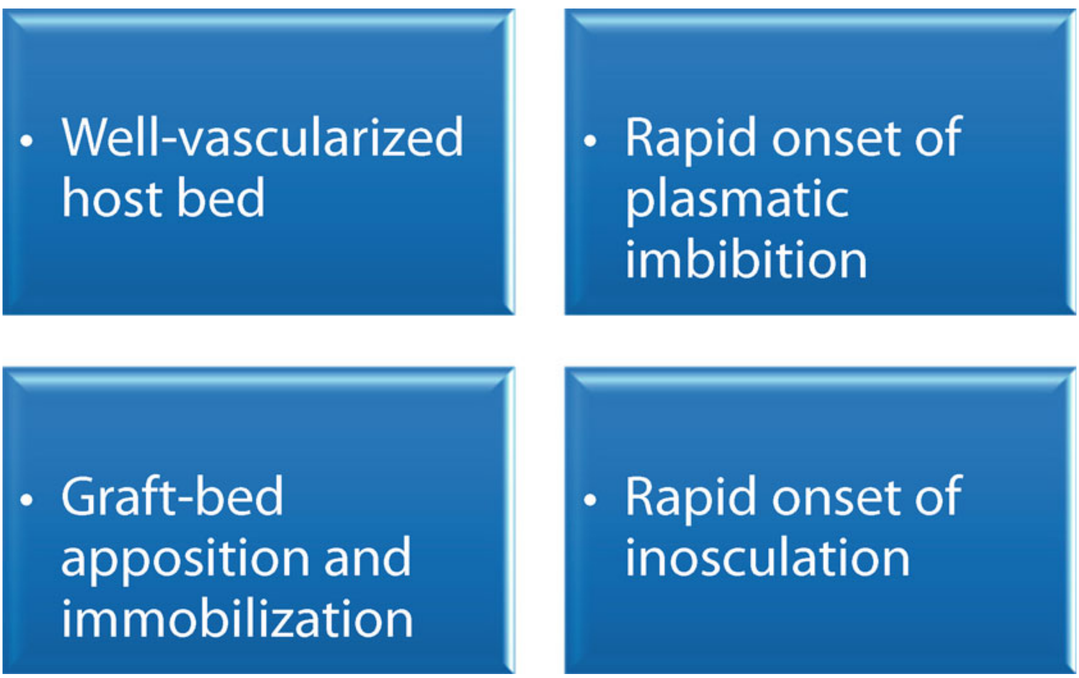

Fig. 6.2 Conditions for graft success

entirely new vessels form, or all of the above, remains an area of ongoing research [22].

Adverse local factors can lead to graft failure. The most common cause of graft failure is fluid accumulation under the graft. Hematoma or seroma formation between the graft and recipient bed increases the distance required for diffusion of nutrients during the imbibition phase.

One important technique to help the egress of fluid is "pie crusting," or creating perforations in the graft. In areas where the graft will be visible (e.g., skin grafts on the penis), orient the perforations in a random pattern to avoid drawing the eye to a pattern of the inevitable small scars. Meshing a graft similarly allows any fluid under the graft to escape and has the added benefit of allowing the graft to be expanded to cover more surface area. Expanded meshed grafts, however, yield a netlike scar pattern upon healing since the interstices heal by secondary intention (Fig. 6.3a, b). A bolster dressing or NPWT device may help the graft to conform closely to the underlying tissue, thus precluding the accumulation of fluid [18] (Fig. 6.3c, d).

In addition, a bolster dressing also holds the graft securely in place, preventing shearing of the graft from the recipient bed. Shearing disrupts the neovascularization from the host bed to the graft and impedes graft take. Infection may also lead to graft loss and can be prevented by meticulous debridement and preparation of the wound bed to ensure that it is clean and able to support the graft.

As discussed previously, in any reconstruction, one would preferably "replace like with like." In urethral reconstruction, the ideal tissue graft would be robust tissue which is hairless and can tolerate a moist environment. In the past, skin grafts have commonly been used to reconstruct a urethral conduit. The advantage of a hairless skin graft is that it may be harvested from a variety of locations and tends to retain the properties of its donor area. Potential donor sites of hairless skin include the abdomen, ventral arm, upper eyelid, postauricular skin, and supraclavicular skin. The thin hairless genital skin (penile or preputial skin) is also well suited for reconstruction and has the added advantage of being within the same operative field [19]. Abundant scrotal skin was once a popular choice for urethral reconstruction, but its hair-bearing nature and tendency towards sacculation have caused it to fade from use [23].

Oral Mucosal Grafts

Presently, oral mucosal grafts are the dominant graft type used in urethral reconstruction. These grafts provide specialized epithelial tissue that is ideal for urethral lining. Mucosal grafts are analogous to skin grafts but supply a secretory epithelium rather than a cornified squamous epithelium. Although mucosal grafts are most commonly obtained from the cheek, alternative donor sites include the tongue, palate, bladder epithelium, and less desirably, intestine [24].

Skin Grafts

Tissue grafts are generally classified as full-thickness skin grafts (FTSGs) or split-thickness skin grafts (STSGs). FTSGs contain epidermis and the entirety of the dermis. These grafts are harvested at the level of the dermis and subcutaneous tissue interface (Fig. 6.4). Conversely, STSGs consist of the epidermis and a small portion of the dermis. A thin STSG is 0.010–0.015 in. (0.25–0.38 mm) thick. An intermediate thickness STSG is 0.016–0.019 in. (0.40–0.48 mm) thick and contains about half of the dermis. A thick STSG is over 0.019 in. (0.48 mm) thick and usually comprises about 75 % of the dermis.

The fact that there is more dermis in an FTSG compared to an STSG results in some important distinctions in the behavior and potential use of both types of grafts (Fig. 6.5). For example, because STSGs are thinner and have less tissue, they also have fewer metabolic demands from the wound bed. Since an FTSG is thicker, survival of the graft is more uncertain and requires a well-vascularized recipient site.

Further, FTSGs display significantly more *primary contraction* than an STSG. *Primary contraction* is the recoil that occurs immediately after a tissue graft is harvested and is directly related to the amount of elastin present in the dermis.

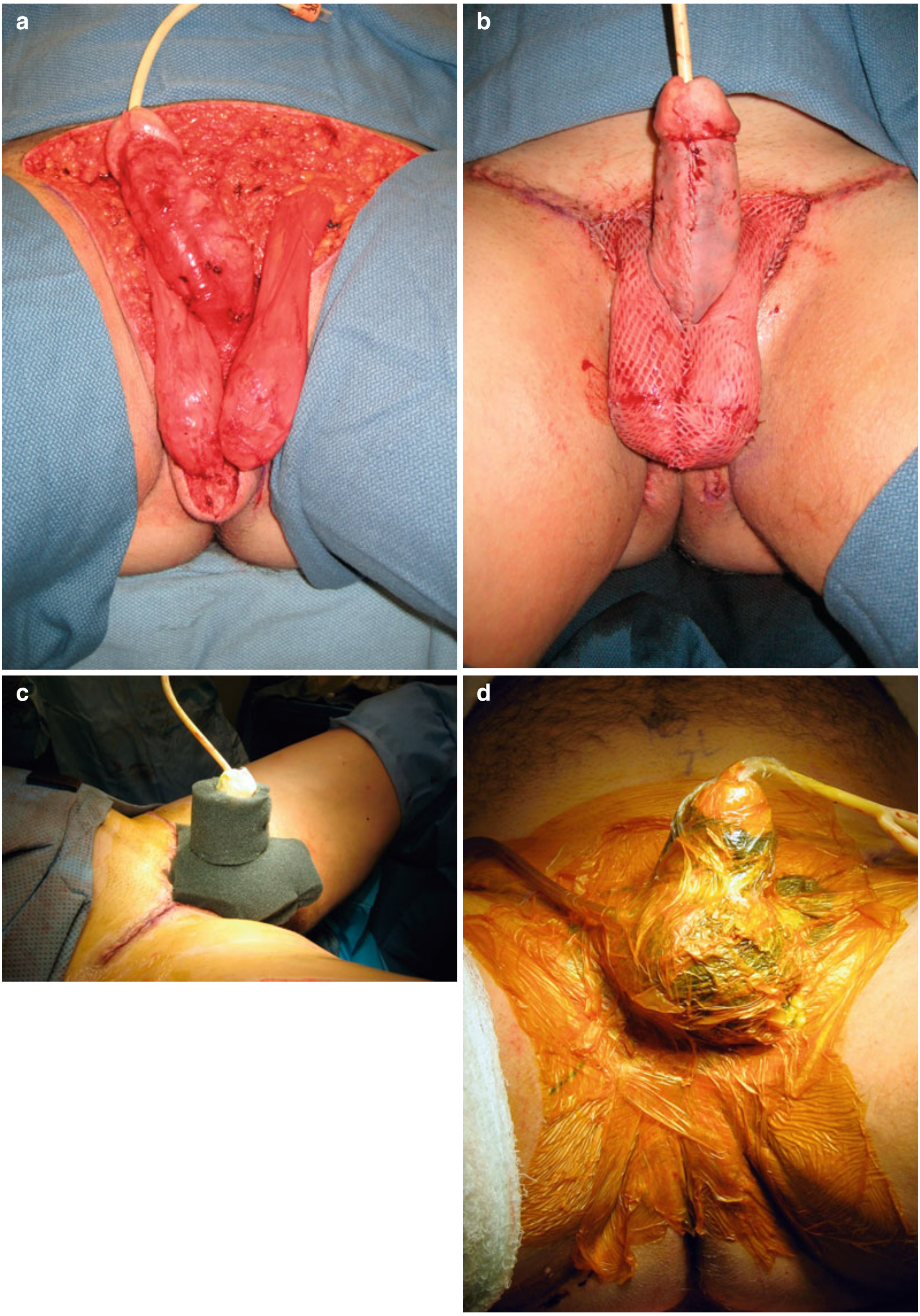

Fig. 6.3 (**a**) Perineal and penile wound after debridement. (**b**) Split-thickness skin grafting of the perineum and penis. Note that the penile skin graft has been applied as a sheet graft and the perineal skin graft has been applied as a meshed graft. Some portions of the wound have been repaired by primary closure. (**c**) Negative-pressure wound therapy sponge is placed over the skin graft as a bolster. (**d**) Negative-pressure wound therapy device set to suction. The sponge has been covered with Ioban™ (3M™, St. Paul, Minnesota) to achieve a seal

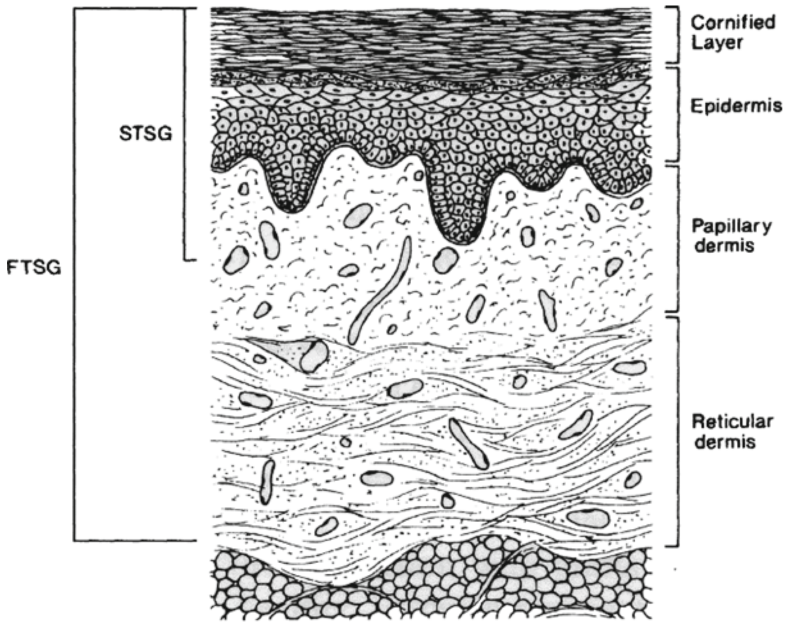

Fig. 6.4 Layers of the skin. Split-thickness skin grafts include a variable amount of dermis, while full-thickness skin grafts contain all the dermis (From Yu and Miller [37])

Fig. 6.5 Characteristics of split-thickness and full-thickness skin grafts

	Full thickness skin grafts	split thickness skin grafts
Amount of dermis	All of it	A part of it
Amount of 1° contraction	More	Less
Amount of 2° contraction	Less	More
Hair growth	More	None
Sensory return	More	Less
Metabolic activity	More	Less

Alternatively, STSGs exhibit more *secondary contraction*. *Secondary contraction,* which can be a serious clinical problem, is caused by the action of myofibroblasts contracting a healed tissue graft. This is diminished by the presence of a dermal layer [25, 26]. In urethral reconstruction, secondary contraction can lead to significant loss of lumen caliber.

Another important distinction between FTSGs and STSGs is the durability of the graft. Once again, this distinction is directly related to the thickness of the dermal layer transferred. Thicker grafts are better able to resist friction. In particular, FTSGs may be less prone to sacculation and better able to resist urine flow pressures.

It is also notable that the skin's appendages, such as sweat and sebaceous glands, are present in the dermis. As such, FTSGs will have a greater ability to sweat or produce oil. Since this ability depends on reinnervation of the glands, it is important to keep FTSGs well moisturized, as the process of reinnervation can take months to years. STSGs in particular require moisturizing with ointments as they are likely to be lacking in these glands. This is of clinical relevance in the postoperative care of grafts in staged urethroplasty.

Hair follicles are also present in the dermis, and FTSGs will demonstrate the hair growth pattern of the donor site. As such, it is important to make sure that when used in urethral reconstruction, an FTSG is obtained from a hairless area. STSGs are generally hairless.

Dermal grafts are created from FTSGs that are subsequently denuded of their epithelium. This yields a graft with vascular channels available for inosculation and vessel ingrowth on both sides. Thus, dermal grafts are ideal as buried grafts and can be useful for the reconstruction of deeper structures such as tunica albuginea and fascia [27].

Dermal allografts also are commercially available in the form of processed cadaveric human or animal dermis and synthetic dermal substitutes and offer the advantage of sparing the patient any donor site morbidity. These have been widely used in other arenas of reconstructive surgery, although their use in urethral reconstruction remains to be defined [28]. The current main uses of the dermal graft in Urology have been for abdominal wall reconstruction where there is concern for infection or "spillage" – or for corporal reconstruction for difficult penile implant insertions. The "off-the-shelf" acellular graft of small intestine submucosa (SIS) has been reported for urethral, ureteral, and bladder reconstruction, yet with disappointing results.

Local Flaps

Flaps represent the next most complex reconstructive tool. A skin flap consists of tissue that is transferred to a new location but, unlike a tissue graft, a flap maintains its own blood supply. Flaps are incredibly versatile and may be employed to transfer healthy vascularized tissue into a wound defect that either could not ordinarily support a graft or in replacing tissue that is completely absent.

Flaps may be composed of skin, fat, fascia, muscle, bone, or specialized tissues and may contain one component or be designed as a composite of multiple tissue types. Muscle or fascial flaps may also be useful in conjunction with grafts because they provide a healthy, vascular recipient bed for engraftment.

Flaps are often described in terms of their blood supply. Skin or local flaps may have either random or axial blood supplies (Fig. 6.6). Random flaps are based on the dermal and subdermal plexuses. These flaps are not supplied by a named blood vessel, and their size is limited is by the hemodynamics of the delicate, interconnecting subdermal and dermal plexuses. The ratio of flap length to width is crucial for flap survival and has traditionally thought to be 3 (length): 1 (width). As such, the random blood supply of these flaps limits their usefulness to smaller defects.

Axial Flaps. In contrast, axial flaps are designed based on a specific vessel that is known to vascularize the flap territory, also known as an *angiosome* [29]. Axial flaps transfer an entire angiosome and are limited only by the feeding vessel.

Axial flaps may be further subdivided based on the nature and course of the vascular pedicle that supplies the overlying tissue. The flap may be classified as a musculocutaneous (the pedicle is contained within a muscle), fasciocutaneous (the pedicle is contained within a fascial septum), or even osteocutaneous (the pedicle is contained within a bone). The penile skin island flaps used for urethral reconstruction are fasciocutaneous flaps, where the vascular pedicle is contained within the dartos and the anterior lamina of Buck's fascia.

Axial flaps can also be defined by their method of transfer. Advancement flaps are moved parallel to the long axis of their pedicle. Rotation flaps, in contrast, are semicircular flaps that are rotated about a pivot point.

The main restriction of an axial flap is the arc of rotation of the tissue. Interpolation and island flaps address this issue. Interpolation flaps are transposed from an area that is not directly adjacent to the defect, such that the pedicle must be tunneled under the intervening tissues. An example of this is a penile flap that is tunneled for use in the bulbar urethra. Island flaps are flaps that

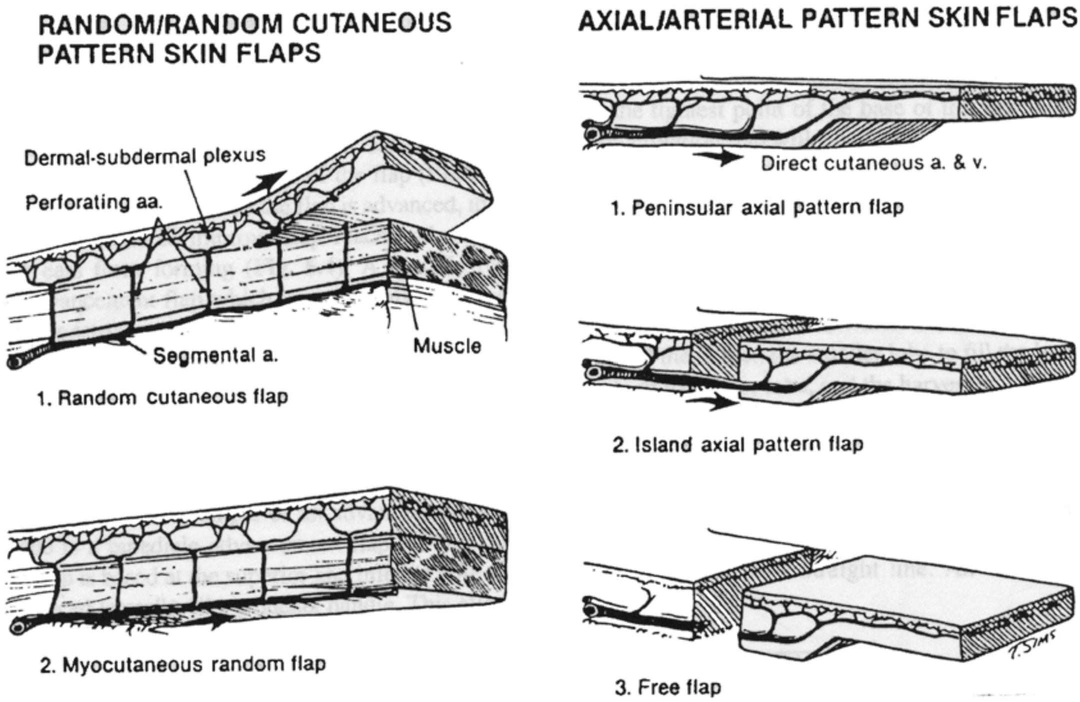

Fig. 6.6 Classification of local flaps according to type of blood supply

are transferred based only on their vascular pedicle without a cuff of surrounding tissue. Although these techniques dramatically improve the arc of rotation of the flap, great care must be taken to protect the vascular pedicle which is prone to kinking and twisting.

Additionally, the limited mobility of local flaps can be addressed with vascular delay. Although not widely described in the reconstructive urology literature, delay phenomenon is used in other types of reconstruction, namely, facial reconstruction. In this technique, a portion of a local flap is raised without disrupting its dominant blood supply or moving the flap from its native location. The subsequent ischemia causes vessels within the flap to dilate, reorients the vessels in the flap into a more longitudinal pattern, and stimulates angiogenesis, in the end increasing the blood supply in the flap. This process takes a minimum of 10 days, although many reconstructive surgeons allow 3 weeks prior to final transfer. This technique is an excellent adjunct to a planned flap but can also be useful when a local flap is raised that appears slightly ischemic or congested. In this case, the flap is returned to its original position, and a vascular delay is allowed. The flap is then re-elevated and inset at a later time to improve the blood supply to the tissue [30], and this concept has been recently implemented in complex urethral reconstruction cases with success.

Pedicled Flaps

A pedicled flap is a flap that is based on a named vessel and transferred from a distant site without disruption of its blood supply. In genital reconstruction, this involves flaps that are based in the lower extremity or trunk. These flaps may be muscular, musculocutaneous, or fasciocutaneous in nature. Indications for the use of these flaps include coverage of vital structures, obliteration of dead space, and improvement of wound vascularity, especially in the setting of radiation [20].

Muscle flaps that are useful and typically employed in genital reconstruction include the gracilis and rectus abdominis flaps. The gracilis flap (Fig. 6.7) is fed by a proximal pedicle from the medial circumflex femoral artery approximately 8–10 cm distal to the pubic tubercle. When detached distally and transposed proximally through a perineal tunnel, it is readily transferred to the genitalia for reconstruction [1]. See herein Chap. 24 by Brandes, for a detailed anatomy and mobilization of the gracilis muscle. The rectus abdominis muscle is also useful in genital reconstruction. For this use, it is based on its inferior pedicle from the deep inferior epigastric artery and can be used as a muscular or musculocutaneous flap. These flaps can also be used as a muscle

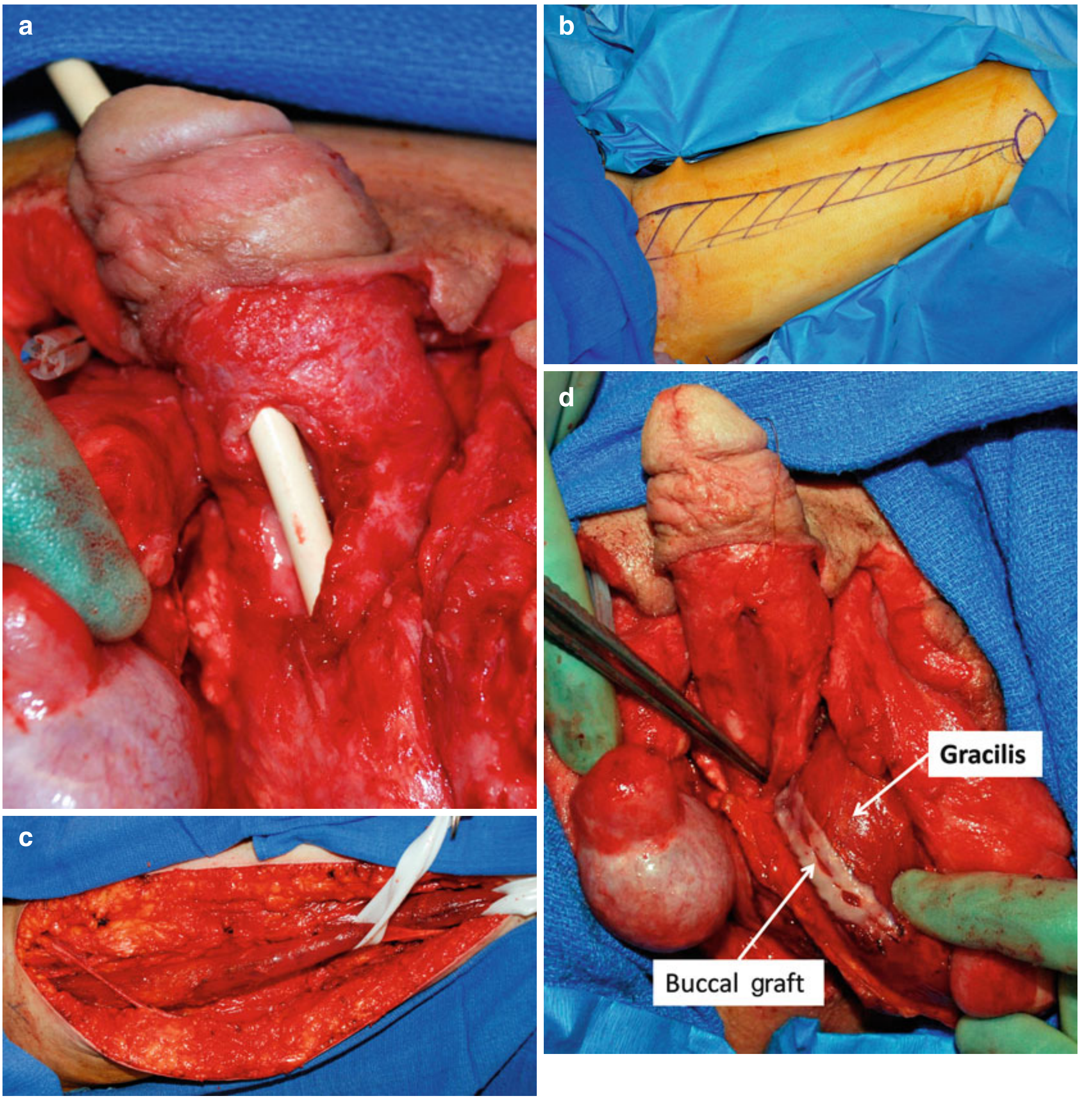

Fig. 6.7 Pedicled gracilis muscle flap used in reconstruction of complex urethral wound. (**a**) Preoperative wound. (**b**) Preoperative markings for gracilis flap. A longitudinal mark is made from the pubic tubercle to the proximal medial tibia. (**c**) The gracilis muscle in situ. (**d**) Oral mucosal graft applied to muscle flap. (**e**) The gracilis muscle has been detached from its insertion and transferred through a perineal tunnel to provide soft tissue coverage of the urethral defect. In this case, the pedicled muscle was used in addition to a buccal mucosal graft to reconstruct the urethra

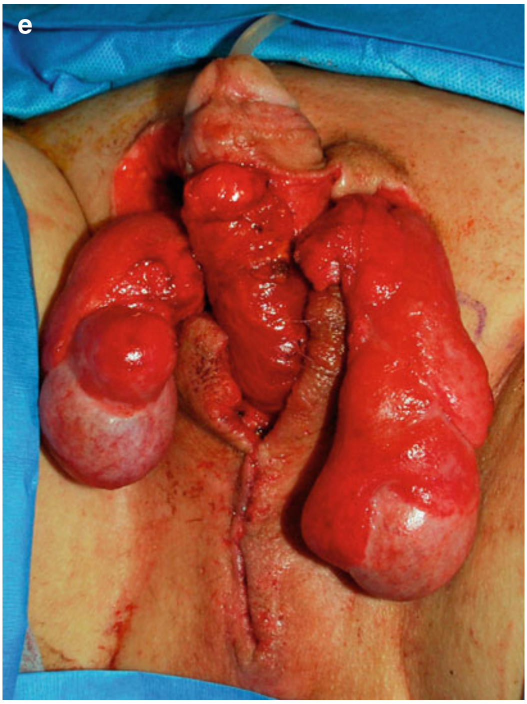

Fig. 6.7 (continued)

flap with the addition of a mucosal graft for layered reconstruction of the urethra (Fig. 6.7d).

The major disadvantage of pedicled flaps is again the limitation on arc of rotation. Generally the arc of rotation can be increased by completely detaching the muscle from its origin and insertion. This of course makes it easier to kink or twist the vascular pedicle. And in some cases, such as a pedicled gracilis flap, the anatomy of the pedicle means that complete detachment of the muscle will not improve its arc of rotation. A thorough knowledge of the shortcomings of particular flaps will help to prevent poor planning in this regard. If no local pedicled flap options are available, a microvascular free flap is indicated.

Free Flaps

Microvascular free tissue transfer constitutes the topmost rung in the reconstructive ladder. Free flaps are defined as distant flaps, harvested based on their axial vessels which are then detached and reconnected to suitable vessels in the region of the defect. Its main advantage lies in the versatility of this technique, as ideal donor tissue can be selected from anywhere in the body and used to correct a tissue defect. An example is a free radial forearm flap transferred to the femoral vessels for total phallic reconstruction. However, the technical complexity of the case and the donor site morbidity of free tissue transfer are substantial.

Indications for free tissue transfer include large defects with exposed vital structures that cannot be closed with local or pedicled tissues. This may be the case in trauma or in radiated tissue where the local zone of injury can be very large and make the blood supply for local options unreliable.

Free radial forearm flaps and anterolateral thigh flaps are used in genital reconstruction, especially after oncologic resection or gender reassignment surgery. These are fasciocutaneous free flaps and provide soft, pliable tissue. In addition, a cutaneous nerve can be harvested with both flaps and potentially used to provide some degree of sensation to the flap, although the degree of sensation after coaptation of the nerves can be unpredictable.

The radial forearm flap is raised along the ventral, non-hair-bearing surface of the forearm and is based on the radial artery. After flap harvest, the neourethra is formed by tubularizing the skin paddle around a catheter. The urethral anastomosis is then performed. The radial artery and venae comitantes are then anastomosed to the femoral vessels or a branch thereof. The large donor site defect on the forearm is the main shortcoming of this procedure. This defect is skin grafted [31, 32].

The anterolateral thigh flap is another example of a versatile fasciocutaneous flap [32, 33]. It is based on the descending branch of the lateral circumflex femoral artery and can provide a significant amount of thin pliable skin.

An important caveat in the use of fasciocutaneous flaps is that they can sometimes be difficult to use in obese patients. These patients have large subcutaneous fat deposits which make the flap thick, increasing the difficulty of insetting the flap. Notably, bulky flaps can be thinned by liposuction several months after healing to help flap contour.

Pre-lamination of Flaps

The technique of pre-lamination or prefabrication can be useful in complex reconstruction when conventional methods are inadequate [34]. In the situation where the periurethral tissues are unable to support a graft, a graft can be placed at a distant site on a possible pedicled or free flap. The graft is then transferred with the flap to the site of the defect (Fig. 6.7d). This has also been described for use in urologic surgery as a delayed flap, specifically as a useful technique in patients with significant periurethral tissue loss due to radiation or pressure ulcers [1].

Tissue Engineering Urethroplasty

Although excellent results in urethral reconstruction can be obtained with the above-discussed methods, whenever tissue is transferred, there is always associated donor site morbidity. This can be as simple as pain from the harvest of a buccal mucosal graft or more complex, such as an abdominal hernia from rectus abdominis muscle transfer. This morbidity could potentially be avoided with the use of bioengineered materials. Of course, a secondary advantage is decreased operative time as a donor graft or flap does not need to be harvested. The experimental use of acellular dermal matrix, stem cells, and cell-seeded constructions have been described, as have case reports of urethral reconstruction using cadaveric acellular matrix [35, 36]. Although these techniques are still in the infancy of study, they appear to be promising and may in the near future add an additional tool to the armamentarium of the urethral reconstructive surgeon. See Chap. 46 for more details.

Editorial Comment (1)

Collaboration between reconstructive urologists and plastic or burn surgeons has proven helpful in attaining optimal outcomes in genital and urethral repair. The tissue destruction caused by acute or chronic inflammation, radiation, infection, burns, external or iatrogenic trauma, and prior surgery can be formidable. Urologists should be encouraged to develop good working relationships with interested plastic surgeons in their centers to enable sharing of expertise. Advances in wound care, tissue glues, and tissue transfer techniques will continue to shape the practice of reconstructive urology.

–Allen F. Morey

Editorial Comment (2)

Surgical techniques that make a good plastic surgeon also make a good urologist. As a reconstructive urologist, it is essential to be familiar with proper tissue handling and in the technique of flaps and grafts. They often speak of a reconstructive ladder in plastic surgery – meaning to do the simplest method to solve the problem, and only if these fail, move on to more complex reconstructions. This is true for the most part.

Plastic Surgical Principles That I Tend to Follow

1. *Ockham's Razor*. This is a principle attributed to the fourteenth-century logician and Franciscan friar William of Ockham. It essentially states that "If you have two equally likely solutions to a problem, choose the simplest." In other words, "less is more" or "keep it simple." The same goes for reconstructive urology. A simple surgical solution is often best. For example, many patients with LS have pan-urethral strictures, but the narrowest part is usually only the meatus. In many cases, just opening up the meatus or doing an extended meatotomy is sufficient to get him to void normally. While the surgery can be elegant, to do an extensive total reconstruction of the urethra (with multiple grafts) is often overly aggressive and not needed. If opening up the meatus does not solve the voiding issues, then a complex reconstruction can always be done at a later date. Another way of looking at this is that everyone does not deserve a 24 Fr urethra – it just needs to be >14 Fr to void relatively normal.
2. *Think Fast and Move Slow*. Tissues are delicate and should be treated with respect. Take your time during surgery and never seem

rushed or anxious in the operating room. Think quickly and thoughtfully but numerous steps ahead – always moving forward and not deterred by unanticipated events. Use a paucity of motion, be deliberate and accurate, and do not waste any motion.

3. *Use Two Hands When Operating and Think in Three Dimensions*. You would be surprised how many of my urology trainees try to operate with only one instrument – with the contralateral hand doing nothing or with no instrument in it (like a Debakey forceps). They also occasionally manipulate the tissues with their hands and not a proper instrument. In such situations, I usually bark that if they "want to persist in operating with their hands, they should change careers and become gynecologists." They also often have trouble translating a 2-dimensional structure or tissue plane into a 3-dimensional reconstruction. It is kind of like those IQ tests that we all took as kids that showed a flat pattern of a cutout with the folding edges marked out. The test then was to imagine what the final shape was, once it was all folded up. This is a skill that is not just inherent – it can be taught and perfected – it just takes practice and the investment of time.
4. *Selection Is the Silent Partner of the Surgeon*. It is often more important to know when not to operate and who not to operate on, then be able to do the surgery. The timing of surgery, the quality of the tissues, and the overall health (nutrition) of the patient often determine the surgical outcome, more than the so-called quality of the surgery. In other words, if a surgical reconstruction falls apart after surgery, it often has more to do with poor patient selection and surgical timing rather than some perceived lack of surgical skill.
5. *Belt and Suspenders*. When it comes to a complex fistula repair or urologic reconstruction, if a one-layer closure is good, then a two- or three-layer closure is better and may help reduce the chance for failure. In other words, if there is a readily available additional flap or local tissue that can easily be mobilized and interposed, it is almost always better to use it.
6. *Better is the Enemy of Good*. Often times after a reconstructive repair, the repair looks okay but not perfect. So there is a temptation to place an additional suture or mobilize the tissue a little more in trying to make it "perfect." Attempts to make the tissue look perfect occasionally compromise the blood supply or cause an unwanted complication and, in so doing, worsen the repair, rather than improving it. Said another way, sometimes "good enough" is really "good enough."

–Steven B. Brandes

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7 The Epidemiology, Clinical Presentation, and Economic Burden of Urethral Stricture

Keith Rourke

Summary

Urethral stricture is a relatively common urologic problem associated with a significant economic burden. The prevalence of urethral stricture is estimated to range from 1 to 9 strictures per 1,000 people. The prevalence is highest and economic impact greatest in developing countries. Risk factors for urethral stricture include advanced age, sexually transmitted illness, socioeconomic status, race, lichen sclerosus, and a history of prostate cancer treatment. Typical presenting symptoms include lower urinary tract symptoms such as weak urinary stream, straining to void, urinary hesitancy, incomplete emptying, nocturia, frequency, and urinary retention. Patients may also present with post-void dribbling, urinary tract infection, genitourinary pain, hematuria, and incontinence. Less typical presentations include urethral cancer, renal failure, urethral abscess, Fournier's gangrene, ejaculatory dysfunction, or chordee. The differential diagnosis of urethral stricture includes obstructive urethral pathology such as benign prostatic hyperplasia, urethral calculi, urethral cancer, or functional disorders of voiding such as Hinman's syndrome or neurogenic detrusor dysfunction. Urethral stricture not only adversely impacts patient-reported quality of life but also impacts overall health status. The optimal treatment of urethral stricture from a fiscal standpoint depends on several factors. In non-industrialized nations with a lack of medical infrastructure and expertise, optimizing the use of endoscopic treatment may be the best approach. In industrialized countries, proceeding with urethroplasty after one initial attempt at urethrotomy or dilation the most fiscally responsible approach. Patients with a high risk of stricture recurrence after endoscopic treatment should undergo treatment with urethroplasty.

Prevalence of Urethral Stricture

Urethral stricture is one of the oldest urologic diseases with treatment of this condition described as early as 600 years BC [1]. The prevalence of urethral stricture appears to have changed substantially over the course of history. In the nineteenth century it was thought that up to 20 % of adult men experienced urethral stricture [2]. The true modern prevalence of urethral stricture is unknown and can only be inferred from population-based data. It appears that the incidence of urethral stricture varies widely throughout the globe. In industrialized nations such as the United States the prevalence of urethral stricture has been reported to be approximately 0.9 % based on epidemiologic data in a Medicare population [3]. In non-industrialized countries the incidence of urethral stricture is

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thought to be much higher. Furthermore even within the same country stricture prevalence may vary. Some epidemiologic data suggests that urethral stricture is more prevalent in urban centers (as opposed to more rural locations). As an example, in urban hospitals urethral stricture is 2.6 times more common than the community hospital setting [4]. This may be potentially explained by a referral bias. It is possible that patients with the diagnosis of urethral stricture are more likely to be referred to larger specialized urban centers for definitive care and urethroplasty. Alternatively it is entirely possible that the indigent urban population is more disposed to urethral stricture from an infectious or traumatic etiology.

Interestingly the incidence of urethral stricture has declined in some nations. In the United States it was estimated that from 1992 to 2001 the diagnosis of urethral stricture in a Medicare population declined from 1.4 to 0.9 % [3]. The exact reason for this decline is not known but may be related to better identification and treatment of sexually transmitted illness, a known risk factor for urethral stricture. This decline in incidence could also represent a sea change in how physicians define urethral stricture. The common clinical practice of routine urethral dilation prior to urethral instrumentation may be declining with the advent of smaller caliber cystoscopes and resectoscopes. There may be less reason to code a patient as having a urethral stricture for the sole purpose of safely accommodating a larger caliber endoscope. Similarly the widespread adoption of improved endoscopic technology may be reducing iatrogenic trauma to the urethra and lowering the risk of iatrogenic causes of urethral stricture. It has also been hypothesized that the decrease in incidence of urethral stricture may be due to an increase in the efficacy and more widespread use of urethroplasty. However, it appears likely that urethroplasty as a treatment modality is underutilized, and this is unlikely to be the main reason for the decline in stricture prevalence over this period [3, 5]. It is also unlikely that the true incidence of urethral stricture will be subject to further decline with the increasing application of energy-based technologies for treatment of common urologic conditions such as benign prostatic hyperplasia and prostate cancer [6, 7].

In the United States urethral stricture accounts for 5,000 inpatient admissions per year, and more than 1.5 million office visits were made for male urethral strictures from 1992 to 2000 [8]. Emergency room visits related to urethral stricture by male Medicare patients are estimated at 6.9 incidents per 1,000,000. Typically ambulatory center visits due to urethral stricture have a bimodal distribution in peak incidence with patients <10 years and >35 years. Although urethral stricture is not the most common urologic condition, it does represent a significant clinical entity in urology. In all likelihood the true prevalence of urethral stricture ranges from 1 to 9 strictures per 1,000 people.

Risk Factors and Demographics

Several clinical and epidemiologic factors are associated with an increased likelihood of developing a urethral stricture. These risk factors include advanced age, a history of sexually transmitted illness, lower socioeconomic status, African-American race, lichen sclerosus, and a history of prostate cancer treatment.

It appears that the likelihood of being diagnosed with a urethral stricture increases with age. In a survey of Medicare patients in the United States, the incidence of urethral stricture was found to rise abruptly after the age of 55 [4]. Men aged 55–64 are 1.5 times more likely to have urethral stricture compared to age-adjusted estimates. The rate then steadily increases throughout each subsequent decade peaking with men over the age of 85 who have a 12-fold risk of urethral stricture. Sexually transmitted illness is also a well-documented cause of urethral stricture [9–11]. Chronic inflammation from an unrecognized sexually transmitted illness results in an inflammatory urethral stricture. This is especially apparent in non-industrialized nations with up to 66 % of diagnosed urethral strictures related to sexually transmitted illness [12]. It is thought that even patients promptly diagnosed and treated may still be at risk for developing urethral stricture especially in the setting of gonococcal urethritis. There also appears to be an increased likelihood of developing a urethral stricture with declining socioeconomic status. This is particularly noticeable in non-industrialized nations with high rates of infectious and inflammatory strictures. In these countries urethral stricture more typically affects a much-younger population. Some races, specifically African-American patients, have also shown increased rates of urethral stricture. Based on the Urologic Diseases in America data, African-Americans have a 2.3-fold higher incidence of urethral stricture compared to a similar Caucasian population [4].

Lichen sclerosus (LS) is a chronic lymphocyte-mediated skin disease with a predilection to the genitalia. Genital lichen sclerosus commonly involves the urethra in males, and it has been estimated that up to 47 % of patients with lichen sclerosus develop urethral stricture and lower urinary tract obstruction [13]. Treatment of lichen sclerosus strictures may be challenging due to the inflammatory changes, dense fibrosis, poor tissue quality, and length of urethra involved. Further discussion on the etiology and pathology of lichen sclerosus can be found in Chap. 4. Patients undergoing treatment for prostate cancer are also at increased risk for developing urethral stricture. This risk is seen in patients undergoing radiation therapy or radical prostatectomy. Based on an analysis of CaPSURE data patients, the risk of urethral stricture requiring treatment after prostate cancer therapy ranges from 1.1 to 8.4 % [14]. Patients at highest risk had a history of combined radiotherapy modalities with a hazard ratio of 4.6, while patients undergoing radical prostatectomy had a hazard ratio of 10.4. It also appears that energy-based treatment modalities are not exempt from this risk. It has been estimated that 19.5 % of patients can develop a clinically significant urethral stricture after high-intensity focused ultrasound treatment of prostate cancer [7]. Further discussion on the etiology and classification of urethral stricture can be found in Chap. 8.

Signs and Symptoms of Urethral Stricture

Urethral stricture is typically a fibrosis or inflammation of the epithelial tissue and corpus spongiosum that results in stenosis of the urethral lumen. As the urethral lumen progressively obstructs symptoms typically occur. Most symptoms of urethral stricture are thought to be directly related to this decrease in urethral caliber. Thorough clinical questioning can reveal a wide spectrum of symptoms associated with urethral stricture. Typical symptoms include lower urinary tract symptoms (LUTS) such as weak urinary stream, straining to void, urinary hesitancy, incomplete emptying, nocturia, frequency, and urinary retention. Patients may also present with post-void dribbling, urinary tract infection, epididymitis, genitourinary pain, hematuria, incontinence, and ejaculatory dysfunction. Deviation or spraying of the urinary stream is often found in the setting of stricture of the urethral meatus. Less typical presentations include urethral cancer, renal failure, periurethral abscess, Fournier's gangrene, or chordee related to an inelastic urethra (Kelami syndrome). Specifically, patients presenting with Fournier's gangrene must undergo evaluation to rule out the presence of a urethral stricture, especially when patients have associated urinary extravasation. Patients with a history of stricture may disclose the presence of previous trauma to the penis or perineum, previous pelvic fracture, or a history of difficult urethral catheterization. A review of past medical history can reveal the presence of medical problems that may have an additional impact on voiding function such as benign prostatic hyperplasia, diabetes mellitus, or other neurological disorders, including chronic self-catheterization which often has a deleterious effect on the delicate urethra over time. These diagnoses can further amplify symptoms related to a urethral stricture.

A recent cohort analysis of 611 patients presenting with anterior urethral stricture outlines the presenting and associated signs and symptoms (Table 7.1) [15]. As one might expect, the most common primary complaint of patients presenting with urethral stricture is lower urinary tract symptoms (LUTS). Fifty-four percent of patients present primarily with LUTS. In total 92.9 % have LUTS as either a primary or associated complaint at the time of assessment. LUTS are most definitely one of the cardinal symptoms of anterior urethral stricture. Additionally, acute urinary

Table 7.1 An analysis of the signs and symptoms of urethral stricture presenting in a "first-world" cohort of 611 patients

Symptom/sign	Presenting	No. of pts. (%) associated	Total
LUTS	332 (54.3)	234 (38.6)	566 (92.9)
Urinary retention	143 (23.4)	39 (6.4)	182 (29.8)
UTI	37 (6.1)	87 (14.2)	124 (20.3)
Difficult catheterization	29 (4.8)	54 (8.8)	83 (13.6)
Gross hematuria	19 (3.1)	50 (8.2)	69 (11.3)
Pain	18 (2.9)	122 (20.0)	140 (22.9)
Urethral abscess	14 (2.3)	6 (1.0)	20 (3.3)
Renal failure/hydronephrosis	8 (1.3)	17 (2.8)	25 (4.1)
Incontinence	6 (1.0)	13 (2.1)	19 (3.1)
Sexual dysfunction	5 (0.8)	69 (11.3)	74 (12.1)

retention accounts for 23.4 % of presenting complaints and 29.8 % of the total symptoms. Acute urinary retention occurs in a higher proportion of patients in non-industrialized nations [12]. Other less typical presenting complaints account for 22.3 % of remaining presenting symptoms. These other presenting complaints include documented urinary tract infections (6.1 %), difficult catheterization (4.8 %), gross hematuria (3.1 %), and genitourinary pain (2.9 %).

Careful assessment of the total presenting and associated symptoms may show a broad spectrum of associated symptoms. Patients experiencing pain thought to be of genitourinary origin account for 22.9 % of all patients diagnosed with urethral stricture. This includes patients experiencing dysuria, suprapubic pain, and genital pain in the absence of urinary tract infection. Pain from a stricture may be related to several factors. Significant lower urinary tract obstruction can cause elevated voiding pressures with intravasation of urine into the corpus spongiosum or prostate stroma. It is thought that this can lead to referred pain in some patients and is one of the proposed theories to explain pain experienced by patients with chronic pelvic pain syndrome [16]. In other patients the stricture itself may be inflamed and could act as a source of perineal discomfort. Pain can be an important symptom in patients presenting with urethral stricture.

Documented urinary tract infection requiring treatment typically occurs in a total 20.3 % of patients. Elsewhere based on Medicare data in the United States, the incidence of urinary tract infection in patients with urethral stricture has been estimated to be as high as 42 % [17]. Additionally, gross hematuria occurs in 11 % of patients and accounts of total symptoms. Although it is uncommon for patients to present primarily with sexual dysfunction or incontinence (1 % or less) as associated symptoms, the prevalence is at least 12.1 and 3.1 %, respectively. Urinary incontinence associated with stricture has elsewhere been estimated to be as high as 11 % in a US Medicare population [17]. Sexual dysfunction as a presenting complaint is typically due to ejaculatory dysfunction presumably related to urethral obstruction of the ejaculate.

In addition to careful clinical questioning symptom assessment can be formally documented using a questionnaire such as the AUA symptom index [18] or a more disease-specific Patient-Reported Outcome Measure (PROM) recently developed in the United Kingdom [19]. The use of validated questionnaires is further outlined in Chap. 30.

Differential Diagnosis

Many conditions can mimic urethral stricture in presentation. The differential diagnosis of urethral stricture includes obstructive urethral pathology such as benign prostatic hyperplasia, urethral calculi, and rarely urethral cancer but also functional disorders of voiding such as Hinman's syndrome (nonneurogenic neurogenic bladder) or neurogenic detrusor dysfunction.

In an older patient the concurrent presence of benign prostatic hyperplasia may make it more difficult to assess voiding symptoms or interpret a low flow rate following treatment of urethral stricture – typically, the urethral obstruction is diagnosed and treated first, thereby unmasking the concomitant diagnosis of BPH, which often requires a secondary endoscopic intervention across the repair.

Physical Examination

Physical examination of the abdomen in a patient with urethral stricture may identify chronic urinary retention and a palpably distended bladder. Examination of the penile skin may reveal the presence of lichen sclerosus, an important cause of inflammatory urethral strictures. Examination of the urethral meatus may reveal stenosis or sequelae of hypospadias. Patients with hypospadias with or without previous surgery are at risk for urethral stricture. A urethrocutaneous fistula may be detected in some instances, particularly in patients who have undergone previous urethral surgery or have long-standing lower urinary tract obstruction. Palpation of the urethra often reveals thickening and/or induration which correlates well to the severity of periurethral fibrosis identified intraoperatively. Diffuse urethral induration often indicates severe spongiofibrosis, as in cases of lichen sclerosus, but if extensive should suggest the diagnosis of urethral carcinoma. Digital rectal examination (DRE) is performed particularly in older males to document the degree of clinical benign prostatic hyperplasia and rule out other possible prostate pathology.

Complications of Urethral Stricture

The prevailing mindset is that urethral stricture adversely impacts voiding function and quality of life but is thought to minimally affect overall health status. Although common complications associated with urethral stricture are typically minor, among them pain, urethral discharge, urinary tract infection, bladder calculi, prostatitis, epididymitis, urethral diverticulum, and urethrocutaneous fistula, almost one-third of patients with urethral stricture will progress to acute urinary retention and require emergent urologic intervention. In addition to minor complications, a significant proportion of patients with stricture present with a condition directly related to urethral stricture that can be considered life-threatening. Even in a contemporary industrialized patient population conditions such as acute renal failure or urethral abscess directly related to urethral stricture occur in 4.1 and 3.3 % of patients, respectively [15]. Both are potentially life-threatening conditions, and in total 7.4 % of patients present with either of these clinical events. Urethral stricture is a known risk factor for necrotizing infection and Fournier's gangrene [20]. Chronic urinary obstruction due to stricture can lead to extravasation of infected urine into periurethral tissues such as the perineum, scrotum, and Colles' fascia (Fig. 7.1). In this setting of urethrocutaneous fistula and causative distal stricture, the urinary fistula and extravasation will persist and progress. With long-standing obstruction multiple fistulae can form and then coalesce into what is often referred to as a "watering can perineum." As this infected material tracks along fascial planes, necrosis of tissue occurs and ultimately a Fournier's gangrene may develop. In addition to abscess, 4.1 % of patients present with renal dysfunction directly related to the chronic urinary retention caused by stricture. Renal failure even as a potentially reversible event carries a significant health risk. Additionally, urethral cancer is a rare but potentially devastating complication of urethral stricture. Historically one-third to half of men with urethral cancer will have a concurrent history of urethral stricture. Chronic infection is associated with the development of squamous cell carcinoma. With long-standing inflammatory urethral strictures in the elderly, one should always exercise a high index of suspicion and be aware of the possibility of malignant degeneration. The diagnosis of urethral stricture adversely impacts patient quality of life in many diverse ways but also has a significant potential to adversely impact overall health status.

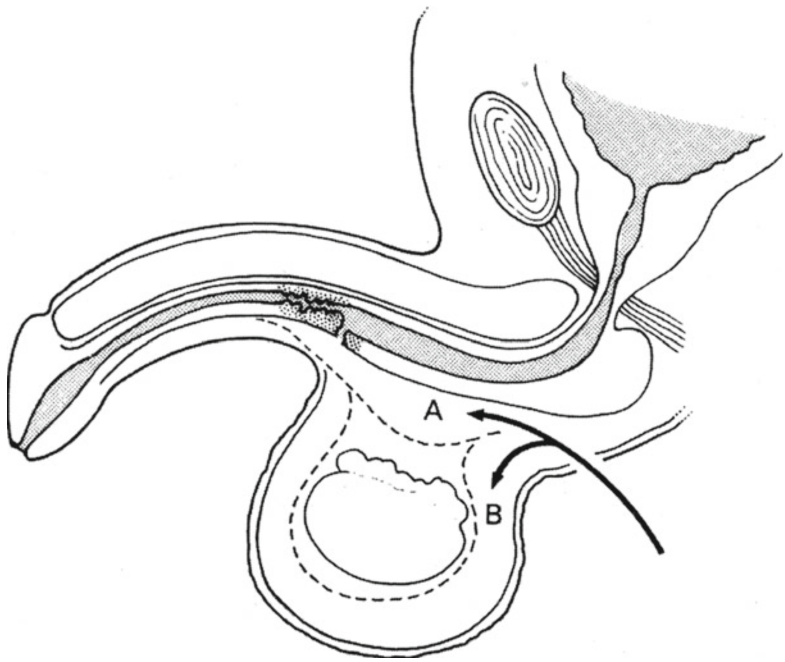

Fig. 7.1 (*A*, *B*) Development of periurethral abscess and Fournier's gangrene secondary to urethral stricture. Urethral stricture with subsequent extravasation of urine into both compartments of Colles' fascia (From Blandy and Fowler [30])

Economic Impact and Considerations

Urethral stricture is a relatively common urologic diagnosis, with yearly individual average cost of disease estimated at $6,000 [4]. Typically the highest prevalence is in third-world countries with limited medical infrastructure and health-care resources. In an industrialized country such as the United States, the estimated annual expenditure for male urethral stricture is $191 million based on year 2000 data. Ambulatory surgeries comprise the majority (70 %) of urethral stricture treatment costs. Typically a practicing US urologist treats 6–20 (median, 11) cases of urethral stricture per year [21]. It is likely that the overall cost of urethral stricture (at least in the United States) has stabilized with a peak in 1998 at a cost of $207 million. These costs are typically less than other more common urologic conditions, such as nephrolithiasis with an economic burden of $2.1 billion over the same time period. But in less developed countries with a higher prevalence of urethral stricture, the cost of treatment and follow-up of patients with recurrent strictures is substantial.

From a fiscal perspective the best treatment of a urethral stricture involves several variables. Open urethroplasty is now considered the "gold standard" of treatment but may be a technically challenging procedure that demands specialized training and relatively high initial cost. Retrospective, nonrandomized case series have reported success rates for urethroplasty ranging from 59 to 90 %. A recent literature review of 86 articles with a total number of 5,617 urethroplasty patients showed that the recurrence rate after urethroplasty was 14 % for bulbar urethral strictures, 18 % for penile strictures, and 18 % for posterior urethral strictures. The recurrence rate was significantly higher for longer strictures (≥5 cm, 17 %) compared to that for shorter strictures (≤5 cm, 12 %). The complication rate after urethroplasty was 19 % and ranged from 0 to 72 % depending on the definition of complication [22]. There are no randomized studies directly comparing the efficacy of DVIU and urethroplasty. DVIU and dilation are clearly less efficacious then urethroplasty, but this is based on multiple retrospective case series. The only randomized clinical trial that comes close is from India. At 2-year follow-up, recurrence rates for traumatic strictures of the posterior urethra following pelvic fracture injury treated by "core-through urethrotomy" were 64 %, while by anastomotic urethroplasty only 24 % ($P<0.05$) [23].

Despite less efficacy, endoscopic treatments for urethral stricture remain attractive options, because of their widespread availability, technical simplicity, and lesser initial cost. Thus, the treatment of a urethral stricture requires a decision between a technically simpler, less efficacious, and less costly procedure (endoscopic treatment) and a highly efficacious but initially more costly open surgery (urethroplasty). Like many matters, the best treatment approach is a matter of perspective. In the non-industrialized world there is often a lack of surgical facilities and adequately trained staff relative to the disease burden. In this specific setting open urethroplasty has several drawbacks. In industrialized countries with greater healthcare resources, the costs of medical care are typically related to equipment, operating room time, and inpatient admission, but there is typically a greater emphasis on improved long-term outcomes. To answer the question "What is the most cost-effective treatment of urethral stricture?" one should consider both perspectives.

In many non-industrialized countries, definitive treatment of urethral stricture is often not feasible despite a large disease burden. This is due to multiple factors including a lack of adequate hospital facilities, inadequate operating rooms, and limited medical expertise. These factors can profoundly impact treatment decisions. As an example of the economics of stricture care in underdeveloped countries, Ogbonna reported on 134 patients treated during a 3-year period in Nigeria [12]. In this circumstance the prevalence of urethral stricture is high, and the short-term goal is to provide treatment to as many patients as possible within these constraints. These factors may override the conflicting long-term aim of minimizing stricture recurrence. In this study, the overall recurrence rate was 22 % using an aggressive endoscopic approach. Urethroplasty was reserved for select cases of completely obliterated strictures, strictures unable to be incised endoscopically, or failing multiple urethrotomies. A combination of direct vision internal urethrotomy (DVIU) plus intermittent self-catheterization had a recurrence rate of 17 % during the study period – similar to the 22 % after urethroplasty. It was estimated that DVIU was ten times cheaper and ten times faster to perform than urethroplasty and offered the surgeon better protection from exposure to human immunodeficiency virus (HIV). The author further points out that in a practice where urethrography is not widely available, urethrotomy and self-dilation suffice to diagnose as well as treat over 75 % of patients in the short term – thereby reducing the need for urethroplasty. The author emphasized the importance of preoperative recognition of strictures with a high risk of recurrence after DVIU, so that they can be selected for primary urethroplasty. Elsewhere in Africa, Van der Merwe and colleagues described that 15 % of patients meeting evidence-based criteria for urethroplasty actually underwent surgery [24]. This discrepancy was related to fiscal constraints, limited operating room resources, and a large clinical burden of other urologic diseases. These studies highlight the harsh economic reality of treating urethral stricture in non-industrialized nations when ideal treatment must often give way to other competing considerations.

Although in many industrialized nations there is an evolving emphasis on fiscal constraint, the primary goal is typically to provide the most cost-effective treatment without compromising long-term patient care. Thus, from a financial perspective and cost to the healthcare system, urethrotomy due to its high failure rate and need for repeat treatment tends to be more expensive than urethroplasty. Greenwell et al. published one of the initial studies examining the cost-effective treatment of urethral stricture in an industrialized nation in 2004 [25]. The authors reviewed 126 patients in the United Kingdom followed for a mean of 25 months after initial treatment with DVIU. The study found that 48 % of patients required more than one endoscopic retreatment (mean, 3.13 each), 40 % performed biweekly intermittent self-catheterization, and 6 % required urethroplasty. They calculated that the most cost-effective strategy was one urethrotomy or urethral dilation followed by urethroplasty in patients with stricture recurrence. This approach yielded a total cost per patient of UK 5,866 lb sterling ($8,799 USD) compared to an average cost of 6,113 lb sterling ($9,170 USD) for the entire cohort. The cost estimates for urethrotomy were $3,375 compared with $7,522 for one-stage urethroplasty and $15,555 for a two-stage urethroplasty. They concluded that this financially based strategy of performing urethroplasty after a single DVIU failure is consistent with evidence-based strategies for urethral stricture treatment.

In 2005, Rourke and Jordan compared the costs of DVIU and anastomotic urethroplasty for a 2-cm bulbar urethral stricture using a decision analysis model [26]. This model was a cost minimization analysis based on a third-party payer perspective. The model predicted that treatment with DVIU was more costly ($17,747 USD per patient) than immediate treatment with urethroplasty ($16,444 USD per patient). Sensitivity analysis revealed that treatment with DVIU became more favorable only when the long-term success rate was >40 %. It was conceivable that DVIU could be less costly but only in select circumstances, such as a short stricture with minimal associated spongiofibrosis. The authors concluded that, from a fiscal standpoint, open urethroplasty should be considered over urethrotomy in the majority of clinical circumstances. Wright et al. in 2006 used a decision analysis model based on a societal perspective to determine the cost-effectiveness of four different management strategies for short bulbar urethral strictures 1–2 cm in length [27]. This model predicted that urethroplasty as initial therapy was cost-effective only when the success rate of the first DVIU was <35 %. The most cost-effective approach was one DVIU before treatment with urethroplasty. The authors recommended urethroplasty for strictures recurring after a single urethrotomy and for longer or obliterative strictures when the success rate of urethrotomy is expected to be less than 35 %.

Widespread practice patterns worldwide are still poorly understood and can substantially impact the economics of urethral stricture. Even in industrialized countries, dilation and DVIU are still commonly performed – as evidenced by the following studies from the USA, UK, and Netherlands. In a nationwide survey of 431 US urologists, it was noted that 33 % of practicing urologists would perform repeated, multiple urethrotomies on a recalcitrant stricture and only 29 % would refer to a specialist for definitive treatment with urethroplasty [21]. In addition, 23.4 % of urologists would use endourethral stents to treat anterior urethral strictures, a practice now abandoned in most centers with surgeons trained in urethral reconstructive surgery because of the collateral damage to neighboring periurethral tissues. In England, among new patient treated for urethral stricture in a general urological setting, between the years of 1991 and 1999, urethrotomy was performed in 72 %, dilation in 26 %, and urethroplasty only in 2.4 % of cases. [25]. There is a reported similar practice pattern in the UK with posterior urethral stenosis after a pelvic fracture-associated urethral injury, where 69 % of urologists perform repeated endoscopic manipulation [28]. In a survey of Dutch urologists, they perform annually at least once, a DVIU in 97 %, dilation in 84 %, and urethroplasty in 23 % [29]. Moreover, only 6 % of Dutch urologists performed more than five urethroplasties annually, yet only 43 % would refer a long stricture to a colleague. A recent analysis of a 5 % random sample of US Medicare patients with the diagnosis of urethral stricture showed that the use of direct vision urethrotomy actually increased from 51 to 58 % over a 9-year period from 1992 to 2001 [3]. One possible economically motivated explanation for this may be that urethroplasty physician reimbursement rates are typically suboptimal when taking into account operative times and complexity. Typically physician reimbursement rates for anterior urethroplasty do not compare favorably to the reimbursement a physician would receive from performing multiple endoscopic procedures of the same patient. In the USA, physician reimbursement for anterior urethroplasty is commonly only twice the amount for a DVIU and steroid injection [21]. This indicates that there is a financial disincentive to performing urethroplasty. Clearly, the stricture patient who is managed by only dilation or urethrotomy is a lifelong repeat customer. Urethroplasty, on the other hand, is often a time-consuming, complex surgery that can achieve cure and be a lost source of ongoing revenue. Despite its superior efficacy it appears that urethroplasty is an underused clinical entity. It is estimated in the US Medicare system that urethroplasty accounts for 0.5–0.8 % of urethral stricture treatments [3]. Urethroplasty was in fact used less than urethral stent or endoscopic corticosteroid injections with an estimated 1.9 % rate of use. In the survey of practicing US urologists by Bullock et al., less than 0.7 % of US urologists perform over ten urethroplasties per year, and 74 % still adhere to the reconstructive ladder in which patients undergo urethroplasty only if failing multiple endoscopic attempts [21].

It appears that the optimal treatment of urethral stricture from a fiscal standpoint depends on several factors. In non-industrialized nations with a lack of medical infrastructure and expertise, optimizing the use of endoscopic treatment may be the best approach. Meanwhile, in industrialized countries proceeding with urethroplasty after one initial attempt at urethrotomy or dilation is likely the most fiscally responsible approach. Patients with a high risk of stricture recurrence after endoscopic treatment should undergo initial treatment with urethroplasty. This includes patients with long urethral strictures (over 2 cm), strictures in the penile urethra, strictures with dense spongiofibrosis, or strictures caused by acute trauma.

Preferred Instruments and Sutures of K Rourke

Forceps
1. Toothed Gerald forceps (7″) – Codman (301146) (harvest of buccal mucosa graft)
2. Brown forceps (6″) (for grasping fibrotic tissue) – Pilling (18-1255)
3. Beasley forceps (5″) – Pilling Weck (57–302) (for handling and mobilization of flaps – in addition to stay sutures)
4. Gregory plaque forceps (7″) (tissue handling) – Biomet (51-9927)
5. Cushing angled toothed forceps – Biomet (51-9712)
6. Horton-Adson Diamond Point – Snow-Pen (32-0503)
7. Castroviejo toothed very fine – Pilling Weck (427384)

Scissors
1. Jamison Supercut (6″) – Mueller (CH5675) (defatting BMG)
2. Strabismus curved blunt (4½″) – Snow-Pen (32-0700)
3. Tenotomy scissors curved (5½″) – Micrins (PR 846-R)
4. Tenotomy scissors curved (6¼″) – Micrins (PR 847-R)
5. Stevens tenotomy (6″) – Storz (N5143)
6. Vascular fine 45° (5½″) – Codman (548008)
7. Goldman-Fox (5″) – Codman (51-8071)
8. Devine curved sharp (4½″) – Snow-Pen (32-0703)
9. Devine-Horton curved blunt (4½″) – Snow-Pen (32-0933-1)
10. Iris straight sharp (4½″) – Snow-Pen (32-0706)
11. Demartel straight (for cutting fine sutures) – Pilling Weck (35-2100)

Needle Holders
1. French eye 5″ Ryder – Jarit (121-160)
2. Fine 6″ – V Mueller (SA-16005)
3. Webster power grip 4½″ – Biomet (51-6611)
4. PAR 4½″ (very fine tip) – Snow-Pen (32-0404-1)

Sutures
1. Vicryl 6-0 on RB1 needle (undyed) – anastomosis
2. Vicryl 5-0 on RB1 needle (undyed) – anastomosis
3. Vicryl 4-0 on SH – bulbospongiosus closure
4. Vicryl 3-0 on SH – closure of Dartos
5. Monocryl 4-0 PS-2 – skin closure
6. PDS II 5-0 on RB1 – on EPA/PFUI
7. Chromic 3-0 on SH – drain stitch

General Instruments
1. Bougie à boules 22–30 Fr (urethral calibration)

2. Flexible cystoscope
3. 0.038 glide wire (for posterior urethral stenoses)
4. Pediatric tonsil Yankaeur suction
5. Jordan perineal Bookwalter retractor
6. Loupes 2.5× Magnification
7. Marking pen
8. Ruler 6″

Editorial Comment

The diagnosis of urethral stricture carries a heavy emotional and financial toll for both the patient and his family. Most stricture patients are breadwinners who cannot afford time out of work for repeated UTI treatment, endoscopic instrumentation, catheter replacement, clinic visits, or hospitalizations. Most patients prefer attempts at cure, rather than chronic management schemes, when given the chance. Endoscopic treatment of urethral stricture often converts a curable problem into a chronic disease.

The standard of care for men with urethral strictures is changing in the same way that laparoscopy and robotics have transformed urologic cancer care. The expertise required for effective urethral reconstruction is increasingly available nowadays as subspecialty reconstructive fellowship training programs have expanded exponentially. Increasingly, endoscopic management of urethral strictures is becoming viewed as an ineffective, antiquated strategy. Self-catheterization is also unpopular among stricture patients, recognized now as a painful and fruitless burden rather than an effective management strategy. Urethral stricture should now be considered an open surgical disease.

–Allen F. Morey

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8 Etiology, Histology, and Classification of Urethral Stricture Disease

Sean Elliot and Steven B. Brandes

Summary

The etiology of urethral strictures has a significant impact on stricture location and the chance of success with reconstruction. Likewise the histology of urethral strictures reflects the etiology and the stricture location. Several classification schemata have been proposed for urethral strictures, with the goal of stratifying strictures into those that are straightforward vs. complex and those that can be managed endoscopically vs. those that require open urethroplasty.

Etiology

Most present-day anterior urethral strictures in industrialized countries are the result of occult or recognized blunt external perineal trauma (e.g., straddle injury) or instrumentation (e.g., traumatic catheter placement/removal, chronic indwelling Foley catheter, or transurethral surgery). A recent meta-analysis of the literature shows that most anterior strictures are iatrogenic (33 %), idiopathic (33 %), and, to a lesser extent, traumatic (19 %) and inflammatory (15 %; see Table 8.1 for details). The site of the stricture also varies considerably in different reports, which may further account for some of the differences in treatment outcome. Bulbar strictures are the most common (44–67 % of patients), followed by penile strictures in 12–39 %, mixed (bulbar and penile) in 6–28 %, external meatal or submeatal (0–23 %), membranous (0–20 %), and prostatic (0–4 %).

Inflammatory strictures, such as secondary to gonococcal urethritis, are relatively very uncommon today. However, there is no apparent relationship between nonspecific urethritis (chlamydia and ureaplasma urealyticum) and subsequent stricture development. In the previous century or in some contemporary undeveloped countries, more than 90 % of strictures are inflammatory and commonly involve the bulbar and pendulous urethra. Gonococcal urethral strictures occur because of abscesses that form in the paraurethral glands of Littre (Fig. 8.1). The abscess then affects the surrounding corpus spongiosum and heals by fibrosis and scarring. The paraurethral glands are in greatest concentration in the bulbar urethra, and it is the bulb then where most inflammatory stricture occurs (Fig. 8.2). In the bulb, the glands extend deeply into the corpus spongiosum and are distributed circumferentially around the urethra. The membranous and the

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Table 8.1 Meta-analysis of anterior urethral stricture etiology [4]

		Cause (*n*)			
Investigator	Stricture (*n*)	Idiopathic	Iatrogenic	Inflammatory	Traumatic
Wessells and McAninch	40	5	12	13	10
Wessells et al.	25	0	11	9	5
Andrich and Mundy	83	35	38	7	1
Santucci et al.	168	64	24	12	68
Elliott et al.	60	37	9	7	7
Andrich et al.	162	38	84	23	17
Fenton et al.	194	65	63	38	28
Total (%); included only bulbar strictures	732	244 (33)	241 (33)	109 (15)	136 (19)

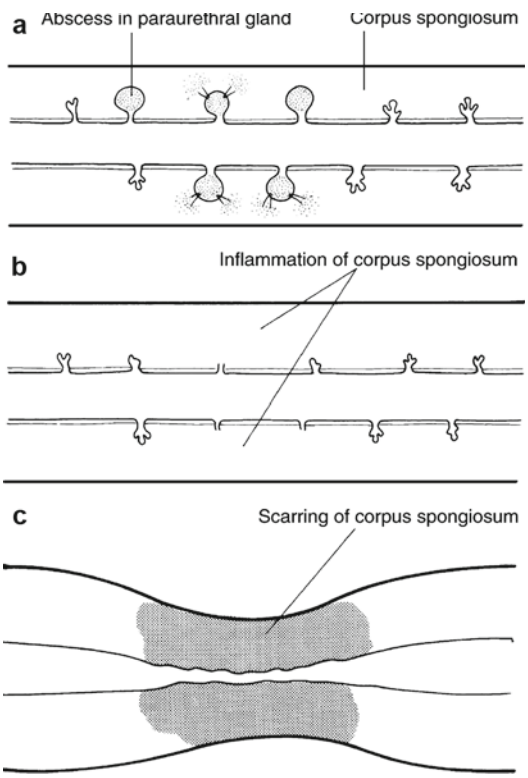

Fig. 8.1 (**a**) Acute gonococcal inflammation of the paraurethral glands bursts out into the corpus spongiosum to produce inflammation (**b**), which heals by scarring and, thus, (**c**) lumen stenosis and spongiofibrosis (From Blandy and Fowler [2], p. 476)

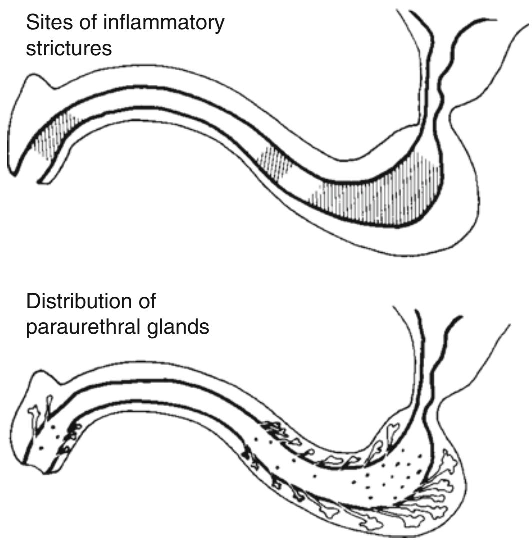

Fig. 8.2 Paraurethral glands are most numerous in the distal pendulous and in the mid/proximal bulb. Inflammatory strictures commonly occur in the same location as the higher concentration of paraurethral glands (From Singh and Blandy [3])

penile urethras (except for a short segment proximal to the meatus) lack glands, whereas the penoscrotal junction has a few sparse and small glands. It is interesting to note that most mammals except humans and guinea pigs lack paraurethral mucous glands. With downstream urethral stenosis, infected urine can accumulate under pressure and extravasate into the corpus spongiosum and result in spongiofibrosis. As a result, a relatively short stricture can slowly progress or "creep" proximally (upstream) (Fig. 8.3). Long tortuous strictures, in particular those associated with fistulas or periurethral abscesses or tuberculous prostatitis, are associated in the developing world with tuberculosis of the urethra. In the classic animal experiments of the 1970s by John Blandy, urine extravasation was shown to exacerbate the post-traumatic inflammatory process and contribute to further

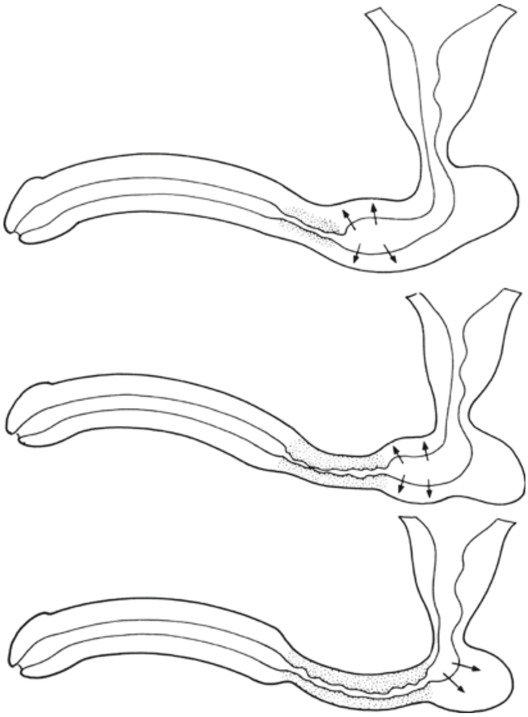

Fig. 8.3 Inflammatory stricture tends to "creep up" the urethra as infected urine is forced into the corpus spongiosum upstream of a stricture (From Blandy and Fowler [2], p. 477)

stenosis of the urethra. In cases of urinary extravasation, urinary diversion is thus essential to help prevent the severe periurethral fibrocystic reaction that can be seen.

In Western countries today, the most common cause for inflammatory strictures is lichen sclerosus et atrophicus (LSA), which starts out as affecting only the glans, meatus, and preputial skin. Metal stenosis can lead to high pressure voiding and, as with gonococcal urethritis, eventually cause inflammation or infection of the periurethral glands ("littritis"). Potentially, panurethral stricture disease can occur in this manner. LSA is a common cause of phimosis and thus is often temporally apparent after circumcision. (*See* Chap. 4 by Virasoro and Jordan in this volume detailing the etiology and histology of LSA).

Posterior urethral strictures are most frequently associated with injuries in traffic accidents, but they may also occur after a fall from a height or severe compression to the pelvic area. The posterior urethral trauma generally is associated with pelvic trauma and fractures of the bony pelvis (*See* Chap. 19 by Mundy and Andrich).

Stricture Etiology by Location of the Stricture

Strictures that involve the fossa navicularis are typically the result of inflammatory (33–47 %) and iatrogenic (33–37 %) causes. In Fenton et al. [4], mean stricture lengths in the anterior urethra were longest in the pendulous urethra at 6.1 cm, shortest in the bulbar urethra at 3.1 cm, and in the fossa navicularis at 2.6 cm. That pendulous strictures were long underscores the customary need for substitution urethroplasty for pendulous strictures, whereas bulbar strictures, which are typically much shorter, are often amenable to an anastomotic urethroplasty or an augmented anastomosis. For their series, most urethral strictures were idiopathic (34 %), iatrogenic (32 %), inflammatory (20 %), or traumatic (14 %).

Etiology of iatrogenic stricture is typically caused by instrumentation. Such strictures are mostly the result of transurethral resection (41 %), prolonged catheterization (36.5 %), and, to a lesser degree, cystoscopy (12.7 %), prior hypospadias repair (6.3 %), and radical prostatectomy surgery (3.2 %). Such strictures are the result of an ischemic insult from the traumatic passage of large instruments into the urethra during transurethral surgery or by prolonged catheterization (particularly when a larger bore catheter is used). Such iatrogenic urethral strictures typically occur at sites of greatest compression and ischemia, namely, points of urethral fixation or lumen narrowness (the membranous-proximal bulb, penoscrotal junction, and the fossa-meatus; Fig. 8.4). Thus, when prolonged catheterization is needed, for short durations, a 16-Fr catheter is advocated, whereas for extended time periods, an SP tube is often placed.

Iatrogenic strictures appear to occur after trauma from faulty catheterization, the inflammatory response provoked by the catheter material, or avascular necrosis (compressive ischemia), such as from a large catheter. From animal experi-

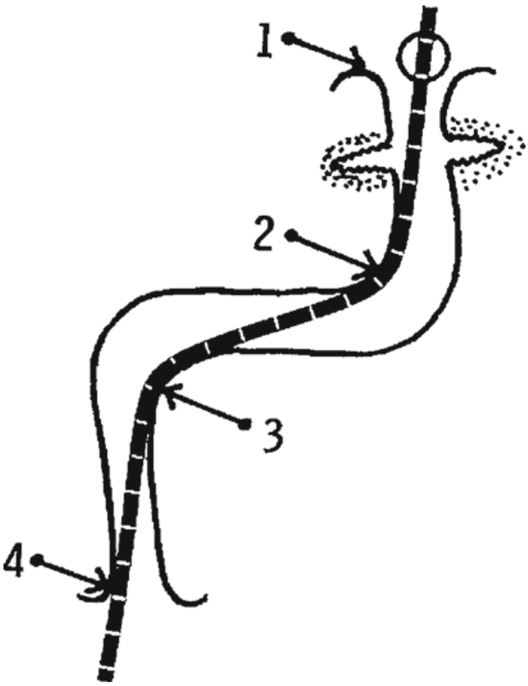

Fig. 8.4 Locations of ischemic urethral strictures from instrumentation. Note strictures occur at the sites of bowstring compression-like effects by a rigid instrument placed per urethra (From Edwards et al. [5]) *1* bladder neck, *2* membranous urethra, *3* penoscrotal junction,*4* fossa/meatus

ments, it is clear that different catheter materials result in differing local tissue reactions and destruction (from best to worst: silicone, plastic, latex, and rubber). Furthermore, instrumentation strictures occur in predictable locations of urethral fixation and narrowing. Traumatic urethral strictures tend to be short and in the bulbar urethra. Most are due to a straddle injury. Idiopathic strictures also can be short and common (up to 38 %). The so-called idiopathic strictures are probably the cause of unrecognized childhood perineal trauma. Baskin and McAninch [6] noted that it can take years from the time of the perineal trauma to the advent of significant stricture.

Histology/Pathology

In general, a urethral stricture is a fibrotic process with varying degrees of spongiofibrosis that results in poorly compliant tissue and decreased urethral lumen caliber. The normal urethra is lined mostly by pseudostratified columnar epithelium. Beneath the basement membrane there is a connective tissue layer of the spongiosum rich in vascular sinusoids and smooth muscle. The connective tissue is composed of mainly fibroblasts and an extracellular matrix that contains collagen, proteoglycans, elastic fibers, and glycoproteins. The most dramatic histologic changes of urethral strictures occur in the connective tissue. Strictures are the consequence of epithelial damage and spongiofibrosis.

Scott and Foote [7] showed that, after trauma, the epithelium became ulcerated and covered with stratified columnar cells. The stricture itself was noted to be rich in myofibroblasts and giant multinucleated giant cells. Both were felt to be related to stricture formation and collagen production. An increase in collagen results in fibrosis. Singh and Blandy [3] showed in rat urethral stricture experiments that the total amount of collagen increases in urethral stricture, resulting in dense fibrotic tissue with decreased smooth muscle and thus elasticity. In contrast, Baskin et al. [8] did not demonstrate an increase in collagen but rather a change in subtype distribution, in favor of type III collagen. The change in the ratio of type I to III collagen was associated with a decrease in urethral elasticity and compliance.

Calvacanti et al. [9] analyzed 15 urethral strictures managed by anastomotic urethroplasty. They noted that, with collagen replacement, there was a complete loss of the relationship between smooth muscle, extracellular matrix, and sinusoids in the perilumen. Fibrosis of the tissue and reduction in vascular density were greatest when the etiology was trauma. Etiology of stricture did not play a role in the content of smooth muscle or collagen in the peripheral corpus spongiosum. Increase in type II collagen was noted in the perilumen and type I in the spongiosum. Strictures also had fewer elastic fibers. Overall, urethral strictures are characterized by marked changes in the extracellular matrix. Bastos et al. [10] noted that the concentration of elastic fibers is high in the healthy spongiosum, in part explaining its high degree of extensibility. In urethral stricture, particularly of traumatic etiology, the scar is dense, hypovascular, and reduced in elastic fibers.

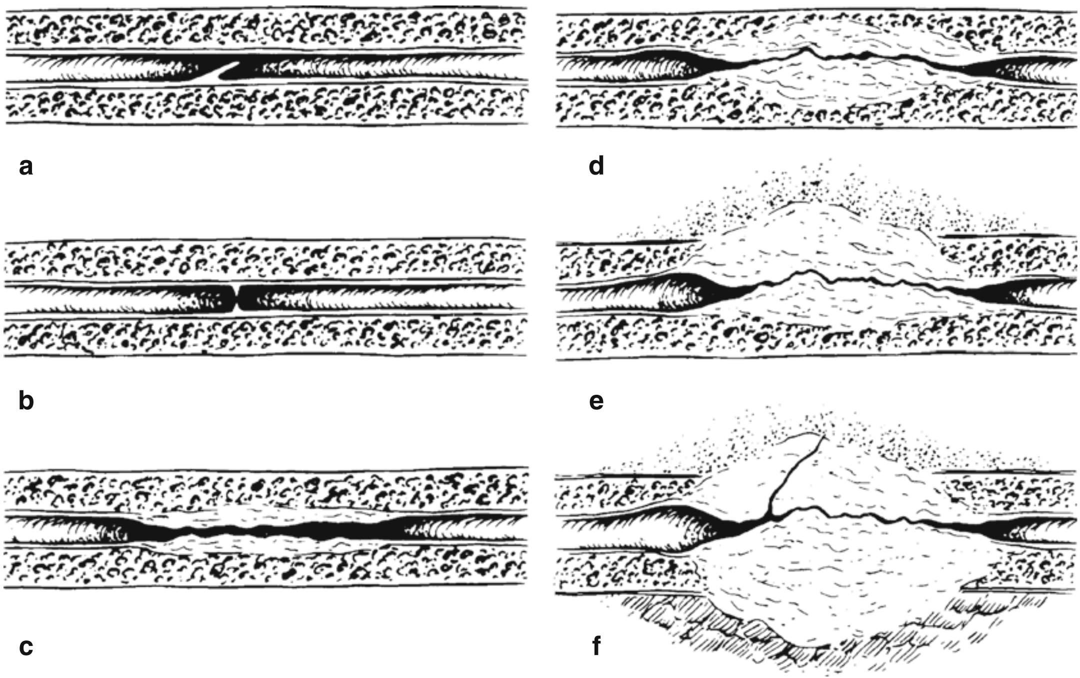

Fig. 8.5 Devine classification of urethral stricture disease according to the anatomy of the stricture. (**a**) Stricture with no spongiofibrosis and an epithelial flap. (**b**) Epithelial scar with minimal spongiofibrosis. (**c**–**e**) Progressive spongiofibrosis. (**f**) Spongiofibrosis occupies the entire corpus spongiosum and potential fistula formation (From Schlossberg and Jordan [12])

Stricture Classification

An anterior urethral stricture is a scar of the urethral epithelium and commonly extends into the underlying corpus spongiosum. The scar (stricture) is composed of dense collagen and fibroblasts and, thus, contracts in all directions, shortening urethral length and narrowing luminal size. Strictures are usually asymptomatic until a lumen size below 16 F. (See Chap. 28 in this volume for more details.)

In 1983, Devine et al. [11] proposed a classification of urethral strictures based on the extent of spongiosal fibrosis (Fig. 8.5). Jordan and Devine [13] subsequently outlined a treatment algorithm with types of surgery or urethrotomy based on the classification stage. For instance, for class D or greater, where spongiosal fibrosis was full thickness, they recommended open urethroplasty. The concept of selecting treatment based on the extent of spongiosal fibrosis is sound; however, it is not clinically practical unless one has an accurate and reliable noninvasive means to evaluate the degree of fibrosis. Conventional urethrography can only detail luminal narrowing and not the character of the underlying tissue. Physical examination (palpation of urethral induration) and urethroscopy (elasticity of the tissue and the color of the epithelium) can be helpful surrogates for underlying fibrosis, but the reliability of such predictions is limited. Ultrasonography has promise as a modality for assessing fibrosis. However, by its very nature, sonography is operator dependent, and clinical stratification of strictures then by this means is very subjective. Excessive external compression with the probe can result in a false urethral lumen narrowing. The healthy spongiosum is generally hypoechoic; with increasing fibrosis [14] there is increased echogenicity and, at times, calcifications. Further, a lack of blood flow on color Doppler suggests fibrosis. McAninch [15] first proposed in 1988 a urethral stricture staging system based on sonographic appearance, ranging from normal to severe, based on the degree of lumen occlusion (Fig. 8.6).

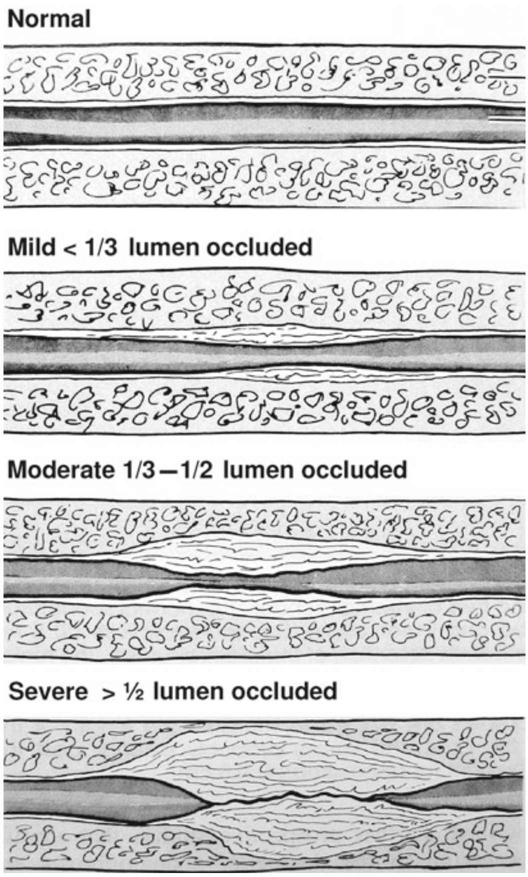

Fig. 8.6 Ultrasound classification of the degree of urethral occlusion, after McAninch and later modified by Chiou (From Ref. [14])

Later, combining the sonographic findings of spongiosal involvement with the length of the urethral stricture, Chiou et al. [14] categorized urethral strictures into five categories:

I: Short stricture (<2.5 cm) with minimal spongiosal tissue involvement

II: Short stricture with moderate (some normal spongiosal tissue in the periphery) spongiosal tissue involvement

III: Short stricture with extensive (full thickness) spongiosal tissue involvement

IV: Long (>2.5 cm) or multiple strictures with moderate spongiosal tissue involvement

V: Long (>2.5 cm) or multiple with extensive spongiosal tissue involvement

Unfortunately, we have not had the same success with assessing fibrosis sonographically as Chiou et al. and thus we do not feel that ultrasound is the modality of choice to assess spongiofibrosis. We have found the best correlation with fibrosis to be the extent of lumen narrowing and the length of stricture. Longer and narrower strictures tend to have more spongiofibrosis. The recent advent of extended field-of-view ultrasound technology produces good images that can help to better assess stricture length and location because the images look like a urethrogram. The lack of blood flow on color Doppler, however, may have more value as a predictor of spongiofibrosis. The less blood flow noted, the more spongiofibrosis suggested.

Because they can be particularly challenging to successfully manage, strictures due to LSA may deserve their own classification system. Barbagli et al. [16] has proposed a classification schema for LSA inflammatory strictures and of the disease process when it involves the penis and urethra. His proposal is as follows:

Stage 1: LSA only involves the foreskin.

Stage 2: LSA involves the foreskin, the coronal sulcus, and meatus.

Stage 3: The foreskin, glans, and external meatus are affected, as well as an associated stricture of the fossa navicularis and anterior urethra. At times, the infectious process spreads to the glands of Littre, and the patient develops a pan-urethral stricture.

Stage 4: An associated premalignant or cancerous lesion is also present.

Pansadoro and Emiliozzi [1] have proposed a classification of prostatic urethral strictures. However, classification is clinically not significant because they suggested that all injuries are best managed in the same fashion, by bladder neck incision. The grading system is as follows:

Type I: Fibrous tissue involves the bladder neck only, termed “bladder neck contracture.”

Type II: Stricture is localized to the median part of the prostatic fossa, with open bladder neck and spared verumontanum.

Type III: Complete prostatic urethral obliteration.

Conclusions

Several classification schemata have been proposed for urethral strictures, with the goal of stratifying strictures into those that are straightforward vs. complex and those that can be managed endoscopically vs. those that require open urethroplasty. Although many clinical factors (such as the etiology or severity of urethral strictures) have a significant impact on stricture location and the chance of success with reconstruction, a unifying comprehensive system of urethral stricture classification does not yet exist.

Preferred Instruments and Suture for Urethroplasty for Sean Elliot

Forceps
1. Toothed Gerald forceps (7″) – Codman (301146)
2. McAninch titanium forceps (7½″) – Sontec (2600–582)
3. DeBakey forceps (7¾″) – V Mueller (CH5902-1)

Scissors
1. Jamison Supercut (6″) – Mueller (CH5675) (defatting BMG)
2. Supercut tenotomy (6¾″) – Jarit (102–315)
3. Supercut straight Mayo (5½″) – Jarit (102–100)

Needle Holders
1. Vital Sarot Straight (7 1/8″) – V Mueller (CH2416) (for RB-1 needles)
2. Euphrate-Pasque Sarot, Fine – Sontec (2300–661) (for RB-2 needles)

Sutures
1. PDS II 6-0 on RB-2 needle – urethral anastomosis (inner layer in 2-layer closure)
2. PDS II 5-0 on RB-2 – anastomosis
3. Vicryl 4-0 on RB-1 – urethral stay suture and skin closure
4. Vicryl 3-0 on SH – closure of Dartos and Colles' fascia
5. Chromic 4-0 on SH – buccal mucosa closure in mouth

General Instruments
1. Bougie à boules 8–28Fr (urethral calibration)
2. Flexible cystoscope
3. Andrews suction tip
4. Jordan Perineal Bookwalter retractor (Codman)

Editorial Comment

Many problems confound the scientific underpinnings of urethral stricture care. We still do not know what causes most strictures nor do we have a clear histological basis for the formation of obliterative lesions. Inflammatory lesions due to lichen sclerosus may involve the urethra, the foreskin, or both, and we don't understand why nor when this occurs. While stricture length and location are usually reported in current reports, stricture severity is virtually never reported. All of these factors influence treatment and outcomes.

Development of a clinically useful schema for classifying urethral strictures has thus far been elusive. Accurate details describing stricture length, severity, and location should be included in clinical reports and thus readily determined by practitioners. Although ultrasound gives precise length and luminal diameter measurements, it is rarely performed in clinical practice and is operator dependent. Although RUG and VCUG demonstrate stricture location nicely, length and severity may not be well illustrated on any particular film. Standardization of outcomes prognostication and other important clinical features will remain suboptimal until the staging process for urethral stricture disease is refined.

–Allen F. Morey

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9 Urethrotomy and Other Minimally Invasive Interventions for Urethral Stricture

Chris F. Heyns

Summary

The minimally invasive interventions most often used for treating urethral strictures are dilation and direct vision internal urethrotomy (DVIU) which are equally effective for the initial treatment of strictures. The reported success rates with DVIU vary from 35 to 90 % and decline progressively with longer follow-up. The recurrence rates are higher with previously treated, long and multiple strictures, penile compared with bulbar strictures, and those with perioperative infection. Specific contraindications to DVIU include suspicion of urethral carcinoma, bleeding diathesis, and active infection.

The advantages of dilation and DVIU are that they can be performed under local anesthesia in an outpatient setting, with a low complication rate and virtually no risk of mortality. Because dilation does not require special endoscopic equipment or operating room facilities, it is the procedure of choice where facilities for DVIU are not available.

The optimal indications for dilation or DVIU are single, bulbar strictures shorter than 2 cm, with no spongiofibrosis and no previous treatment. A second DVIU for early stricture recurrence (at 3 months) is of limited value in the short term (24 months) but of no value in the long term (48 months), whereas a third repeated dilation or DVIU is of no value. There is some evidence that DVIU is being used excessively and inappropriately because of its simplicity and ease of repetition and because there is a lack of familiarity with urethroplasty.

Introduction

Urethral stricture is one of the oldest known urological diseases and dilation was the first known form of minimally invasive intervention [1]. Subsequently, several other modalities for minimally invasive treatment of urethral strictures have been developed. This chapter reviews the techniques, complications, results, and indications for minimally invasive stricture treatment.

Urethral Dilation

The urethra can be dilated with metal sounds or bougies (e.g., Lister's, Clutton's, or Béniqué's dilators), urethral catheters of increasing size, filiforms and followers, Amplatz dilators, or an inflatable balloon. The goal of dilation is to stretch the scar tissue without causing trauma which induces more fibrosis. Forceful dilation until bleeding occurs implies that the stricture has been torn and healing is likely to occur with even more fibrosis [2–7]. The need for

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nontraumatic dilation gave rise to the statement: "The skill of the urologist is measured by his gentleness" [8].

Historically, the least traumatic way of dilating the urethra is to use multiple treatment sessions with gradually progressive serial soft catheter dilations. However, the logistics and cost implications are considerable; therefore this treatment option has been largely abandoned.

Metal dilators with curved tips are very effective, but must be used with extreme caution, because it is very easy to make a false passage (Fig. 9.1). The operator has to learn by experience the skill of passing the tip of the dilator up to the stricture and then swiveling it around so that the curve of the tip conforms to the curve of the bulbar urethra. If resistance is met, the exertion of force easily results in urethral trauma and a false passage. The thinner the dilator, the easier it is for the tip to make a false passage. Therefore, it is best to start with a large- or medium-sized dilator, gently sounding the urethra up to the stricture, and then trying serially smaller dilators until one of them is passed through the stricture. Thereafter, serially larger dilators are passed through the stricture, keeping in mind that the objective is to stretch the fibrosis, not to tear open the whole urethra and cause torrential bleeding. It is usually adequate to dilate the urethra to 20 or 24F.

Filiform dilators are safer because they do not easily make a false passage, but it is difficult to pass the filiform leader if the stricture is narrow or its opening is not in the center of the lumen. The easiest technique is to pass the filiform leader under direct vision with a rigid or flexible urethrocystoscope. Alternatively, if the straight-tip leader cannot be passed, one can try one of the variety of spiral tips, twirling it in the hope of finding the stricture opening, or one can continue gently passing multiple straight filiforms to fill up the urethra, eventually allowing one of them to pass through the stricture (Fig. 9.2a, b).

Balloon dilation has been reported as relatively atraumatic and painless; it eliminates the risk of false passages by reducing urethral trauma due to shearing forces; it may reduce subsequent spongiofibrosis and stricture recurrence [9, 10]. However, it may require flexible cystoscopy to pass a guide wire through the stricture and fluoroscopy for proper positioning of the balloon [11, 12]. In patients with impassable strictures, percutaneous transvesical antegrade passage of a guide wire through the stricture can be done, with subsequent balloon dilation [13, 14]. A balloon with a peripheral electrodiathermy cutting wire has been used to treat bulbar urethral strictures in a few patients [15]. A balloon dilator that can be placed and inflated under direct vision has also been described [16].

New instrumentation and techniques that have been proposed in order to minimize trauma to the urethra during dilation include a flexi-tip lubricated guide wire inserted under cystoscopic guidance followed by insertion of a series of sheath dilators [17], an S-shaped coaxial urethral dilator [18], a radially expanding sheath for urethral dilation [19], and a hydrophilic guide wire

Fig. 9.1 Metal dilators (Lister's)

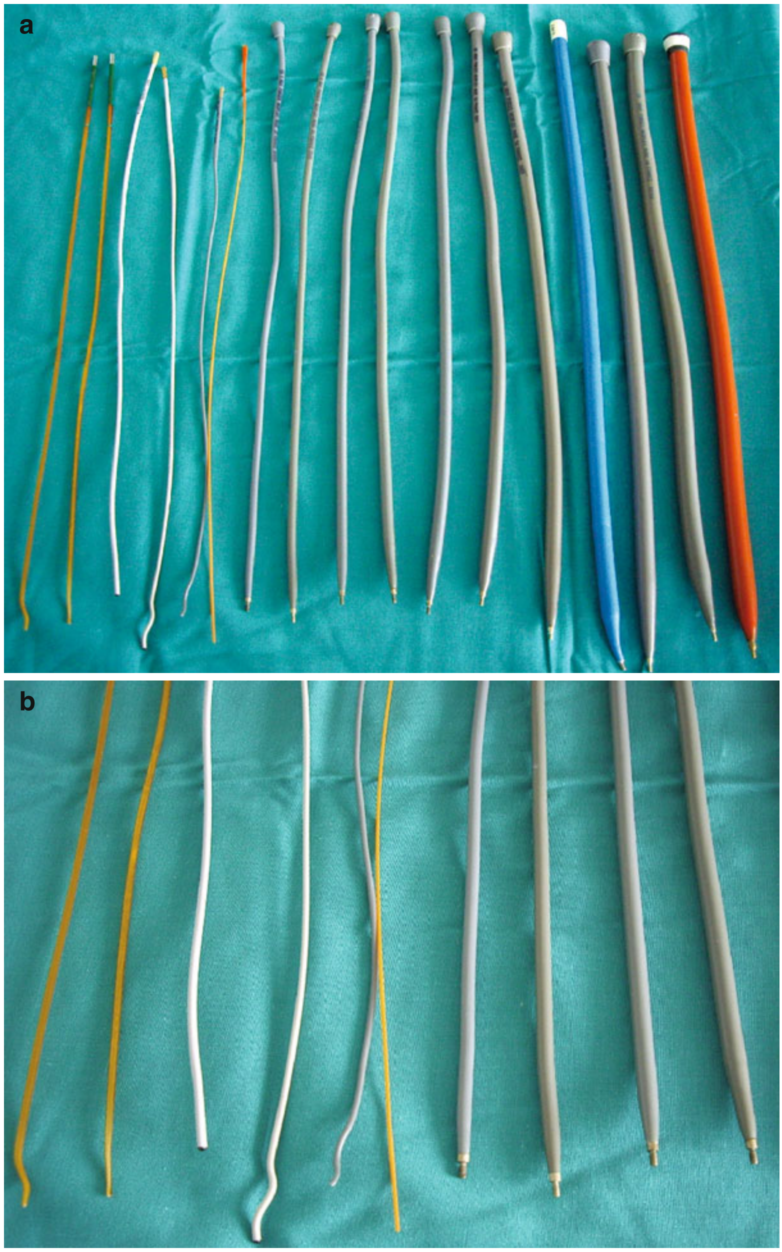

Fig. 9.2 Filiform dilators – (**a**) followers and (**b**) leaders

and ureteric access sheath for extremely narrow strictures [20].

Internal Urethrotomy

Internal urethrotomy can be performed with a Mauermayer or Otis urethrotome. The Otis instrument consists of two legs which can be progressively opened by turning a screw at the rear end. The Otis urethrotome has a dial which shows in the F-gauge how wide the legs have been separated and a small blade which can be retracted to make a shallow incision along one of the legs. The disadvantage of the urethrotome is that it has to be passed blindly and will usually not traverse a stricture <16F in diameter (Fig. 9.3). In these cases, a small ureteric catheter may be passed and left in place for 3–4 days to dilate the stricture. It has been suggested that Otis internal urethrotomy should be performed in the 12 o'clock position, with the urethrotome opened to a maximum size of 45F. However, opening the Otis device to its full extent may cause tearing rather than cutting of the stricture, with a less favorable outcome [3]. Some authors advocate performing Otis urethrotomy up to 35F in the 12 o'clock position [21].

Direct Vision Internal Urethrotomy (DVIU)

Although the first endoscopic urethrotomy was performed in 1893 by Oberländer [22], the modern technique of optical internal urethrotomy using a small knife introduced via a cystoscope was initiated by Sachse in 1971 [4, 23]. The technique described by Sachse involved a single cold knife incision through all visible scar tissue at the 12 o'clock position. Modifications of this technique aimed at increasing its efficacy and safety include the following [24]:

1. Multiple radial incisions [25]
2. Resection of the scar tissue between the 1 and 11 o'clock positions [26]
3. Substituting the cold knife for a hook electrode [27]
4. Laser urethrotomy using different types of laser [28]
5. Targeted incision of fibrosis as demonstrated by ultrasound [29]
6. Bipolar plasmakinetic vaporization [30]

Sachse theorized that electric incision causes tissue necrosis and scarring, which could be avoided by simple sharp incision [23]. This theory is supported by a study which noted a success rate of 82 % with cold knife urethrotomy and 40 % with electrosurgical urethrotomy [31]. It has been stated that the trauma of urethral dilation is in stark contrast to internal urethrotomy which minimizes tissue trauma [32]. However, this theory is not supported by a study in dogs which found that urethral dilation to 45F did not lead to any histological changes, whereas urethrotomy always resulted in scarring [33].

The technique of cold knife DVIU is relatively simple (Fig. 9.4a, b). The urethrotome with a 0- or 12° telescope and a 19 or 21F sheath is inserted through the external meatus and advanced under vision up to the stricture. It is, of course, important to keep the blade withdrawn. The irrigation fluid should be isotonic (normal saline is ideal, unless electrodiathermy is to be used) because if there is extravasation it minimizes tissue damage and avoids the risk of hyponatremia.

Via the side-channel of the urethrotome, a 5F ureteric catheter or guide wire is inserted through the stricture, preferably all the way into the

Fig. 9.3 Otis urethrotome – (**a**) closed and disassembled, (**b**) opened, with urethrotomy blade inserted

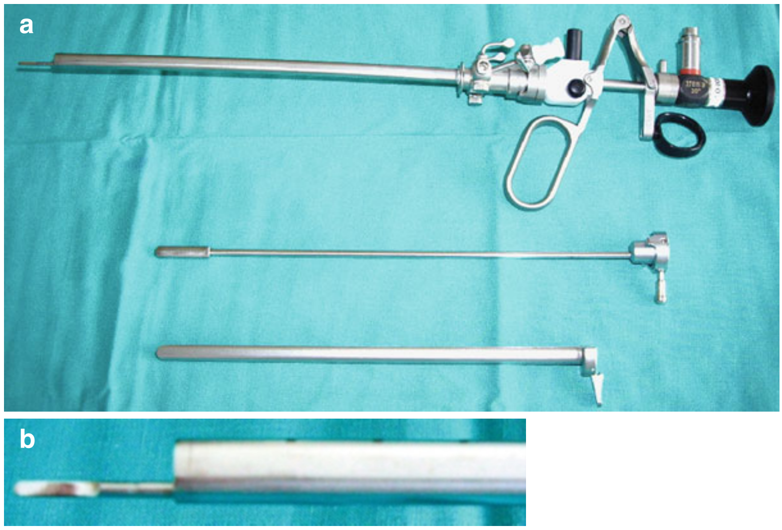

Fig. 9.4 Sachse urethrotome (**a**) with close-up view of cold knife (**b**)

bladder. The stilet of the ureteric catheter should be removed because if it is too rigid, it may become stuck against the verumontanum, prostate, or bladder neck. If the stricture is very short, and if the operator is experienced, the stricture may be incised without a guide wire, but there is a real risk of cutting a false passage and even ending up in the rectum (Fig. 9.5). The knife blade (which may be straight, semicircular, curved, or serrated) is extended along the upper surface of the guide wire, and incisions are made by tilting and slightly withdrawing the urethrotome. Care should be taken not to cut through the ureteric catheter used as guide wire.

As the stricture is opened up, the urethrotome is advanced, and further incisions are made until the full thickness of the stricture has been divided up to the normal proximal urethra. It is important to enter the bladder and perform a quick but thorough cystoscopy, because on occasion stones or even a bladder tumor may be discovered [2, 34]. If there is severe bleeding from the incised urethra, hemostasis may be obtained with a Bugbee or ball electrode, but this is rarely necessary [35, 36].

A transurethral Foley catheter is usually inserted after DVIU. It is advisable to fill the bladder before removing the urethrotome, so that when the catheter is inserted, the efflux of irrigation fluid shows that the catheter tip is inside the bladder before the balloon is inflated. When there is difficulty in passing the Foley catheter, the urethrotome is passed under vision, the telescope is removed, and a ureteric catheter or firm guide wire is introduced through the urethrotome sheath, which is then withdrawn. The Foley catheter tip is cut off, and the catheter is then threaded over the ureteric catheter or guide wire.

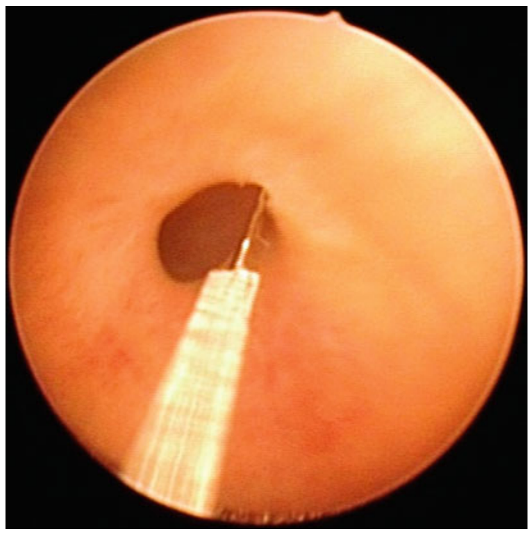

Fig. 9.5 Urethral stricture being incised with cold knife in 12 o'clock position

Alternatively, a urethrotome with a half-round sheath can be introduced into the bladder. The telescope is removed, and the catheter is guided through the urethrotome sheath, which is withdrawn, leaving the catheter indwelling. The only drawback is that the urethrotome sheath usually does not take a catheter larger than 16F [37]. A curved metal introducer may be used to insert the transurethral catheter, provided the operator is sufficiently experienced, because there is a real risk of making a false passage with the rigid introducer [38].

If no guide wire can be passed, but the patient has a suprapubic cystostomy, the bladder can be filled with methylene blue and by forcefully pressing on the full bladder, while the irrigation inflow through the urethroscope is turned off, it is often possible to see where the methylene blue squirts or billows through the tract and then to incise the stricture, following the "blue route."

A pediatric cystoscope or a ureteroscope is useful if the stricture is difficult to negotiate or is complicated by a false passage, fistula, or calculus. An 8 or 10F pediatric cystoscope is used to traverse the urethral stricture under direct vision, the optical system is then removed, and a 5 or 3F ureteric catheter is passed via the sheath into the bladder and used as a guide to perform the DVIU [7].

To deal with long strictures where a guide wire cannot be passed, a semirigid 6F ureteroscope can be negotiated through the stricture under direct vision [39]. The ureteroscope is then pulled back, while a holmium:YAG laser incision is made at the 10 o'clock and 2 o'clock positions to a diameter of 17F. The ureteroscope is replaced with a 17F urethrotome and an antegrade incision can be made up to 22F [39].

Most reports describe doing a simple incision at the 12 o'clock position, because it minimizes the risk of severe hemorrhage due to incising the corpus cavernosum [2, 5, 35, 40–44]. A survey of urologists in the USA showed that 86 % perform one cut at the 12 o'clock position [45]. Some authors feel that the 12 o'clock incision is not ideal because the dorsal aspect of the corpus spongiosum is usually thinner than the ventral aspect and there is less room for spongiosal tissue supported healing after urethrotomy, which may increase the risk of stricture recurrence [46].

Some authors maintain that most strictures are circular and therefore advocate the use of multiple incisions made close together radially. Some studies have indicated that the stricture recurrence rate after multiple incisions is not markedly lower than after a single incision [25, 37]. A survey of urologists in the USA showed that only 12 % perform radial cuts [45].

Incisions at the 4 and 8 o'clock positions have been recommended because the spongiosum is thicker; therefore incisions are more likely to reach healthy spongiosum [47, 48]. Others use incisions at the 6 and 12 o'clock or laterally at the 5 and 7 o' clock positions [49].

It has been suggested that DVIU for anastomotic stricture after radical prostatectomy should be performed at the 4 and 8 o'clock positions to avoid injury to the rectum. The scar tissue is incised down to bleeding vessels, and hemostasis is obtained with a 5F Bugbee electrode only when there is major arterial bleeding. Urinary continence can be preserved by not extending the urethrotomy into the sphincteric mechanism [36, 50]. Alternatively, incisions can be made at the 3 and 9 o'clock positions [51].

Color Doppler ultrasound may be useful to evaluate the length and diameter of the stricture and the extent of spongiofibrosis and also to locate the urethral arteries [52–54]. Contrary to the belief that the urethral arteries are located at the 3 and 9 o'clock position, color Doppler ultrasonography has shown that there is no predictable pattern for their anatomy [55]. In normal men, the site of the urethral arteries varies among individuals, but the symmetry of arteries is maintained. In men with urethral stricture, there is a loss of symmetry in all cases, and in some men with a dense stricture, the urethral arteries cannot be detected on ultrasound [56].

Laser Urethrotomy

The first endoscopic laser urethrotomy in humans was performed by Bülow in 1977 using a neodymium:yttrium-aluminum-garnet (Nd:YAG) laser [4, 28]. Several different types of laser have been used for the incision, resection, or vaporization of urethral strictures, including potassium-titanyl-phosphate (KTP-532), argon, excimer, diode, holmium:YAG (Ho:YAG), and thulium lasers [24, 57–62].

It has been suggested that wounds made by a laser heal with less scarring than those cut by electrocautery or by a knife, which might lead to a lower recurrence rate [57]. During laser urethrotomy the scar tissue is not only divided but also evaporated, with negligible thermal effects on the deeper tissues [63]. Laser urethrotomy can be performed on an outpatient basis without general anesthesia and without postoperative catheterization, due to the lower risk of hemorrhage [64]. In patients with long or narrow strictures, a ureteroscope can be used for antegrade laser incision without using a guide wire [39].

Core-Through Urethrotomy

In 1983 Gonzalez and associates described DVIU for the treatment of complete occlusion of the membranous urethra [65]. This procedure has become known as core-through urethrotomy (CTU) or "cut to the light," because it involves coring a channel through the blocked site toward the light of an endoscope introduced via a suprapubic tract and through the bladder neck to the proximal end of the urethra [37, 38, 66, 67].

CTU is possible only if there is a short area of occlusion with a thin membrane separating the ends of the urethra [67]. When there is a long obliterated segment, various techniques have been used to guide the urethrotome while cutting from the distal to the proximal urethra. These techniques include transrectal digital guidance with a Béniqué bougie in the proximal urethra [37, 67], C-arm fluoroscopy on an X-ray screening table [67, 68], and transrectal ultrasonography combined with a suprapubic cystoscope or nephroscope placed via the bladder neck [67, 69].

Perforation of the occluded urethra can be performed with a thin trocar introduced through the urethrotome from below [37, 66], a 19 gauge sternal guide wire passed through the working channel of a 19F cystoscope [51], or an Evrim bougie passed through the cystostomy tract – it has a curved end and a built-in channel of 1.5 mm in diameter for a sliding needle exiting at its tip [68]. Various types of laser have been used to vaporize the obliterating tissue [70].

Endoscopic Urethroplasty

Pettersson and associates performed the first endoscopic urethroplasty by securing a split skin graft to the urethral catheter inserted after urethrotomy [71]. Other authors performed endourethroplasty using a free patch of full-thickness foreskin fixed to a catheter after DVIU [72, 73]. However, with this technique movement between the graft and its bed could not be eliminated, potentially compromising graft take. Naudé reported using a specially designed balloon device with endoscopically placed needles to secure an ultrathin penile skin or buccal mucosa graft in the stricture area after DVIU [74].

Anesthesia

Although some authors have reported routinely using general or regional anesthesia for DVIU [35, 37, 44, 57], several studies have reported performing urethrotomy under local anesthesia in an outpatient setting, with sedation in some cases [2, 5, 24]. DVIU can be performed using 10 mL of 2 % lidocaine (lignocaine) or mepivacaine instilled into the urethra [2, 25, 47, 75]. After urethroscopy, a second dose of 10 mL of 2 % lidocaine can be administered and 10 min is allowed to elapse before performing DVIU.

DVIU under local anesthesia in an outpatient clinic could be performed successfully in 83–93 % of cases, and pain was mild or absent in 61–96 % [47, 76–80]. Conversely, it has been stated that the 17 % failure rate and high incidence of patient discomfort have made transurethral lidocaine an unattractive means of providing analgesia for DVIU [81].

Intracorpus spongiosum anesthesia (performed by injecting 3 mL of 1 % lidocaine slowly into the glans penis) has been described. The act of injection into the glans caused immediate minor pain in 88 % of patients, but 91–96 % had no pain or discomfort during the procedure, while the anesthesia lasted for about 1.5 h [48, 80].

Transperineal urethrosphincteric block using 1 % lidocaine for DVIU has been described, and 92 % of patients reported being very satisfied with this method of analgesia [81].

Antibiotics

In patients with infected urine, bacteremia may occur in up to 70 % during DVIU [82]. Antibiotic prophylaxis has been shown to reduce the incidence of bacteriuria after DVIU in men with sterile urine [83], and antibiotic treatment of postoperative urinary tract infection (UTI) may reduce the stricture recurrence rate [34].

Most authors reported using antibiotics with DVIU [26, 36]. The type of antibiotic prophylaxis has varied from sulfonamides [35] to first-generation cephalosporins [7], co-trimoxazole [47], gentamicin [2, 75], nitrofurantoin [21], or oral quinolones [84]. On the other hand, some authors reported using no prophylactic antibiotics when performing DVIU [37]. The recommended duration of antibiotic treatment varies from a single preoperative dose [2, 75] to continuous treatment until 24 h after catheter removal [3, 7, 50, 84].

Catheterization

The size of the transurethral catheter inserted after DVIU has varied from 14 to 24F, but there is no convincing evidence that the catheter size has a significant effect on stricture recurrence rates [1–5, 21, 34–39, 42, 44, 48, 50, 51, 66, 67, 69, 70, 72, 85, 86].

Silicone catheters were shown to be superior to conventional catheters when used after DVIU [21]. Although some authors have used PVC or latex catheters, most have reported using silicone or silicone-coated catheters [34, 44].

Sachse suggested that a urethral catheter should be left postoperatively for 10–14 days [23]. Some authors recommend that the duration of catheterization should be adapted to the characteristics of the stricture, with no catheter drainage for short strictures, and 5–7 days for long, fibrotic, or multiple strictures or when a false passage has been made [7].

The reported duration of catheterization has varied from 1 day to 3 months. Earlier studies reported catheterization for as long as 6 weeks [21, 87]. However, most studies have reported catheterization for 1–4 days [2, 3, 34–36, 42, 48, 50, 84–86, 88, 89]. Longer periods have been used for more complicated procedures: 5 days after DVIU for failed previous urethroplasty [41], 8 days after DVIU and TUR of fibrous callus [26], and 2 weeks to 3 months after CTU for an obliterated urethra [38, 70]. This long period is thought to permit urethral mucosal regeneration. However, it seems unlikely that prolonged catheter drainage improves the outcome [40]. A survey of urologists in the USA found that 35 % leave a Foley catheter in place for 1 day and 51 % use a catheter for 2–7 days [45]. A survey of Dutch urologists showed that 81 % use a transurethral catheter for 1 day after DVIU [90].

Inserting a catheter may have the disadvantages of preventing the drainage of blood and secretions and promoting infection, which may result in delayed healing and stricture recurrence [3, 25]. Therefore, some authors believe that the stenting catheter should have multiple sideholes to drain blood and secretions [26]. Alternatively, it has been suggested that using a suprapubic catheter may lead to lower recurrence rates [35, 43, 91].

Complications

Dilation

Stormont and associates [92] reported in a retrospective, nonrandomized study that DVIU compared to dilation resulted in a greater incidence of post-procedure cystitis (5 % versus 3 %), epididymitis (5 % versus 3 %), and penile hemorrhage

(8 % versus 2 %), with total complications of 18 % for DVIU and 8 % for dilation. Steenkamp and associates [2] in a prospective, randomized study reported complications in 14 % of the dilation and 11 % of DVIU group. Failure to perform the procedure occurred in 13 % of DVIU and 18 % of dilation patients. The causes of failure were difficult or tight stricture, hemorrhage, false passage, extravasation, pain, breakage of the blade, and, in the dilation group, knotting or breaking of the filiform leader or bending of the filiform follower [2]. It should be noted that these procedures were performed under local anesthesia; therefore the procedure failure rates of 13–18 % may have been lower under general or spinal anesthesia.

DVIU

The relative safety of DVIU has been documented, with morbidity rates as low as 8–9 % [92]. Minor complications usually occur in less than 10 % of cases [43], although a complication rate as high as 27 % has been reported [49]. In an early study perioperative infection occurred in 38 % of cases [34].

A review of the literature showed that the most commonly reported complications of DVIU are urethral hemorrhage and perineal hematoma (each 20 %) [24]. Other complication rates reported in various studies include scrotal edema 13 %; creation of a false passage 10 %; rectal perforation 10 %; epididymo-orchitis, meatal stenosis, and incontinence (each 9 %); fever 3.6 %; extravasation 3.4 %; bacteremia 2.7 %; urinary sepsis 2.1 %; and scrotal abscess 1.4 % [24]. It should be noted that most of these numbers are derived from single studies and the 10 % rate of rectal perforation reported in one study is exceptional.

Further examples of complication rates after DVIU in various studies are the following: pyrexia 5 %, septicemia 2 %, extravasation 3 %, bleeding 3 %, retention 2 %, blocked catheter 2 %, and DVT 1 % [34]; hemorrhage 3 %, urinary sepsis 2 %, septicemia 1 %, scrotal abscess 0.7 %, extravasation 0.7 %, and epididymo-orchitis 0.7 % [7]; urethral bleeding 11 %, extravasation 3 %, and chordee 1 % [44]; and hemorrhage 3.4–4 %, fever 1–2.2 %, epididymitis 1 %, and incontinence 0.5 % [43]. In the pediatric population, urethralgia and urethral diverticulum occurred in 2 % of children after laser DVIU [49].

Erectile dysfunction (ED) is reported by some authors as a complication of DVIU in 2–11 % of cases [93, 94]. It is presumably caused by direct severance of the cavernous nerves with the cutting blade by incising at the 3 and 9 o'clock positions, late fibrosis after extravasation and infection, or by DVIU of long and dense strictures causing a shunt between the corpora cavernosa and corpus spongiosum.

Rare complications include high-flow priapism, or a urethral-internal pudendal artery fistula, which can be treated with embolization [95–97]. Rarely, life-threatening septicemia may occur, requiring active fluid resuscitation and ventilation [52]. After Otis urethrotomy to 45F, complications occurred in 8 % of patients, hemorrhage requiring blood transfusion in 4 %, bacteremia in 3 %, and incontinence in 1 % [3].

A late complication of repeated dilation or DVIU may be that it increases the degree of spongiofibrosis and thus compromises the success rate of subsequent urethroplasty. De la Rosette and associates [98] reported a higher stricture recurrence rate in patients who underwent three or more urethrotomies compared with none before onlay urethroplasty (47 % versus 15 %). Roehrborn and McConnell [99] reported that the failure rate of onlay urethroplasty increased from 14 to 28 % after previous dilation or urethrotomy and to 32 % after previous urethroplasty. Martinez-Pineiro and associates [100] reported that after anastomotic urethroplasty in patients with traumatic strictures who had not undergone previous manipulations or failed urethroplasty, a perfect result was achieved in 92 %, while in those who had undergone previous surgical repair, excellent results were obtained in 71 %.

Barbagli and associates [101, 102] reported that the success rate after urethroplasty for bulbar strictures was 85 % in those who had not undergone previous urethrotomy and 87 % after previous failed urethrotomy. The authors suggested that repeat urethrotomy or dilation may influence the choice of the surgical procedure and will most likely make the surgery more difficult, but will not alter the long-term results of urethroplasty [101, 102].

Andrich and associates [103] reported that after bulbar anastomotic urethroplasty, stricture recurred in 42 % of men who had undergone previous urethrotomy and in none of those who had not. After substitution urethroplasty stricture recurred in 6 % who had undergone prior endoscopic surgery and in none of those who had not. The authors suggested that urethrotomy seems to jeopardize the outcome of a bulbar stricture suitable for simple anastomotic repair, whereas the outcome of bulbar strictures amenable to substitution repair seems to be unaffected [103].

Park and McAninch [104] reported on urethroplasty for strictures due to blunt straddle injury of the anterior urethra and suggested that previous urethral manipulation made short strictures longer, necessitated more complex graft or flap urethroplasty, and was associated with stricture recurrence, but this was not statistically significant. Fenton and associates [105] stated that short traumatic strictures may be converted to intermediate length strictures after repeated instrumentation, thus complicating the reconstructive approach.

Culty and Boccon-Gibod [106] reported on patients who underwent anastomotic urethroplasty for posttraumatic urethral stricture following pelvic fracture or perineal blunt trauma. The patients without urethral manipulation before anastomotic urethroplasty had a satisfactory result of more than 90 % versus more than 60 % in patients with previous urethrotomy or urethroplasty [106]. Lumen and associates [107] reported on men treated with anastomotic urethroplasty for strictures after pelvic fracture. The recurrence rate was higher in patients who had undergone previous urethral manipulation or urethroplasty (19 % versus 12.5 %), but this difference was not statistically significant [107]. In a study of anastomotic urethroplasty for posttraumatic posterior urethral strictures, Singh and associates [108] found that previous endoscopic realignment or urethroplasty had a significant adverse effect on the success rate, but previous DVIU (up to two times) did not affect the outcome.

There seems to be some agreement in these reports that failed endoscopic realignment or repeated DVIU after pelvic fracture injuries of the posterior urethra decreases the success rate of anastomotic urethroplasty. With regard to anterior (bulbar) strictures treated with substitution or augmentation urethroplasty, previous repeated DVIU may make the surgery more difficult, but does not significantly affect the outcome.

TUR of Scar Tissue

Transurethral resection (TUR) of scar tissue after DVIU compared with DVIU alone leads to greater complication rates: epididymitis in 10 % versus 7.5 %, scrotal edema in 12.5 % versus 15 %, perineal hematoma in 20 %, and extravasation of irrigating fluid in 40 %. These complications can usually be managed successfully with oral antibiotics and anti-inflammatories [26].

CTU

Complication rates of CTU for urethral obliteration include hematuria 9 %, symptomatic UTI 7 %, extravasation of blood or irrigation fluid into the perineum 3 %, stress incontinence 0.6 %, and knife breakage 6.5 % [37]. CTU for obliterated urethra may lead to formation of a false passage and damage to the rectum. CTU with TUR of fibrotic tissue may cause severe hemorrhage requiring transfusion as well as hyponatremia from irrigant absorption [67, 109].

Results

Dilation

The success rate of Otis urethrotomy has been reported as 82 % at a follow-up of 29 months [3]. However, these patients probably did not have very severe strictures, because the Otis urethrotome cannot be passed through strictures less than about 16F in diameter. The results reported after Otis urethrotomy followed by 3–6 weeks of silicone urethral catheter drainage are similar to those after DVIU [35].

The question whether dilation is less effective than cold knife DVIU has been addressed in only two studies. Stormont and associates [92] reported a retrospective review of 199 consecutive patients with a newly diagnosed urethral stricture. Mean patient age at diagnosis was 64 years. The etiology was iatrogenic in 47 % and the strictures were short (<2 cm) in 96 %, single in 99 %, bulbar in 57 %, and large diameter (>20F) in 65 % (the authors assumed the normal diameter of the bulbar urethra as 33–36F). Of 151 patients treated at initial diagnosis, 67 % underwent dilation (the type or technique was not explained), 26 % were managed with DVIU, and in 7 % a cystostomy tube was placed. With a median follow-up of 3.5 years, the probability of not requiring retreatment was 65 % for dilation and 68 % for DVIU [92].

Steenkamp and associates [2, 77] performed a prospective, randomized study comparing filiform dilation to 24F (106 patients) with cold knife DVIU (104 patients) as an outpatient procedure under local anesthesia. Mean patient age was 49 and 50 years in the dilation and DVIU groups, respectively (i.e., 15 years younger than the study group of Stormont and associates). Follow-up was available in 70 % of the dilation and 74 % of the DVIU groups. Mean follow-up was 15.4 months in the dilation group and 14.4 in the DVIU group. Stricture recurrence (defined as inability to pass a 16F transurethral catheter) at 48 months was 10 % greater in the dilation than in the DVIU group ($p=0.22$) [2, 77]. These studies indicate that dilation and DVIU are equally efficacious as initial treatment (Fig. 9.6) [2].

In a subsequent report on these patients at a mean follow-up of 24 months, Kaplan-Meier survival function analysis showed that the estimated stricture-free rate at 48 months was 39 % after DVIU and 12 % after dilation ($p=0.13$) [75]. It may be argued that the study was underpowered to show statistical significance, but it could also be argued that the difference is not clinically significant, because dilation does not require expensive equipment and operating room facilities.

It should be noted that in this patient cohort, the stricture etiology was urethritis in 51 %, external trauma in 19 %, and iatrogenic trauma in 14 %; the location was bulbar in 60 %, penile in 24 %, and peno-bulbar in 26 %. Overall, 32 % of patients had undergone previous stricture treatment, and 45 % had presented with urinary retention or complications due to the stricture. The mean stricture length was 2.3 cm (range 0.5–10 cm). Therefore, compared to the patient cohort reported by Stormont and associates, the majority of these patients had much more severe stricture disease [2, 75, 77, 92].

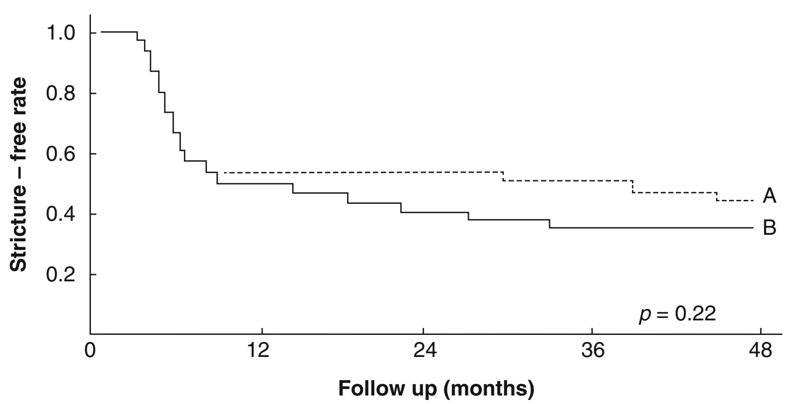

Fig. 9.6 Stricture-free rate after cold knife DVIU (*A*) or filiform urethral dilation (*B*) [75]

DVIU

In the early 1980s, the reported "immense success" of the Sachse urethrotomy was reflected in a dramatic decrease in the number of urethroplasties being performed worldwide [7, 110]. It was stated that, in cases of short and/or proximal strictures, the 2-year cure rate was well above 80 %, identical to what the best open urethroplasty could offer [35]. DVIU became the initial treatment of choice for most strictures of the male urethra [7].

However, it soon became clear that the length of follow-up was the most important determinant of recurrence. For example, various studies reported success rates of 56 % at 6 months, 43 % at 1 year, and 25 % at 2 years [35]; 95 % at 6 months and 55 % at 38 months [43]; and 55 % at 6 months and 35 % at 2 years [26]. Some studies noted stricture recurrence long after DVIU, with 5-year success rates of 25–36 % [44, 111].

The reported success rates with DVIU vary from 66 to 90 %, depending on the series and the length of follow-up [25, 40, 43, 75, 92]. In some literature reviews the success rates vary from 56 to 95 % [44], 35–60 % [26], 70–80 %, or 40–50 % [35, 112]. DVIU for strictures after hypospadias repair has a success rate of 21–40 % [49, 113, 114].

Most reports showed that the majority of stricture recurrence occurred within 3–12 months after DVIU, whereas the risk of failure after 12 months was slight [2, 5, 34, 42, 44, 58, 82, 84, 115]. The reported median interval to recurrence after DVIU has varied from 4 to 12 months [42, 75, 116]. In one study the mean time to recurrence was somewhat longer (16 months; range, 0.5–132) [112]. In pediatric patients the time to recurrence varied from a median of eight to a mean of 26 months [49, 113].

Pansadoro and Emiliozzi [44] noted stricture recurrence within 12 months after DVIU in 56 % of their patients, at 12–24 months in a further 26 %, at 24–36 months in 8 %, at 36–60 months in 7 %, and after 60 months in 6 %. Steenkamp and associates [2] found that after dilation or DVIU, the risk of stricture recurrence was greatest at 6 months and very small after 12 months (Fig. 9.7). The median time to recurrence was 12 months after DVIU and 6 months after dilation. However, strictures can recur up to 8 years after DVIU; therefore follow-up to 10 years is recommended [75].

Repeated Dilation or DVIU

Some authors believe that with each repeated DVIU or dilation the fibrotic process becomes less virulent and that most strictures eventually "stabilize" and require no further treatment [7, 67]. Holm-Nielsen and associates reported

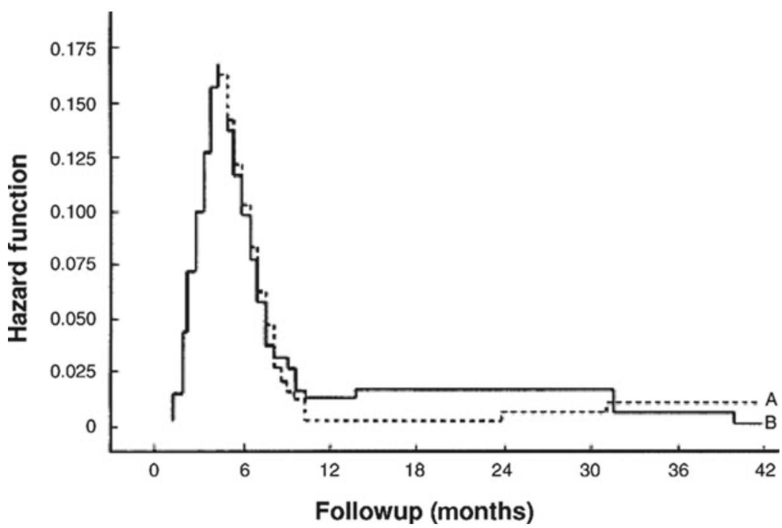

Fig. 9.7 Risk of first stricture recurrence after DVIU (*A*) or dilation (*B*) [1]

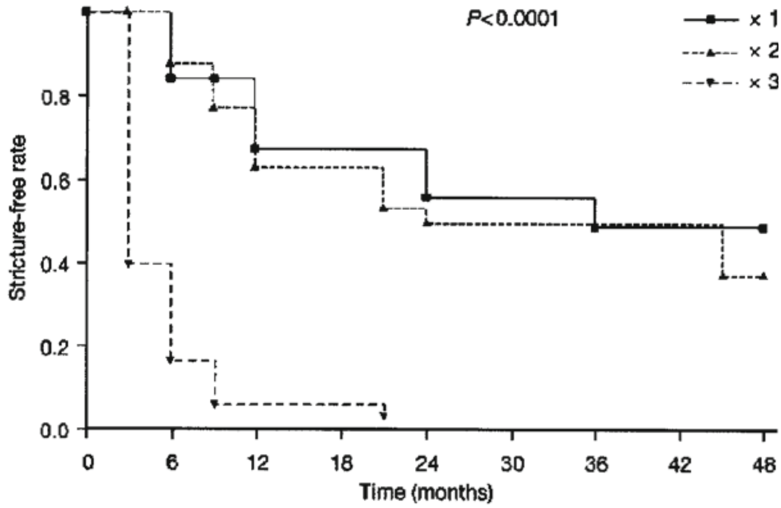

Fig. 9.8 Stricture-free rate after dilation or DVIU in patients not treated before randomization [75]

an overall "cure rate" of 77 % at 2 years of follow-up, but the cure rate after each individual operation was less than 50 % [40]. Albers and associates reported that approximately 90 % of patients were cured with up to two urethrotomies at a follow-up of longer than 3 years [43]. In the pediatric population the success rate after initial DVIU was 36 %, a second DVIU improved the success rate to 58 %, and the overall success rate after more than two urethrotomies was 71 % [117].

However, since the early 1980s some authors have reported the observation that a second DVIU had a lower success rate than the initial procedure and that repeated DVIUs did not improve the success rate [44, 118]. Heyns and associates [75] combined the data of men prospectively randomized to filiform dilation or DVIU and compared the recurrence rates among those who had only one treatment at study entry, those who had a repeated procedure for stricture recurrence at 3 months, and those who underwent a third treatment for recurrences at 3 and 6 months after initial treatment. In patients not treated before randomization, the estimated stricture-free rate after 1, 2, or 3 repeated treatments was approximately 60, 40, and 0 % at 24 months and about 50, 40, and 0 % at 48 months, respectively (p <0.0001) (Fig. 9.8). After a single dilation or DVIU not followed by restricturing at 3 months, the estimated stricture-free rate was 55–60 % at 24 months and 50–60 % at 48 months [75].

The authors concluded that dilation or DVIU is useful in patients who are stricture-free at 3 months (comprising 70 % of their study cohort) because 50–60 % of such patients will remain stricture-free up to 48 months. A second dilation or DVIU for early stricture recurrence (at 3 months) is of limited value in the short term (24 months) but of no value in the long term (48 months), whereas a third repeated dilation or DVIU is of no value [75].

Santucci and Eisenberg [119] reported a retrospective chart review of 136 patients who underwent DVIU in 1994 through 2009 at a center with expertise in urethroplasty. The stricture-free rates after 1, 2, 3, 4, and 5 DVIUs were 8, 6, 9, 0, and 0 %, respectively, and the authors concluded that DVIU has a much lower success rate than previously reported. However, the analysis was based on only 56 % of the cohort that underwent DVIU. The mean age of the patients increased with the number of DVIUs, being 53, 57, 61, 68, and 74 years in those who had undergone 1, 2, 3, 4, and 5 previous DVIUs, respectively, indicating that the decision to repeat DVIU was influenced by the patient's age. The low success rates of first and second DVIU in this study (8 and 6 %) are at variance with a large body of evidence in the literature [119].

A study of men with urethral strictures treated in the Veterans Affairs health care system in the

USA found that during a 5-year period, 65 % underwent urethral dilation, and of these men 79 % underwent only 1 procedure and 12 % underwent 2 dilations [120]. DVIU was performed in 24 % and of these men 96 % underwent only 1 procedure. Urethroplasty was performed in only 5 % of the study cohort. The authors could not determine whether the fact that the vast majority of men treated for stricture disease underwent only 1 procedure over a 5-year period was a quality-of-care issue or patients refusing intervention [120].

A German study of men treated with DVIU for single bulbar or penile strictures found a high recurrence rate of 70 % at 2-year follow-up but noted that 80 % of the patients preferred, in cases of recurrence, a repeated urethrotomy as the treatment of choice [22]. It seems probable that patient preference plays an important part in the selection of treatment for recurrent strictures.

Balloon Dilation

Balloon dilation of urethral strictures has been reported in a few studies with patient numbers ranging from 4 to 287, follow-up ranging from 3 to 26 months, and success rates varying from 0 to 100 % [10, 14–16]. There are no randomized comparisons of balloon dilation versus simple dilation or DVIU.

Laser Urethrotomy

Initially it was thought that circumferential laser ablation of stricture fibrosis would lead to lower recurrence rates [57]. However, the reported success rates with laser are comparable with those of conventional cold knife DVIU, varying from more than 90 % at 10–28-month follow-up to around 30 % or less at 12–26-month follow-up [57–59, 63, 72, 85, 88].

Several studies have shown that the success rates decline over time, for example, 90 % after 6–12 months and 75 % after 27 months or 76, 67, and 52 % after 6, 12, and 24 months, respectively [60]. The success rate with laser urethrotomy was greater in patients with previously untreated strictures than after previous cold knife DVIU (e.g., 79 % versus 13 %) [59].

A randomized comparison of Nd:YAG laser and cold knife urethrotomy in 50 men showed stricture recurrence in 30 % in the laser and 65 % in the cold knife DVIU group at 12-month follow-up ($p = 0.02$) [121]. A randomized comparison of Ho:YAG laser and cold knife DVIU in 51 men with single iatrogenic strictures reported recurrence rates of 19 % versus 47 % at 12-month follow-up in the laser and cold knife groups, respectively ($p = 0.04$) [122].

A review of 44 papers reporting on 3,230 patients showed success rates of 74.9 % for laser and 68.5 % for cold knife DVIU ($p = 0.004$) [123]. However, when smaller subgroups were compared, the differences were not statistically significant. For example, the success rates of cold knife versus laser DVIU were 53 % versus 60 % for bulbar and 77 % versus 63 % for membranous strictures, respectively. Success rates were 43 % versus 59 % for the procedure (cold knife versus laser) repeated once and 39 % versus 50 % for the procedure repeated twice. The complication rates of urinary retention (9 % versus 0.4 %) and hematuria (5 % versus 2 %) were statistically significantly higher after laser compared with cold knife DVIU, which is contrary to the expectation that laser may decrease the risk of hemorrhage. Urinary incontinence, extravasation, and UTI rates were not significantly different [123].

There is no evidence that the type of laser used makes any difference to the outcome [39, 60, 70, 85, 88]. Laser technology is expensive and not available in all centers, and it does not appear to offer major advantages over cold knife DVIU [58, 63].

CTU

The reported success rates of CTU vary from 0 to 100 %, but most studies reported moderate success rates after repeated treatment, varying from 22 to 88 % [37, 38, 51, 67–70, 72, 124, 125]. This large variation is largely due to differences in the duration of follow-up and the definition of success.

CTU is more likely to be successful if there is no loss of urethral continuity, the stricture length is 2 cm or less, there is no active infection at the site, and if there has been no previous urethral manipulation or associated false passage [38, 70, 124]. A comparison of CTU with perineal anastomotic urethroplasty for strictures of the posterior urethra after pelvic fracture showed that DVIU offers no significant advantages over urethroplasty [125].

Endoscopic Urethroplasty

Endourethral split skin grafting after DVIU has been reported in studies with 1–22 patients, follow-up of 9–25 months, and success rates up to 90 % [74, 126, 127]. Naudé reported the results of endoscopic urethroplasty in 53 patients. The overall graft take was 95 %. At 2-year follow-up patients with good graft take showed maintained urethral patency in 100 % of inflammatory and iatrogenic strictures, in 50 % of established strictures after pelvic fracture, and in 75 % of patients with urethral rupture treated 2–3 weeks after the injury [74]. The need for procedure-specific instruments and the intricacy of the operation may be factors responsible for the lack of its widespread application [24].

Endoscopic urethroplasty using small intestinal submucosa (SIS) as a substitute for skin in patients with bulbar strictures proved completely unsuccessful in one study with ten patients [126], while in another study it was reported as successful in 8 of 10 patients [128].

Risk Factors for Recurrence

The following factors have been investigated with regard to their effect on the risk of stricture recurrence after dilation or DVIU:

Age of the Patient

One study reported a "cure rate" of 85 % in men younger than 60 and 71 % in men older than 60 years of age [40]. However, most studies found no correlation between the recurrence rate and the age of the patient [35, 43, 49, 117].

Symptoms at Presentation

One study reported a greater recurrence rate in men who had had symptoms for several years [3]. Another study found a marginal statistical significance for a greater risk of recurrence in men presenting with complications such as retention or infection [2]. However, most studies did not comment on this or found no significant correlation [117].

Etiology

There is conflicting evidence as to whether the cause of the stricture determines the risk of recurrence. Various studies have reported higher recurrence rates in iatrogenic [34, 40, 43, 54, 112], traumatic [5, 44, 116], infective or inflammatory [34, 35, 43, 111], or idiopathic strictures [116]. Several studies found no relationship between stricture etiology and the risk of recurrence [2, 3, 44, 117]. From these conflicting results it appears that stricture etiology cannot be considered a major predictive factor for stricture recurrence [24].

Previous Stricture Treatment

Most studies found that the recurrence rate was greater with previously treated strictures [24, 34, 40, 44, 59, 75, 84, 111, 116]. For example, the success rates were 47 % for previously untreated strictures versus 0 % for those with previous treatment [44] and 75 % for primary versus 45 % for secondary treatment [26]. However, some studies found that previous stricture treatment had no effect on the risk of recurrence [2, 3, 34, 35, 129, 130].

Periurethral Scarring (Spongiofibrosis)

Several studies have shown that the risk of recurrence was greater for strictures with significant periurethral scarring [2, 5, 29, 34, 44, 54, 75, 111, 113, 129–131].

Geavlete and associates [29] provided good evidence that the stricture recurrence rate after DVIU is determined by the location and extent of spongiofibrosis. They performed a prospective, randomized trial in 562 patients with inflammatory urethral strictures <1.5 cm long, who were divided into group 1 (319 patients in whom urethral ultrasound was used to determine the site of DVIU) and group 2 (243 cases with DVIU performed in the 12 o'clock position). All patients had single strictures located in the bulbar urethra in 83 % and the penile urethra in 17 %. The mean follow-up was 38.7 months in group 1 and 37.9 months in group 2. The stricture recurrence rates in the two groups were the same when the fibrosis was located dorsally but were lower in group 1 where the incisions were made in the area of fibrosis seen on ultrasound (Table 9.1) [29].

Overall, the recurrence rate was not much lower in group 1 compared with group 2 (45 % versus 52 %), but this is probably due to the fact that in 48 % of patients the fibrosis was located dorsally only. The recurrence rate was directly proportional to the extent of the fibrotic process, regardless of the technique used. Even when the site was specifically incised, the recurrence rate was much higher for ventral and circumferential fibrosis than dorsal only fibrosis, and it increased progressively with the extent of involvement of the corpus spongiosum (Table 9.1) [29].

Table 9.1 Stricture recurrence rates after DVIU relative to location and extent of spongiofibrosis [29]

Location of spongiofibrosis	Group 1 DVIU at site of stricture	Group 2 DVIU at 12 o'clock
Dorsal only	29 %	28 %
Ventral only	41 %	64 %
Dorsal and ventral	55 %	72 %
Circular	68 %	83 %
Total	45 %	52 %
Extent of fibrosis in corpus spongiosum		
"Iris" type	12 %	9 %
Minimal involvement	30 %	46 %
Full involvement	55 %	64 %
Outside the corpus spongiosum	81 %	87 %

Length of the Stricture

Many studies did not report the stricture length, possibly because it is difficult to measure accurately. Most studies have found that the recurrence rate is lower with short strictures and higher with long strictures (Table 9.2) [5, 7, 35, 43, 44, 75, 84, 131]. A few studies reported no correlation between the stricture length and the risk of recurrence [3, 111].

Steenkamp and associates [2] reported that for each 1 cm increase in the length of the stricture, the risk of recurrence was increased by 1.22 (95 % confidence interval 1.05–1.43) (Fig. 9.9).

Table 9.2 Stricture recurrence rate in relation to stricture length

Author	Stricture length (cm)	Recurrence rate (%)
Holm-Nielsen [40]	>1	62 %
	<0.5	45 %
Boccon-Gibod [35]	>0.5	85 %
	<0.5	Lower (% not stated)
Andronaco [132]	>3	66 %
	<3	33 %
Ishigooka [115]	>1	43 %
	<1	4.4 %
Pansadoro [44]	>1	71 %
	<1	18 %
Albers [43]	>1	51 %
	<1	28 %
Hafez [133]	>1	50 %
	<1	6.6 %
Steenkamp [2]	>2	75 %
	<2	40 %

Diameter of the Stricture

Very few studies have reported on the stricture diameter, which may be due to the inherent difficulties of measuring the caliber [92]. One study found that the success rate was 69 % for strictures more than 15F in caliber and 34 % for those less than 15F [44]. Mandhani and associates used

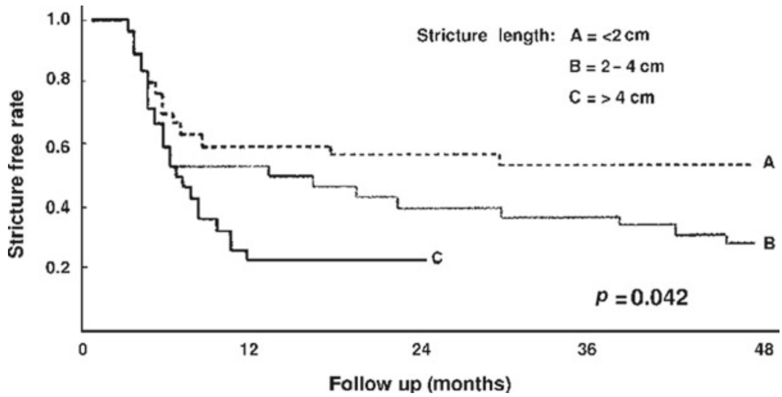

Fig. 9.9 Association between stricture length and stricture recurrence after dilation or DVIU [2]

retrograde urethrography to assess the degree of narrowing at the stricture site, which depends on the degree of spongiofibrosis [131]. Mean percentage narrowing was significantly greater with treatment failure after DVIU (70 % versus 49 %). A cutoff of 74 % for urethral narrowing predicted the outcome of DVIU with 78 % probability.

Site of the Stricture

Several studies reported a lower recurrence rate in bulbar compared with penile strictures, which may be explained by better vascularization of the proximal urethra [2, 26, 35, 43, 44, 75, 82, 84, 111, 116]. One study found a marginal statistical significance with a higher recurrence rate of penile strictures [2]. Another study reported that penile strictures recurring after DVIU were significantly longer than those not recurring: 3.9 versus 1.5 cm [112]. In contrast, one study found that strictures in the bulbar region recurred more commonly [34]. Posterior (membranous or bulbomembranous) strictures related to pelvic fracture injury appear to have a higher recurrence rate after DVIU than anterior strictures [134]. A few studies found no relationship between stricture location and the risk of recurrence [3, 117].

Geavlete and associates [29] reported that the recurrence rate was significantly higher in penile compared with bulbar strictures (68 % versus 40 %) despite echographic guiding of DVIU. The higher recurrence rate for penile versus bulbar strictures may be related to a greater extent of spongiofibrosis in the penile urethra, but unfortunately the study did not provide a comparison of the type or extent of spongiofibrosis in penile compared to bulbar strictures [29].

Number of Strictures

Several studies found that the recurrence rate is lower with single compared with multiple strictures [7, 43, 44, 63, 75, 84]. However, a few studies found no correlation between the number of strictures and the risk of recurrence [2, 34, 117]. Examples of reported recurrence rates are 28 % for single strictures compared with 51 % for multiple strictures [43], 50 % for single versus 16 % for multiple strictures [44], and 60–70 % with a single stricture versus 35–50 % with multiple strictures [26].

Number and Location of Incisions

The study by Geavlete and associates showed that recurrence rates were somewhat lower after ventral DVIU for ventral spongiofibrosis and circumferential ("star incision") DVIU for circular fibrosis (Table 9.1) [29]. Two studies in children found no relationship between the type of incision and the risk of recurrence [49, 117].

Complications During the Procedure

One study found a marginal statistical significance for the higher recurrence rate in patients where complications occurred during the procedure [2].

Perioperative Infection

Several studies have reported a higher recurrence rate with perioperative infection, especially if it was untreated [2, 24, 34, 35, 40, 111, 113, 129, 130]. However, a few studies found no relationship between infection and the risk of recurrence [40, 44]. Many studies have reported using antibiotic prophylaxis during DVIU to decrease the risk of infective complications, but it is unknown whether this affects the recurrence rate.

Type of Catheter Used

Latex catheters have been implicated in the etiology of urethral strictures [112]. There is no reported relationship between the type of catheter used after DVIU and the risk of recurrence, possibly because most recent studies have used silicone catheters [35].

Duration of Catheterization

Some studies showed that the risk of recurrence was increased if postoperative catheter drainage was longer than 3 days [35, 43]. However, other studies showed no relationship [40, 49, 117]. It remains unclear whether the period of catheterization after DVIU affects the stricture recurrence rate, but it has been suggested that 3 days is the optimal period [40, 43]. A few prospective randomized studies supported the use of no catheter or 1-day catheterization after DVIU [89, 135, 136]. A small, prospective randomized study comparing urethral catheterization versus a suprapubic cystostomy reported recurrence in 65 % of patients in the catheterized group compared to 24 % in the cystostomy group [137]. It is possible that in the cystostomy group, restricturing of the urethra occurred due to the absence of a catheter or normal voiding to keep the urethra open.

Albers and associates reported that leaving the urethral catheter in place for 3 days or less was associated with a lower recurrence rate (34 %) compared to leaving it for 4–7 or more than 7 days (recurrence rates of 43 and 65 %, respectively) [43]. Since this was a nonrandomized study, it is possible that longer catheterization was necessitated by intraoperative complications due to a “difficult” stricture, which could explain the higher recurrence rate. Another possibility is that catheter-associated infection predisposed to stricture recurrence.

Length of Follow-Up

There is a clear correlation between the duration of follow-up and the risk of recurrence, with most recurrences occurring within 6–12 months after DVIU [26, 35]. In pediatric patients the length of follow-up was the most important risk factor for recurrence: 19 % at 6 months and 65 % after 4 years [117]. However, late recurrence can occur after 3–10 years [44, 82, 112]. It has been suggested that there is an attrition rate of 10–20 % per year, which could continue for up to 5 years after DVIU [26, 35].

Time to Recurrence

Albers and associates [43] reported that a high recurrence rate correlated with a short time to recurrence (average 18 months) whereas a low recurrence rate correlated with a long time to recurrence (average 35 months). Heyns and associates [75] reported a similar finding, with a median time to recurrence of 21 months after two treatments and 4.5 months after three treatments, where the risk of recurrence was greater after three compared with two treatments. Mandhani and associates [131] reported a mean recurrence-free duration of 13 months versus 45 months in cases of treatment failure and success, respectively.

Heyns and associates found that after a single dilation or DVIU in men without previous stricture treatment and no stricture recurrence at 3 months, the estimated stricture-free rate was 55–60 % at 24 months and 50–60 % at 48 months. However, in patients with stricture recurrence at 3 months, repeated DVIU had a stricture-free rate of 0 at 24 months [75].

Repeated Treatment

As explained above, repeated DVIU for early stricture recurrence after DVIU is a strong predictor of further stricture recurrence (Fig. 9.8) [44, 75].

Prevention of Recurrence

TUR of Fibrous Callus

Guillemin's technique consists of DVIU followed by endoscopic resection of the stricture callus in an attempt to prevent the regrowth of fibrotic tissue causing stricture recurrence. Giannakopoulos and associates [26] performed a randomized comparison of this technique versus cold knife DVIU and found that the differences between the two groups were statistically significant at 5-year follow-up (70 % versus 25 %). In the literature Guillemin's technique has been reported with 5-year success rates of 75–80 % [26, 84].

Hydraulic Self-dilation

Hydraulic self-dilation is performed by the patient, who compresses the urethra intermittently during micturition so that dilation of the whole urethra occurs [5, 35, 135]. Some authors have advocated using this for 3–6 months, beginning 15 days after DVIU [5, 34, 35, 44]. Hjortrup and associates [3] advised against hydraulic self-dilation after Otis urethrotomy, because they believe that extravasation of infected urine could lead to recurrent stricture.

Intermittent Self-Dilation

Intermittent self-dilation (ISD) using a "low-friction" catheter for the prevention of stricture recurrence was first described in 1986 [138]. Several open, uncontrolled studies using ISD after DVIU reported no stricture recurrence in patients who continued performing ISD for 6–8.5 months [42, 139–141]. There is some evidence that ISD should be started within 1 month after surgery, the dilation frequency need not be more than once a week, but the duration should be more than 12 months or even permanently [42, 130, 139, 142]. ISD has not been reported to be significantly beneficial in randomized studies with long, follow-up, because the recurrence rate approximates that of the control group after termination of catheterization [84]. The long-term result of ISD was not significantly different from that of DVIU alone, with a 78 and 82 % recurrence rate following the two methods [42, 72].

Two studies have suggested that ISD performed by the patient is better than regular dilation performed in the clinic, whereas one study suggested the converse [84, 140, 143].

Several studies have suggested that ISD has low morbidity and is well accepted, especially by elderly patients [138, 139]. Complications of ISD include hemorrhage, urethral stricture, and false passage formation. The minor complication rate (mainly bleeding) may be up to 50 % [43]. In one study, 9 % of patients discontinued ISD after DVIU because of urethral hemorrhage [43]. UTI has been reported in 14–25 % of patients on ISD, especially with long-term use of the same catheter, and in 73 % of patients on regular clinic dilation with Clutton sounds [78, 143].

Patient compliance was reported as a problem in a study where 35 % of patients dropped out during the scheduled 6-month regimen [144]. However, another study reported that at a mean follow-up of 58 months, 68 % of men were continuing on ISD with a stricture-free rate of 83 %. ISD was well tolerated by 84 % of patients and 80 % had no technical difficulty [145].

Patient acceptance of ISD may be low in regions where handling of the genitals is considered taboo, privacy is not available, or sterilization of the catheters is problematic. It has been stated that ISD is a traumatic maneuver that most patients view with considerable disdain as a painful, time-consuming, embarrassing, difficult, and unnatural practice they would gladly abandon if given the choice [146].

Balloon catheter ISD has been described, and the majority of patients noted improvement in voiding, 19 % complained of discomfort with balloon placement, 10 % noticed minor bleeding with dilation, and 13 % had UTI [147]. The use of a stainless steel chopstick for ISD after DVIU has been described in a small study, with no recurrence of stricture at a mean follow-up of 42 months [148].

Clinic Dilation

Tunc and associates [84] randomized men with bulbomembranous urethral strictures shorter than 2 cm recurring after DVIU to observation alone or urethral dilation with Béniqué dilators (maximal 21F) beginning 10 days after DVIU, weekly for 1 month, once after 3 and 6 months, and then once a year. Stricture recurred within 12 months in 56 % in the observation group and in 11 % in the dilation group [84]. This confirms the efficacy of the "dilation clinics" which were quite common in former years, but adopting this form of management has significant logistical and cost implications [42]. On the other hand, Gnanaraj and associates [140] found in a non-randomized study that regular intermittent ISD resulted in a lower restricture rate (5 %) compared with regular outpatient dilation after DVIU (16 %).

Urethral Stenting

Various types of urethral stents have been used in an attempt to prevent stricture recurrence. Endourethral prostheses are discussed in this volume in Chap. 10.

Nonsurgical Modalities

Inhibition or stimulation of cell types or growth factors involved in the healing process after urethral injury may influence scar formation. Understanding the molecular mechanisms responsible for stricture formation may lead to the development of adjuvant medical therapy to prevent stricture recurrence [148]. However, there are relatively few studies on the histopathology and molecular pathogenesis of urethral strictures [149]. Studies have shown that total collagen and the ratio of type I versus type III collagen is increased in stricture tissue, which may explain the noncompliant nature of stricture tissue [150]. Changes in extracellular matrix glycosaminoglycans (GAGs), collagenase activity, smooth muscle-to-collagen ratio, and vascularization have also been described in stricture tissue [150, 151].

Steroids

Sachse claimed good results with longer strictures by using weekly intraurethral installations of steroid jelly, kept in place by a specially designed ribbon wrapped around the glans penis [5]. Hebert in 1971 reported transurethral injection of triamcinolone to reduce stricture recurrence and claimed an 84 % success rate [152]. Steroids impair scar formation and contracture by inhibiting collagen synthesis, increasing collagenase production, and reducing levels of collagenase inhibitors.

Several nonrandomized studies have described using intraurethral steroids to prevent stricture recurrence after cold knife or laser urethrotomy [5, 32, 85]. A study of men who underwent DVIU and performed ISD for 6 months with either triamcinolone 1 % ointment or a water-based gel for lubrication of the catheter showed that the recurrence rate in the triamcinolone versus control group was 30 % versus 44 % [153]. In a prospective randomized trial, men with short bulbar strictures were allocated to DVIU with or without submucosal injection of triamcinolone (40 mg) at the urethrotomy site. At a mean follow-up of 13.7 months, urethral stricture recurred in 22 % in the triamcinolone group and 50 % in the control group ($p = 0.04$) [154].

In a small randomized controlled trial, triamcinolone used as a catheter coating was compared to a hydrophilic catheter for 2 weeks and a silicone catheter for 3 days following DVIU. At 16.4-month follow-up, recurrence occurred in

20 % of the steroid-coated catheter group compared to 47 % in the hydrophilic catheter and 60 % in the silicone catheter groups [155]. A double-blind, randomized, placebo-controlled study showed that triamcinolone acetonide injection after DVIU did not significantly reduce the stricture recurrence rate but did decrease the mean time to recurrence significantly from 8.1 to 3.6 months [156].

Cyclooxygenase-2 (COX-2) Inhibitors

Sciarra and associates reported a prospective study of men with benign prostatic hyperplasia who underwent transurethral resection of the prostate (TURP) and were randomly assigned to receive or not receive a COX-2 inhibitor (rofecoxib 25 mg/days) for 20 days. At 1 year of follow-up, a urethral stricture had been diagnosed in 17 and 0 % of cases without and with COX-2 treatment, respectively [157].

Halofuginone

In an experimental study with rabbits, a diet containing halofuginone, a potent inhibitor of type I collagen synthesis, was effective in limiting the occurrence of de novo and recurrent urethral stricture after DVIU [158, 159]. A study in a rat model has shown that halofuginone can be coated successfully on silicone catheters and that it inhibits periurethral type I collagen deposition after urethral injury [160].

Botulinum Toxin

Botulinum toxin type A (Botox) has been used to prevent scar formation in facial wounds. Botox blocks the transport of acetylcholine at the neuromuscular junction and by decreasing muscle contractions acting on the wound edges may prevent scar formation. A preliminary study reported improvement in 2 of 3 patients with posterior urethral strictures treated with Botox injection after DVIU [161].

Mitomycin C (MMC)

MMC inhibits fibroblast proliferation and is effective in preventing scar formation. In an experimental rat model, intraurethral irrigation with low dose MMC appeared to be effective in preventing fibrosis after DVIU [162]. In a prospective clinical trial of men with anterior urethral strictures randomized to DVIU with or without submucosal injection of MMC at the urethrotomy site, the stricture recurred in 10 % versus 50 % [163].

Captopril Gel

Captopril, an angiotensin-converting enzyme inhibitor (ACE-I), has an antifibrotic effect by decreasing angiotensin II, which increases collagen type I synthesis and decreases collagenase activity. A study of patients who underwent DVIU and were treated with placebo gel, 0.1 % captopril gel or 0.5 % captopril gel instilled intraurethrally for 6 weeks, respectively, showed that the recurrence rate was less in the captopril-treated groups [164].

Rapamycin

A recent study has shown that rapamycin (sirolimus) inhibits experimentally induced urethral stricture formation in rabbits. This effect may be due to its inhibition of fibroblast proliferation and collagen expression [165].

Hyaluronic Acid

Human urethral stricture tissue has a low level of hyaluronic acid (HA) and a high level of dermatan sulfate, which suggests that administration of HA into stricture sites may decrease the recurrence rate [150]. HA instillation during DVIU in 28 patients did not show success rates significantly better than reported in the literature for conventional DVIU [166].

Brachytherapy

Endourethral brachytherapy to prevent stricture recurrence has been described, using iridium-192 or rhenium-188 delivered via a catheter or balloon. In a few studies with small patient numbers and relatively short follow-up, the recurrence rates varied from 7 to 60 % [167–169].

Gene Therapy

Endoscopic virus-mediated gene transfer into urethral stromal cells has been studied in an animal model. Vascular endothelial growth factor gene therapy to enhance new microvessel formation and improve urethral regeneration after trauma in an animal model has also been described [170].

Cost-Effectiveness

See Chap. 7, herein by K. Rourke, for a detailed analysis of the economic impact of urethral stricture disease.

Indications for Dilation or DVIU

Successful treatment depends more on appropriate case selection than on the technicalities of any particular procedure. Koraitim has pointed out that DVIU and urethroplasty should be regarded not as competing modalities, but as different complementary techniques available for the cure of different types of strictures, each with its own indications and limitations [117, 124].

It has been suggested that DVIU is being used excessively because of its simplicity and ease and because there is a lack of familiarity with major urethral reconstruction techniques. Although urethroplasty is technically much more difficult than DVIU, this should not be an excuse for performing an unsuitable procedure rather than referring the patient to someone who is proficient in urethroplasty [103, 171].

The advantages of dilation and DVIU are that they can be performed under local anesthesia in an outpatient setting, they have a low complication rate and virtually no risk of mortality, so they are attractive options in elderly patients who are unfit for anesthesia and open urethroplasty [35, 40, 47, 48]. Because dilation does not require special endoscopic equipment or operating room facilities and the results are equivalent to those of DVIU, it is the procedure of choice where the facilities for DVIU are not available [2].

The ideal indications for DVIU or dilation are single strictures shorter than 2 cm, with uninfected urine, no extensive spongiofibrosis, and no previous dilation or DVIU. Patients who are poor candidates for initial or repeated DVIU include those with multiple, long (2–5 cm), penile or posterior strictures, with infected urine, extensive spongiofibrosis, or stricture recurrence ≤3 months after previous DVIU.

DVIU for posterior urethral strictures after pelvic fracture injury is indicated only if the stricture is limited in length, circumference, and depth, but not if there is a dense stricture extending into the periurethral tissues or involving the entire circumference.

A second DVIU or dilation for early stricture recurrence (at 3 months) is of limited value in the short term (24 months) but of no value in the long term (48 months), whereas a third repeated dilation or urethrotomy is of no value. Repeated DVIU (≥3 procedures), with long-term ISD, may be an option in men with severe comorbidities and limited life expectancy or stricture recurrence after urethroplasty.

Otis urethrotomy has been advocated for the prevention of urethral stricture after TURP [172]. Dilation or DVIU prior to TURP is certainly indicated if the urethra does not easily accommodate the resectoscope. However, there is insufficient evidence to recommend "routine prophylactic" urethrotomy prior to TURP [173, 174]. Several studies have described the use of dilation or DVIU as salvage procedures in patients with stricture recurrence after urethroplasty, hypospadias repair, or phalloplasty. It has been suggested that strictures appearing after urethroplasty tend to be thin, soft, and weblike and amenable to early dilation or DVIU because the fibrotic tissues have been excised and replaced by healthier tissues [41, 107, 125, 146].

Posterior urethral stricture or stenosis after radical prostatectomy, brachytherapy, or external beam radiotherapy for prostate cancer can be successfully managed by dilation or DVIU. The reported success of dilation or DVIU in these conditions varies from 50 to 90 %, but in most patients periodic dilation is required [36, 175–177]. If an anastomotic stricture after radical prostatectomy is immature (presenting within 8 weeks), the procedure of choice may be dilation with placement of an indwelling urethral catheter for 48–72 h and subsequent optical DVIU 2–6 weeks later. In patients who present with mature anastomotic strictures, most can be treated successfully with one endoscopic incision [36, 50].

Specific contraindications to DVIU include suspicion of urethral carcinoma, bleeding diathesis, and active infection (cystitis, urethritis, or periurethral abscess) [21].

Editorial Comment

Chris Heyns has written a masterful chapter and thus I will only detail our technique and practice pattern.

As to our technique of urethrotomy, we initially cystoscopically place a Benson guidewire across the stricture and into the bladder. We then use the bayonet like cold knife, a zero degree lens, and a Sachse urethrotome to make multiple small radial incisions, circumferentially, to open up the mucosal scar, without cutting too deep into the corpus spongiosum, which has the potential to bleed profusely. We do not move the blade in and out of the scope to cut the stricture. Instead, we keep the blade fixed outside the scope for about 1 cm and move the whole urethrotome back and forth like a sea saw, fulcruming the scope with the thumb at the penoscrotal junction to make the radial cuts. As scar revision surgery, the goal of urethrotomy is to have the epithelium regrow before the spongiosal scar recurs – in this way the scar still recurs but creates a larger caliber and diameter lumen/ stricture. If the stricture springs open very easily and with few cuts and no bleeding, we leave the Foley in for 24–48 h. If the stricture is dense and requires multiple incisions to open the stricture and/or the spongiosum bleeds, we typically leave the Foley in for 1 week and place a compressive elastic wrap dressing on the penis for 24 h. In our nationwide survey of US urologists [45], only 12.1 % use the radial cut technique, which suggests that this technique is used by the "experts" but is not the community standard of practice (Table 9.3). What appears to be the US community standard as to stricture length maximum for a bulbar urethrotomy is <2 cm (Table 9.4). The literature also supports a 2 cm or less cutoff, when considering outcomes and economics. Duration of catheterization after endoscopic incision is variable in prior reports, ranging from 24 h to 6 weeks. From our recent survey, common practice is 1 week (36 %), followed closely by 24 h (35 %) and 2–5 days (a distant third at 15 %) (Table 9.5). Clearly, duration of catheterization is important to epithelization, as well as helps prevent urinary retention and corpus spongiosum fibrosis (from urine extravasation). Extrapolating from dog experiments on the ureter by Hinman, the urethral epithelium should regenerate and cover the urethrotomy site within 1 week. Thus, the com-

Table 9.3 Urethrotomy technique by US urologists

Urethrotomy method	Frequency	Percentage
12 o'clock cut	372	86.3
Radial cuts	52	12.1
No response	7	1.6
Total	431	100

From Ref. [45]

Table 9.4 Maximal bulbar urethral stricture length managed by urethrotomy by US urologists

Urethral stricture length treated	Frequency	Percentage
<1 cm	99	23
<1.5 cm	91	21.1
<2.0 cm	106	24.6
<2.5 cm	34	7.9
<3.0 cm	67	15.5
>3 cm	13	3
Total	431	100

From Ref. [45]

Table 9.5 Time interval from urethrotomy to Foley catheter removal by US urologists

Time Foley in place after OIU	Frequency	Percentage
No Foley	7	1.6
24 h	152	35.3
2–5 days	64	14.8
1 week	157	36.4
2 weeks	28	6.5
3 weeks	8	1.9
No response	15	3.5
Total	431	100

From Ref. [45]

munity practice of leaving an indwelling catheter for 1 week seems sound. The other issue is if injection of biological modifiers into the stricture after urethrotomy improves overall success. I typically inject 5 to 10 ml of Triamcinolone (40 mg/ml) into the urethrotomy bed with a Williams needle and Leveen injector. It takes less then 5 minutes and is easy to perform. The literature is scant as to the efficacy of adjuvant biological modifier injections, but it makes intuitive sense and at the very least, causes no harm. Surveyed US urologists, however, do not believe it does, with only 8 % injecting steroids into the urethra [72].

In summary, the best candidates for urethral dilation or urethrotomy are patients with a single, bulbar stricture <2 cm in length, with minimal spongiofibrosis, no previous treatment, and non-traumatic etiology. Subsequent urethrotomies are futile and of no long-term efficacy. In the most recent published series of urethrotomy patients with long-term follow-up, the stricture-free rates were even more abysmal than the reports from the mid-1990s [119]. Thus, except for the select patient, urethral stricture disease treatment should predominantly be open surgery. Successive urethral dilation and urethrotomy also make eventual urethroplasty more difficult and with lower than predicted long-term success [106].

In developing countries, however, there is a general lack of medical infrastructure, resources, and surgical expertise. For such countries, endoscopic treatments are often times the best approach. This apparent gap in treatment between nonindustrialized and industrialized counties can be lessened by educational surgical workshops and surgical camps in the developing world. The Society of Genitourinary Reconstructive Urologists (GURS) and the British Association of Urologic Surgeons (BAUS) currently each have outreach programs in the developing world – teaching the local surgeons “how to fish” rather than “giving them fish.” I personally go on such a trip annually and recently returned this summer from a week in Haiti – where we demonstrated urethroplasty and gave lectures to the local urologists and trainees. I urge all reconstructive urologists worldwide to share and disseminate their knowledge and expertise.

–Steven B. Brandes

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10 Endourethral Prostheses for Urethral Stricture

Daniel Yachia and Zeljko Markovic

Summary

The gold standard for treating a recurrent urethral stricture in a definitive way remains an open surgical urethroplasty. However, most urologists continue to manage their stricture patients with repeated dilation or urethrotomy, which are typically not curative methods. Since the introduction of urethral stents in the 1980s for the treatment of urethral strictures, two different methods to prevent scarring contraction have been introduced, namely, permanent stents versus temporary stents that undergo a staged removal. Examples of permanent urethral stents are the UroLume, Wallstent, and Memotherm, while temporary stents are the UroCoil, Memokath, and Allium. Indications for stent placement are limited and typically for recurrent bulbar urethral strictures. Despite initial enthusiasm, with time, the results obtained with permanent urethral stents have been disappointing. Results with the newer temporary stents are encouraging.

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Introduction

Urethral stricture is the result of scar tissue development after either traumatic or inflammatory injury of the urethra. Although not a life-threatening condition, the treatment of urethral stricture is one of the most challenging situations for the urologist and a very troublesome condition for the patient [1, 2]. The treatment of this condition has one main aim: to allow the patient to void with a satisfactory stream and control. This aim can be achieved by creating a urethra with an adequate caliber either by dilation or endoscopic incision of the stricture or preferably by one of the many urethroplasty techniques developed for this purpose. Today, the gold standard for treating a recurrent urethral stricture in a definitive way is to perform a urethroplasty. However, most urologists manage their stricture patients with repeated dilation or urethrotomy, which are less curative methods.

There is a great variation in reporting recurrence rates after urethral dilations and urethrotomies because of the poor classification of the treated strictures in the reports. Although a 50–60 % success rate can be obtained with dilations or urethrotomy in short strictures without spongiofibrosis, in longer strictures and in strictures involving the corpus spongiosum, the recurrence rate is about 80 % because of new stenotic scar development. Because of repeated dilations or urethrotomy, local inflammatory reaction can occur and result in more extensive strictures than the treated one.

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Conventionally, after an endoscopic manipulation and sometimes after a urethral dilation, a urethral catheter is left indwelling for one or for several days to allow urine drainage during the edematous stage of the dilated urethra and to help in its remodeling. At the time the catheter is removed, the edema disappears, but the tissue-healing process continues to be active. The continuing tissue-healing process makes the outcome of the treatment unpredictable which in many cases results in a recurrent stricture. To improve the poor overall outcomes of dilation and urethrotomy, urethral stents (endourethral prostheses) are being used and continually modified as a minimally invasive treatment.

Urethral Stricture and Wound Healing

Wound healing is an integrated series of cellular, physiological, and biochemical events occurring in the tissues. There is a difference between wound repair (scarring) and tissue embryogenesis (tissue regeneration). All wounds seem to heal by the same basic process. However, there are some basic differences between the healing of an acute and a chronic injury wound and between a clean versus an infected wound. During the healing process of a clean wound and under normal conditions, there is equilibrium between collagen synthesis and collagen degradation. Repeated trauma and infection cause disequilibrium in this process. A change in the equilibrium of the healing process causes an increase in collagen synthesis and a decrease in its degradation, creating a hypertrophic scar tissue development. During the healing process, after the appearance of inflammatory cells, fibroblasts and capillaries invade the fibrin clot to form a contractile granulation tissue. About a week after wounding, the wound clot becomes fully invaded and replaced by activated fibroblasts that are stimulated by growth factors to synthesize and remodel the new collagen-rich matrix [3]. This granulation tissue draws the wound margins together, and the epithelial edges migrate forward to cover the wound surface. This is made easier by the underlying contractile connective tissue, which shrinks to bring the wound margins toward one another. In undisturbed tissue healing, programmed cell death occurs in some of the wound fibroblasts, probably the myofibroblasts, after wound contraction has ceased [4], marking the stabilization of the scarring process. The healing of a urethra injured during dilation or urethrotomy also develops under similar conditions as with other injured tissues. Although an incised or dilated urethra may appear to be healed within a few weeks, having a complete epithelial coverage, in most cases the stricture will recur because of the ongoing wound healing/scarring process in the deeper layers of the urethra that continues for several months, resulting in stricture recurrence. As in other cylindrical organs, this scar usually involves the entire circumference of the injured segment causing the recurrence of the circumferential urethral stricture.

As detailed in Chap. 36 in of this volume by Terlecki, attempts are being made to stimulate the regeneration of tissues. Some early success has been achieved by bridging lesions with artificial or natural biomaterial "scaffolds" for promoting migration, proliferation, and differentiation of cells [5].

Stents in the Treatment of Recurrent Urethral Strictures

As explained previously, all wounds heal almost by the same basic process. A chronic wound in the urethra usually fails to heal primarily, as would an acute wound. Healing of a chronic wound is unpredictable. A chronic wound heals up to a point and then the healing process turns toward contraction. Attempts to predict this course and to change the direction of the process with pharmaceutical means, such as local injections with biological modifiers, like steroids, is typically ineffective. However, trials to prevent contraction of the wound by mechanical interference show very encouraging results, especially in urethral strictures. The idea behind the use of large-caliber metallic stents for preventing urethral stricture recurrence is based on mechanical interference to prevent the scarring process from ending in contraction. Since the introduction of stents in the late 1980s for the treatment of urethral strictures, two different concepts have been studied to prevent the scarring contraction, namely, stents for permanent implantation versus stents temporarily left indwelling for limited periods of time and then removed.

Permanent Stents (Wallstent)

The era of self-expanding stents in medicine started with the introduction of the braided Wallstent for vascular disease, as developed by Hans Wallsten (Fig. 10.1). This stent became widely recognized and used in many medical disciplines, including urology. The design of this stent was based on a wire-braiding technology similar to the "Chinese finger trap," an old Chinese trick in which one can insert a finger that is trapped when the finger is retracted. This braiding technology is also used widely for the manufacturing of coaxial cables. The concept of using a permanently implanted stent to maintain the patency of a strictured bulbar urethra was first described by Milroy et al. in 1988 [6]. Urological use was a natural extension of the concept of vascular stenting, where the stent becomes imbedded into the wall of the blood vessel and covered by endothelium. Vascular stents are about 1.2 times the blood vessel diameter to ensure its anchoring, without causing unnecessary pressure to the wall of the vessel. After its release, the entire mesh stent comes in contact with the vessel wall. The constant pressure that the stent struts apply to the wall cause traumatic damage to the endothelium. This damage induces a chain reaction in the tissue until the stent becomes covered with endothelium. In the urethra, these Wallstents were intended to push themselves into the urethral wall and remain permanently as a fixed reinforcement, akin to the reinforcing iron bars (Rebar) of concrete pipes, which help keep the lumen open. Milroy et al. [6] first described the use of the UroLume Wallstent (American Medical Systems, Minnetonka, MN) stent after dilating the urethra.

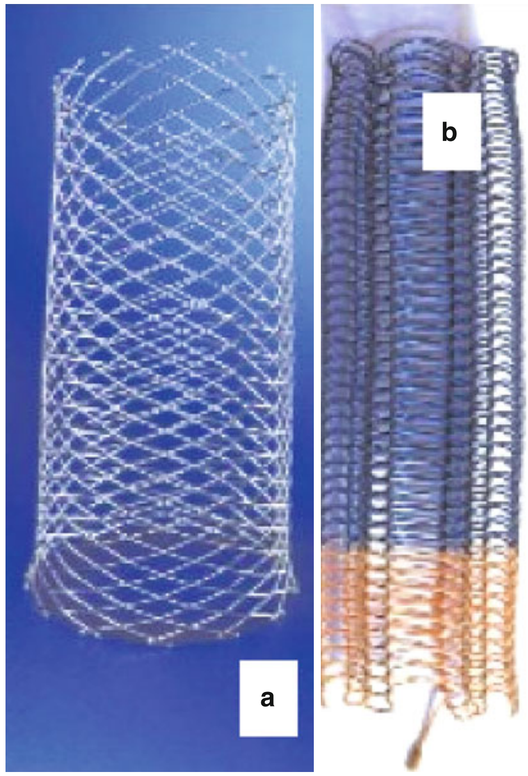

Fig. 10.1 (**a**) UroLume Wallstent. (**b**) Memotherm

The UroLume Wallstent is made from a biocompatible nonmagnetic superalloy woven into a tubular mesh which is flexible and self-expanding to 42 F. Soon after the UroLume Wallstent (Fig. 10.1a), another mesh stent (knitted) became available: the thermoexpandable Memotherm (C. R. Bard, Murray Hill, NJ; Fig. 10.1b). Both stents were deployed under vision with an endoscopic tool on which the stent comes pre-loaded (Fig. 10.2). The large caliber and the radial expansion force of the stents kept these stents in place until the stent pushes itself into the urethral wall and epithelialization completely buries it.

UroLume Wallstent: Clinical Outcome

Candidates for UroLume Wallstent or Memotherm stent placement are patients with bulbar urethral strictures less than 3 cm long and at least an interval of 10 mm of healthy urethra distal to the external sphincter. The stent should be at least 10 mm longer than the stricture, because 5 mm has to be added to each end of the estimated stricture length.

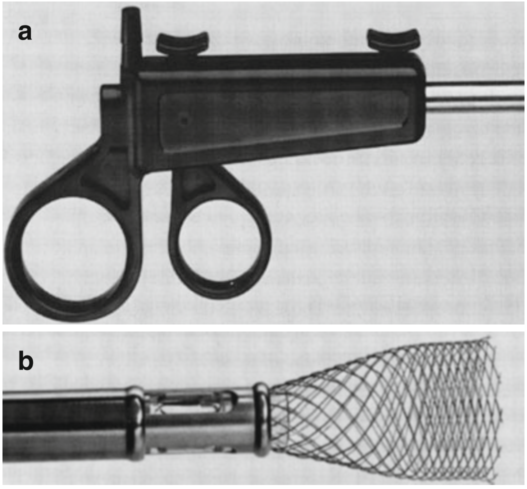

Fig. 10.2 (**a**) The deployment tool for inserting the UroLume stent. (**b**) The UroLume (wire mesh stent) attached to the end of the deployment device (From Oesterling and Kletscher [27])

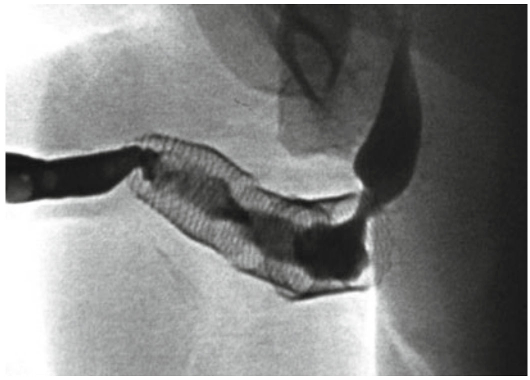

Fig. 10.3 Retrograde urethrogram showing restenosis by hypertrophic tissue within tandem placed UroLume stents in the bulbar urethra (Image courtesy SB Brandes)

Researchers from the North American UroLume trial (between March 1989 and April 1996) enrolled 179 patients with recurrent strictures in the bulbar urethra [7]. Most of these patients had been treated for more than 5 years by dilations or urethrotomies at least 5 times. The initial results of this study were encouraging. In the short term, insertion of the UroLume stent decreased re-treatment rates from 75.3 % before insertion to 14.3 % after insertion in 105 patients, who were followed for at least 1 year [7]. No similar study with a large number of patients was performed with the Memotherm. At 2-year follow-up, narrowing of the UroLume stent lumen was noted in 74 of 179 (41.3 %) patients. Narrowing was the result of urethral epithelium overgrowth through the interstices of the stent (Fig. 10.3). In 62 (83 %) of these cases, the narrowing was mild, whereas in 12 patients (16 %) occlusion was severe enough to require adjunctive procedures, such as transurethral resection of the occluding tissues [7]. Other short-term complications (7–28 days) were perineal discomfort (86 %) and dribbling (14 %). The long-term complications were painful erection (44 %), mucous hyperplasia (44 %), recurring stricture (29 %), and incontinence (14 %). Although long-term success of the UroLume stent is generally disappointing, there are some centers which reported higher success rates [8].

The incidence of hyperplastic tissue ingrowth and excessive intrastent tissue proliferation and subsequent urethral stenosis frequently occurred in patients with posttraumatic strictures [9, 10]. Thus, permanent stents are felt to be contraindicated in traumatic strictures. Furthermore, because of their shape and large caliber, the use of the UroLume Wallstent or other permanent stents is limited to the bulbar urethra. Their use in the mobile parts of the urethra (penile) is contraindicated because the sharp ends of these stents can cause pain, injury, or even perforate the urethra, as well as inhibit or preclude urethral extensibility for normal penile tumescence. The permanent stents also had a high failure rate in patients who underwent previous urethroplasty, in particular, prior substitution urethral surgery with skin. Such stents when placed in a prior urethroplasty bed could not become entirely incorporated or covered by urethral epithelium. Such bare wires of the stent were subsequently prone to stone formation, recurrent infection, urethritis, and dysuria.

Despite initial optimism, with time, the results obtained with permanent urethral stents are disappointing. Reports started to appear that on longer-term follow-up (3–6 years) the restenosis rates were high. Long-term results with the urethral UroLume Wallstent for recurrent bulbar strictures in 60 consecutive men followed for 12 years showed that 58 % had complications, with reoperation required in 45 %. The most frequent nonsurgical complications were postmicturition dribble (32 %) and recurrent urinary tract infections (27 %). The most common surgical interventions required were transurethral resection of obstructing stent hyperplasia (32 %), urethral dilation or urethrotomy for stent obstruction or stricture (25 %), and endoscopic litholapaxy for stent encrustation or stone formation [7].

These reports also note difficulties in stent removal that frequently required resection of the entire urethral segment together with the stent and subsequent complex urethroplasty [11–15]. (*See* Chap. 26 of this volume by Buckley detailing the surgical removal of the UroLume stent.) In some patients who developed an intrastent occlusion, a temporary stent was inserted instead of surgical removal of the permanent stent and a concomitant urethroplasty.

The accumulating experience has thus narrowed the indications for use of the self-expanding permanent stents (UroLume Wallstent) to the select populace of only frail patients older than 55 years of age or to those refusing surgical treatment [14]. The UroLume Wallstent remains the only FDA-approved endourethral prosthesis approved by the US Food and Drug Administration for urethral strictures. Such UroLume difficulties and lack of durability have spurred interest in other potential stents, ranging from the retrievable temporary stents to biodegradable stents.

Temporary Stents

In 1989, the concept of a large-caliber temporary urethral stent was introduced as a reduced profile stent, deployed to self-expand. The concept of using a temporary device instead of a permanent one was based on an entirely different mechanical interference technique. The new concept of a temporary stent was to leave the stent in place only long enough to act as a mold and until stabilization of the scarring process. The presence of the stent in the lumen aimed to prevent scar contraction during the healing process. After up to 12 months, the stent would be removed, potentially leaving behind a large-caliber urethra,

Fig. 10.4 UroCoil-S placed within in an occluded UroLume Wallstent

remodeled around the stent. The initial results with a removable temporary stent (UroCoil System, InStent Inc., Minneapolis, MN) in 18 patients were published in 1991 [16] (Fig. 10.4). The temporary UroCoil System stents were made of a nickel-titanium alloy (nitinol) and expanded to 24–30 Fr, with an insertion caliber of 17 Fr. UroCoils came in three different configurations, allowing their use along the entire urethra, from the bladder neck to the external meatus (Fig. 10.5 [17, 18]). Later, the Memokath urethral stent (Engineers & Doctors, Hornbaek, Denmark), which was also made of nitinol, was launched in Europe (Fig. 10.6 [19]). The Memokath is a thermoexpandable stent that contract and softens at <10 °C and returns to a preformed shape when warmed to >40 °C. Once placed into position, prewarmed saline is flushed through the stent, resulting in stent expansion of the bell-shaped ends from 24 Fr to a final diameter of 44 Fr, anchoring the stent. The main body of the stent remains 24 Fr. This feature makes the stent easy to insert and remove. Furthermore, its tight spiral structure helps prevent urothelial ingrowth.

The introduction of these stents opened up a new minimally invasive approach to the treatment of recurrent urethral stricture disease [20].

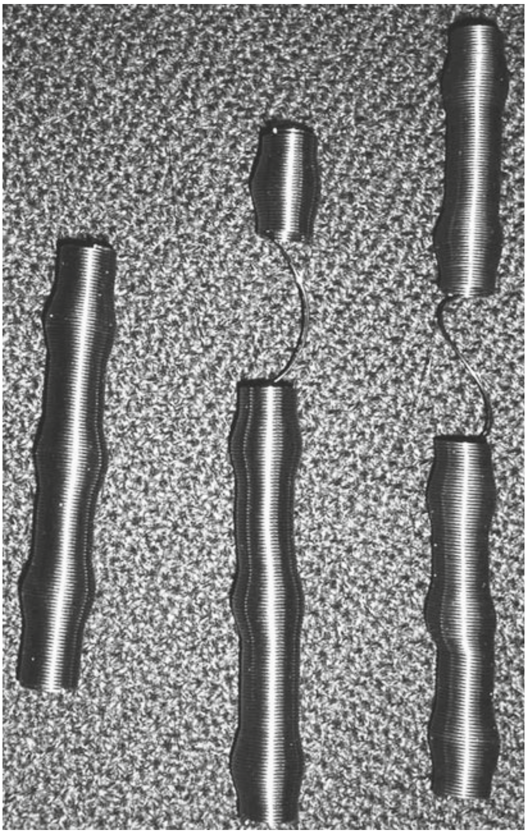

Fig. 10.5 From *left to right*: The UroCoil for penile urethral strictures, the UroCoil-S for bulbar strictures, and the UroCoil-Twins for combined posterior urethral and bulbar strictures

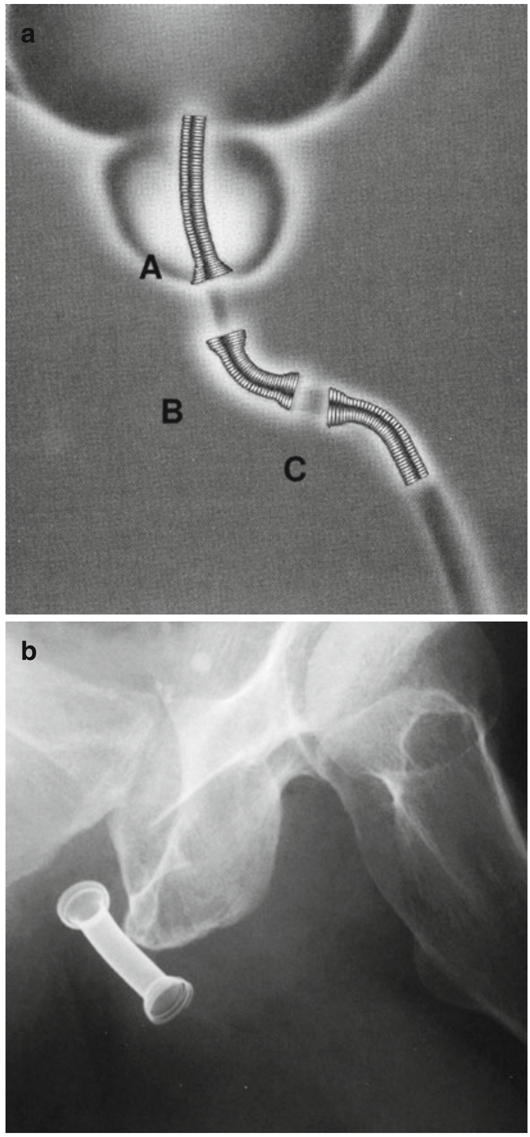

Fig. 10.6 (**a**) The three configurations of the Memokath urethral stents: *a-* Memokath 028 for prostatic obstructions, *b-* Memokath 044 for bulbar strictures, *c-* Memokath 045 for post-bulbar strictures. (**b**) Radiograph of Memokath 044 placed in the bulbar urethra

In addition to their use in urethral strictures, they were also used with varying success in the treatment of post-prostate surgery, urethrovesical anastomotic stenoses [21, 22]. In these cases, a different configuration of the stent (ProstaCoil) was inserted into the dilated or incised bladder neck and left indwelling for 1 year and then removed. In patients with a very short distance between the external sphincter and the bladder neck, severe stress incontinence typically developed while the stent was in place. Patients who remained continent after stent insertion were advised to perform Kegel exercises. Those who were continent before stent insertion continued to be continent shortly after stent removal.

In contrast to permanent stents, temporary stents showed that they could be used for post-traumatic strictures or in post-urethroplasty strictures, because such stents rarely become infiltrated by tissue and did not have to cut through the skin patch to become imbedded. However, when occlusive hypertrophic scar did occur in some of the UroCoil or Memokath stent patients, it was typically at the ends of the stents.

UroCoil System: Clinical Results

From 1990 to 2000, 172 patients with recurrent urethral strictures have been treated with the three configurations of the UroCoil System stents by the author (Fig. 10.5). The strictures were situated all along the urethra, from the urethral meatus up to the posterior urethra [23]. All patients had undergone at least three urethral dilations or two optical urethrotomies during the year preceding the procedure. The average indwelling time of the stent was 12 months (range 9–14) and average follow-up after stent removal was 36 months (range 8–50). At the end of the second year, 83 % of the patients had a patent urethra and were voiding with a stream that was found to be within the normal range. The recurrence rate rose to 20 % in year 3 but stayed at the same level during year 4.

Although the UroCoil System stents were developed by a US-based company and the results looked promising, they were never approved by the Food and Drug Administration. Regardless, the UroCoil System is no longer commercially available due to fiscal reasons. At this time, there are no temporary urethral stents for use in urethral strictures in the United States. However, there is an ongoing multicenter trial in the States with the Memokath urethral stent.

Limitations of Previous Generations of Permanent and Temporary Stents

Accumulating experience has shown that adopting and then adapting permanent vascular stents for use in the prostatic and bulbar urethra has not been terribly successful. Also the previous generation of temporary urethral stents (UroCoil System, Memokath 044, Memokath 045) also have had their limitations and varied success (Figs. 10.5 and 10.6).

One of the problems with the self-expanding metallic permanent and temporary stents is stent shortening upon release. The deployed UroLume Wallstent is about 30 % shorter than its constricted length. Furthermore, the UroCoils shorten by roughly 40–50 % upon deployment and the Memokath by about 10 %. In inexperienced hands this shortening may cause the stent to not properly overlap the stricture and thus predispose stricture recurrence.

Other common problems seen with both the permanent and temporary stent were:

- Development of sphincteric dysfunction when they were deployed near to the external sphincter
- Tissue proliferation into the stent lumen (mainly seen with the permanent stents, occasionally between the loops of the temporary stents)
- Tissue proliferation at the ends of the stents

The external sphincter, during its contraction, gives a fusiform shape to the urethral lumen at the proximal bulb. Placing a cylindrical stent with a ring-shaped end adjacent to the external sphincter often interferes its proper functioning and thus causes partial or total incontinence in 10–20 % [24]. Additional problems encountered with the current urethral stents were occasional tissue ingrowth between the loops of the coils or reactive tissue proliferation at their sphincteric end, causing partial or complete obliteration of the stent. The reason for such reactive tissue proliferation is the radial stiffness of the sphincteric end of the stent causes repeated friction to the urethral wall during opening and closure of the sphincter. A similar phenomenon occurs at the ends of vascular stents and is typically referred to as the “candy-wrap effect.”

Allium Bulbar Urethral Stent

The limitations detailed herein of prior endourethral prostheses (stents) induced us to search for new designs based on the specific needs of proximal bulbar urethra.

Stent Characteristics

The ideal stent for the bulbar urethra needs to accurately fit the dimensions and shape of an adult bulbar urethra (so it can act as a mold), not interfere with the function of the external sphincter, and prevent tissue ingrowth into the lumen and tissue proliferation at its ends. Other desirable stent characteristics include the ability to be inserted in reduced caliber, the ability to not shorten upon deployment, and to exhibit a compressibility and recoil ability to make it effective, yet comfortable, to the patient. The

Allium Bulbar Stent was engineered to take into consideration all these requirements (Fig. 10.7a). An Allium stent for post-prostatectomy anastomotic stenoses has also been developed (Fig. 10.7b). It has a nitinol wire skeleton that is covered with a biocompatible polymer that is resistant to the urine environment. As an impermeable walled tube, the Allium stent should also prevent tissue ingrowth into the lumen. The stent is deployed using a special 24-Fr delivery mechanism for easy endoscopic insertion (Fig. 10.8). On deployment, the stent continues to self-expand until it reaches its maximum of up to 45 Fr. This self-expansion process can take days.

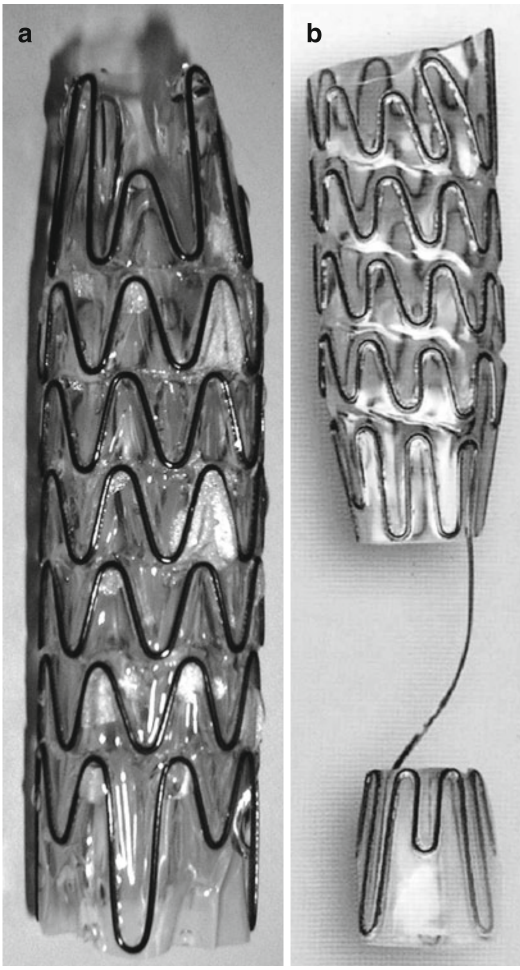

Fig. 10.7 (**a**) The hybrid (alloy skeleton and polymeric cover) Allium Bulbar Urethral Stent (BUS) with its slightly conical sphincteric segment and low radial force downstream end. (**b**) Allium urethrovesical anastomotic stent (RPS) for post-prostatectomy stenoses

The end segments of the stent exert low radial force and thus reduce mechanical interference to the external sphincter and help reduce the friction between the end of the stent and the urethral wall and help prevent reactive tissue growth. Having a "sphincter-friendly" segment of dynamic stent with low radial force in a lumen adjacent to a sphincter also allows the stent to be more accurately positioned in the lumen. When the sphincter closes and the diameter of the lumen adjacent to the sphincter decreases, the diameter of the sphincter ends of the stent also decreases into a conical shape while remaining in contact with the lumen wall. When the sphincter opens for voiding, and the diameter of lumen adjacent to the sphincter increases, the diameter of the sphincter ends of the stent also increases, allowing for unobstructed urination. To prevent stent migration, the caliber of the stent is larger than the distal bulbar urethra. The Allium stent is also compressible. Thus, when sitting on a hard surface, the stent is comfortable to the patient. After the compressive force is released, the stent rapidly returns to its original shape and caliber.

Fig. 10.8 Endoscopic deployment device of the Allium Bulbar Urethral Stent

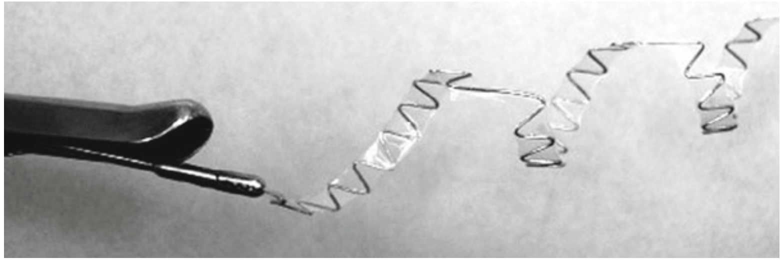

Fig. 10.9 The Allium Bulbar Stent can be removed easily even after 1 year by pulling its downstream end with an endoscopic forceps. If the pulling force is more than 500–600 g, the stent will unravel

Insertion Technique

The entire insertion procedure is performed under direct vision or fluoroscopic guidance. Before insertion of the stent, the stricture needs to be opened up to at least 24 Fr (the size of the delivery device), either by internal urethrotomy, dilation, or progressive dilation. After dilation of the stricture, a Foley-like ruler catheter with centimeter marks is inserted into the bladder. To determine the appropriate length stent to insert, cystoscopic measurements are taken from between the end of the external sphincter and the proximal end of the stricture, and the other measurement being the length of the stricture plus 1 cm. The stent is released under direct vision by pulling the trigger of the device to retract the overtube. After stent release, the radial expansion of the stent opens the stricture to its maximum caliber. Once the release process is started, the stent cannot be retracted back into the delivery device; instead, the stent should be removed and a new one inserted. Under local sedation, the stent can be removed with endoscopic grasping forceps. As a safety feature, if the pulling force during removal exceeds 500–600 g, the stent starts to unravel (Fig. 10.9).

Clinical Experience with the Allium Bulbar Stent

Since 2003, we have deployed the Allium stent in 24 patients who had recurrent bulbar urethral strictures, eight of them 1 cm distal to the sphincter. Before stent insertion, the strictures were dilated by an endourethral balloon to 30 F (18 patients) or by urethrotomy (6 patients). Stents were inserted endoscopically (19 patients) or under fluoroscopy (5 patients; Fig. 10.10) in ambulatory conditions and under topical anesthesia. Stricture etiology was traumatic in 11 patients and inflammatory in 13. The age of patients ranged from 34 to 72 years. During the indwelling period of the stent (≥12 months), the urine was acidified (pH <6) and encouraged urine outputs of 1,500–2,000 mL/day to delay biofilm formation and encrustations. Stents were left indwelling for 8–14 months (mean, 11 months). Mean follow-up after stent removal has been 20 months. After stent removal, peak flow rates typically decreased by up to 15 % from baseline. In follow-up, patients with peak flow rates that decreased by >20 % were imaged and cystoscoped. In two patients, recurrence was observed after 12 and 18 months. No stent migration was observed. No patients requested stent removal because of discomfort. Patients who were sexually active before stent insertion maintained potency after stent placement. Initial results of the Allium stent have been encouraging in the short term. However, true stent efficacy and durability are still to be determined. Recently an additional group of patients with anastomotic (bladder neck) strictures after radical prostatectomy are being treated with a slightly different design and larger-caliber stent (Fig. 10.7b).

Clinical Experience with Temporary Bladder Neck Stents

Stents specially designed for placement at the bladder neck started to be used for the management of postsurgical stenoses. Although not peer reviewed, recently early experience with two temporary bladder neck stents (Memokath SW 28 and Allium RPS) has been presented at international meetings. Clinical results of both stents were presented during the Symposium on

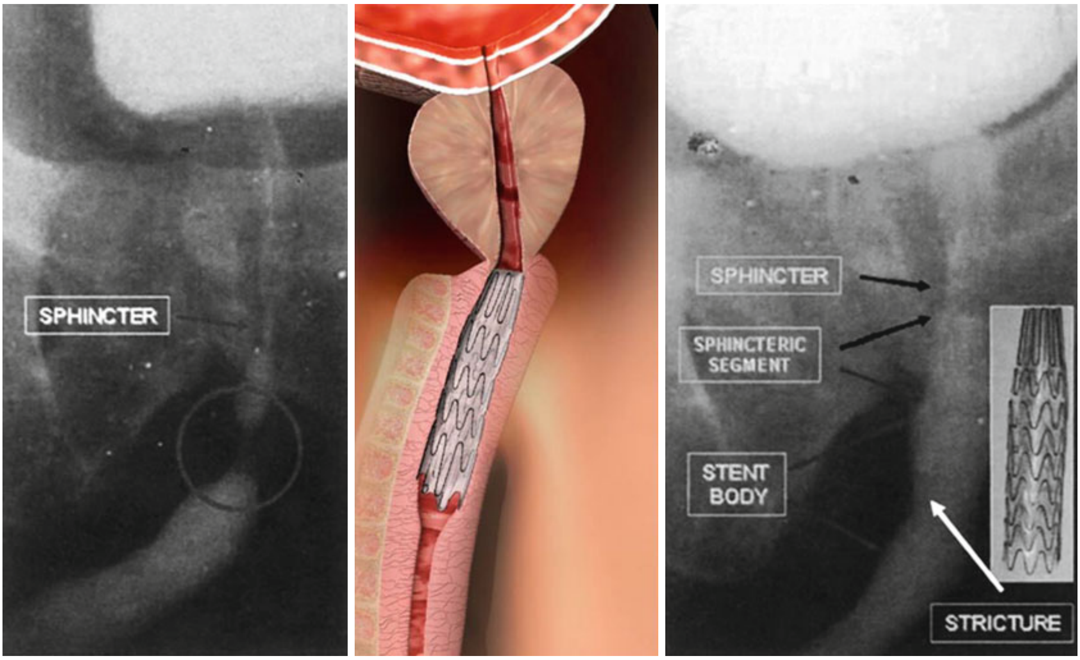

Fig. 10.10 Pre- and post-deployment retrograde urethrography of the Allium Bulbar Urethral Stent within a proximal bulbar stricture

Fig. 10.11 The Memokath SW 28

Urological Stents organized during the 32nd Congress of the Societe Internationale d'Urologie held in Berlin (October 16, 2011).

Memokath SW 28: C.L.A. Negro from the UK presented their experience with the Memokath SW 28 in 7 patients who developed intractable bladder neck stenoses nonresponsive to conservative treatments [25]. Each patient had at least 2 bladder neck incisions or resections before stent insertion. Five patients developed the stenosis after RPP, 1 after TURP, and 1 after photoselective vaporization of the prostate. The thermoexpandable Memokath SW 28 (Fig. 10.11) which is a longer modification of the Memokath 044 (Fig. 10.6b) was inserted under fluoroscopic and endoscopic guidance. In 1 patient the stent migrated and it was replaced with a new one. The authors reported satisfactory early results.

Allium RPS: O. Nativ from Israel presented their experience with the Allium RPS in 13 patients who developed recurrent bladder neck stenoses nonresponsive to conservative treatments [26]. All patients underwent at least 4 bladder neck incisions, or resections, or were on self-cali-

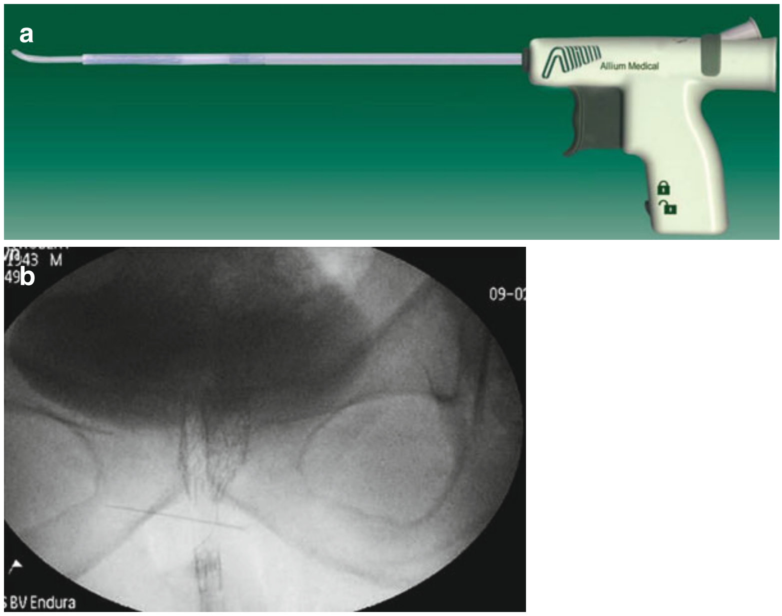

Fig. 10.12 (**a**) The Allium RPS deployment device. (**b**) The Allium RPS after deployment

bration before stent insertion. Seven patients developed the stenosis after RPP, 1 after TURP, 1 SPP, 1 iatrogenic, 1 after HIFU, 1 after pelvic trauma, and 1 after cystoplasty. The Allium RPS is a self-expandable stent also deployed under fluoroscopic guidance (Fig. 10.12a, b). Four patients who had a preserved sphincter remained continent with the RPS in place. Despite the anchoring segment to prevent migration, in 4 patients, the stent migrated, requiring removal and replacement. In 6 patients the stent was removed after 12 months and at a follow-up of an additional 6–13 months all are voiding satisfactorily.

These early reports indicate that easily removable temporary stents may provide a simple and minimally invasive alternative to non-curative conservative treatments in postsurgical bladder neck or prostatic urethral stenoses. They may reshape the bladder neck when they remain long enough until stabilization of the scar tissue around them.

Surgical Pearls and Pitfalls

Key Surgical Points

- The only instruments needed for inserting the Allium BUS and RPS as well as the Memokath 028 are the standard rigid endoscopic equipment, C-arm for fluoroscopy, nonionic contrast material for performing a urethrogram, and a foreign body “alligator” forceps for repositioning or removing the stent.
- For placement, dilate the urethra to >24 Fr (we prefer a balloon dilation to 30 Fr).
- Size the stent to 1 cm plus stricture length.
- Since the Memokath is a thermoexpandable stent, only about 50–100 cc of warm saline (40 °C) is needed for expanding its flares at the time of insertion and 50–100 cc of cold saline (5–10 °C) instilled per urethra for softening the stent at removal.

Editorial Comment

The promise of a successful and durable permanent endourethral stent for urethral stricture has never materialized. The UroLume (American Medical Systems, Minnetonka, MN) stent was approved by the Food and Drug Administration for a very narrow and specific indication. Regardless, the Urolume is no longer commercially available, reportedly because of limited use and lack of profitability. However, I have found the UroLume to be a useful part of the armamentarium for post-prostatectomy refractory bladder neck contractures and radiation-induced membranous urethral strictures. After a formal anastomotic urethroplasty for a post-prostatectomy stricture, the patient is usually rendered totally incontinent and then has to suffer for roughly 1 year with incontinence until a sphincter can be placed. Placing a UroLume for these patients avoids a major reconstruction and avoids the need to wait many months till placement of an artificial urinary sphincter.

The overall high complication rate with the UroLume and the general lack of durability have spurred interest in other potential stents, ranging from retrievable temporary stents to biodegradable stents. As an alternative to the permanent UroLume stent, early reports using easily removable temporary stents are promising however, time will tell.

Initial results with the retrievable Memokath Allium stent, are encouraging. Jordan et al. [28] recently published the United States Study Group, randomized prospective trial results of the Memokath 044TW Stent for recurrent bulbar stricture (mean length 2.7 cm) in 92 patients at 12 mo, follow up. Stented patients had markedly improved urethral patency (292 vs 84 days $p<0.001$). The stent was successfully removed in all patients and side effects were mostly minor except for stent dislocation in 8 and occlusion in 3. At interim length follow-up, the retrievable Memokath Stent is safe and reasonably effective. Long term follow-up is obviously needed. Drug-eluting stents are another recent innovation to prevent restenosis in the urethra. There are numerous pilot studies with drug elution with such medications as paclitaxel, indomethecin, and dexamethasone. Such stents are biocompatible and can be used effectively as a platform for local drug delivery. The bioabsorbable endourethral stents, made of the high molecular weight polymers of polylactide (PLA) or polyglycolide (PGA). While good in concept, had high restricture rates and in many cases, the stent collapsed at the time of bioabsorption, and the fragments of the stent perforated the mucosal lumen and often obstructed the lumen.

Formal open urethroplasty is clearly the gold standard. However, for frail patients, or those with poor life expectancy, or patients who desire to avoid a major operation, a urethral stent can be indicated – and occasionally work well and with durability. However, in the cases where these stents fail or are utilized for off-label indications, the complications can be very difficult to correct.

–Steven B. Brandes

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11 Fossa Navicularis and Meatal Reconstruction

Noel A. Armenakas

Summary

The correction of strictures involving the fossa navicularis and meatus poses a distinct challenge. Unlike surgical repair of strictures involving other urethral segments where the primary concern is restoration of urethral patency, management of glanular urethral strictures also requires particular attention to cosmesis. Various options are available, the choice of which depends on the etiology and characteristics of the stricture, prior failed procedures, the patient's expectations, and the surgeon's operative familiarity and preference. No single technique is applicable to all strictures. In general, minimally invasive procedures are usually palliative, whereas reconstructive procedures should be performed with a curative intent. Paramount to the success of any reconstructive procedure is the careful selection of non-diseased tissue for urethral substitution. If the penile skin is healthy and the glans is not extensively involved with LSA, our preferred urethral substitute is the fasciocutaneous ventral penile transverse island flap. In cases of extensive LSA or penile scarring, extragenital tissue transfer techniques should be considered, preferably in one stage, using the versatile buccal mucosal graft. Equally important is the choice of glanuloplasty. Where possible, a glans-cap repair is preferred because of the limited dissection required with this relatively simple technique.

The careful selection of the optimal urethral tissue substitute and glanuloplasty technique, as well as meticulous attention to surgical principles, are mandatory in achieving a satisfactory functional and aesthetic outcome when reconstructing strictures of the fossa navicularis and meatus.

Introduction

The fossa navicularis and meatus constitute the glanular segment of the male anterior urethra. The two prevailing theories regarding its embryologic development include ectodermal ingrowth and endodermal differentiation. The former theory postulates that the epithelium of the fossa navicularis develops by the canalization of an ectodermal cord of cells, the glanular plate that extends from the meatus into the glans. The latter theory suggests that the urethral plate, which is an extension of the endodermal urogenital sinus, extends to the tip of the phallus [1]. Histologically, the glanular urethra is lined by stratified squamous epithelium. Anatomically, the distal portion of the penile urethra dilates, forming the fossa navicularis and then narrows to create a vertical slit, the meatus.

Strictures involving the fossa navicularis and meatus have distinct etiologic characteristics. In

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addition, their management is particularly challenging. Reconstruction of these strictures involves creating a functional urethral conduit while maintaining an aesthetically suitable glans penis.

Etiology

A urethral stricture is a scar from tissue injury after local trauma, inflammation, or infection. During healing, the scar contracts compromising the caliber of the urethral lumen which limits urine and seminal flow. Strictures are classified according to their location and the extent of scarring with associated spongiofibrosis. Unlike other anterior urethral strictures, which are caused primarily by external trauma, strictures of the fossa navicularis and meatus are most commonly inflammatory, iatrogenic, or a result of failed hypospadias repairs (Table 11.1).

Inflammatory

Lichen Sclerosus et Atrophicus

Lichen sclerosus (LS) is the broad term encompassing the urethral and genital skin manifestations of what is often referred to as balanitis xerotica obliterans. It was first described in 1928 by a German dermatologist, Dr. Stűhmer, who believed it was caused by glans exposure after circumcision; however, this theory has been disproved by the finding of LS in uncircumcised males [2].

LS is a chronic, often progressive, sclerosing process that can involve the glans, prepuce, penile skin, and anterior urethra. Although the exact etiology is uncertain, genetic predisposition, infections, trauma, prior surgery, and autoimmune factors have been implicated in its pathogenesis [3, 4]. The true incidence of LS is similarly obscure. It has been documented in up to 3.6 % of all circumcision specimens and up to 40 % of patients presenting with phimosis [5, 6]. It is more frequently identified in middle-aged men, but it has been reported in patients ranging from 2 to more than 90 years old. Although most of the published reports include predominantly Caucasians, the incidence of LS may be higher in Blacks and Hispanics [7].

Table 11.1 Etiology of strictures of the fossa navicularis and meatus

Inflammatory
Lichen sclerosus et atrophicus
Vitiligo
Iatrogenic
Endoscopic procedures (cystoscopy, TURP)
Urethral catheterization
Urethral dilation
Urethral fulguration-laser treatment
Circumcision
Failed hypospadias repairs

Fig. 11.1 Lichen sclerosus et atrophicus with extensive glans involvement

The onset of LS is insidious, evolving over many years. In uncircumcised males, the prepuce is usually involved. The lesions appear as patchy to diffuse dry white-colored plaques with well-defined margins, giving the glans a characteristically mottled appearance (Fig. 11.1). Further progression of these sclerotic lesions can include the meatus and fossa navicularis, leading to urethral scarring with proximal meatal migration. The disease may involve the penile skin or entire anterior urethra, resulting in extensive stricture formation. Overall, it is the most common inflammatory cause of glanular urethral stricture disease.

The diagnosis of LS is typically made clinically and can be confirmed by biopsy. The most common presenting symptom is urinary obstruction, occurring in up to 47 % of patients [8]. Uncircumcised patients usually present with phimosis. Histologically, LS is characterized by marked epithelial atrophy with mild hyperkeratosis [9]. The differential diagnosis includes erythroplasia of Queyrat, leukoplakia, scleroderma, and cicatricial pemphigoid. A causal relationship between LS and squamous cell carcinoma has been suggested but not substantiated [10].

Topical therapies using class I corticosteroids (clobetasol propionate or betamethasone dipropionate), immunomodulators (tacrolimus), or retinoids (acitretin) have been reported with varying efficacy [11–14]. Alternatively, intralesional corticosteroid injections have been proposed. Rarely are any of these agents curative.

Vitiligo

Vitiligo is an idiopathic pigmentary disorder that can involve the genitalia. Its peak incidence is in the second and third decades, but can present at any age. Clinically, vitiligo is characterized by pale white macules that enlarge centrifugally over time [15]. Although they are usually asymptomatic, an inflammatory variant of vitiligo can cause meatal atrophy and stricture. Unlike strictures from LS, those from vitiligo are confined to the meatus.

Iatrogenic

Urethral Instrumentation

Strictures resulting from urethral instrumentation frequently involve the fossa navicularis. They arise from urethral luminal trauma caused by endoscopic procedures, urethral 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.

Diagnostic cystoscopy and urethral dilations are the most common procedure-related causes of fossa navicularis and meatal strictures, although their true incidence is unknown. 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 [16]. Fulgurating or lasing the urethral mucosa, frequently used to treat urethral condylomata acuminata, can similarly result in stricture formation.

Circumcision

Meatal stenosis is the most common significant long-term complication of circumcision. The mechanism is thought to be disruption of the normal preputial glanular adhesions and excision of the foreskin, resulting in an inflammatory reaction which causes a meatitis and subsequent scarring.

Failed Hypospadias Repairs

Secondary hypospadias repairs are a consequence of unsuccessful previous procedures. Often patients present as adults and, in some cases, are characterized as “hypospadiac cripples” based on multiple prior reconstructive failures. Common causes of failure include technical errors, the use of hair-bearing tissue (leading to infection and stone formation), persistent chordee, and distal urethral stenosis as a consequence of a urethrocutaneous fistula.

Patient Evaluation

The proper diagnosis and adequate characterization of glanular urethral strictures must be based on data obtained from a combined clinical, radiographic, and endoscopic evaluation.

Clinical Evaluation

The clinical evaluation of a stricture involving the glanular urethra is relatively straightforward. The patient will present with obstructive lower urinary symptoms, including a decreased force of stream, dribbling or splaying, and prolonged voiding; progression to acute urinary retention may occur. A thorough history should reveal any previous surgery, instrumentation, infection, or external trauma to the urethra. On physical examination, a pinpoint opening with permeate scarring is pathognomonic of a meatal stricture. A solitary fossa navicularis stricture 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, confirming the diagnosis. It is very important to carefully inspect the entire glans and penile skin to identify any coexisting pathology suggesting an inflammatory etiology. The presence of LS involving the penile skin precludes its use in urethral replacement.

In addition, a urinary flow rate and AUA Symptom Score Questionnaire are obtained preoperatively, as a baseline with which postoperative results can be compared.

Radiographic Evaluation

The radiographic evaluation of glanular urethral strictures is difficult. The introduction into the distal urethra of a small Foley catheter, a Brodney clamp, or a catheter-tip syringe for contrast instillation during retrograde urethrography will usually obscure the stricture. Sonourethrography, although superior to conventional radiography in defining the degree of spongiofibrosis, is similarly limited by the need for distal urethral instrumentation. If properly performed, a voiding cystourethrogram is the preferred imaging modality for the fossa navicularis and meatus. The bladder should be filled with an enhanced concentration of contrast material (60 % solution) and roentgenograms 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. Alternatively, if a catheter cannot be passed through the narrowing, a voiding cystourethrogram can be performed using contrast material injected intravenously (2 ml/kg body weight). This process is more time consuming and the diluted contrast may yield suboptimal images.

Endoscopic Evaluation

Lower urinary tract endoscopy should be performed to confirm the extent of the stricture and to identify any coexisting lower urinary tract pathology. This is usually undertaken at the time of the reconstructive procedure. A pediatric cystoscope can be used initially. Once the stricture has been incised, a complete cystourethroscopy should be performed with a flexible cystoscope.

Management Considerations

The management of fossa navicularis and meatal strictures includes various minimally invasive and reconstructive techniques. The selection of the proper procedure is paramount to achieving a successful outcome. Factors affecting this selection should include the age and overall condition of the patient; the etiology and specific characteristics of the stricture, glans, and penile skin; and any prior failed procedures. No single technique is applicable to all strictures. Treatment of simple glanular urethral strictures with minimal spongiofibrosis, in select patients, includes dilation, direct visual internal urethrotomy, and meatotomy. These minimally invasive procedures are usually palliative with long-term cure rates limited only to short (<5 mm) mucosal strictures without associated spongiofibrosis. Recurrent and inflammatory glanular urethral strictures are best managed by surgical reconstruction, which should be performed with a curative intent. Alternatively, densely scarred, obliterative strictures may be bypassed proximally by simply creating a subcoronal neo-meatus or a perineal urethrostomy. This approach may be beneficial in patients with extensive urethral LS, in the elderly, or in cases of multiple failed prior procedures.

Minimally Invasive Techniques

Urethral Dilation

Urethral dilation is accomplished by gradual progressive stretching of the urethra to a maximal diameter of 24 Fr. It must be performed in a manner that will not cause further urethral trauma. Aggressive dilation can lead to excessive urethral stretching and further scarring. Ideally, an acceptable result should limit the interval between dilations to every 6 months. Although select strictures of the fossa navicularis and meatus may respond to dilation, it should be regarded as a palliative rather than a curative procedure. Urethral dilation should be avoided in patients with LS as it may accelerate the inflammatory process.

Direct Visual Internal Urethrotomy

Conventional cold-knife direct visual internal urethrotomy is technically difficult in the glanular urethra. This terminal urethral segment provides a poor fulcrum, making any cutting motion awkward, with poor manual control. Alternatively, a laser fiber can be used, through a pediatric cystoscope, to incise short strictures with minimal spongiofibrosis. All incisions should be shallow in order to avoid inadvertent extension into the surrounding thick corpus spongiosum which can cause significant bleeding and additional subsequent spongiosal scarring.

Meatotomy

A ventral or dorsal midline meatotomy can be performed for select meatal strictures. The urethra is incised sharply and the mucosal edges are everted and approximated to the glans using absorbable sutures (e.g., 4-0 chromic catgut or undyed poliglecaprone 25 [Monocryl]). The ventral approach will produce a small degree of hypospadias. This is preferable to a dorsal incision which can result in profuse bleeding by cutting into the vascular glans penis. It is important to incise, or even widely excise, all visible scars in order to limit restricturing. The goal should be to create a patent 24 Fr urethral lumen. This is particularly important in patients with LS and can be challenging. In such cases, adjuvant topical therapy may be beneficial.

Reconstructive Techniques

Several procedures have been described for reconstructing the fossa navicularis and meatus. All include substitution techniques, using grafts, or flaps. Grafts involve the transfer of nonvascularized tissue and are dependent on a healthy recipient bed for survival. Flaps consist of tissue that is transferred with its own blood supply; their survival is dependent on a well-vascularized and preserved pedicle. Most glanular urethral reconstructions can be performed in a single stage. As a general rule, partial urethral replacement, using an onlay configuration, is preferable to circumferential substitution using tubularized tissue, as the latter has a very high recurrence rate [17, 18]. In cases of complete urethral luminal obliteration with limited remaining viable tissue from multiple failed prior surgeries, combined tissue transfer techniques (e.g., simultaneous dorsal and ventral grafts or a dorsal graft and a ventral flap) may be used [19, 20]. Alternatively, these cases can be managed with staged reconstructions. However, staged repairs often require several procedures, with prolonged delays resulting in a high patient attrition [21, 22]. In such cases, permanent proximal urethral diversion may be preferable to multiple reconstructions [23].

For a successful repair, appropriate preoperative urethral and penile skin assessment and adherence to basic surgical principles are mandatory (see Key Intraoperative Surgical Points). Penile or urethral biopsies can be helpful in confirming the diagnosis of an inflammatory process or, very rarely, carcinoma. The choice of the particular reconstructive technique is dictated by the etiology and characteristics of the stricture, the patient's expectations, and the surgeon's operative familiarity and preference.

Optical magnification, afforded by surgical loupes, is a valuable aid for all reconstructive procedures. A 3-0 polypropylene (Prolene) suture is placed in the dorsal mid-glans for cephalad penile traction. A self-retaining Lone Star retractor with elastic stays facilitates exposure. Fine surgical instruments are used to handle the delicate tissues, including the following: Gerald, Bishop-Harmon, and DeBakey forceps, Stevens tenotomy scissors, skin hooks, and a bipolar cautery.

Graft Urethroplasty

Full-thickness, rather than split-thickness, skin grafts should be used to reconstruct the fossa navicularis and meatus. The avoidance of split-thickness grafts is predominantly because of their significant and unpredictable contractility, yielding an unacceptably high failure rate.

One of the earliest reconstructive procedures for glanular urethral strictures is the patch-graft urethroplasty, described by Dr. Devine [24]. It incorporates a full-thickness distal penile skin graft to "repave" the fossa navicularis. Subsequent procedures incorporate extragenital tissue, using postauricular skin, bladder mucosal, and buccal mucosal grafts. More recently, lingual grafts have been described as an alternate option for urethral substitution. In general, the rich glanular blood supply provides an excellent host environment for successful imbibition and inosculation.

Extragenital tissue always should be used in patients with LS involving the penile skin. Urethral substitution incorporating diseased tissue inevitably will lead to recurrent stricture formation.

Over the past 20 years, buccal mucosa has emerged as the preferred tissue for most urethral substitutions. Although first described by Dr. Humby in 1941, it did not gain popularity until its successful use was reported separately by Drs. Bűrger and Dessanti, in 1992, for hypospadias repair and by Dr. El-Kasabi, in 1993, for adult urethral substitution [25–28]. Advantages of buccal mucosa over other grafts include its ease in harvesting without any noticeable cosmetic deficit and the tissue's thick epithelium and dense subdermal plexus which provide resilience and excellent graft-take.

Buccal Urethral Grafting

Graft Harvest

The buccal graft is harvested using the technique described by Drs. Morey and McAninch [29]. A full-thickness rectangular- or oval-shaped mucosal graft, measuring 1.5 × 3–6 cm, is obtained from the inner cheek. The dimensions are tailored to the urethral defect, allowing for 10–15 % graft contracture. During the dissection, care is taken to avoid injuring Stenson's duct located at the level of the second molar. The graft is defatted and placed in normal saline. The donor site can be closed primarily, covered with cadaveric dermis (e.g., AlloDerm) or left to heal by secondary intent. Although our preference is primary closure, the literature does not support any clear advantage of one technique over the other [30–32].

Graft Placement

A subcoronal ventral penile skin incision is made and carried down through Buck's fascia to the corpus spongiosum. The glanular urethra is exposed by elevating the ventral glans in a glans-cap fashion. Alternatively, in cases of severe scarring or inflammation (as with extensive LS), the strictured urethra can be exposed by splitting the glans ventrally, creating glans-wings. The entire stricture is incised longitudinally, on its ventral surface, and the meatal scar tissue is thoroughly excised. The urethrotomy should be extended into the normal urethra for 0.5–1.0 cm. The distal urethra is calibrated to 24 Fr using bougie-à-boule dilators. Flexible cystourethroscopy is performed to evaluate the lower urinary tract.

The buccal graft is placed ventrally, as an onlay, with its mucosal surface facing the lumen. The lateral edges of the graft are sutured to the native urethra using one running 5-0 absorbable monofilament suture on each side (e.g., polydioxanone [PDS] or polyglyconate [Maxon]). Similar interrupted sutures are placed at the proximal anastomosis to limit undue apical narrowing. The distal edge of the graft is appropriately tailored, excising any redundant tissue, and sutured to the ventral glans using interrupted 4-0 chromic catgut or undyed poliglecaprone 25 (Monocryl). The repair is stented with either an 18 or 20Fr Foley catheter. The glans-cap is then repositioned anatomically and sutured in place using 3-0 absorbable sutures (e.g., chromic catgut or undyed poliglecaprone 25 [Monocryl]). In cases where the glans has been split, the glans-wings are closed in two layers, using similar absorbable sutures. Meticulous hemostasis is obtained, using the bipolar cautery forceps, and the ventral penile skin incision is closed in two layers.

A penile compression dressing (e.g., Coban self-adherent wrap) is loosely applied to limit graft mobility and fluid accumulation which can disrupt neovascularization and lead to graft failure. The Foley catheter is taped in a nondependent position, on the patient's abdomen, limiting undue downward catheter pressure and decreasing postoperative penile edema.

Flap Urethroplasty

The simplest flap used to reconstruct the glanular urethra is the Y-V glans flap. This flap may be applicable for select short, noninflammatory strictures with minimal scarring. A V-shaped incision is made on the ventral glans, above the meatus, and a thin flap of spongiosum is elevated (Fig. 11.2a). The flap is advanced inferiorly and sutured to the dorsal aspect of the fossa navicularis, widening the meatus (Fig. 11.2b). Although technically simple, this flap has limited utility. In addition, aggressive glans dissection can result in unnecessary bleeding.

A flap using penile skin to reconstruct the fossa navicularis and meatus was first described by Dr. Cohney in 1963 [33]. This technique involves the rotation of a ventrally based penile flap to cover the previously incised glanular urethra. Problems with this repair include glanular torsion and flap necrosis. Several modifications followed, representing mostly adaptations from hypospadias surgery. In general, they incorporate an inverted U-shaped ventral penile skin flap to reconstruct the glanular urethra (Fig. 11.3) [34–36]. These procedures require significant flap mobilization to achieve adequate meatal advancement and can result in a retrusive meatus.

Penile flaps should be avoided in patients with any degree of penile skin or extensive glans involvement with LS as the recurrence rate is high [37]. In such cases, where tissue substitution is required, an extragenital graft should be used.

Fasciocutaneous Ventral Penile Transverse Island Flap

A more versatile flap for reconstruction of the fossa navicularis and meatus is the fasciocutaneous ventral penile transverse island flap, initially described by Dr. Jordan [38]. This is a rectangular penile skin flap, based on a broad island of dartos fascia. It is vascularized by branches of the superficial external pudendal artery which form an axial network of superficial penile vessels within the dartos. The relative laxity of the penile skin and the reliable dartos blood supply provide a dependable, versatile flap for urethral substitution. This flap can be developed in both circumcised and uncircumcised patients.

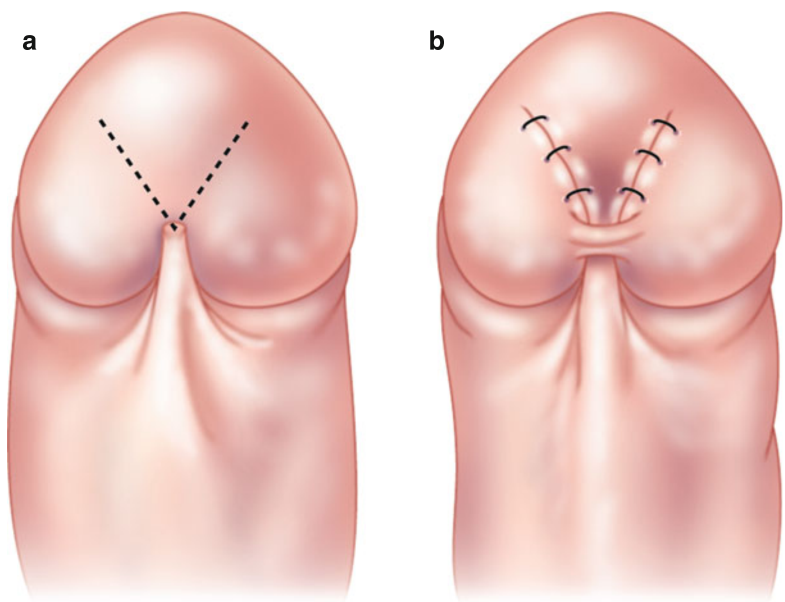

Fig. 11.2 Glans flap urethroplasty using a Y-V technique. (**a**) A V-shaped incision is made on the ventral glans and a flap of spongiosum is elevated. (**b**) The flap is advanced into an incision on the dorsal aspect of the urethra

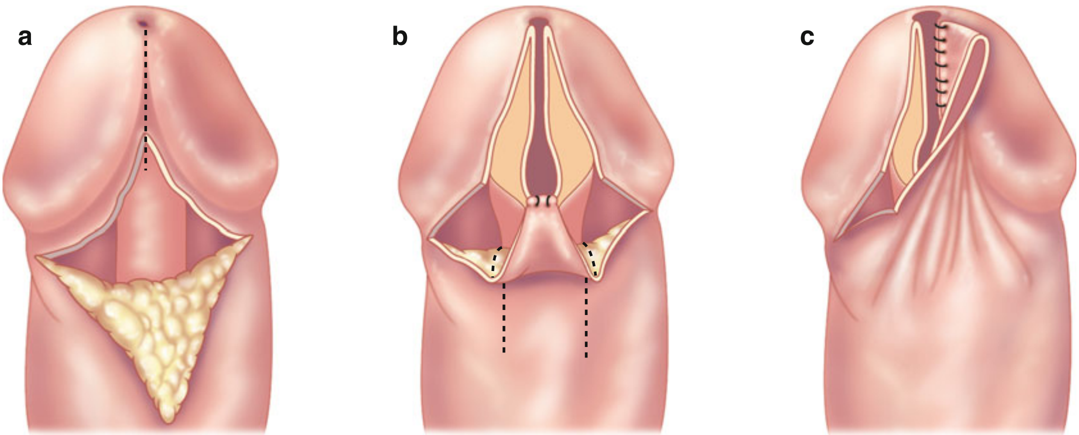

Fig. 11.3 Penile skin flap urethroplasty. (**a**) A subcoronal ventral penile skin flap is raised and the strictured glanular urethra is incised. (**b**) The distal flap segment is inverted into the proximal end of the exposed urethra. (**c**) An epithelial strip is created allowing advancement of the flap to bridge the glanular urethral defect

The glans reconstruction is an integral part of this procedure. Where possible, avoiding an incision directly on the glans will provide a superior cosmetic result [39]. This is of paramount importance to the patient and can overshadow the functional success of the urethroplasty procedure.

Operative Technique

Urethral Exposure

The patient is positioned supine on the operating table. Distal urethroscopy may be attempted, under anesthesia, using a pediatric cystoscope to evaluate the fossa navicularis as well as the more proximal anterior urethra.

A subcoronal incision is made on the ventrum of the penis leaving a 0.5–1.0 cm mucosal cuff. The incision is carried down through the dartos and Buck's fascias, exposing the underlying distal anterior urethra (Fig. 11.4a).

The appropriate glans reconstruction is chosen, depending on the physical characteristics of the glans. If the glans is conical-shaped without undue scarring, inflammation, or distortion, a glans-cap glanuloplasty is preferred. This has the aesthetic advantage of preserving the integrity of the entire glans, limiting unnecessary scarring to this most prominent terminal penile segment. With a severely diseased or flattened glans, glans-wings are preferable because they allow the excision of all fibrotic tissue with anatomic resculpturing of the glans penis.

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 corporal bodies (Fig. 11.4b). For a glans-wings glanuloplasty, a full-thickness incision is made in the ventral glanular groove, exposing the underlying urethra (Fig. 11.4c). A ventral longitudinal stricturotomy is then made and the incision extended proximally, at least 0.5 cm, into normal urethral tissue (Fig. 11.4d). Usually, the dorsal urethral surface can be preserved unless there is severe circumferential urethral disease necessitating complete urethral excision. In such cases, the options include combined tissue transfer techniques, a staged reconstruction, or a tubularized flap. Once the scar tissue is appropriately removed, the proximal urethral lumen and meatus should be calibrated, with metal bougie-à-boule dilators, ensuring a diameter of at least 24 Fr. An endoscopic evaluation of the entire urethra and bladder should be performed to identify any additional lower urinary tract pathology.

Creation of a Fasciocutaneous Ventral Penile Transverse Island Flap

An appropriate transversely oriented rectangular segment of penile skin is properly marked after

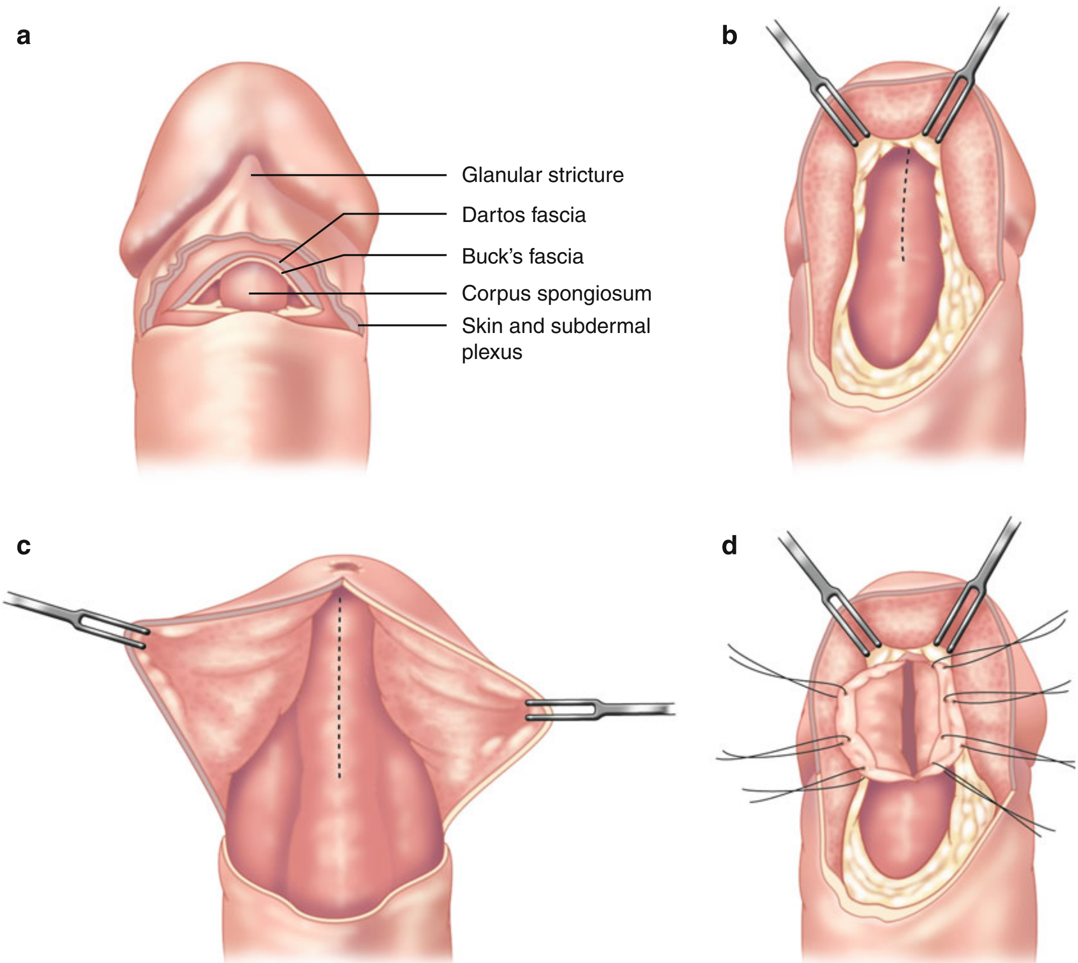

Fig. 11.4 Fasciocutaneous penile flap urethroplasty: *urethral exposure.* (**a**) A ventral subcoronal skin incision is made and taken down to expose the distal penile urethra. (**b**) The glanular urethra is exposed using either a glans-cap or (**c**) a glans-wings approach. (**d**) A ventral longitudinal stricturotomy is made, making sure to incise the entire length of the stricture

measuring the length of the urethral defect (Fig. 11.5a). The width of the proposed flap is dependent on the type of urethral substitution required and can be calculated by using the following formula:

$$\text{Circumferential length} = 2\pi r, \text{ where } \pi = 3.14 \text{ and } r = \text{urethral luminal radius.}$$

When used as an onlay, a flap width of 1.5 cm is sufficient. In cases were complete substitution is required, a 2.5 cm wide flap can be fashioned over an 18Fr Foley catheter.

In general, tubularization of the flap should be avoided as it is prone to circumferential restricturing. Because contraction is not a problem with flaps, accurate measurements can limit subsequent sacculation apparent with oversizing.

The fasciocutaneous ventral penile transverse island flap is developed by superficially incising the previously marked segment of penile skin down to the dartos fascia (Fig. 11.5b). The penile skin is dissected from the fascial pedicle in a plane between the superficial dartos fascia and the subdermal plexus. Preservation of the

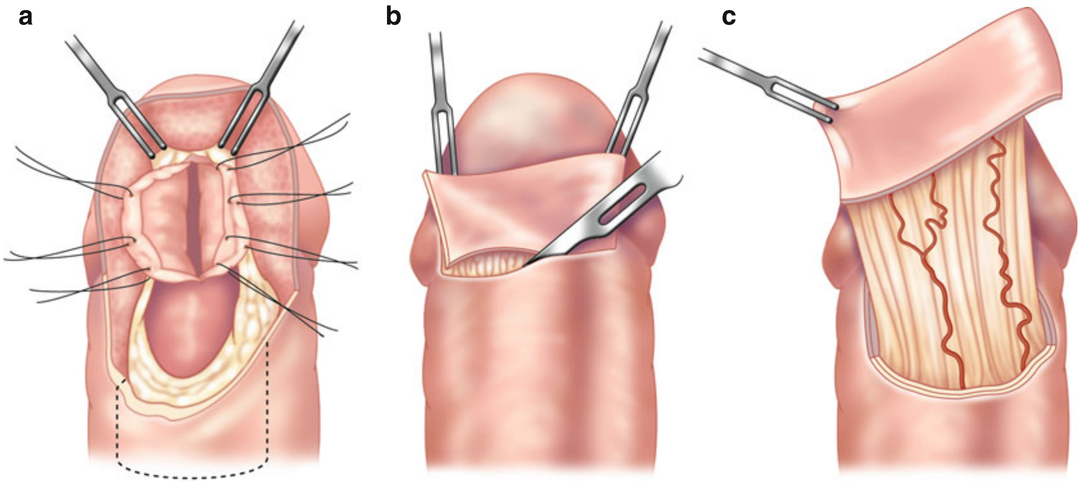

Fig. 11.5 Fasciocutaneous penile flap urethroplasty: *creation of the fasciocutaneous ventral penile transverse island flap* (**a**) An appropriate segment of penile skin is measured and marked. (**b**) The flap dissection is started by creating a plane between the subdermal and dartos fascias. (**c**) The pedicle is completely mobilized

subdermal plexus is vital in ensuring viability of the remaining penile skin. A deeper tissue plane is developed superficial to Buck's fascia, creating a broad well-vascularized dartos fascial pedicle (Fig. 11.5c). The dissection is usually continued to the mid-penis, but can be extended more proximally, as needed, for a tension-free flap transposition.

Urethral Substitution

The newly created flap is rotated 90° and inverted ensuring its unobstructed tension-free transposition into the urethrotomy defect, where it is sutured as an onlay. Absorbable monofilament 5-0 sutures (e.g., polydioxanone [PDS] or polyglyconate [Maxon]) are used. A running suture is placed on each side, approximating the cutaneous side of the flap to the urethral mucosal edge. Interrupted sutures are placed at the proximal anastomosis. The repair is stented with an 18 or 20Fr Foley catheter.

Glanular Reconstruction

After completion of the urethral reconstruction, attention is directed to the glanuloplasty, the choice of which has been previously decided. A generous core of glanular tissue needs to be excised, ensuring complete removal of all perimeatal fibrosis. With the glans-cap repair, the neo-urethra has been tunneled under the glans (Fig. 11.6a). The glans-cap is then repositioned anatomically and sutured in place using 3-0 absorbable sutures (e.g., chromic catgut or undyed poliglecaprone 25 [Monocryl]). With the glans-wings repair (Fig. 11.6b), the two full-thickness glans flaps are loosely reapproximated over the neo-urethra in two layers, using similar sutures. This gives the glans a physiologic conical shape with a ventrally placed linear suture line. The distal flap is sutured to the tip of the glans, using 4-0 chromic catgut or undyed poliglecaprone 25 (Monocryl), to create an orthotopic, widely patent neo-meatus (Fig. 11.6c).

Penile Skin Closure

Before closing the penile skin, meticulous hemostasis is accomplished with the bipolar cautery forceps. The penile skin is reapproximated using 3-0 absorbable sutures (e.g., chromic catgut or undyed poliglecaprone 25 [Monocryl]). Burrow's triangles can be developed to eliminate any dog-ears which can occasionally form at the corners of the 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.

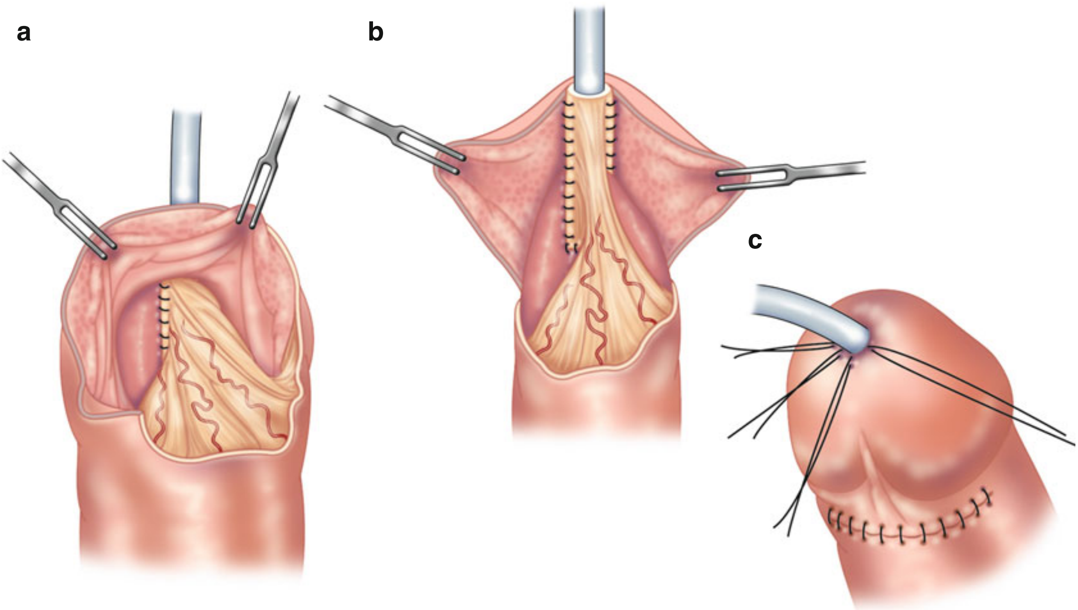

Fig. 11.6 Fasciocutaneous penile flap urethroplasty: *urethral substitution and glanular reconstruction* The flap is transposed either (**a**) below the glans-cap or (**b**) between the glans-wings and is sutured in place laterally and proximally. (**c**) The distal flap is sutured to the tip of the glans, creating a patent neo-meatus. The penile skin is closed in two layers

Postoperative Management

Postoperative ambulation is encouraged the day of surgery, and patients are typically discharged on the first postoperative day. Perioperative intravenous antibiotics are continued for 24 h. Oral antibiotics are given for 5 days postoperatively and then again for 24 h starting 2 h prior to catheter removal. The neo-meatus should be kept lubricated, with antibiotic ointment, to prevent drying. The urethral catheter is removed, at 3 weeks, in conjunction with a voiding cystourethrogram. Follow-up is obtained at 3 and 12 months using office flow rates and the AUA Symptom Score Questionnaire. In addition, patients are instructed to measure 5 s flow rates, at home, every month. Urethrography and urethroscopy are performed selectively if a problem is suspected. In general, we avoid further urethral manipulation in order to limit patient discomfort and the risk of additional procedure-induced scarring. Lifelong follow-up is required as the success of these reconstructive procedures declines over time. These failures are likely due to disease progression as well as the limitations of our current tissue transfer techniques.

Complications

Early complications of fossa navicularis and meatal urethral reconstruction include urinary stream splaying and a small degree of glanular torsion. Both of these problems are usually transient, resolving once the initial healing process is complete. Delayed complications include restricture, fistula formation, and neo-urethral prolapse or retrusion [39–41]. Most recurrent strictures will occur at the proximal urethral anastomosis or meatus and are short, making them amenable to treatment by minimally invasive procedures. Small fistulas often heal spontaneously. Treatment for persistent fistulas should be delayed for 6 months, after which time circumferential excision and multilayer closure may be considered.

Erectile dysfunction, chordee, incontinence, and position-related complications, which can occur after reconstruction of the more proximal urethral segments, should not occur with glanular urethral reconstruction.

Surgical Pearls and Pitfalls

Key Intraoperative Surgical Points

- Optical magnification, afforded by surgical loupes, is a valuable aid for the reconstructive procedure.
- Selection of the most appropriate tissue for urethral substitution is dependent on the physical characteristics of the penile skin and urethra, the etiology of the stricture, and any prior failed procedures. Extragenital skin (i.e., buccal mucosal grafts) should always be used in patients with any degree of penile skin or extensive glans involvement with LS.
- The entire urethral stricture should be incised and all meatal scar tissue excised, achieving a urethral caliber of 24 Fr.
- Partial urethral replacement is preferable to circumferential substitution using tubularized tissue. With extensive scarring, circumferential urethral replacement can be achieved using combined tissue transfer techniques. Alternatively, a staged reconstruction or permanent proximal urethral diversion may be considered.
- A water-tight neo-urethra should be created using absorbable fine monofilament sutures.
- The choice of glanuloplasty depends on the physical characteristics of the glans penis. Where possible, a glans-cap reconstruction is preferred as it avoids an incision into the glans penis, which limits scarring.
- Meticulous attention to hemostasis and gentle tissue handling using fine instruments are paramount in achieving a successful outcome.

Potential Intraoperative Problems

- Underestimation of stricture length or inaccurate assessment of tissue characteristics will result in stricture recurrence. Urethral calibration should be performed, using bougie-à-boule dilators, ensuring a diameter of 24 Fr. The appropriate urethral substitute must be chosen based on a thorough knowledge of the particulars of each case and proper surgical planning.
- In cases of extensive glanular urethral scarring with obliteration of the corpus spongiosum, such as with widespread LS or after multiple failed hypospadias repairs, a staged approach or proximal urethral diversion may be preferable to a single-stage reconstruction.
- A hematoma will compromise a graft, by impeding neovascularity and a flap by compressing its vascular pedicle. Meticulous homeostasis is important in avoiding failure of the neo-urethral substitute.

Editorial Comment

Imaging of glanular strictures is difficult when a catheter cannot be introduced through the stenotic meatus during retrograde urethrography; in those without suprapubic tubes, antegrade imaging can also be challenging. Determining the length of the stricture is often aided by careful preoperative examination of the distal urethra—palpable fibrosis correlates well with the extent of stenosis discovered intraoperatively.

Short skin flaps as outlined in this chapter are often effective for men with discreet fossa navicularis strictures. In men with chronic and/or severe distal obstruction (e.g., lichen sclerosus), an alternative to two-stage surgery is the extended meatotomy maneuver, which is simple and at least 90 % effective. Recent evidence suggests that unobstructing the distal urethra may stabilize the progression of the inflammatory periurethral disease process. I like to incorporate wedge excision of the periurethral glanular fibrosis in conjunction with extended meatotomy. Spraying of the stream is an issue that needs to be discussed with the patient, as part of informed consent. Another recent advance for fossa strictures is the circular buccal mucosa graft procedure.

–Allen F. Morey

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12 Stricture Excision and Primary Anastomosis for Anterior Urethral Strictures

Reynaldo G. Gomez

Summary

Stricture excision and primary end-to-end anastomosis is the most durable surgical treatment for anterior urethral strictures. After resecting all fibrotic urethral walls, proximal and distal urethral ends are mobilized so they can be approximated without tension to bridge the gap. Natural urethral elasticity is used to elongate the urethra, and the distance can be shortened by opening the inter-crural septum. A wide mucosa-to-mucosa, tension-free anastomosis is then performed using fine interrupted absorbable sutures. This procedure is ideally suited for bulbar strictures 1–3 cm long, but it can also be successful in some selected cases with proximal bulbar strictures up to 5 cm in length. Because the anterior penile urethra is stretched during erection, this procedure is limited in the penile urethra, as it can produce shortening of the urethra and ventral curvature of the penis on erection. Complications are rare, mainly infection or hematoma of the operative wound. Sterile urine at the time of surgery and meticulous hemostasis are required to avoid them. Late failures are related to excessive tension at the anastomosis or incomplete fibrous resection. Complete excision of the fibrotic urethra is essential, and the surgeon must be prepared to perform an alternative form of repair if this resection results in a defect too long for a tension-free end-to-end reconstruction. When performed properly, excision and primary anastomosis is a well-tolerated, low-morbidity, and highly effective procedure, with an average long-term cure rate of over 90 %.

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Stricture Excision and Primary Anastomosis for Anterior Urethral Strictures

When performed properly, excision and primary anastomosis (EPA) is the best surgical procedure for the treatment of anterior urethral strictures available today. The involved principle is simple: a perineal approach with resection of the strictured urethral segment and reconstruction by means of an end-to-end anastomosis. Results are excellent with long-term cure rates at approx 92 % in the published experience of major reference centers. Although simple, success with this procedure is linked to a number of important clinical and technical details, which are the basis of this chapter.

Etiology

Before the antibiotic era, sexually transmitted diseases, mainly gonorrhea, were the main cause of strictures of the urethra. Gonorrhea and other urethritis are still very frequent, but early antibiotic treatment can avoid infectious damage to the

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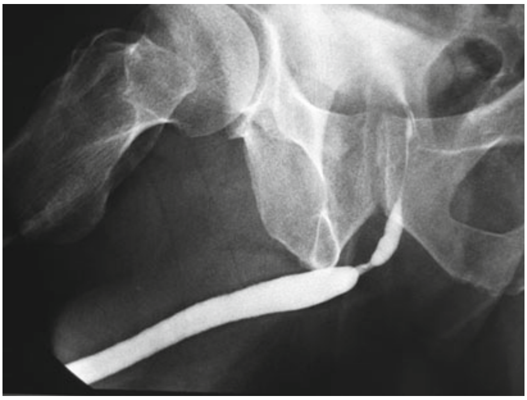

Fig. 12.1 Mid-bulbar urethral stricture in a patient with remote history of childhood bicycle blunt injury, presenting at 38 years of age

urethra, so these strictures are less frequent in developed countries nowadays. External trauma and iatrogenic injuries are now the etiology of most anterior urethral strictures, although in many cases the etiology is unknown and is reported as "idiopathic." Fenton et al. [1] performed a meta-analysis of the etiology of anterior strictures from seven series of the literature with a total of 732 patients, founding a 33 % idiopathic, 33 % iatrogenic, 15 % inflammatory, and 19 % traumatic etiology.

Traumatic strictures of the bulbar urethra usually are short and, in most cases, result after a straddle injury in which the urethra is crushed against the inferior border of the symphysis pubis. This injury may cause partial damage of the urethra that heals with scar formation, which eventually leads to a stricture. With more severe injuries, the urethra can be transected with total loss of urethral continuity. Some strictures of unknown origin may in fact be the delayed result of an unrecognized childhood perineal trauma, with strictures often appearing many years later [1, 2] (Fig. 12.1).

Iatrogenic strictures are related to endoscopic procedures and prolonged urethral catheterization. Although they tend to be longer and located at the penoscrotal junction or penile urethra, sometimes they can be short and proximal enough in the bulbar urethra as to be repaired by a primary anastomosis.

Some idiopathic strictures are located in the proximal half of the bulbar urethra, occur in young men, and contain smooth muscle. These strictures are linked with the so-called Cobb's collar and may represent an embryological fusion defect, for which they are referred by some authors as "congenital" [3]. These strictures tend to be thin and diaphragmatic, amenable to visual urethrotomy, but some may be candidates for anastomotic repair should the endoscopic treatment fail.

Patient Selection for Excision and Primary Anastomosis

Patient selection is essential for success. The objective of this procedure is to obtain a wide mucosa-to-mucosa anastomosis without tension. A 1-cm spatulation of the urethral ends is a useful maneuver to create a wide overlapping oblique anastomosis that reduces the risk of annular retraction and recurrence. This means that the urethra needs to be mobilized on both ends to replace the length of the excised segment plus the urethral spatulation. For this reason, length of the stricture and its location are the limiting factors. The anterior penile urethra is stretched during erection, so the length of penile urethra that can be excised without causing chordee is very limited. With a 1-cm spatulation on each side, the resection of a 2-cm stricture will cause a 4-cm urethral shortening, which could be unacceptable on many patients, and, indeed, some authors stated that excision and primary anastomosis may never be used in the penile urethra, except in previously impotent patients [4]. Moreover, strictures of the penile urethra tend to be multiple and long, so the number of patients amenable for primary anastomosis in the penile urethra is quite small. In some selected cases this technique can be used for strictures up to 1 cm, but in most instances a substitution urethroplasty will be necessary [4–6].

On the contrary, the bulbar urethra does not participate in an erection and can be extensively mobilized proximally to the genitourinary diaphragm and distally to the penoscrotal junction without causing erectile impairment. The bulbar urethra has a very rich bilateral blood supply, proximally from the bulbar and urethral arteries and distally by retrograde flow from the glans penis and from perforating arteries, branches of the cavernosal and dorsal arteries. Once mobilized, the natural elasticity of the urethra can be stretched without tension to bridge short defects up to 1–2 cm. If the defect is longer, the natural curve of the bulbar urethra can be straightened to bridge the gap. The curve of the bulbar urethra is produced at the junction of the two crura at the base of the penis, where the urethra bends to penetrate the perineal diaphragm towards the apex of the prostate. Between the crura, there is a virtual space that can be developed by separating the crura to allow the distal urethra to lie between them; this will straighten the urethra, gaining additional length to allow a tension-free anastomosis. With these combined maneuvers, up to a 5-cm gap can be bridged without tension in most patients. For this reason, excision and primary anastomosis is suitable for bulbar strictures 1–3 cm long considering a 1-cm spatulation on each end [3–10]. Because the elasticity of the bulbar urethra is greater on its distal half than on its proximal half, the more proximal the stricture, the longer the segment that can be removed [6]. In 2006 Morey and Kizer [11] reported on a series of 11 patients in whom an extended anastomotic repair was performed with strictures 2.6–5.0 cm long (average, 3.78 cm). All these patients had proximal bulbar strictures within 1 cm from the membranous urethra and were young sexually active men with healthy and well-vascularized tissues. There were no differences in recurrence or sexual dysfunction when compared with a similar group with strictures 2.5 cm or shorter [11]. Recently, the same group reviewed their experience comparing proximal (PB) to distal (DB) bulbar strictures. Proximal was defined as the segment within 5 cm from the membranous urethra, and distal was the subsequent segment up to the penoscrotal junction. All PB strictures (median length, 2 cm; range, 1–5 cm) were able to be reconstructed by EPA with a 98.6 % success rate. On the contrary, DB strictures required a substitution repair in 90 % of cases and recurrence was much higher (28 %). However, those DB cases amenable to EPA had the same cure rate than PB strictures [12]. These results illustrate that length and location of the stricture are the key issues. Those strictures located in the proximal bulb can be reconstructed by EPA in the vast majority of cases even up to 5 cm in length and have an excellent prognosis. Care should be exerted in the distal bulb where a substitution may be necessary. In the end, the reconstructive surgeon should select the procedure to be used according to the operative findings and be prepared to modify his original plan when required. The patient should be warned that a substitution repair may be necessary if the stricture results to be longer than anticipated.

Preoperative Evaluation

Proper selection of patients for primary anastomotic reconstruction requires a thorough clinical and imaging evaluation with appropriate management of comorbid medical conditions preoperatively. Previous surgical management of the stricture may introduce important alterations to the normal anatomy and vascular supply. On physical examination, fibrosis, inflammation, or fistula in the perineal area may be found. Penile and hairless skin, foreskin, and buccal mucosa are evaluated as possible sources of tissue for reconstruction.

Because the feasibility of performing a primary anastomotic repair depends on the stricture's location, its length, and degree of spongiofibrosis, a precise anatomical knowledge of the stricture is essential. Retrograde urethrogram is the standard imaging study for this purpose because it can demonstrate the location and extent of the stricture. In most cases, a voiding cystourethrogram should be also included to best define the proximal urethra and bladder neck. However, it is well known that these radiographic studies often underestimate stricture length because they are preformed in an oblique position with relation to the anteroposterior x-ray beam, resulting in a shorter projected view of the stricture [13, 14]. Also, in some severe strictures, high voiding pressure will hydrodilate the proximal urethra, masking areas of proximal

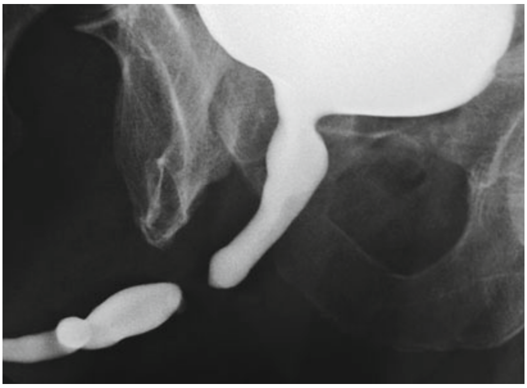

Fig. 12.2 "Up-and-down" retrograde urethrogram combined with voiding cystourethrography in a patient who suffered a straddle injury with complete obliteration of the mid-bulbar urethra

fibrosis so the stricture may look shorter than it really is. For this reason, when in doubt it may be helpful to allow the urethra to rest for a few weeks by means of a temporary suprapubic diversion to get a more precise estimation of the true length of the stricture [4, 5]. Recently, Terlecki and coworkers prescribed urethral rest to 28 patients because of recent urological manipulation immediately before referral (54 % of these patients received suprapubic catheters). Urethral rest promoted identification of severe fibrotic segments in 75 % of cases allowing for a more complete reconstruction [15]. Because of the limitations of the radiographic studies, sonographic evaluation of the stricture has been advocated to improve preoperative staging. This study has been shown to be highly accurate in predicting the true length of the stricture and may also provide some valuable estimation of the degree of spongiofibrosis and presence of other pathologic conditions like diverticulae, fistulas, urethral calculi, false passages, and periurethral abscesses [13, 14, 16]. Endoscopy, preferably flexible urethroscopy, may be useful to visualize the mucosa at the distal side of the stricture. Pink mucosa means healthy urethra, but a pale-gray mucosal aspect reflects submucosal fibrosis that will need to be removed during surgery. This evaluation may be particularly important in patients with previous urethroplasty or those managed with visual urethrotomy. In patients with complete urethral disruption unable to void, imaging of the proximal urethra may be a problem. These cases will have a suprapubic tube and an "up-and-down" retrograde urethrogram combined with voiding cystourethrography, similar to that performed to study posterior urethral injuries, can be performed (Fig. 12.2). Alternatively, antegrade flexible cystoscopy through the catheter tract may be done to evaluate the proximal stump.

Surgical Technique

The patient is operated under general anesthesia and with broad-spectrum prophylactic antibiotic coverage. It is imperative that the urine be sterile at the time of surgery, which is particularly important in patients with a suprapubic tube, who may be chronically colonized. Failure to operate with sterile urine is the main reason for wound infection and postoperative urinary sepsis.

We prefer to place the patient in the exaggerated lithotomy position because of better and more direct perineal exposure, particularly in obese patients and proximal bulbar reconstructions (Fig. 12.3). A cushion or bean bag is placed under the sacrum to elevate the pelvis, and the hips are flexed to make the perineum as oblique as possible. Slight Trendelenburg tilt of the table can also be useful. Neuroskeletal complications caused by this position have been well documented in the literature, especially severe compartment syndrome [17–19]. However, the risk is directly related to the surgical time, especially for surgeries longer than 5 h. Because most primary anastomotic procedures can be completed in less than 3 h, the incidence of such injuries is negligible. Anyway, care is taken in padding the contacts points to avoid pressure, and Allen-type stirrups are used when available to limit flexion at the knee joint and decrease stretch on the peroneal nerve. Thromboembolic prophylaxis is provided by the use of elastic leggings and pneumatic intermittent leg compression device.

Patient's genitalia, perineum, lower abdomen, and thighs are prepared for surgery. Surgical drapes and towels are placed to expose the perineum and hypogastrium. We use a number 1,016 adhesive plastic Steri-Drape Irrigation Pouch (3M Health Care) to keep the anus away from the operative field. When necessary, two stitches can be placed

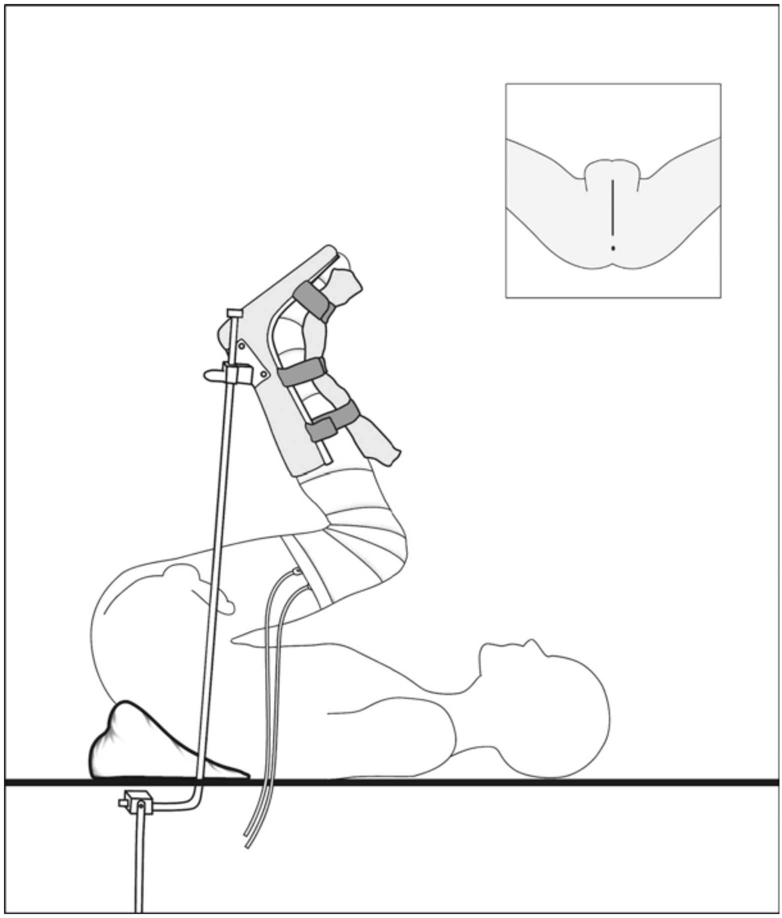

Fig. 12.3 The patient is positioned in the lithotomy position with the pelvis rotated anteriorly and the legs secured in Allen stirrups

from the sides of the scrotum to the pubic area to elevate the scrotum, obtaining better exposure of the perineal surgical field (Fig. 12.4). We always use 2.5× magnification loupes and a head lamp; bipolar electrocautery is used for hemostasis around the urethra to minimize the risk of thermal nerve damage that may cause erectile impairment. The Scott's retractor ring is another very useful aid; besides a very effective radial retraction capability, this device also exerts elastic traction of tissues. This traction brings deeper structures to the surface, reducing the depth of the working cavity. The spongiosum is mainly a vascular structure and should be managed as such; consequently we use DeBakey vascular forceps for its dissection. Angled Potts vascular scissors are used when performing longitudinal urethrotomy incisions. The bougie-a-boule probes are very useful for calibration of the urethral ends and identification of residual spongiofibrosis.

Fig. 12.4 Note excellent exposure to the perineum in the exaggerated lithotomy position and scrotum elevated by sutures

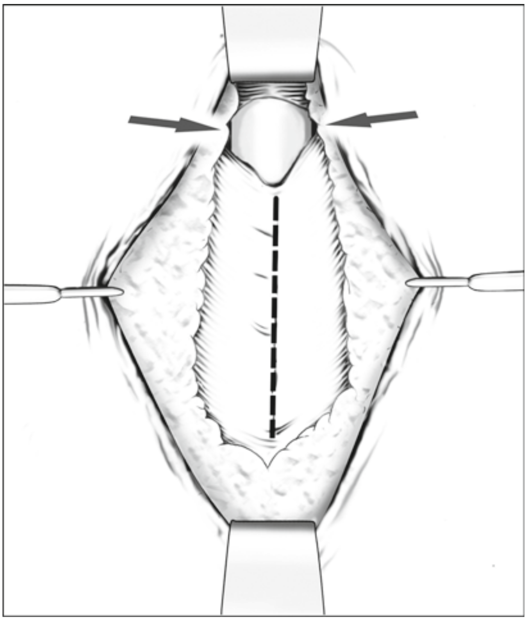

Fig. 12.5 Initially mobilize the urethra at the distal margin of the bulbospongiosus muscle (see *arrows*)

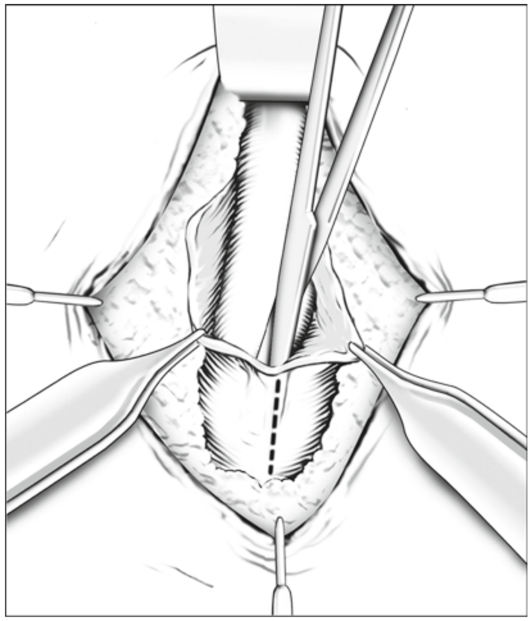

Fig. 12.6 Sharply split the bulbospongiosus m. in the midline (see *dotted lines*) to expose the bulb

A vertical skin incision is used in most cases, extending from the base of the scrotum almost to the anal margin. After incision of Colles' fascia, a 20-F soft rubber catheter is placed in the distal urethra to help with its identification; the urethra is then located by palpation and dissected. The best approach to the urethra is at the distal margin of the bulbospongiosum muscle (Fig. 12.5). Buck's fascia is opened on either side of the urethra, and a plane is developed between the spongiosum and cavernous bodies. Once the urethra has been separated from the corpus cavernosum, a vascular tape is placed to elevate the urethra and facilitate its proximal and distal dissection. The bulbospongiosum muscle is now opened in the midline with scissors and separated laterally on each side to expose the underlying corpus spongiosum. The muscle is not adhered to the spongiosal tunica albuginea, except in the ventral midline raphe where sharp dissection is necessary to expose the bulb (Fig. 12.6).

The location of the stricture is sometimes marked by fibrosis and an hourglass retraction of the spongiosum, especially after traumatic straddle injuries (Fig. 12.7). It can also be determined by gentle retrograde probing of the urethra with the soft rubber catheter; the idea is to locate the stricture site, taking care to avoid urethral perforation or dilation of the stricture with this maneuver. Inadvertent perforation of the distal side of the stricture may lead to unnecessary loss of valuable urethral length, whereas dilation of the stricture at this time may make it more difficult to identify the limits of the fibrous process to be resected. Once the urethra has been separated from the corpus cavernosum, it can be transected at the site of maximum stricture (Fig. 12.8). However, if the surgeon is in doubt about the feasibility of performing a primary anastomosis, a longitudinal urethrotomy should be performed through the stricture and extended proximally and distally until healthy urethra is found. If the resulting defect is too long for an end-to-end reconstruction, then a patch graft urethroplasty should be considered. This urethrotomy can be dorsal or ventral and buccal mucosa is the preferred tissue for urethral graft nowadays.

With short strictures amenable to excision and primary anastomosis, the urethra is divided and the strictured portion is excised completely (Fig. 12.9). If too much bleeding occurs after

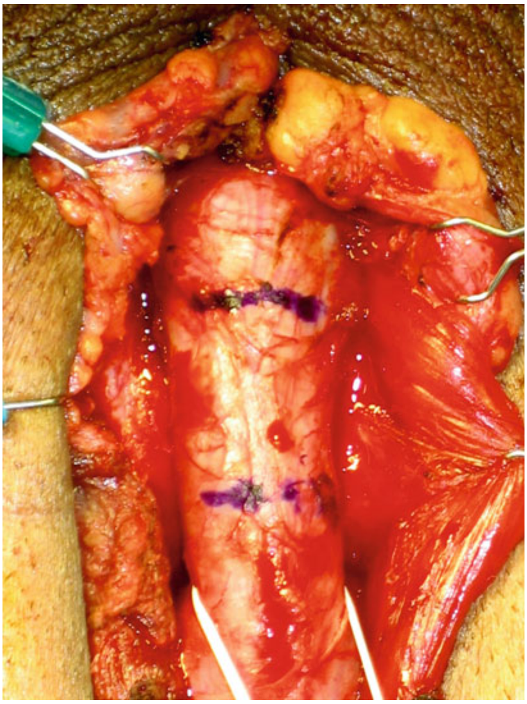

Fig. 12.7 Patient with a straddle injury: note the scar and slight retraction between the marks

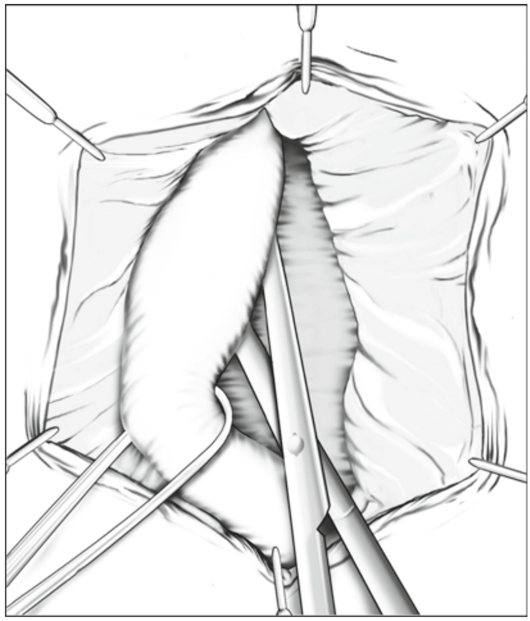

Fig. 12.8 Sharp circumferential mobilization of the bulbar urethra

dividing the urethra, soft bulldog-type vascular clamps can be applied to both ends of the urethra to reduce blood loss and improve view, facilitating urethral inspection. All diseased fibrotic urethra is resected until completely healthy urethra is found. This step is crucial, as one main cause of failure is incomplete scar removal. Partially fibrous urethra can look "acceptable," but the mucosa usually has a grayish aspect, clearly distinguishable from the truly healthy pink mucosa; for this evaluation liberal use of intraoperative urethroscopy is strongly recommended. Forceps manipulation of the urethral mucosa should be minimized to avoid attrition damage of this delicate tissue. The bougie-a-boule probes are used to identify healthy urethral walls by gently calibration of the proximal and distal urethral lumen. Failure of bougies to smoothly calibrate the ends up to 26–28 F indicates residual spongiofibrosis that limits urethral elasticity, which also needs to be removed.

Dissection proceeds now distally separating the urethra from the corpus cavernosum, but not beyond the penoscrotal angle to avoid penile shortening or chordee during erection. In the impotent patient, this factor is not of concern and the urethra can be completely mobilized distally. The urethra is also dissected proximally, freeing the bulb from the perineal body. At this point the paired bulbar arteries will be found; sometimes they need to be suture ligated to properly mobilize and advance the bulb. However, with short strictures extensive mobilization of the bulb may not be necessary and these arteries can be preserved. These arteries should be spared whenever possible to ensure good vascular supply of the spongiosum [8, 20, 21]. Splitting the intercrural septum in the midline is also very helpful in reducing the distance between both urethral ends. This maneuver will allow the distal portion of the urethra to lie within the intercrural space, straightening the natural curve of the bulbar urethra and gaining length to relieve tension at the anastomosis.

A 1-cm spatulation is performed on each urethral end to create an oblique anastomotic line, thus reducing the risk of annular retraction recurrence. Typically, the proximal end is spatulated dorsally and the distal end ventrally (Fig. 12.10). Interestingly, Hosseini and coworkers in a recent

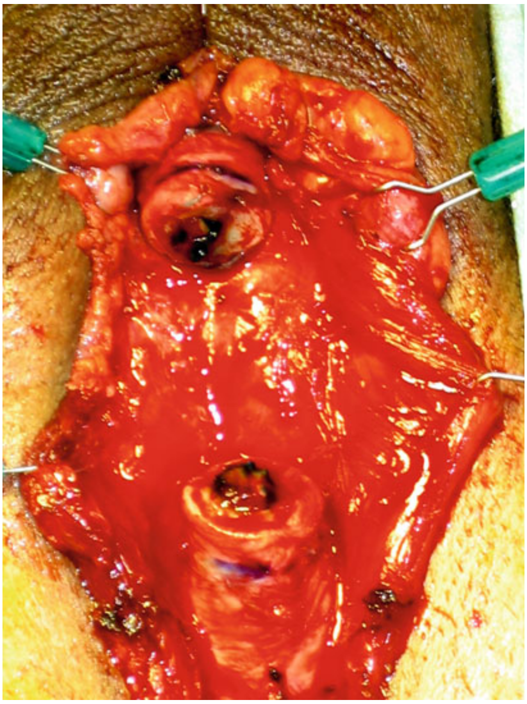

Fig. 12.9 A 1.5 cm stricture has been removed; note elastic retraction of urethral ends

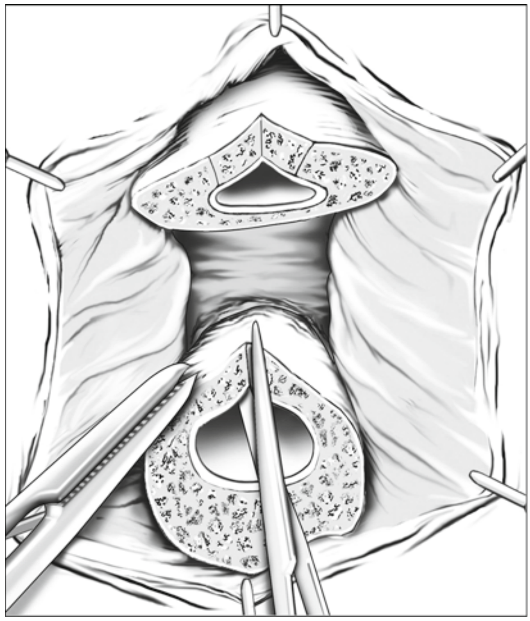

Fig. 12.10 The proximal urethral end is spatulated dorsally and the distal end ventrally

paper compared distal-dorsal and proximal-ventral (101 patients) versus distal-ventral and proximal-dorsal (219 patients) urethral spatulation and found a 96 % versus a 87.6 % success rate ($p = 0.025$), respectively; however, this was in pelvic fracture posterior urethral injury patients, and this finding has not been validated in bulbar end-to-end reconstructions [22]. Usually the anastomosis is performed with six to eight interrupted fine absorbable sutures (our preference is 5-0 poliglecaprone (MONOCRYL®)). In the dorsal half of the urethra, through-and-through stitches include the urethral wall and the thin spongiosum in one single layer; the knots can be tied from the inside or the outside of the urethra (Fig. 12.11). Some surgeons like to anchor these dorsal stitches to the corporal tunica albuginea to stabilize the anastomosis and keep the dorsal plate flat and open [8]. In the ventral half, the spongiosum is much thicker so the anastomosis can be performed in two layers: the first layer includes only the urethra and the spongiosal tunica is closed separately in a second watertight layer; these knots are tied on the outside (Figs. 12.12 and 12.13). In this way, blood is allowed to flow across the anastomosis, ensuring good irrigation. Although some authors use a single-layer anastomosis [4, 8], most prefer the two-layer technique. A 16-F Foley catheter is placed for urinary diversion and secured with tape to the hypogastrium to avoid decubitus at the penoscrotal angle. All-silicone rubber catheter is used because they cause much less urethral inflammatory reaction than latex rubber catheters. The incision is closed by layers, approximating the bulbospongiosum muscle and Colles' fascia with running absorbable sutures, mainly 3-0 polyglactin, and the skin is closed with a subcuticular suture or with staples. The wound is permanently irrigated with saline plus gentamicin throughout the procedure.

The use of drains is a matter of personal preference and case selection. Some leave a quarter-inch Penrose or a small suction drain overnight if there is too much bloody oozing, if a periurethral abscess has been drained, or if there is a potential space that can collect fluid [5, 8, 9]. Others do not use drains at all, providing careful satisfactory

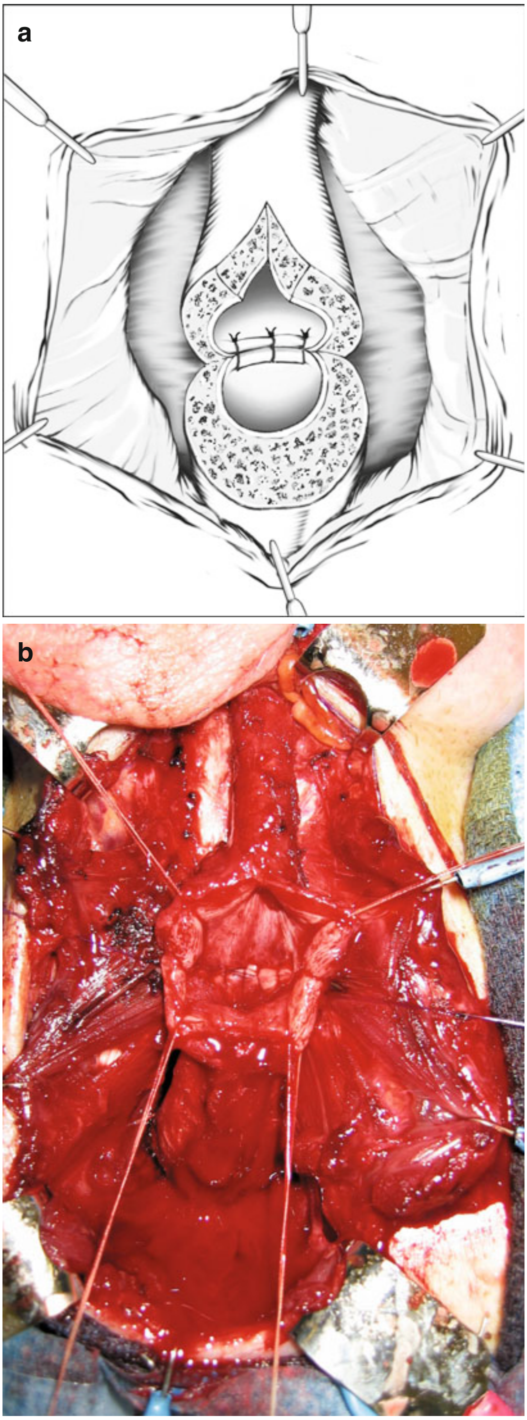

Fig. 12.11 (**a**) The dorsal suture line has been completed in one layer. Knots are in the inside. (**b**) Mid-bulbar anastomotic urethroplasty. Note wide spatulation (Image courtesy SB Brandes)

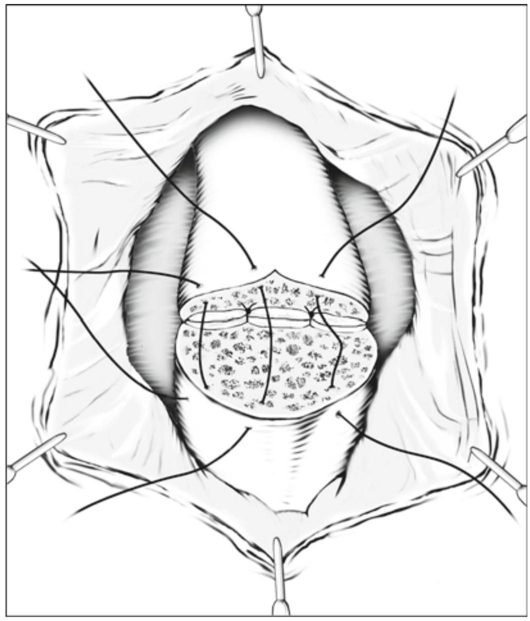

Fig. 12.12 The ventral anastamosis is performed in two layers, a mucosal and a tunical layer

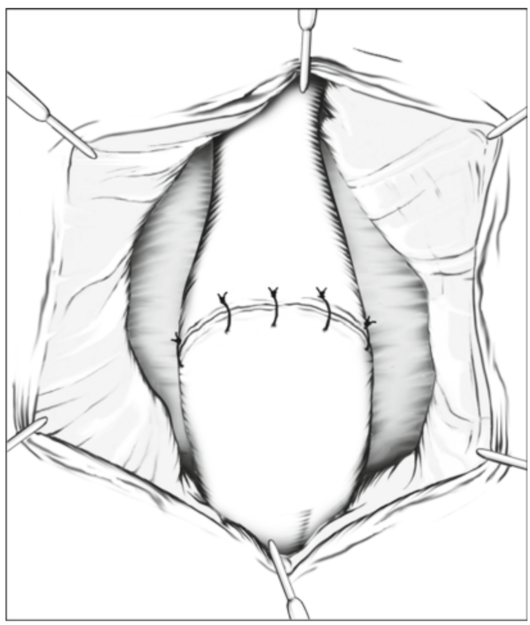

Fig. 12.13 Completed anastomosis

hemostasis has been obtained. Because the spongiosum is a highly vascular structure and wound hematoma is a recognized postoperative complication, it has been our routine to use a closed-suction drain for the first 24 h. This may be particularly useful in young patients who might experience nocturnal erections or patients undergoing extensive intercrural dissection.

Refinements of Technique

Urethral reconstruction is a very dynamic field and authors strive permanently to improve their results. As a consequence, several interesting refinements of the classic technique for EPA have been proposed recently, following a trend for an each time more anatomic- and function-sparing approach.

Vessel Sparing Technique

In 2007 Jordan introduced the concept of vessel sparing for proximal bulbar reconstruction [20, 21] (see Chap. 34 by Kulkarni for details). Although the spongiosum is a highly vascular structure, ischemia has been claimed as one of the possible factors for reconstruction failure. Advanced age, previous trauma or surgery, intensive spongiofibrosis, smoking, diabetes mellitus, peripheral vascular disease, and radiation therapy among others can compromise urethral blood supply and theoretically a well-irrigated reconstruction should heal better. Moreover, some patients may need future implantation of an artificial sphincter, and the vascular status of the bulb is crucial to avoid cuff erosion. This approach is suitable when performing EPA for proximal bulbar or bulbo-membranous strictures. The proximal bulbar urethra is detached from the triangular ligament and is exposed as it exits the bulb to become the membranous urethra. At this point a posterior plane is developed between the membranous urethra and the bulb through which a vessel loop is placed to retract the bulbar arteries away; the membranous and proximal bulbar urethra is then adequately exposed for EPA as usual. Despite that this concept has not been validated with comparative data, it makes good sense to preserve as much blood supply as possible.

Non-transecting Anastomotic Technique

Following the same aim, Andrich and Mundy described a similar approach for proximal bulbar strictures, but instead of dissecting the membranous urethra for vessel isolation and retraction, the proximal bulbar urethra is approached exclusively from its dorsal (anterior) aspect and dissected from the surrounding corpus spongiosum without transection of the bulb [23] (see Chap. 38 for more details of this technique). The stricture is removed and the spatulated end-to-end anastomosis is performed with standard technique. Blood supply to the bulb is preserved since the corpus spongiosum remains intact. They report on 22 patients without recurrence at 1 year of follow-up; in four of their cases with short strictures, the fibrosis was not excised but the urethra was simply opened longitudinally and closed transversely using the Heineke-Mikulicz principle, in what they called “stricturoplasty.” Using this same principle, Lumen and coworkers report the use of the Heineke-Mikulicz urethroplasty in 10 patients, 6 of whom were located in the bulbar urethra, with 100 % success at a mean follow-up of 46.6 months. Only patients with a short (<1 cm) and a not too narrow stricture were candidates for this procedure [24].

Muscle Preserving Technique

In addition to vascular sparing, there is also interest for preservation of the bulbospongiosum muscle and its perineal innervation. In a recent report, Barbagli and coworkers propose a new technique for muscle- and nerve-sparing bulbar urethroplasty [25] (see Chap. 34). In this procedure, the bulbospongiosum muscle is not opened in the midline as in the standard bulbar approach, but carefully dissected from the underlying corpus spongiosum and gently retracted down proximally to expose the bulb. The authors claim that in this way innervation and function of the bulbospongiosum muscle is better preserved to avoid post-void dribbling and ejaculatory dysfunction. Although the patients in their report were reconstructed exclusively using oral mucosa grafts, this principle is clearly also suitable for EPA.

Postoperative Care

Oral intake can be resumed a couple of hours after recovery from anesthesia. Usually patients are kept under bed rest for 12–24 h and discharged home the day after surgery. However, there is a trend for outpatient surgery in urology just like in most areas of surgery. Anterior urethroplasty and particularly stricture excision and primary anastomosis are well suited for this approach in properly selected cases. According to recent reports, outpatient surgery decreases costs and increases patient satisfaction without compromising the overall surgical outcome [7, 26, 27]. Eligible candidates are well-motivated patients, able to understand and follow hospital instructions regarding precautions and postoperative self-care. Patients who are of advanced age or have significant comorbidities, complex difficult reconstructions, poor reliability, or unsatisfactory social support system are best admitted for hospital management. Nevertheless, even with these restrictions, a considerable percentage of patients can be good candidates for outpatient surgery. Soft elastic compressive perineal dressings, effective oral analgesia, and limited home activity are important. Some surgeons also use local wound anesthesia and perineal ice packs. For outpatient surgery drains are not used, and precise surgical technique with meticulous hemostasis is very important to avoid hematoma. In our opinion, the decision to perform outpatient urethroplasty should be taken according to the social and cultural status of the particular population under care in each center. Unfortunately, it may not be feasible in many parts of the world.

Regarding catheter removal, there is no consensus about the time the catheter is left in place after surgery, and it is mainly an issue of personal preference. Most authors would leave the catheter for 1–3 weeks and perform a pericatheter urethrogram before its removal to exclude the presence of extravasation [5, 8, 9, 28]. However, in the present time of minimal impact surgery, some authors have advocated early catheter removal to reduce patient disability. Al-Qudah et al. [29] performed voiding cystourethrogram on day 3 and noted extravasation in only 2 of 12 patients (17 %) with anterior anastomotic reconstructions. In the 10 patients without extravasation, the catheter was removed immediately, while patients with extravasation had their Foley replaced. The voiding cystourethrogram was repeated 1 week later in these two cases and was normal in both. There were no differences in outcome compared to another group of patients with "late" (8–14 days) catheter removal [2]. Although larger series are needed to confirm this approach, it seems feasible to individualize the management of each case and each type of reconstruction in order to avoid unnecessary time of catheterization.

Clinical Outcomes of Excision and Primary Anastomosis

Excision and primary anastomosis is the procedure that offers the best chance for long-term cure of anterior urethral strictures. Table 12.1 shows a collection of 12 series from the literature with more than 1,000 patients and long follow-up; cure rates ranged from 86 to 98.8 %, with an average of 92 %. Particularly notable is the series by Eltahawy et al. which is the largest cohort of bulbar EPA in the literature to date. They reported on a series of 260 patients with only 3 failures (98.8 % success rate) at a mean follow-up of 50.2 months. Length of follow-up is important because it has been shown that failures may appear many years after surgery. In a cohort of 166 patients, Andrich et al published re-stricture rates of 7, 12, 13, and 14 % after 1, 5, 10, and 15 years [31]. However, recurrence rate is influenced by the type of reconstruction, and although some late failures may occur as late as 15 years, most present within the first 5 years [31, 36].

As with any open surgery, urethral reconstruction may be associated with significant patient discomfort and postoperative pain.

Table 12.1 Results of excision and primary anastomosis for anterior urethral stricture

Author	No. of patients	Avg. length	% Success	Follow-up
Eltahawy et al. [30]	260	1.9 cm	98.8	50.2 month
Santucci et al. [9]	168	1.7 cm	95.2	72 month
Andrich et al. [31]	82	-	86	180 month
Micheli et al. [6]	71	0.5–3 cm	93	60 months
Martinez-Piñeiro et al. [32]	69	<3 cm	88	44.4 months
Jakse et al. [33]	60	1–4 cm	93.3	45 months
Lindell et al. [34]	49	<2.5 cm	95.9	12–48 months
Panagakis et al. [35]	42	<2 cm	95.2	3–72 months
Kessler et al. [36]	40	–	86	72 months
Gupta et al. [37]	24	2.2	87.5	26.7 months
Barbagli et al. [38]	165	1–5 cm	90.9	64 months
Elgammal [39]	25	1.5 cm	96	36 months
Total	1,055		92	

However, in one prospective survey of 25 consecutive patients, Shenfeld et al. [40] found that recovery of a normal urinary flow after urethroplasty was linked to a very high degree of patient satisfaction, which clearly overcame the bother and pain associated with the surgery. As it can be anticipated, degree of satisfaction correlated directly with the objective results of surgery, as evaluated by peak urinary flow improvement [40].

Surgical complications of urethroplasty are more frequent and significant with long, time-consuming, or complex reconstructions. Excision and primary anastomosis has a low surgical complication rate, ranging from 6 to 10 % in different series, most of which were minor [4, 9, 32, 33]. Complication rates can be greater when investigated purposefully. In a detailed study of urethroplasty complications, Al-Qudah and Santucci performed a thorough review of their series looking for any possible complication and also directly questioned the patients for self-reported complaints. Early complications in 24 anterior anastomotic urethroplasty were 25 % minor and 0 % major. Late complications were 42 % minor and 21 % major (erectile dysfunction in 4 patients and chordee in 1). All early complications were resolved but some late complications were not [17]. However, mean follow-up in this series was only 26 months, and some late complications were prone to favorable resolution in time, particularly those related to sexual function.

Impact on sexual function is a well-known concern with urethral surgery. Surgery around the bulb can theoretically damage neurovascular structures important for erection. Although some studies have shown very little or insignificant effect on erectile function [41], others have reported that acute dysfunction can be as high as 53 % after anastomotic urethroplasty, but it resolved with time in most cases with a definitive erectile failure rate around 5 % [42, 43]. In a prospective study, Erickson and coworkers evaluated the erectile function of 52 patients undergoing anterior urethroplasty (35 bulbar and 17 penile). Postoperative erectile dysfunction was observed in 38 % of patients, and bulbar urethroplasty was more likely than penile surgery to cause erectile function impairment; by 6 months 90 % of patients returned to normal function [44]. The incidence of sexually related problems may be higher when studied using self-applied questionnaires [17, 30, 45]. In one survey, questionnaires were mailed to 200 patients who underwent anterior urethroplasty and to 48 patients who underwent circumcision. Overall satisfaction with erection worsened after surgery in 30.9 % of patients in the urethroplasty group; however, there were no statistical differences in sexual complaints compared with the circumcision group [45]. Reported cases with permanent postoperative erectile dysfunction correspond mainly to bulbo-prostatic anastomosis after pelvis fracture injury or tend to have longer strictures and increasing age [31, 41, 43]. Definitive erectile failure after bulbo-bulbar anastomosis is rare and has been reported in large series to go from 0 to 1.8 % [4, 9, 30, 43].

Failure of this procedure is usually the result of ischemia or incomplete resection of the fibrous disease. Ischemia occurs because of poor vascularity of the corpus spongiosum or excessive tension at the anastomosis. Advanced age, previous surgery, heavy smoking, and certain comorbidities (diabetes mellitus and peripheral vascular disease) are risk factors for poor vascular status. Too much tension can also cause suture dehiscence, urine extravasation, and increased collagen deposit in the healing wound leading to undesired fibrosis. Fortunately, in most cases this fibrosis is mild and failures can be “rescued” with a single optical urethrotomy, taking the final success rate close to 100 % [6, 9, 36].

Conclusions

Stricture excision and primary anastomosis is the simplest and most effective surgical treatment for anterior strictures. After resecting all fibrotic urethra, a wide mucosa-to-mucosa tension-free end-to-end anastomosis is performed to restore urethral continuity. This procedure is ideally suited for bulbar strictures 1- to 3-cm long. According to the local anatomy, this technique can also be successful in some selected cases with bulbar strictures up to 5 cm in length. Because the anterior penile urethra is stretched during erection, this procedure is limited in the penile urethra, as it can produce excessive shortening of the urethra and ventral curvature of the penis on erection. Complications are rare, mainly infection or hematoma of the operative wound. Sterile urine at the time of surgery and meticulous hemostasis are required to avoid them. Late failures are related to excessive tension at the anastomosis or incomplete stricture resection. Complete excision of the fibrotic urethra is essential, and the surgeon must be prepared to perform an alternative form of repair if this resection results in a defect too long for a tension-free reconstruction. When performed properly, excision and primary anastomosis is a well-tolerated, low-morbidity, and highly effective procedure, with a well-documented long-term cure rate of up to 92 %.

Surgical Pearls and Pitfalls

Key Points

- Obtain a precise preoperative anatomic diagnosis of the disease to be treated. Reject low-quality studies. If possible, perform your own radiology.
- The stricture is always longer than what is suggested by radiology. Be prepared to perform a reconstruction longer than anticipated.
- Use a soft rubber catheter to locate and expose the urethra and to identify the distal stricture site but be extremely gentle to avoid perforation or dilation of the stricture.
- Avoid injury to the urethra when mobilizing from the corpus cavernosum.
- Retrograde methylene blue can be used for better visualization of the urethral mucosa, but injection must be gentle to avoid dye extravasation.
- Be sure to remove all scar tissue: urethral walls should be free of fibrosis, both ends should calibrate softly to 26–28 F, and mucosa should be smooth and pink.
- Perform a wide spatulated anastomosis.
- Watertight closure of the spongiosum is important to avoid hematoma, particularly when the bulbar arteries have been preserved.
- Pay attention to bleeding: blood loss from the open spongiosum can be substantial.

Potential Problems

- *Failure to accurately identify the stricture site*: Perform a long buccal mucosa graft instead.
- *Too much bleeding obscuring the field*: Apply a soft bulldog clamp to the proximal stump or a soft vessel-loop tourniquet to bulbar arteries.
- *Too much tension at the anastomosis*: Further distal mobilization of the urethra and remotion of Buck’s fascia to increase elasticity, deep opening of the intercrural septum, proximal mobilization dividing the perineal body, and detaching the membranous urethra from triangular ligament.

Preferred Instruments and Suture of Reynaldo G. Gomez

Instruments

Although I use pretty much standard surgical instruments for urethroplasty, I also use:

2.5× magnifying loupes

Fiber-optic headlight

Intraoperative rigid urethroscopy

Bipolar electrocautery for hemostasis around the spongiosum and proximal urethra

DeBakey vascular forceps to handle the spongiosum and urethra

Ball-point curved Potts scissors for longitudinal urethrotomy

A rubber inter-molar retractor (for oral mucosa procurement)

I always use the Scott (Lone Star ®) retractor. My favorites are the medium-size (blue) hooks and the double (green) hooks.

Suture

As suture material in the urethra, I almost always use 4/0 and 5/0 poliglecaprone (MONOCRYL ®) on a RB-1 needle.

Editorial Comment

Stricture excision and primary anastomosis is among the most reliable operations in all of urology. Substitution urethroplasty, in contrast, has a lower short-term success rate and a recurrence rate that progressively increases with time. Whenever possible, end-to-end urethroplasty is the urethral reconstructive method of choice. In order to bridge the gap of excised urethra, the distance between the ends of the urethra needs to be shortened by taking advantage of the natural elasticity of the mobilized urethra.

What are the key steps for performing EPA urethroplasty on long strictures? After initial perineal exposure, we visualize the stricture by passing a flexible scope to the point of obstruction, where the spongiosum is marked with electrocautery. We then amputate at the distal end of the stricture – we would rather trim a few millimeters of scar from the distal segment than amputate too distally, thus wasting valuable normal urethra. We then mobilize the scrotal attachments from the ventral aspect of the distal bulb while pulling down with a 3-0 traction suture. Toothed Gerald or “rat tooth” forceps are helpful for grasping the corpora precisely next to the spongiosum. We mobilize immediately after amputation, thus completing the entire distal part of the operation at this stage while maintaining proximal hemostasis with an angled DeBakey vascular clamp. Segmental resection of the proximal segment is then performed until an ample lumen is identified. Intermittent irrigation with a small syringe of saline is helpful to promote good visualization in a deep surgical field. We preserve the surrounding proximal spongiosum whenever possible, thus secondarily preserving the bulbar arterial supply. A ventral spongioplasty with fine running suture ensures hemostasis.

Although sterile urine is nice to have, I have never canceled a case due to positive urine culture. Most patients are chronically colonized from obstructive voiding or SP tubes, all patients receive several doses of IV broad-spectrum antibiotics perioperatively, and wound infection is extraordinarily rare in this well-vascularized surgical field.

–Allen F. Morey

Editorial (2)

Whenever possible, anastomotic urethroplasty is clearly the preferred method of urethral reconstruction, because of its high success rate and durability. However, in young patients with bulbar urethral strictures that are nonobliterative and of a nontraumatic etiology, I am concerned about the potential sexual side effects to erection and glans sensation with stricture excision and primary anastomosis (EPA) surgery. I have been influenced by the Italian reported series (Barbagli, Palminteri) and British series (Andrich, Mundy). Therefore, for bulbar urethral strictures that are of nonobliterative and nontraumatic etiology, for the last few years, I have been performing either a dorsal or ventral buccal graft urethroplasty or a non-transecting anastomotic urethroplasty and stricturoplasty (see Chap. 38). When the urethral plate is segmentally very narrow (<9 mm, yet

>4 mm), I have been using the Palminteri technique (see Chap. 33 herein). Admittedly, the results of a graft urethroplasty are poorer than in an EPA, but urethroplasty is a quality of life surgery. And to render a young patient with sexual dysfunction after urethroplasty, even if the chances are remote, has potentially gave long-term quality of life consequences. For such select young patients, I feel that the remote risks of ED outweigh the benefits of more durable voiding by EPA. Therefore, I will accept the slightly poorer long-term outcomes of substitution and chance post-void dribbling to avoid any ED. While the answer may be to perform more non-transecting anastomotic urethroplasty and stricturoplasty for short bulbar strictures, I have had technical difficulty performing such surgery when the strictures were proximal. I admit that ED after urethroplasty is controversial and that a recent meta-analysis did not show a statistical difference. However, I feel that future studies with sufficient powered size, and with properly evaluated patients with validated sexual questionnaires and glans sensory testing, will bear out my concerns.

–Steven B. Brandes

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13 Oral Mucosal Graft Urethroplasty

Guido Barbagli and Salvadore Sansalome

Summary

Oral mucosa has received increased attention in the field of urological reconstructive surgery because it is readily available, it is easily harvested from the cheek, and it leaves a concealed donor site scar.

Surgical treatment of adult penile and bulbar urethral strictures has been a constantly evolving process and considerable changes have recently been introduced. Here we report the development and the evolution of one-stage oral mucosal graft urethroplasty with detailed surgical techniques. We describe penile dorsal inlay oral mucosal graft urethroplasty, bulbar ventral onlay oral mucosal graft urethroplasty, and bulbar dorsal onlay oral mucosal graft urethroplasty. New tools such as muscle- and nerve-sparing techniques, fibrin glue, or engineered material will become a standard in future treatment. In reconstructive urethral surgery, the superiority of one approach over another is not yet clearly defined. The surgeon must be competent in the use of various techniques to deal with any condition of the urethra present at the time of surgery.

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Introduction

In an interesting historical overview on the employment of oral mucosa as surgical substitute material, Filipas et al. [1] traced its use in other medical areas to its development and application in urology. In 1993, for the first time, El-Kasaby et al. [2] reported that the oral mucosal graft from the lower lip was used for treatment of penile and bulbar urethral strictures in adult patients without hypospadias. In 1996, Morey and McAninch [3] reported indications, operative technique, and outcome in 13 adult patients with complex urethral strictures in which oral mucosa was used as a non-tubularized onlay graft for bulbar urethra reconstruction. Since that time, oral mucosa has become an increasingly popular graft tissue for penile or bulbar urethral reconstruction performed in single or multiple stages.

Oral mucosa has received increased attention in the field of urological reconstructive surgery as it is readily available in all patients and is easily harvested from the cheek with a concealed donor site scar with low postoperative complications and high patient satisfaction [4]. Moreover, oral mucosa is hairless, has a thick elastin-rich epithelium which makes it tough yet easy to handle, and has a thin and highly vascular lamina propria which facilitates inosculation and imbibition [4–6]. Surgical treatment of adult penile and bulbar urethral strictures has been a constantly evolving process, and considerable changes have been introduced with the dorsal onlay approach [7, 8], also known as the Barbagli procedure [9].

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Development and Evolution of Dorsal Onlay Graft Urethroplasty

Several experimental studies and clinical experiences have contributed to the development and evolution of dorsal onlay urethroplasty in surgical treatment of penile and bulbar urethral strictures. In 1979, Devine et al. [10] popularized the use of free skin graft techniques in anterior urethral reconstruction. In 1980, Monseur [11] described a new urethroplasty opening the urethra along its dorsal surface and fixing the opened urethra over the corpora cavernosa. Regeneration of the urethral mucosa is obtained by leaving a catheter in place for a long period of time [11]. In 1996, we combined Devine's technique with Monseur's and described the first penile and bulbar dorsal onlay skin graft urethroplasties [7, 8]. In our technique, the graft is sutured to the corpora cavernosa, and the urethra, which is opened along its dorsal surface, is sutured to the lateral margins of the graft. Regeneration of urethral mucosa is facilitated by the graft that works as an epithelial roof strip, thus considerably reducing the time for urethral regeneration. According to experimental and clinical studies by Weaver and Schulte [12, 13] and Moore [14], the dorsal buried epithelial strip facilitates urethral regeneration without formation of the scar tissue. Over time, our original technique has been greatly improved and new changes are continuously being suggested [15, 16]. Moreover, the dorsal placement of the graft may be combined with Snodgrass's incision of the urethral plate [17], as suggested by Hayes and Malone for childhood hypospadias surgery [18] and by Asopa et al. for penile and bulbar urethroplasty in adults [19].

Significance of Urethral Anatomy and Selection of Surgical Technique

Penile urethroplasty is usually a simple procedure in patients with a normal penis, but it can be a difficult challenge in men with strictures associated to failed hypospadias repair or genital lichen sclerosus, in which the penis is fully involved in the disease [20]. In general, the choice of surgical technique for repair of penile urethral stricture is based on the etiology of the disease [20]. In patients with a normal penis, the penile skin, urethral plate, corpus spongiosum, and dartos fascia are suitable for urethral reconstruction, and one-stage urethroplasty using a dartos fascial flap with a penile skin island or using a free graft is the surgery of choice worldwide [21]. In patients who have experienced failed hypospadias repair or lichen sclerosus, rendering the penile skin, urethral plate, and dartos fascia unsuitable for urethral reconstruction, staged urethroplasty is generally recommended [20]. Selection of a surgical technique for penile urethra reconstruction, in addition to respecting the status of the penile tissue and components, must also be based on proper anatomic characteristics of the penile tissues to ensure flap or graft take and survival. Furthermore, sexual function can be placed at risk by any surgery on the genitalia; thus, dissection must avoid interference with neurovascular supply to the penis. Flaps or grafts should not compromise penile length or cause penile chordee and should certainly not untowardly affect penile appearance [20, 21].

In the bulbar urethra, the relationship between the spongiosum tissue and the urethral lumen is different from that noted in the penile urethra. The corpus spongiosum is thicker in its ventral aspect and dorsally thinner. Furthermore, the urethral lumen is located dorsally and not centrally; thus, a dorsal incision may more likely to preserve the residual blood supply to the spongiosum tissue. Adequate neovascularization of the graft is achieved by applying the patch so that it adheres to the corpora cavernosa, and spread fixation may decrease the risk of graft contraction and sacculation [7–9]. The oral graft is covered by the intact overlying urethral plate and corpus spongiosum (Fig. 13.1), and fistula formation or graft necrosis has not yet been reported in the literature following this procedure. In patients who have undergone repeated and deep internal urethrotomies at 12-o'clock position, the urethral lumen may be adherent and firmly fixed to the tunica albuginea because the longitudinal internal cut involves the urethral mucosa, spongiosum tissue, and tunica albuginea. Unfortunately, the healing of this kind of urethrotomy, along with the urine

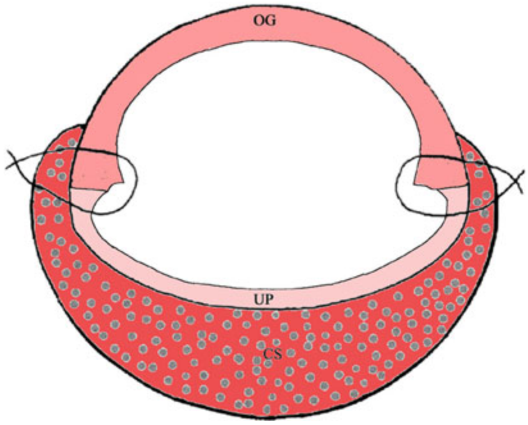

Fig. 13.1 Dorsal onlay graft: the oral graft (*OG*) is applied on the corpora cavernosa and covered by the urethral plate (*UP*) and by the intact spongiosum tissue (*CS*)

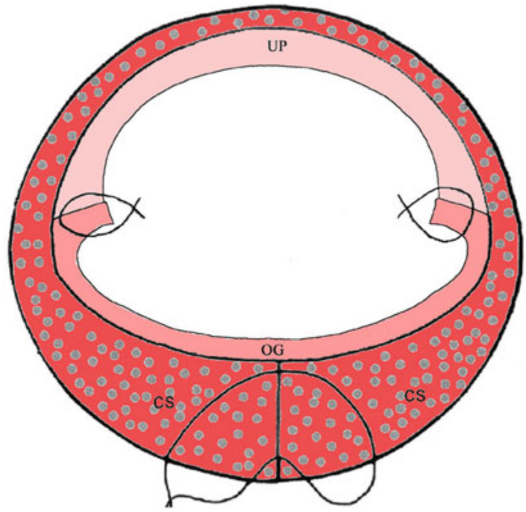

Fig. 13.2 Ventral onlay graft: the oral graft (*OG*) is applied on the urethral plate (*UP*) and the spongiosum tissue (*CS*) is closed over the graft

extravasation, can cause a scar that fuses the urethral mucosa to the tunica albuginea. In this situation, mobilization of the urethra from the corpora cavernosa may be difficult. In patients with a urethral stent in place, it likewise may be more difficult to approach and free the dorsal urethral lumen. In obese patient, exposure of the dorsal urethral surface may also not be optimal. Finally, in patients with previous failed urethroplasty or with bulbar strictures located more proximally to or just at the external distal sphincter, the dorsal approach to the urethra may be particularly difficult or dangerous for damage to neurovascular penile supply. In these situations, the urethra is not mobilized from the corpora cavernosa but is opened along its ventral surface, and the oral graft is ventrally sutured to the urethral plate and covered by the spongiosum tissue (Fig. 13.2). At present, the dorsal and ventral onlay urethroplasties are made using a minimally invasive approach with the muscle- and nerve-sparing techniques [16, 22]. We present here three surgical techniques for one-stage repair of penile or bulbar urethral strictures using oral mucosal grafts.

Preoperative Evaluation

The clinical history and medical charts of the patient requiring penile urethroplasty must be carefully reviewed, and the genitalia meticulously inspected taking into consideration glans shape, scars in the penile and scrotal skin, the presence of residual foreskin, hair in the meatus, or stones in the urethra.

In addition, the presence of genital lichen sclerosus disease must be excluded. Preoperative retrograde urethrography is mandatory to evaluate the urethral plate. Patients selected for a penile one-stage procedure should be informed that early or later complications, such as hematoma, infection, meatal stenosis, or fistula may occur with any surgical technique.

In patients undergoing bulbar urethroplasty, clinical history and medical charts are reviewed to evaluate present effects of previous perineal blunt trauma or repeated failed urethrotomy or urethroplasty. Preoperative retrograde urethrography is mandatory to evaluate the site, number, and length of stricture, and voiding cystourethrography is useful in evaluating continence of the bladder neck and urethral dilation proximally to the stenosis. Sonourethrography and urethroscopy are suggested to collect more detailed information on stricture characteristics. Patients are fully informed that bulbar urethroplasty is a safe procedure as far as sexual function is concerned.

The patient's clinical history as well as the stricture etiology, location, and length must be carefully examined to better define the characteristics needed in the oral mucosa graft. Patients who currently had an infectious disease of the mouth (such as Candida, Varicella virus, or Herpes virus) or who have had previous surgery in the mandibular arch that prevented the mouth from being opened wide or who play a wind instrument are informed that genital or extra genital skin would be used for the urethroplasty.

Three days before surgery, the patient should begin using chlorhexidine mouthwash for oral cleansing and continue using it for 3 days following surgery. A broad-spectrum antibiotic is administered intravenously during the procedure and for 3 days afterward.

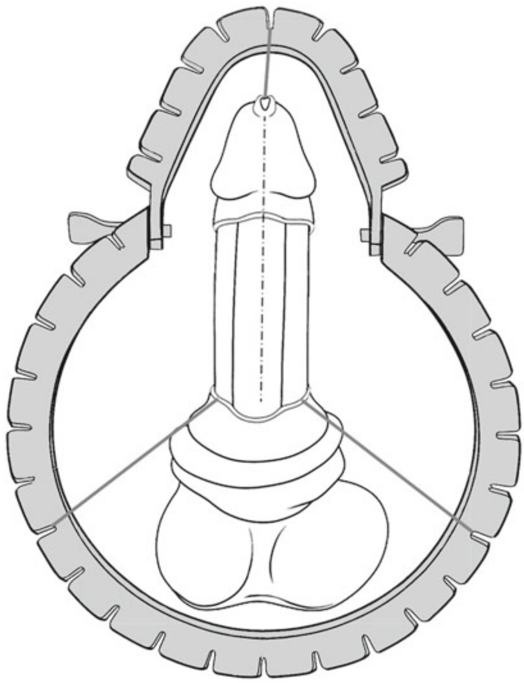

Fig. 13.3 Degloving of the penis with circumcoronal incision. The ventral longitudinal incision on the glans and penile urethra is noted by dotted line

Surgical Techniques

Penile One-Stage Dorsal Inlay Oral Mucosal Graft Urethroplasty

The patient is placed in supine position for distal penile stricture and in simple lithotomy position for proximal penile stricture. Methylene blue is injected into the urethra. In patients with a distal penile stricture, a circumcoronal incision is made, and the penile urethra is exposed (Fig. 13.3). In patients with a proximal penile stricture, the stricture is approached using a midline perineal incision. The stenosis is ventrally opened and the midline incision of the mucosal urethral plate is underlined (Fig. 13.4). The urethral mucosal plate is longitudinally incised on the midline down to the tunica albuginea of the corpora cavernosa, and the wings of the urethral mucosal plate are laterally mobilized to create a bed for the graft (Fig. 13.5). The oral mucosal graft is sutured and quilted onto the bed of the dorsal urethral incision using interrupted 6-0 polyglactin sutures, and an augmentation of the urethral plate is thus obtained (Fig. 13.6). The urethra is closed and tubularized up to the glans over a Foley 12 Fr grooved silicone catheter, taking advantage of the mobilized wings of the urethral plate (Fig. 13.7). The glans and the urethra are closed (Fig. 13.8). The catheter is left in place for 2 weeks.

Preparation of the Bulbar Urethra

The patient is placed in simple lithotomy position. The patient's calves are carefully placed in Allen stirrups with sequential inflatable compression sleeves, and the lower extremities are then suspended by the patient's feet within the boots of the stirrups. Proper positioning ensures that there is no pressure on any aspect of the calf muscles and no inward boot rotation to avoid peroneal nerve injury. The skin of the suprapubic region, scrotum, and perineum is shaved, and the region is draped appropriately and disinfected using chlorhexidine.

Methylene blue is injected into the urethra to better define the urethral mucosa involved in the disease. A midline perineal incision is made (Fig. 13.9).

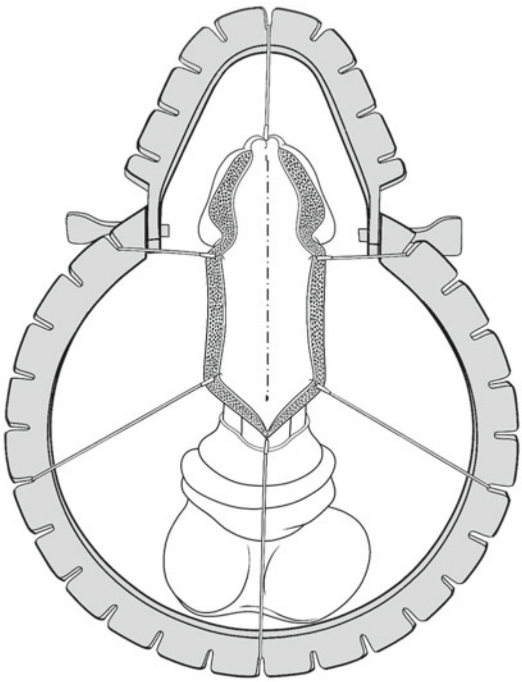

Fig. 13.4 The glans and the penile urethra are fully opened, and the midline incision of the mucosal urethral plate is noted by dotted line

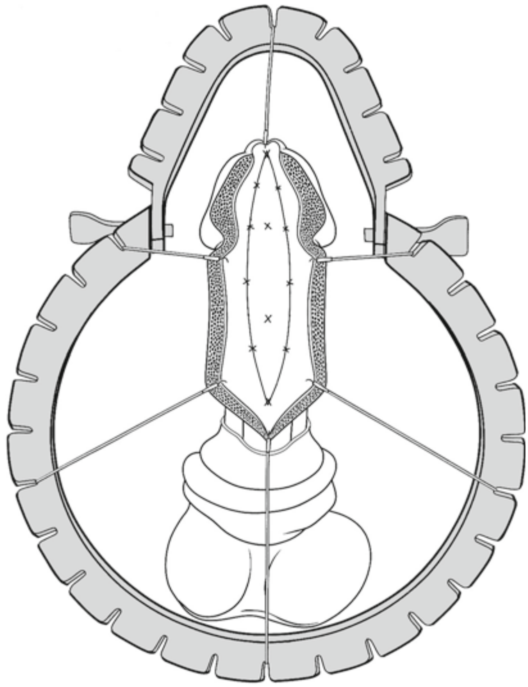

Fig. 13.6 The graft is sutured and quilted in the middle of the urethral plate

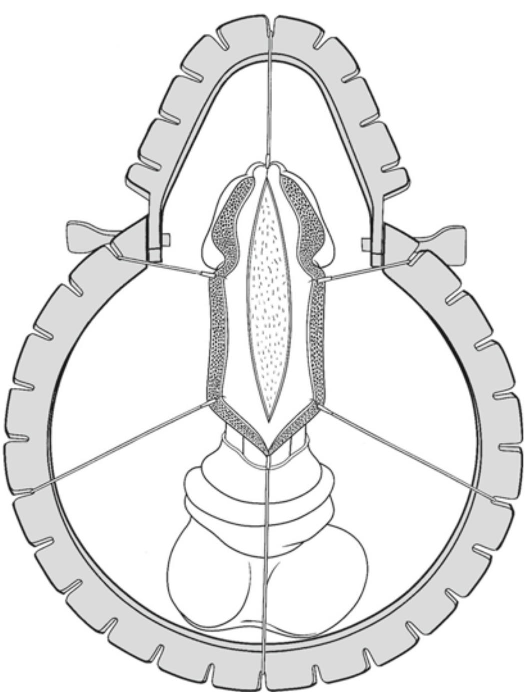

Fig. 13.5 The mucosal urethral plate is incised in the midline

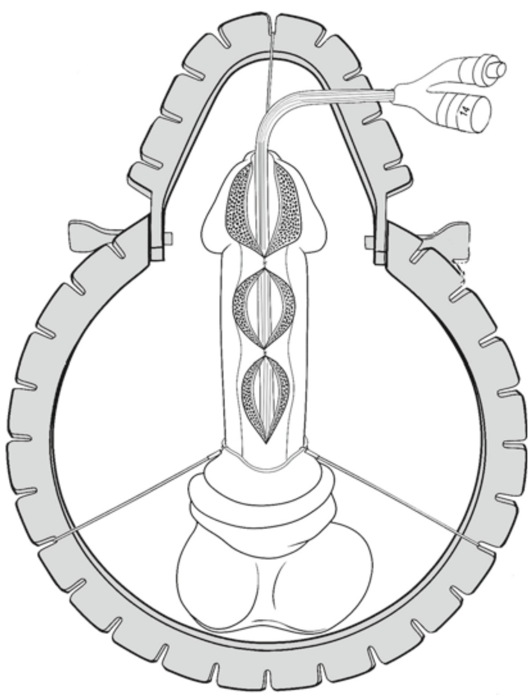

Fig. 13.7 The catheter is inserted and the ventral urethral surface is closed

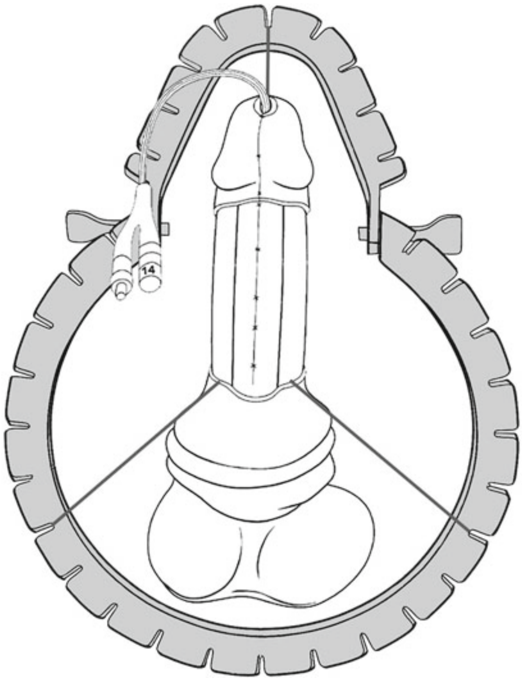

Fig. 13.8 The glans and the urethra are closed

Ventral Onlay Oral Mucosal Graft Urethroplasty

The bulbo-spongiosum muscle is separated from the corpus spongiosum of the bulbar urethra using delicate smooth scissors, leaving the lateral margins of the muscle and the central tendon of the perineum intact (Fig. 13.10). The bulbo-spongiosum muscle is pulled down, the ventral urethral surface is exposed, and the corpus spongiosum is opened along its ventral surface (Fig. 13.11). Once the entire stricture has been fully opened, the length and width of the oral graft required for the augmentation of the urethral plate are measured. The nasal speculum is inserted into the proximal urethral opening, and the white mucosal ring is incised until pink mucosa is identified near the verumontanum (Fig. 13.12). This incision should be limited to the urethral mucosa and does not involve the underlying spongiosum tissue to avoid bleeding. The needle used for a 5-0 polyglactin suture is modified into a J-shaped needle and passed through the spongiosum tissue in front up to the verumontanum (Fig. 13.13).

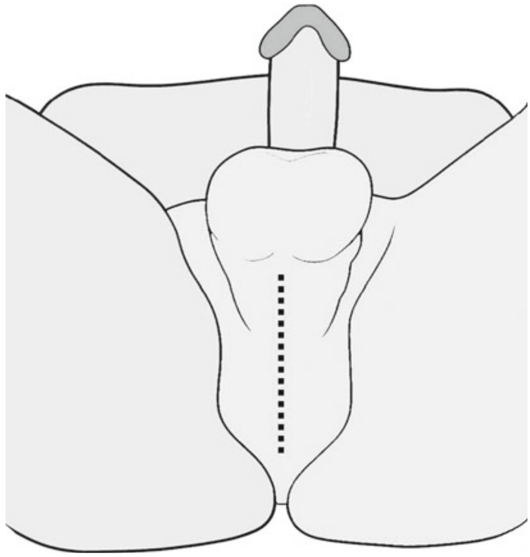

Fig. 13.9 The midline perineal incision is as noted by dotted line

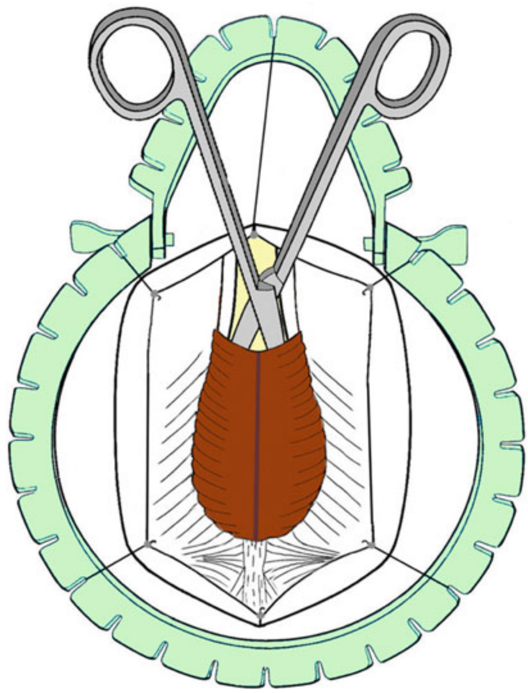

Fig. 13.10 The bulbo-spongiosum muscle is separated from the corpus spongiosum using delicate smooth scissors

Using this technique, three stitches are passed in front up to the verumontanum, at 5, 6, and 7 o'clock (Fig. 13.14). The oral mucosal graft is trimmed to its appropriate size, according to

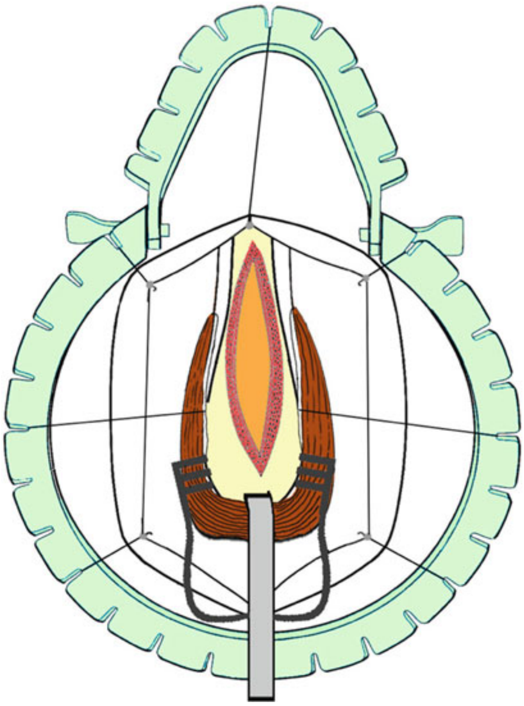

Fig. 13.11 The bulbo-spongiosum muscle is pulled down, and the ventral urethral surface is opened

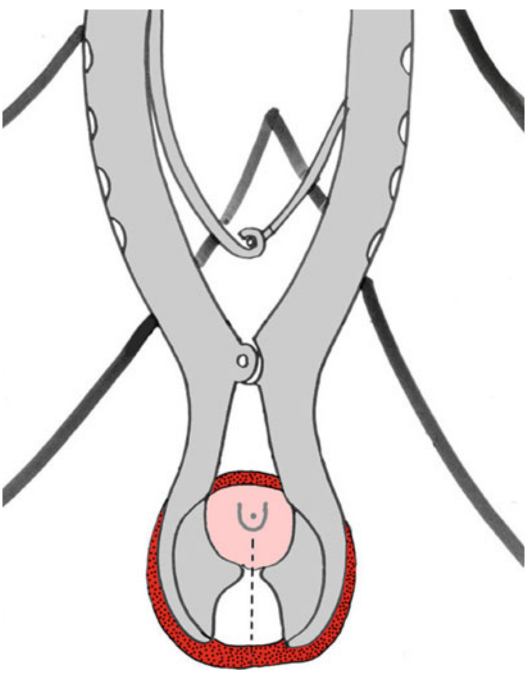

Fig. 13.12 The nasal speculum is inserted into the proximal urethral opening, and the white mucosal ring is incised at 6 o'clock, until pink mucosa is identified near the verumontanum

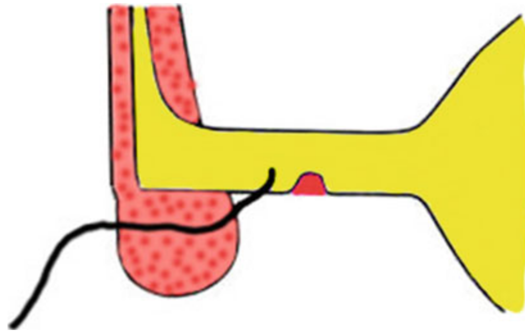

Fig. 13.13 The J-shaped needle is passed through the spongiosum tissue in front up to the verumontanum

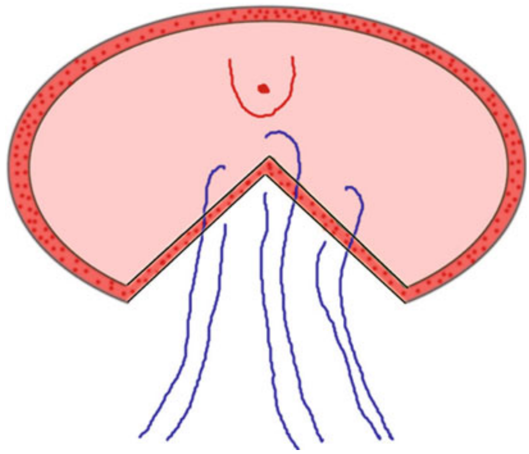

Fig. 13.14 Three stitches are passed in front up to the verumontanum at 5, 6, and 7 o'clock

the length and width of the urethrotomy. A running 6-0 polyglactin suture is used to complete a watertight anastomosis between the margin of the graft and the margin of the urethral mucosal plate (Fig. 13.15). The stitches previously placed at 5 and 6 o'clock in front up to the verumontanum are passed in the proximal oral mucosal graft edge (Fig. 13.15). Using this step, the oral mucosa graft is pushed very deeply inside the healthy urethral mucosa near the verumontanum, where the mucosa is not involved in the scarring process. The stitch previously placed at 7 o'clock in front up to the verumontanum is passed in the proximal oral mucosal graft edge (Fig. 13.16). A Foley 16 Fr grooved silicone catheter is inserted. The graft is rotated over the catheter, and a running 6-0

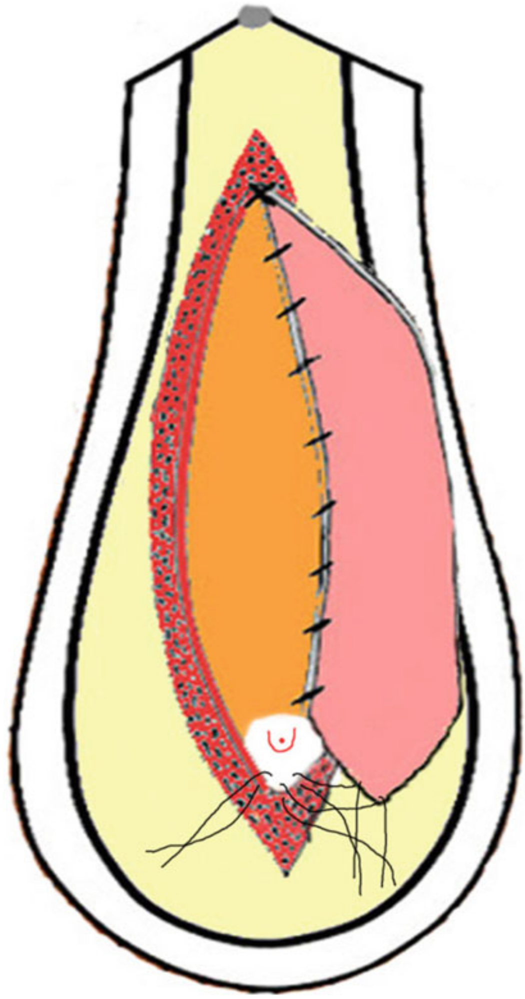

Fig. 13.15 A running 6-0 polyglactin suture is used to complete the anastomosis between the margin of the graft and the margin of the urethral mucosal plate. The stitches placed at 5 and 6 o'clock in front of the verumontanum are passed in the oral mucosal graft edge

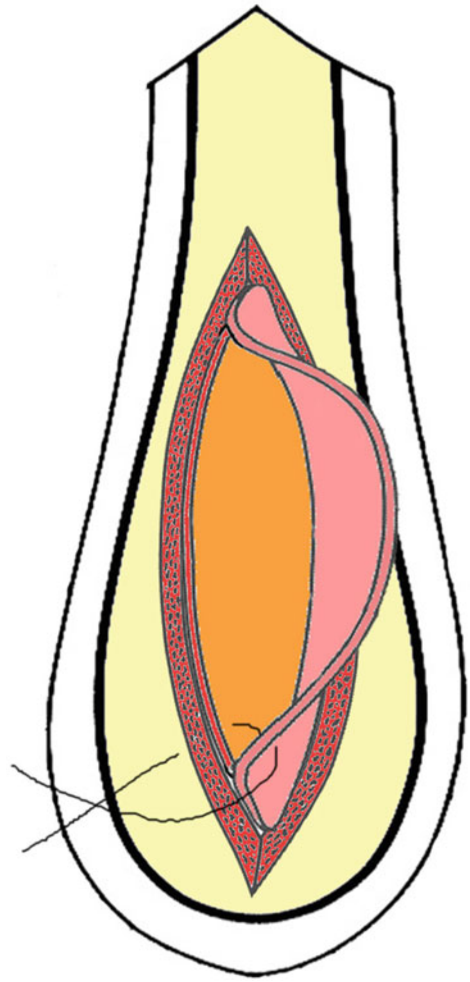

Fig. 13.16 The stitch placed at 7 o'clock in front of the verumontanum is passed in the oral mucosal graft edge

polyglactin suture is used to complete a watertight anastomosis between the right margin of the graft and the right margin of the mucosal urethral plate (Fig. 13.17). The spongiosum tissue is closed over the oral mucosal graft using interrupted 5-0 polyglactin suture and 2 ml of fibrin glue are injected over the suture line of the corpus spongiosum (Fig. 13.18). The bulbo-spongiosum muscle is picked up to cover the spongiosum tissue (Fig. 13.19). Drain is unnecessary. The catheter is left in place for 3 weeks.

Dorsal Onlay Oral Mucosal Graft Urethroplasty Using Fibrin Glue

The bulbar urethra is dissected from the corpora cavernosa only along the left side, starting from the distal tract where muscles are absent, leaving the bulbo-spongiosum muscle and the central tendon of the perineum intact (Fig. 13.20). Along the right side, the urethra remains attached to the corpora cavernosa for its full length, thus preserving its vascular blood supply. On the left side, the urethra is partially rotated and the lateral urethral surface is underlined (Fig. 13.21). The distal extent of the stenosis is identified, the dor-

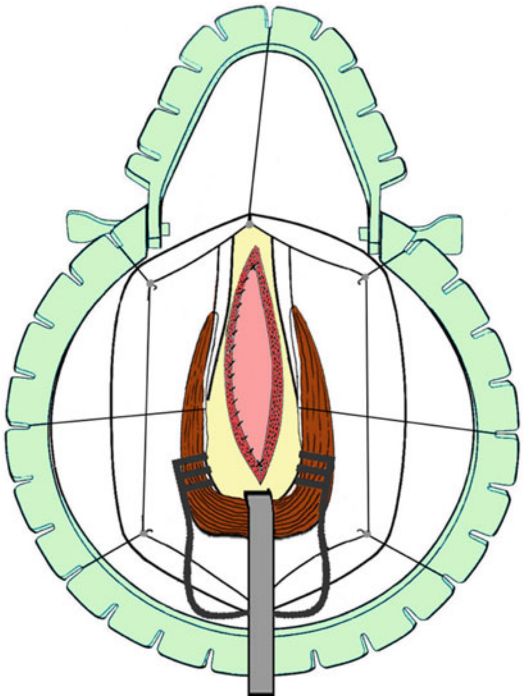

Fig. 13.17 The graft is rotated over the catheter and a running 6-0 polyglactin suture is used to complete the anastomosis between the graft and the mucosal urethral plate

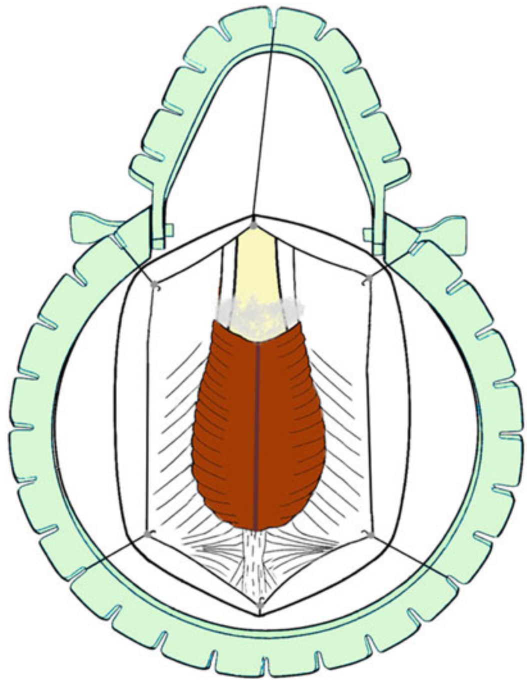

Fig. 13.19 The bulbo-spongiosum muscle is pushed back to its original position

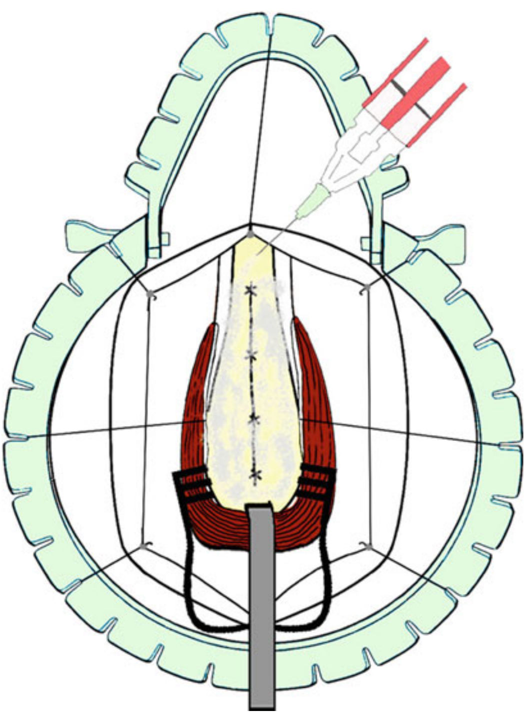

Fig. 13.18 The corpus spongiosum is closed over the oral graft using interrupted sutures and fibrin glue is then injected over the suture line

sal urethral surface is incised along the midline, the urethral lumen is exposed, and the stricture is then incised along its entire length by extending the urethrotomy distally and proximally (Fig. 13.22). Once the entire stricture has been incised, the length and width of the remaining urethral plate are measured. Proximal and distal calibration of the urethra with a special modified nasal speculum is critical for identifying any residual narrowing. The oral mucosal graft is trimmed to an appropriate size according to the length and width of the urethrostomy. The bulbar urethra is moved on the right side, 2 ml of fibrin glue are injected over the albuginea of the corpora cavernosa, and the oral graft is spread fixed over the fibrin glue bed. The two apices of the graft are sutured to the proximal and distal apices of the urethrotomy, and the margin of the oral graft is fixed to the margin of the urethral mucosal plate (Fig. 13.23). A Foley 16 Fr grooved silicone catheter is inserted, and the urethra is rotated to its original position (Fig. 13.24). Interrupted 5-0 polyglactin sutures are used to stabilize the

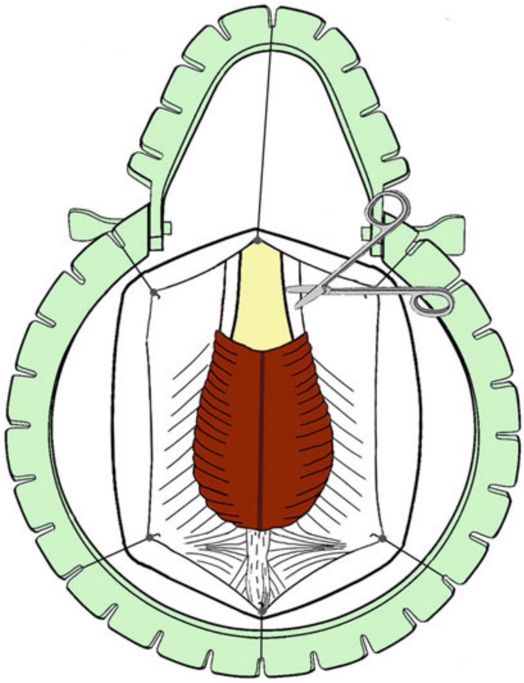

Fig. 13.20 The bulbar urethra is dissected from the corpora cavernosa only along the left side, starting from the distal tract where muscles are absent, leaving the bulbo-spongiosum muscle and the central tendon of the perineum intact

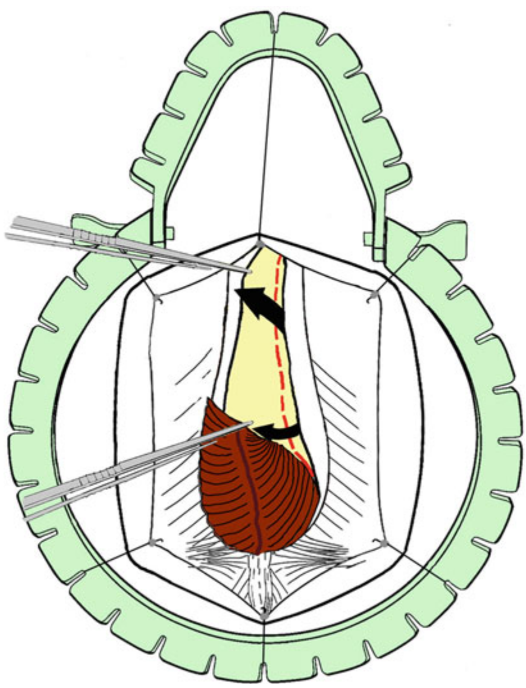

Fig. 13.21 On the left side, the urethra is partially rotated and the lateral urethral surface is underlined

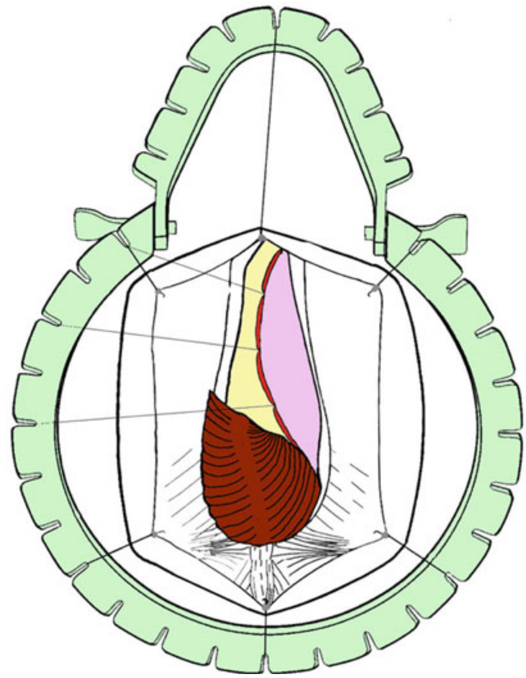

Fig. 13.22 The stricture is opened along its entire length

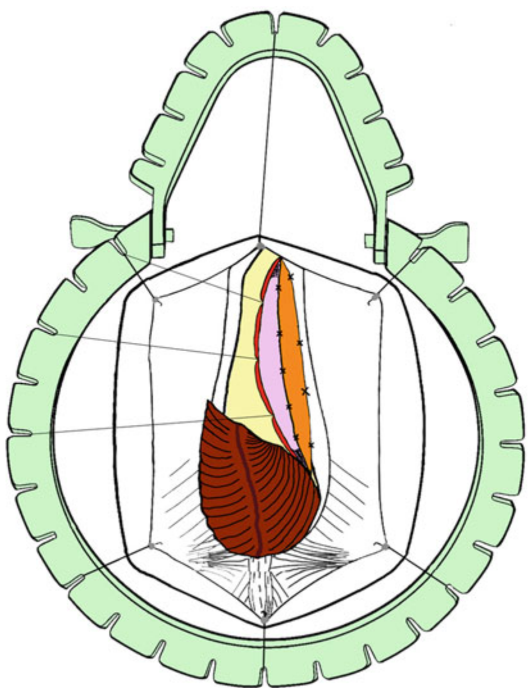

Fig. 13.23 The graft is sutured to the urethral mucosal plate

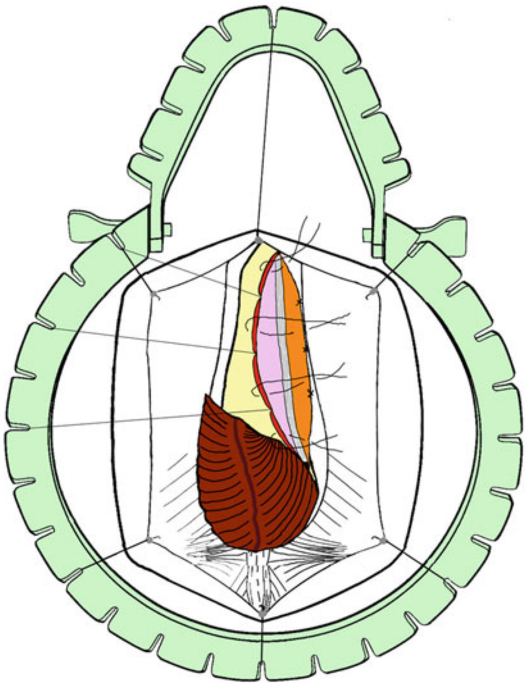

Fig. 13.24 The catheter is inserted and the urethra is rotated to its original position

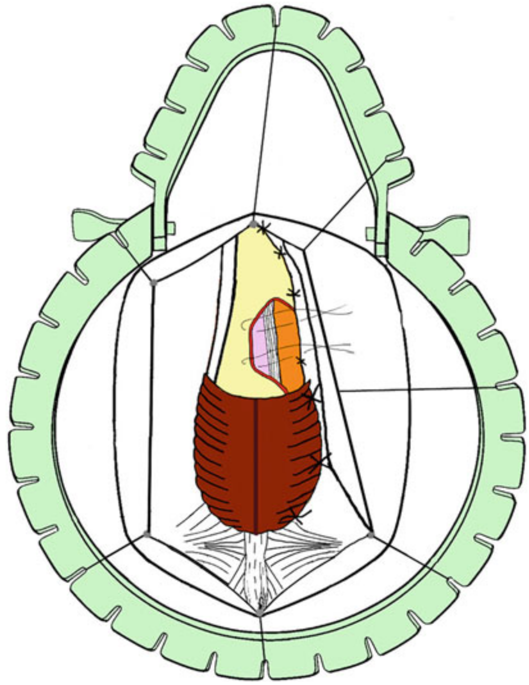

Fig. 13.25 The urethra is fixed to the corpora cavernosa over the graft

urethral margins onto the corpora cavernosa over the graft (Fig. 13.25). At the end of the procedure, the graft is completely covered by the urethra, then by the muscles, and 2 ml of fibrin glue are injected over the suture line (Fig. 13.26). Colles' fascia, the perineal fat, and the skin are closed with interrupted absorbable sutures. The catheter is left in place for 3 weeks.

Postoperative Care and Complications

Two ice bags are immediately applied on the cheek and genitalia to reduce edema, pain, hematoma, and nocturnal erections. The patient initially consumes a clear liquid diet and ice cream before advancing to a soft, then regular diet. The patient is discharged from the hospital 3 days after surgery. Three weeks following surgery, the catheter is removed and voiding cystourethrography is at that time obtained. All patients are

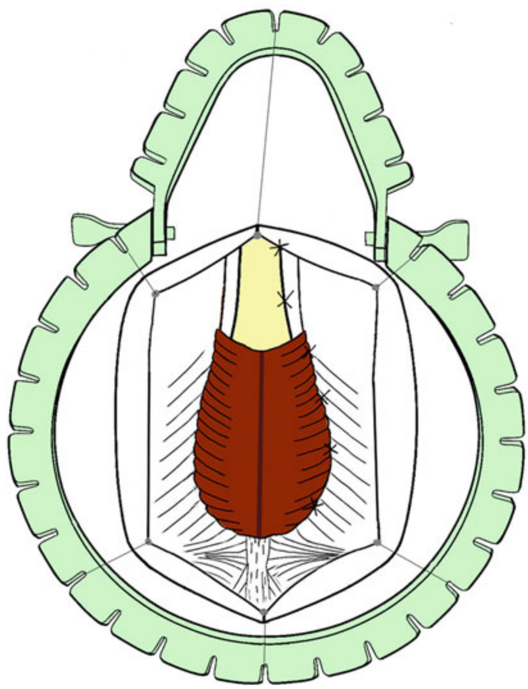

Fig. 13.26 The graft is completely covered by the urethra, then by the muscles, and fibrin glue is injected over the suture line

maintained on oral antibiotics until the catheter is removed.

In patients who have undergone penile urethroplasty, early complications include edema, hematoma, and infection. If infection is present and pus discharges from the urethral meatus, the catheter should be immediately removed and a suprapubic urinary drain left in place. In addition, the patient should be instructed to void through the new urethra twice daily to wash the pus from it. Unfortunately, patients who have early complications, such as hematoma and infection, frequently develop major complications such as suture dehiscence, tissue necrosis, and fistulas. Additional late complications include fistulas, meatal stenosis, meatal retraction, cosmetic defects, and penile skin necrosis. After penile urethroplasty, spontaneous fistula closure has rarely been observed. In such cases, a new surgical approach may be necessary to repair the fistulous tract, or a wide meatotomy may be required for meatal stenosis. In patients who have undergone ventral or dorsal bulbar urethroplasty, a possible early minor complication is urethrorrhagia due to nocturnal erections. Possible later minor complications are temporary numbness, dysesthesia to the perineum, and scrotal swelling.

Discussion

The surgical treatment of adult anterior urethral strictures is continually evolving, and there is renewed controversy over the best means of reconstructing the anterior urethra, since the superiority of one approach over another is not yet clearly defined. The reconstructive urologist must be fully familiar with the use of both flaps and grafts to deal with any condition of the urethra at the time of surgery.

Penile Skin Versus Oral Mucosa

Oral mucosa has become the most popular substitute material in the treatment of urethral stricture disease, and its success is well documented in numerous series of patients having undergone anterior urethral reconstruction. Before the use of oral mucosa as a substitute material, penile skin was the substitute material suggested for anterior urethroplasty. However, is oral mucosa really superior to penile skin? Alsikafi et al. [23] compared the outcome of 95 oral urethroplasty and 24 penile skin graft urethroplasties in an effort to answer whether oral mucosa is really the best. The overall success rate of penile skin urethroplasty was 84 % with a mean follow-up of 201 months, whereas the success rate of oral urethroplasty was 87 % with a mean follow-up of 48 months, and no statistically significant difference was found between the two groups (Table 13.1 [23]). Alsikafi et al. [23] concluded that penile skin and oral mucosa are excellent materials for substitution urethroplasty with a comparable success rate, though penile skin appears to have a longer follow-up. Gozzi et al. [24] reported the outcome of 194 patients with penile, bulbar, and posterior urethral strictures treated using genital and extragenital free skin grafts and concluded that the skin grafts provide excellent results with an average follow-up of 31 months (Table 13.1).

At our center, 95 consecutive patients, average age of 44 years (range, 17–79 years), underwent bulbar urethra reconstruction between January 1994 and December 2004 for urethral strictures [25, 26]. In 45 patients the stricture was treated using penile skin as a substitute material [25], and in 50 patients oral mucosa was used as a substitute material [26]. Thirty-three of the 45 penile skin urethroplasties were successful (73 %) and 12 (27 %) were failures [25]. Forty-two of the 50 oral mucosa urethroplasty were successful (84 %) and 8 (16 %) were failures [26]. Thus, the skin graft urethroplasty showed a higher failure rate (27 %) compared to buccal mucosa (16 % Table 13.1). The penile skin group of patients did have a longer follow-up (mean 71 months) compared with the oral mucosa group of patients (mean 42 months; Table 13.1). Yet, the penile skin group showed a higher number of failures involving the entire graft area (17 % vs. 6 %), requiring surgical revision using staged procedure [25].

Finally, in patients requiring anterior urethroplasty, the use of oral mucosa avoids cosmetic

Table 13.1 Penile skin versus oral mucosal (OM) onlay grafts

Authors	Journal, year	No. of patients	Substitute material	Success rate %	Mean follow-up (months)
Alsikafi et al.	*J Urol* 2005	119	Skin 24	84 %	201
			OM 95	87 %	48
Barbagli et al.	*J Urol* 2004–2005	95	Skin 45	73 %	71
			OM 50	84 %	42
Gozzi et al.	*J Urol* 2006	194	Skin	Excellent	31

disadvantages and consequences caused by the use of genital skin, as it is readily available in all patients with a concealed donor site scar [4–6]. Moreover, the elasticity and easy handling of the buccal mucosa is superior to penile skin, promoting the use of graft in original techniques [15, 16, 21, 22, 26].

Flap Versus Graft in Penile Urethroplasty

The controversy over the best mean of reconstructing the penile urethra has been renewed, and in recent years free grafts have been making a comeback, with fewer surgeons using genital flaps [21]. The current literature, however, does not clearly support the use of one technique over the other, and some prospective randomized studies on the use of graft versus flap are not useful because they compared a nonhomogeneous series of patients and stricture diseases [27]. That being said, however, the use of free grafts does not require extensive training in tissue-transfer procedures, as is required with the use of penile flaps [21].

At present, we do not know which patients undergoing one-stage penile urethroplasty with oral mucosa graft will have a successful outcome [21]. Nor are we certain about the proper anatomic characteristics the penis should have to ensure that the graft take [21]. The penile spongiosum tissue and dartos fascia do not ensure good vascular and mechanical support to the graft in all patients, and this leads to a number of questions. What type of vascular support can be used? In which patients will the use of a pedicled flap have better chances of success than a free graft? What is the role of urethral plate salvage in the reconstructive armamentarium? Morey [28] suggests that urethral plate replacement may be necessary in patients with complex, long, severe strictures, and he describes a new penile urethroplasty that uses a combined graft-flap procedure. Identification and use of criteria to more carefully select the appropriate procedure for the patient should help answer all of these questions and might clarify whether the use of oral mucosa graft is preferable to the use of a penile flap.

Ventral Versus Dorsal Bulbar Onlay Graft Urethroplasty

Oral mucosa graft onlay urethroplasty represents the most widespread method used for the repair of strictures in the bulbar urethra due to its thick and highly vascular spongiosum tissue [20]. Location of the graft has recently become a contentious issue [9, 26, 29, 30]. Wessells [31] suggests that the technical advantages of ventral onlay urethroplasty are considerable: complete circumferential mobilization of the bulbar urethra is not necessary, thus preserving arterial and venous connections to the corpora cavernosa; the stricture is easily visualized; and the lumen is clearly delineated with urethrotomy, allowing the surgeon to identify mucosal edges, measure the size of the plate, carry out a watertight anastomosis, and, if necessary, excise portions of the stricture and perform dorsal reanastomosis. Moreover, Armenakas [32] emphasizes that ventral graft placement, requiring less urethral dissection and mobilization, is technically easier.

Success with oral mucosa grafts for repairing bulbar urethral strictures has generally been high with dorsal [7–9, 24, 25, 33–36] or ventral onlay grafts [3, 31, 32, 37–39], and the different graft positions have shown no difference in success rate

Table 13.2 Ventral versus dorsal oral mucosal (OM) onlay grafts

Authors	Journal, year	Substitute material	Graft location	No. of patients	Success rate (%)	Failures (%)
Barbagli et al.	*J Urol* 2005	OM	Ventral	17	83	17
			Dorsal	27	85	15
			Lateral	6	83	17
Abouassaly et al.	*J Urol* 2005	OM	Ventral	100	92	8
			Dorsal			
			Combined			

Table 13.3 Prevalence of anastomotic fibrous rings in 107 substitution bulbar onlay graft urethroplasty

				Type of failure		
Urethroplasty (substitute material)	No. of patients	Success rate no. %	Failure rate no. %	Entire grafted area no. %	Anastomotic ring stricture no. %	Site of ring (no.)
Dorsal onlay skin graft urethroplasty (skin)	45	33 (73 %)	12 (27 %)	8 (17 %)	4 (8 %)	Distal (2), proximal (2)
Oral mucosal onlay graft urethroplasty (oral mucosa)	50	42 (84 %)	8 (16 %)	3 (6 %)	5 (10 %)	Distal (2), proximal (3)
Augmented end-to-end urethroplasty (oral mucosa)	12	10 (84 %)	2 (16 %)	1 (8 %)	1 (8 %)	Proximal (1)
Total	107	85 (80 %)	22 (20 %)	12 (11 %)	10 (9 %)	Distal (5), proximal (5)

(Table 13.2 [26, 40]). We retrospectively reviewed the outcome analysis of 50 patients who underwent three types of urethroplasty with the oral mucosal graft placed on the ventral, dorsal, or lateral surface of the bulbar urethra [26]. Out of 50 cases, 42 (84 %) were successful and 8 (16 %) failed. The 17 ventral grafts were successful in 14 cases (83 %) and failed in 3 (17 %); the 27 dorsal grafts were successful in 23 cases (85 %) and failed in 4 (15 %); the 6 lateral grafts were successful in 5 cases (83 %) and failed in 1 (17 %) (Table 13.2). Failures involved the anastomotic site (distal in 2 and proximal in 3) and the entire grafted area in 3 cases. In our experience, the placement of the buccal mucosa grafts onto the ventral, dorsal, or lateral surface of the bulbar urethra showed the same success rates (83–85 %), outcome was not affected by the surgical technique, and stricture recurrence was uniformly distributed in all patients (Table 13.2 [26]). Others authors have found that these rings cause stricture recurrence after substitution bulbar urethroplasty [33, 38–40].

We retrospectively reviewed the patterns of failure after bulbar substitution urethroplasty [41]. In particular, we investigated the prevalence and location of anastomotic fibrous ring strictures occurring at the apical anastomoses between the graft and urethral plate after using the above three types of onlay graft techniques (Table 13.3). A review of 107 patients undergoing bulbar urethroplasty between 1994 and 2004 was performed [41]. The mean patient age was 44 years old. Forty-five patients underwent dorsal onlay skin graft urethroplasty, 50 patients underwent oral mucosa onlay graft urethroplasty, and 12 patients underwent augmented roof-strip anastomosis with oral graft. Clinical outcome was considered either a success or a failure depending on whether any postoperative procedure was needed, including dilation. The mean follow-up was 74 months (range, 12–130). Out of 107 patients, 85 (80 %) were successful and 22 (20 %) failures. Failure in 12 patients (11 %) involved the entire grafted area, and in 10 patients (9 %) involved the anastomotic site (five distal, five proximal; Table 13.3). Urethrography, sono-urethrography, and urethroscopy were fundamental in order to see the difference between full-length and focal extension of restricture. The prevalence and location of anastomotic ring strictures after bulbar urethroplasty were uniformly distributed in the three different surgical techniques using skin or oral mucosa (Table 13.3 [41]). Further studies are necessary to clarify the etiology of these fibrous ring strictures.

We developed a new technique of dorsal onlay graft urethroplasty using fibrin glue to fix the graft to the albuginea of the corpora cavernosa [15]. The use of fibrin glue avoids the necessity of numerous interrupted stitches to fix the graft: this is a tedious and time-consuming step in onlay urethroplasty. Moreover, the apposition of the graft and its adhesion to the corpora cavernosa can be simplified by the use of fibrin glue, which allows ideal fixation of the graft to its vascular bed and therefore better revascularization of the transplanted tissue. Tenacious adhesion of the graft keeps it wide open, reducing the risk of sacculation and shrinkage, thus allowing the surgeon to perform an easier anastomosis between the graft and the urethral margins. Fibrin glue shortens graft revascularization time, because a fibrin clot represents the first link in a chain of events, which rules the process of revascularization of any free graft (followed by imbibition and inosculation). Experimental studies done in the rat documented better healing and smaller shrinkage of the free skin graft when fibrin glue was utilized [42].

Bulbar Urethroplasty: Graft Versus Anastomotic Repair

The current literature suggests that the surgical technique for the repair of the bulbar urethral stricture is selected according to the stricture length [20, 43]. End-to-end anastomosis is suggested for 1–2 cm stricture, augmented roof-strip anastomosis is suggested for 3–5 cm strictures, and substitution urethroplasty is suggested for longer strictures [20, 43]. In patients with strictures associated with local adverse conditions, a staged urethroplasty should be preferred [20, 43]. Starting from the 2009 AUA Meeting, the controversy over the use of end-to-end anastomosis or augmented roof-strip anastomosis in nontraumatic bulbar urethral strictures is a new open issue to debate [44]. Transecting the urethra to perform an end-to-end anastomosis or augmented roof-strip anastomosis allows complete removal of the scarred tissue but may cause vascular and neuronal damage to the urethra and penis, thus promoting postoperative sexual dysfunction [44]. Not transecting the urethra is a vascular- and neuronal-sparing procedure, but it does not allow removal of the scarred tissue [44]. In stricture following blunt perineal trauma and urethral injury, it is mandatory to remove the traumatic scarred tissues and to perform a direct anastomosis between the two healthy urethral edges, because not removing this tissue is a cause of stricture recurrence over time. In nontraumatic urethral stricture, is it mandatory to transect the urethra and to remove the tissues? Or will it be sufficient to open the urethra and to perform only an augmentation of the original urethral plate?

Traumatic (blunt perineal trauma and urethral injury) bulbar strictures are generally amenable to scar excision and direct anastomosis using a simple perineal approach. This technique has a 90–95 % success rate, as reported by some authors [45, 46]. Guralnick and Webster [47] suggested that end-to-end anastomosis is appropriate only for bulbar strictures of 1 cm or less, because excision of a 1 cm urethral segment with opposing 1 cm proximal and distal spatulation results in a 2 cm urethral shortening, which may be adequately accommodated by the elasticity of the mobilized bulbar urethra without chordee. These authors emphasized that longer excision risks penile shortening or chordee even using lengthening maneuvers [47]. On the contrary, Morey and Kizer [48] suggested the use of an extended anastomotic approach also in patients with proximal bulbar urethral strictures longer than 2.5 cm. Al-Qudah and Santucci [49] reported postoperative sexual dysfunctions (chordee and erectile dysfunction) in 18 % of patients who underwent anastomotic urethroplasty and concluded that oral mucosal urethroplasty had a superior success rate and fewer complications than anastomotic urethroplasty, even for short strictures. Barbagli et al. [46] investigated, using a non-validated questionnaire, 60 patients who underwent bulbar end-to-end anastomosis and reported that 23.3 % of patients experienced ejaculatory dysfunction, 18.3 % had decreased glans sensitivity, 11.6 % had a glans that was neither full nor swollen during erection, and 1.6 % had a cold glans during erection. No patient complained of penile chordee or impotence [46]. Petersen and Webster [43] suggested that for bulbar urethral strictures ranging from 2 to 4 cm, the best option is augmented anastomotic urethroplasty. In this procedure, the worst section of the stricture is removed and the urethra is reanastomosed and dorsally augmented with a free graft [43]. Other authors also suggested the use of this procedure in patients undergoing urethroplasty for strictures that contain a particularly narrow or dense area of 1–2 cm [50]. All these authors suggesting to transect the urethra also in nontraumatic bulbar urethral strictures do not report any investigation about the incidence of sexual postoperative complications on these patients, and this represents a great limit of these studies [43, 47, 48, 50]. In the future, large and homogeneous series of patients with adequate follow-up are necessary to investigate the incidence of postoperative sexual dysfunctions in patients who underwent fully transection of the bulbar urethra to arrange an anastomotic repair in nontraumatic strictures.

Surgical Pearls and Pitfalls

Key Intraoperative Surgical Points

- In penile urethroplasty, create a very large and wide bed for the graft that is quilted using multiple sutures onto the bed of the dorsal urethral incision.
- In penile urethroplasty, use a small 12 Fr grooved silicone catheter.
- In bulbar urethroplasty, place the graft as proximal is possible.
- Avoid completely transecting the bulbar urethra.
- Use meticulous hemostasis.
- Leave the catheter in place for 3 weeks minimum to promote the complete urethral re-epithelialization.

Potential Intraoperative Surgical Problems

- Loss of the proximal opening of the urethral lumen. In penile urethroplasty insert before opening the urethra a small 3 Fr ureteral catheter. In bulbar urethroplasty insert before opening the urethra a small 3 Fr sensor guidewire using a pediatric urethroscope.
- Stricture longer than the graft. Avoid stretching the graft. Use two grafts instead.
- Bleeding from the spongiosum tissue. Ask the anesthesiologist to reduce the blood pressure.
- Bleeding from the spongiosum tissue. In a young boy, close the spongiosum tissue in two layers.
- Patient presenting with abscess and/or pus from the urethra. Take biopsies from the urethral mucosa and surrounding tissues to exclude cancer.
- Urethral mucosa with leukoplakia or other abnormal lesions. Take biopsies from the urethral mucosa and surrounding tissues to exclude cancer.

Preferred Surgical Instruments of Guido Barbagli

Allen stirrups (Allen Medical System, The Org Group, Anton, MA, USA)

Sequential compression sleeves (Tyco Healthcare Group LP, Mansfield, MA, USA)

Mouth self-retractor with its own light (Ce.Di.Sa. Srl, Sesto Fiorentino, Italy)

Plastic ring retractor with atraumatic plastic hooks (Lone Star, Medical Products, Houston, TX, USA)

Modified nasal speculum with atraumatic thin round tip (Ce.Di.Sa. Srl, Sesto Fiorentino, Italy)

Silicone board (Ce.Di.Sa. Srl, Sesto Fiorentino, Italy)

Turner-Warwick needle holder (Lawton GmbH and Company, Fridingen, Germany)
Superlight titanium needle holder (Lawton GmbH and Company, Fridingen, Germany)
Microsurgical needle holder (Lawton GmbH and Company, Fridingen, Germany)
Microsurgical scissors (Lawton GmbH and Company, Fridingen, Germany)
Black porcelain scissors (Lawton GmbH and Company, Fridingen, Germany)
Methylene blue
Foley grooved silicone catheter (Rush GMBH, Kernen, Germany)
Polyglactin suture (Vicryl) (Ethicon, Johnson & Johnson Intl., St-Stevens-Woluwe, Belgium)

Editorial Comment

This is a wonderful chapter and I urge you to read this chapter at least twice, so as to not miss any of its pearls of wisdom.

Over the years, I have moved all my bulbar urethral reconstructions to almost exclusively to buccal graft urethroplasty. I have been influenced by Dr. Barbagli and perform his surgery almost identical to as he has detailed above. I would like to emphasize a few key pearls and pitfalls of buccal graft urethroplasty.

1. Start off all bulbar urethroplasties with cystoscopy and place a guidewire into the bladder and then inject methylene blue into the urethral lumen. The blue stain helps facilitate suturing to the mucosa. This is especially useful for the urethral surgeon trainee, as the spongiosum is white and the mucosa is white, and they will often sew to the wrong structure. The guidewire helps with the urethrotomy, so as to not lose the lumen. When the stricture is segmentally very tight, without a guidewire, it is easy to get off track and lose the lumen and just cut into the spongiosum.
2. For proximal bulbar strictures, I place the graft ventral, as it is very difficult to technically sew the graft in dorsal when the stricture involves the proximal bulb or membranous urethra. Here, it is much easier to sew the graft ventral as you can more easily see the mucosa and veru and technically more easily place the sutures. I typically use a “ski” needle (an RB needle bent into a J shape) for placing proximal sutures. A nasal speculum to hold the mucosa apart is very useful and facilitates suturing. Initially, I typically perform the proximal anastomosis first by placing five interrupted sutures through the mucosa and graft from the 4–8 o’clock position and tag them. I then tie them serially and parachute the graft down to achieve mucosa-to-mucosa apposition. I prefer to place the knots on the outside of the lumen and then temporarily rotate the graft down, like a door on a hinge, to inspect the suture line. I do not think that there is anything wrong with placing the interrupted sutures within the lumen (urethral side). Turner-Warwick showed that it was perfectly safe to do so and outcomes were not compromised. It’s just esthetically more appealing and elegant to place the sutures extraluminal. For dorsal grafts, only after once the proximal anastomosis is performed do I quilt it to the corpora. I do not “spread fix” the entire graft initially to the corpora and then do the suturing. I have found this makes the distal and proximal sewing technically more challenging.
3. Once the proximal end of the anastomosis is performed, I keep the graft on stretch and suture the left side, from proximal to distal with a running suture, until about 1 cm from the distal end. I then run the right side suture line, also till about 1 cm of the distal end. I then place five interrupted sutures at the distal end and tag them all first – and then tie them in sequence. Placing interrupted sutures at the ends are potentially less ischemic and technically easier to place then running sutures. It is very important to keep the penis on stretch while you sew in the graft. Inadequate penile stretch risks ventral chordee with a dorsal graft. I have had my fair share of ventral chordee patients after a dorsal graft, and I quickly learned that I was not keeping the penis on sufficient stretch. For that reason, I always place a 2-0 Prolene glans penis stitch at the beginning of the case to act as a handle.

4. For mid and distal bulbar strictures, I typically place the grafts dorsal. The main reasons I do so are that ventral urethrotomy can often bleed a lot and I do not like operating in a bloody field. The blood loss of a ventral graft urethroplasty can be significant – I have occasionally lost up 500 ml or more with long ventral urethrotomies. As the urethra is eccentrically placed in the spongiosum, a dorsal urethrotomy goes through a thin segment of spongiosum. If the edges bleed dorsally, the mucosa can be sewed to the tunica for hemostasis. Furthermore, the more distal on the bulb, the urethra gets smaller, and there is often insufficient tissue to create a good spongioplasty. In my experience, the annular stricture that occurs after a ventral urethroplasty seems to always be at the distal end – the end with the least wide spongiosum. You can avoid distal ischemia of your graft by placing the graft dorsal and quilting it to the host bed of the corpora, which is much more reliable and vascular rather than the narrow and insufficient distal bulbar spongiosum.
5. Widely mobilizing the urethra is the key to making the dorsal graft approach technically easy to sew. Without sufficient mobilization, the urethra cannot be properly rotated 180°. If you find yourself struggling to properly place the sutures, you probably have not mobilized the urethra enough proximally and distally. Poor exposure and poor mobilization make dorsal graft urethroplasty difficult.
6. If the harvested buccal graft is longer than the urethrotomy, should you shorten the graft or extend the urethrotomy? I feel that the urethrotomy should be extended to meet the length of the buccal graft because the degree of spongiofibrosis is always underestimated, and the further the urethral spatulation is made into normal appearing tissue, the better. As a rule of thumb, I prefer to make the urethrotomy at least 1 cm into normal appearing urethra on each end.
7. For penile strictures, I like the lateral approach or the Asopa technique of a graft inlay. For an Asopa, the urethral plate preferably should be >1 cm wide, in order to easily tubulariz the edges. A 2 cm wide graft, plus a 1 cm wide plate, will generally give you a 24 Fr urethra in the end. If the plate is <1 cm, the final urethral tube is <24 Fr – which is less than ideal. If the plate is <5 mm wide, I have found it impossible to do an Asopa, as there are no remaining edges to sew to.

–Steven B. Brandes

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14 Lingual Grafts

Alchiede Simonato and Andrea Gregori

Summary

Today, if free extragenital tissue is needed to perform urethroplasty, an oral mucosal graft is considered the best tissue, providing excellent clinical results.

The mucosa of the tongue is identical to the mucosa of the rest of the oral cavity. Lingual mucosa is a safe and effective graft material for urethral reconstruction with low risks of donor site complications.

The graft may be bilaterally harvested in order to obtain an adequate length. Graft's size depends on the tongue's dimension and on specific anatomical limits which must be respected with a minimal 0.5 mm distance: the frenum, the ventrolateral mucosal surface of the tongue, and below the lining that separates the dorsum, where the papillae, and the opening of the Wharton's duct are situated.

Lingual mucosa graft may be used alone or in combination with buccal mucosa, when longer grafts are needed.

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Buccal mucosa has become the extragenital donor site preferred by urologists who perform urethroplasty and provides excellent clinical results [1–6].Up to 2006, the oral mucosal grafts were harvested from the mucosa of the inner cheek or from the mucosa of the lip. The majority of studies in the literature reported the harvesting techniques and urethroplasty functional results with few data about morbidity at the donor site [1–6].

Buccal mucosal graft harvesting is an excellent procedure, but it carries long-term oral complications, although infrequent. The main long-term donor site complications are persistent perioral numbness, salivatory changes, and difficulty in opening the mouth [7, 8]. Other complications are bleeding [9], scarring, and lip deviation or retraction [10, 11].

The research of a donor site with favorable properties for urethroplasty leads us to experiment the use of a tongue graft, following the experience of Guerrerosantos et al. [12] which used it in plastic surgery to correct lip defects.

In February 2006, we described the results of a pilot study on the use of the tongue as an alternative donor site for graft urethroplasty with good functional and aesthetic results [13]. Like buccal mucosa, the lingual mucosa has the same embryologic origin, easy harvesting, favorable immunologic properties (resistance to infection), and tissue characteristics (thick epithelium, high content of elastic fibers, thin lamina propria, rich vascularization) that are favorable properties

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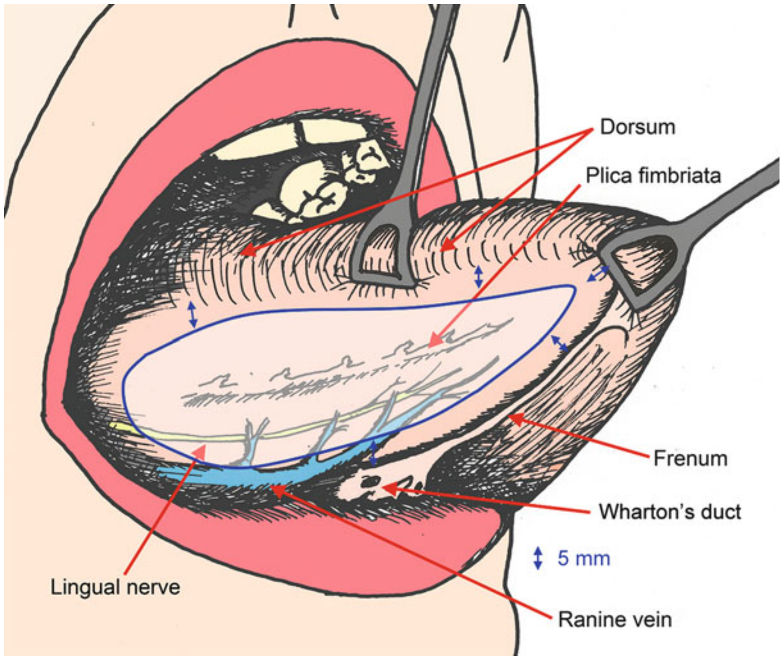

Fig. 14.1 The graft harvest site is shown. The *blue line* indicates the area of the graft. Anatomical landmarks are the following: the frenum, the dorsum, where the papillae are situated, and the opening of the Wharton's duct

for imbibition, inosculation, and revascularization of the graft [13].

Excellent functional results and minimal donor site complications were confirmed in the long term by us [14] and by many other authors, which expanded the indications and the length of the harvested graft [15–18].

The graft may be bilaterally harvested in order to obtain an adequate length. Graft size depends on the tongue's dimension and on specific anatomical limits which must be respected and avoided: the frenum, the ventrolateral mucosal surface of the tongue, below the lining that separates the dorsum, where the papillae are situated, and the opening of the Wharton's duct (Fig. 14.1).

When the above limits are respected, the risk of long-term donor site's complications is very low or absent.

The tongue mucosal graft may be used alone or in combination with a graft of the mucosa of the inner cheek or from the mucosa of the lip when very long grafts are required. We prefer two small grafts from different sites than a single-long graft from one site in order to minimize donor site's complications.

The interest for donor site's morbidity has been grown after the first reports on the use of lingual mucosal grafts. Many authors evaluated donor site's complications, but no precise correlations with graft's extension were made. Xu et al. [19] demonstrated that complication rates were higher if very long grafts were harvested. The same concept is known for inner cheek grafts: Barbagli et al. [16] recommend graft <4 cm in order to avoid complications. Every donor site has specific limits for harvesting without long-term morbidity.

Surgical Technique

A mouth opener may be placed but it is not mandatory. The apex of the tongue is passed through with a 1-0 suture for traction, or direct traction is applied with a Babcock clamp to expose the ventrolateral surface of the tongue (Fig. 14.1). The site of the harvest graft is the ventrolateral mucosal surface of the tongue, below the lining that separates the dorsum, where the papillae are situated, from the sublin-

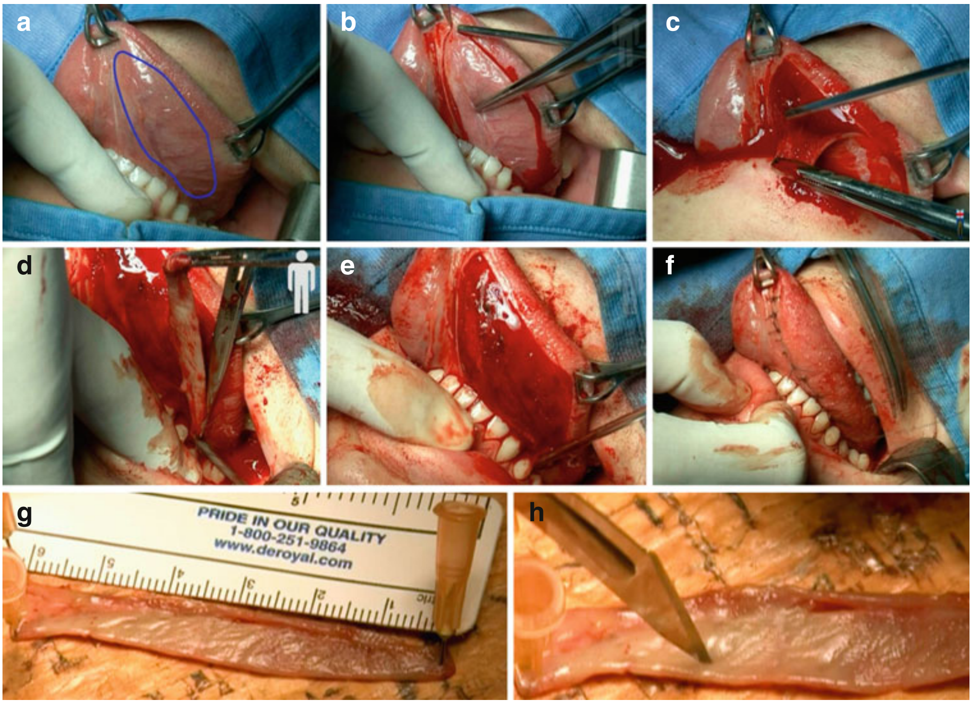

Fig. 14.2 (**a**) The required graft is measured after identification of the opening of the Wharton's duct. (**b**) The graft edges are incised with a scalpel. (**c** and **d**) A full-thickness mucosal graft is harvested using sharp instruments. (**e**) The donor site is carefully examined for bleeding. (**f**) The donor site is closed with interrupted 3-0 sutures. (**g** and **h**) The graft is prepared for urethroplasty by defatting and pricking

gual mucosa. The required graft (which is not infiltrated with any solution) is measured after identification of the opening of the Wharton's duct (Fig. 14.2a). The graft edges are incised with a scalpel (Fig. 14.2b) and a full-thickness mucosal graft is harvested using sharp instruments beginning at the anterior land mark of the graft (Fig. 14.2c, d). A 4-0 traction stitch may be useful to better handle the graft. The donor site is carefully examined for bleeding (Fig. 14.2e) and easily closed with interrupted polyglactin 3-0 sutures (Fig. 14.2f). When submucosal tissue is present, graft defatting is performed (Fig. 14.2g). Now, the graft may be prepared for urethroplasty (Fig. 14.2h). When a further graft is needed, the procedure may be performed on the contralateral side (Fig. 14.3a–d). Figure 14.4 shows the donor site healing process.

Surgical Pearls and Pitfalls

Key Points

- The mucosa of the tongue and the buccal mucosa have the same embryological origin
- The lingual mucosa has excellent immunologic properties (resistance to infection) and tissue characteristics (thick epithelium, high content of elastic fibers, thin lamina propria, rich vascularization) that are favorable properties for imbibition, inosculation, and revascularization of the graft
- Harvesting of the lingual mucosa is easy and does not require special surgical instruments
- The risk of long-term donor site complications is very low or absent if the graft does not exceed 5–6 cm in length and 2–3 cm in width

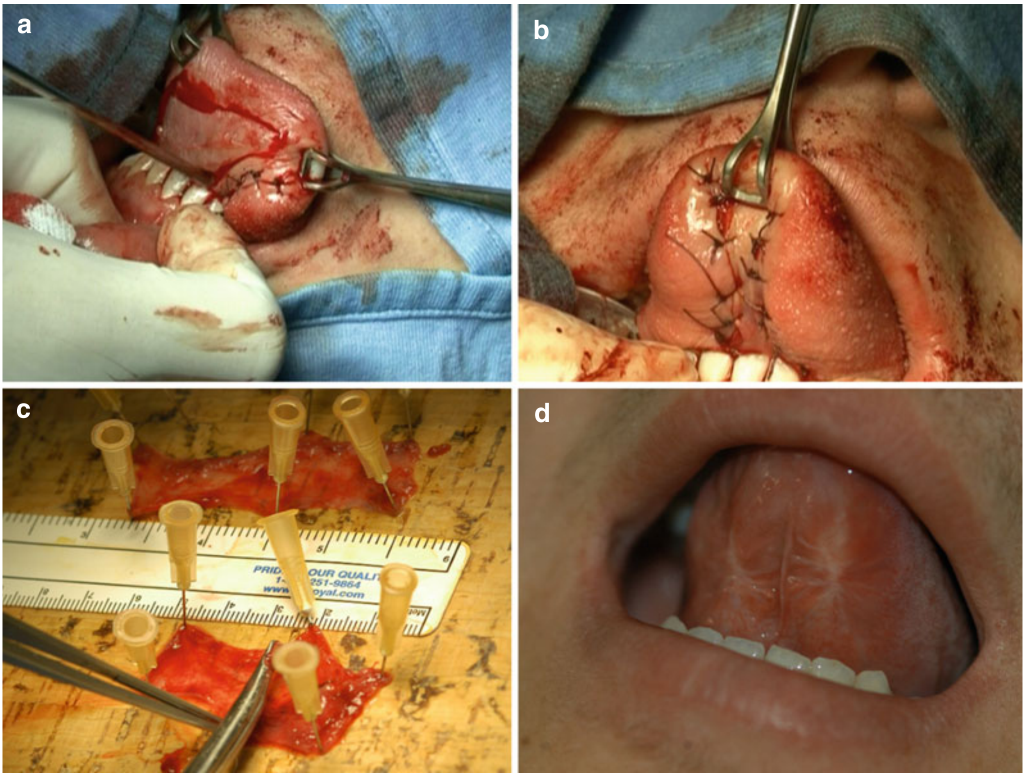

Fig. 14.3 Bilateral mucosal graft harvesting: (**a**) after the first graft harvesting, a second incision is contralaterally performed; (**b**) final intraoperative aspect of the tongue after bilateral graft harvesting; (**c**) preparing the two grafts for urethroplasty; (**d**) aesthetic outcome after 6 months

Potential Problems

- In order to avoid complications, it is mandatory recognizing the Wharton's duct.
- The mucosa of the tongue is thinner than the buccal mucosa; therefore, it is most delicate to handle during the urethroplasty.
- Possible perioperative complications (bleeding, edema, difficulty in articulating words, burning, pain, and difficulty of salivation) are temporary and easy to manage.

Editorial Comment

Lingual mucosa is an important secondary tissue source for urethral substitution, widely available in all patients. Because lingual grafts tend to be thinner both in width and depth than buccal mucosa, we tend to use them only when necessary after both cheeks have already been harvested. Although harvesting is easy and well tolerated, lingual grafts are rather flimsy; nonetheless, lingual grafts are preferred to reharvesting from a previously operated cheek or even lip.

Lingual grafts are usually employed in cases with long segment defects. Their width is usually 1–1.5 cm at best, and thus, they function well as a dorsal graft for urethral plate reconstitution under a penile skin flap or overlapping ventral buccal graft.

–Allen F. Morey

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Fig. 14.4 The healing of the tongue after graft harvesting at different times

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15 The Augmented Anastomotic Urethroplasty

Michael L. Guralnick and R. Corey O'Connor

Summary

Primary anastomotic urethroplasty with complete stricture excision provides for the most successful outcome in bulbar urethral reconstruction. However, there are times when, following stricture excision and urethral spatulation, too much tension would be present for a primary anastomosis. The augmented anastomotic urethroplasty is a combination repair that incorporates the principles of excision and substitution urethroplasty. It is intended for bulbar strictures deemed too long for straightforward primary anastomosis, particularly those with a dense area of scarring and adjacent wider caliber stricture. With this technique, up to 2 or 3 cm of strictured urethra may be excised, followed by reapproximation of either the dorsal or ventral walls. The opposite urethral wall is then closed with an onlay graft. In this chapter, we discuss our graded approach to the management of bulbar strictures and our rationale for utilizing the augmented anastomotic repair and outline our surgical technique.

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Introduction

Various urethroplasty techniques may be appropriate for the repair of bulbar urethral strictures. Ultimately, stricture length and severity will be the most important factors in determining the chosen technique. The most successful procedures require complete stricture excision and a spatulated, circumferential reanastomosis of healthy urethra to healthy urethra. Although a primary anastomosis is appropriate for shorter bulbar strictures (i.e., <2 cm in length), its use is limited by the potential risk of penile shortening or chordee when used too aggressively. Substitution urethroplasty involves utilization of a graft or flap to augment the urethral lumen in lieu of an anastomotic repair when an excision and anastomosis are not feasible. Full-thickness dorsal or ventral incision of the urethral wall converts a narrowed urethral tube into a trough that is then "patched" with the graft or flap. This is typically used in cases of long, relatively uniform strictures. However, there are instances when the stricture is too long for complete excision and anastomosis but has a dense area of stricture that makes onlaying a graft or flap precarious. In such instances, a combination of stricture excision and urethral substitution/augmentation (augmented anastomotic repair) may be useful. In this chapter, we review the principles behind the augmented anastomotic urethroplasty and a graded approach for managing bulbar urethral stricture disease. The intraoperative technique and postoperative management are described.

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Procedure Selection

A variety of factors influence the management of bulbar urethral stricture disease such as stricture location, length, and etiology. In addition, other variables including local inflammation, scarring from previous treatments (spongiofibrosis), radiation effects, and surgeon preference must be taken into account when determining the optimal course of repair.

Stricture length is typically the most important factor in determining an appropriate repair. It must be realized that at least 1 cm of healthy urethra should be spatulated in both the proximal and distal directions prior to anastomosis. Thus, for strictures 1 cm in length, one will create a gap of 2 cm that must be traversed (Fig. 15.1). The length of bulbar urethra that can safely be excised and still allow for a spatulated tension-free anastomosis is variable and dependent on penile length, stricture location, and urethral elasticity. Generally, the elasticity of the mobilized bulbar urethra can accommodate a 2-cm gap without causing tension or penile chordee [1]. With strictures in the proximal bulbar urethra, mobilization maneuvers such as releasing the central perineal tendon and separation of the corporal bodies at the crus have allowed surgeons to shorten the distance between the spatulated urethral ends and permitted successful extended anastomotic repairs longer than 2 cm to be successfully performed [2]. Ultimately, the patient's acceptance of some penile shortening or chordee makes the decision easier.

Stricture etiology is variable, even multifactorial, and in many instances the exact cause is not known. Although stricture etiology and previous therapies may complicate procedure selection and adversely affect outcome, most strictures are surgically correctable. Exceptions to this predictability are those associated with lichen sclerosis (LS) [3], radiation therapy, cryotherapy, and local inflammatory changes from multiple fistulae. Alternatives to urethroplasty, such as permanent suprapubic tube drainage, perineal urethrostomy, or formal urinary diversion, may be appropriate.

The Augmented Anastomotic Repair

The augmented anastomotic urethroplasty is an open surgical repair that utilizes both excision and substitution techniques. The term was first coined by Turner-Warwick [1], who described

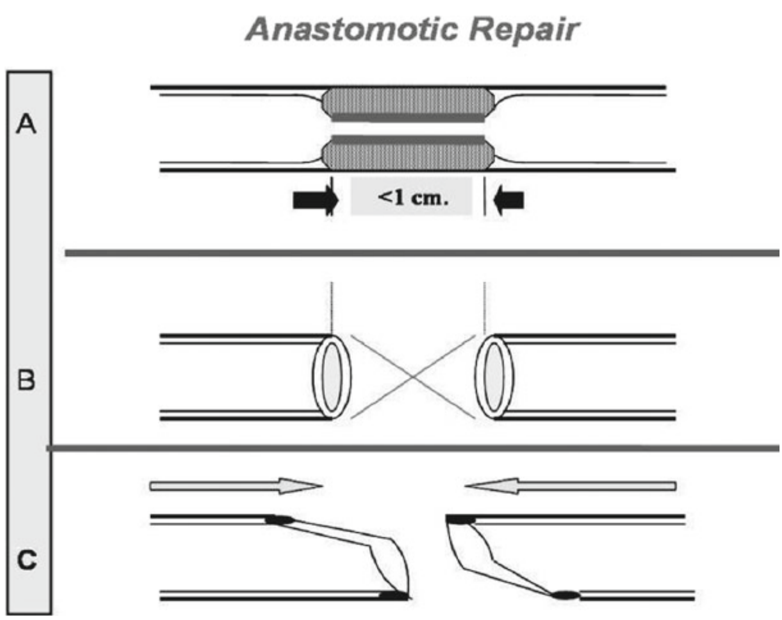

Fig. 15.1 Primary anastomotic repair. When bulbar urethral stricture disease is approximately 1 or 2 cm in length (*line A*), the entire stricture can be excised (*line B*) and then the urethral ends are spatulated for 1 cm into healthy tissue (*line C*) to allow for a direct anastomosis of healthy urethra mucosa, resulting in 2–3 cm of urethral shortening

the procedure as a means by which an "anastomotic" repair could still be performed when the stricture was marginally longer than could be safely repaired by a spatulated end-to-end reanastomosis. He described excision of the stricture, reanastomosis of the roof strip (i.e., dorsal wall) of the urethra, proximal and distal ventral spatulation, and placement of a flap or graft to augment and close the ventral urethral wall. The technique minimizes the need for extensive urethral mobilization normally required for an extended end-to-end anastomosis and allows for excisional urethroplasty for slightly longer strictures (Fig. 15.2).

The augmented anastomotic technique is particularly useful in patients with wide-caliber spongiofibrosis adjacent to a shorter stricture that would otherwise be a candidate for simple excisional repair. One can excise the shorter strictured portion (up to the allowable limits of the individual patient based on the aforementioned variables) and spatulate (dorsally or ventrally) through the remaining spongiofibrotic urethra. A graft is then fashioned to "patch" the spatulated urethral defect. This technique thereby addresses the potential risk of failure with a purely anastomotic urethroplasty that might otherwise leave unaddressed the wide-caliber spongiofibrosis. Along these lines, many long strictures have a central portion where the lumen is narrowest and spongiofibrosis is its worst. Pure onlay grafts or flaps to this location carry poor results as the urethral "foundation" is scarred and has a poor local blood supply. Excision of the most narrowed, diseased portion of the stricture along with a roof-strip or floor-strip anastomosis results in a wider and healthier urethral wall to which the onlay graft/flap is applied (Fig. 15.3). As a result, less circumference of the reconstructed urethra consists of substituted material and a shorter graft/flap can be utilized [4].

Graft Versus Flap

The use of grafts or flaps in substitution urethroplasty is discussed elsewhere in this textbook. Historically, flaps constructed as pedicle islands of penile (and less commonly scrotal) skin were favored to repair bulbar strictures. More recently, grafting has become more commonly used. A randomized study did not find any difference in stricture recurrence between buccal mucosal grafts and penile skin flaps [5]. However, flaps

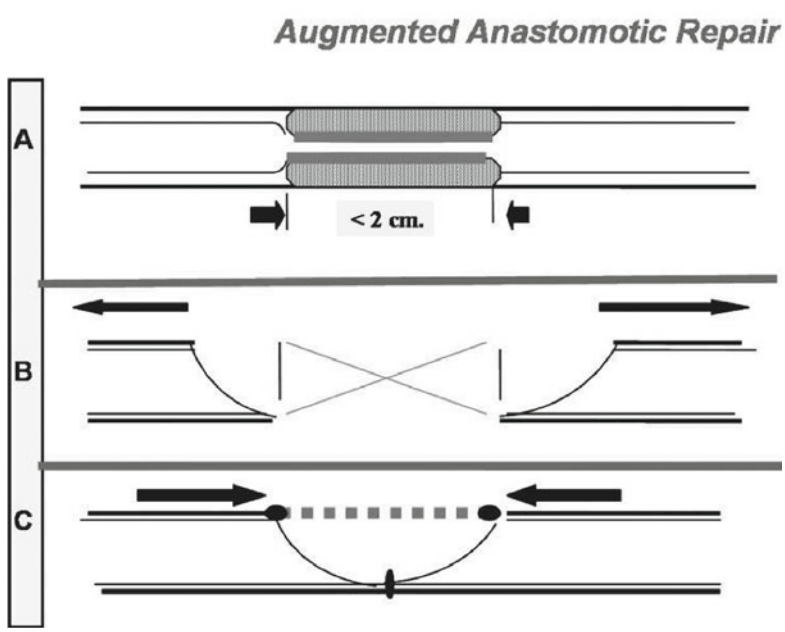

Fig. 15.2 Augmented anastomotic repair. When bulbar stricture disease is 2–3 cm in length (*line A*), the diseased urethra is completely excised. The dorsal or ventral urethra is spatulated for 1 cm proximally and distally (*line B*). The wall of native urethra opposite the spatulation is reapproximated. (*line C*) A graft (*dashed line*) is placed across the spatulated defect, resulting in approximately 2–3 cm of urethral shortening

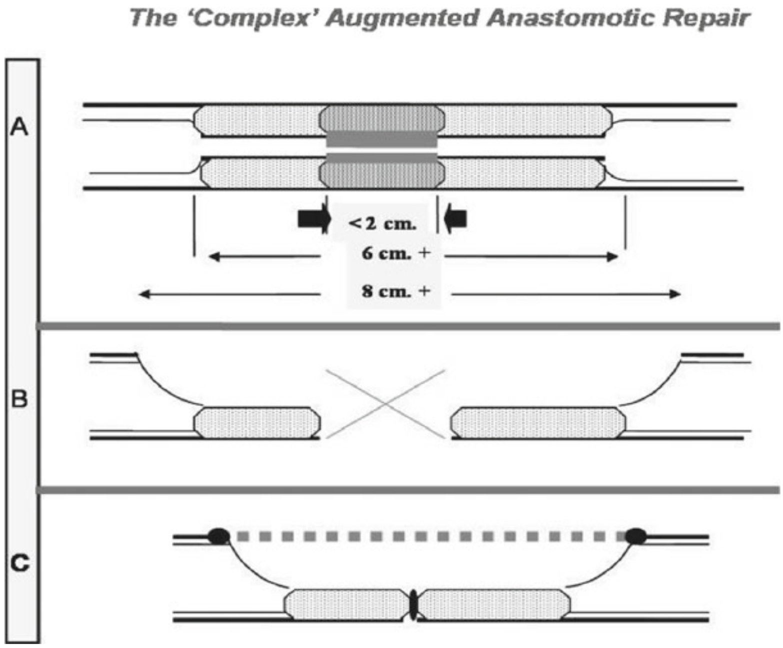

Fig. 15.3 "Complex" augmented anastomotic repair. With longer stricture disease, there is frequently an area of stricture that is more diseased than the remainder of the stricture (*line A*). For example, if a stricture 6 cm in length contains a 2-cm tight stricture and a less tight but still-strictured 4-cm area, the tight 2-cm stricture is completely excised and the remaining urethral ends are anastomosed as a floor/roof strip. The opposing urethral wall is opened through the remaining stricture and for an additional 1 cm into healthy urethra proximally and distally (*line B*). A 6-cm onlay is then placed on the urethral wall opposite the floor-strip/roof-strip anastomosis and the resultant urethral shortening is only 2 cm (*line C*)

were thought to be technically more difficult and associated with greater morbidity. In our practice, substitution bulbar urethroplasty almost invariably involves use of an oral mucosa graft.

Graft Type and Location

Various graft materials used for substitution urethroplasty are discussed elsewhere in detail in the textbook. Currently, oral mucosa (buccal, lingual) is favored over penile skin [6]. In our practice, oral mucosa is the preferred graft choice. The use of buccal or lingual mucosa is based on the perceived ease of harvest at the time of surgery. In some cases, both tissues are used.

Historically, grafts were placed as ventral onlays in the bulbar urethra. Following ventral graft placement, one relies on corpus spongiosum and/or bulbocavernosus muscle to serve as the graft bed. In 1996, Barbagli proposed a dorsal technique (dorsal stricturotomy and patch technique) in which the graft is secured to the corporal bodies [7]. The perceived benefits of this procedure over ventral onlays include a better graft bed for neovascularization, reduced risk of long-term graft sacculation, and preservation of the thicker ventral blood supply to the spongiosum [8, 9]. Barbagli et al. noted that dorsal graft placement is simpler and safer in the distal bulbar urethra [10]. Ventral placement, however, was noted to be more efficacious in the proximal portion where the spongiosum is thicker and better vascularized [10]. The spongiosum of the distal bulbar urethra is less robust, possibly making spongioplasty more precarious. However, in their review of the literature, Mangera and colleagues noted no reported differences in stricture recurrence between ventral and dorsal onlays [11]. As a result, the main determinant of graft placement location may be surgeon preference.

A Graded Approach for the Management of Bulbar Urethral Stricture Disease

While the approach to bulbar urethral stricture repair is usually guided by its appearance on retrograde urethrography, it must be recognized that intraoperative findings dictate the final operative plan. Our initial goal is to always repair a bulbar stricture by primary anastomotic urethroplasty, if possible, as this technique provides the most durable outcomes.

If the stricture has no associated adjacent spongiofibrosis but is too long for a primary anastomotic repair, then an augmented anastomotic procedure is performed using either a dorsal or ventral oral mucosal onlay graft. As described above, this technique saves 1 cm of urethral shortening (Fig. 15.2). When the bulbar stricture is long, including a centrally located section of extensive urethral narrowing (Fig. 15.4), a "complex" augmented anastomotic repair is performed. The densely scarred segment is excised and the urethrotomy (dorsal or ventral) is extended into the adjacent spongiofibrosis. An oral mucosal graft is harvested to an appropriate length and the dorsal/ventral onlay performed. The third step in our progression is to simply perform a full-length dorsal or ventral urethrotomy and onlay the graft, particularly if the stricture is long and uniform with no particularly scarred area that requires excision (Fig. 15.5).

Fig. 15.4 Retrograde urethrogram: long bulbar urethral stricture with tight proximal segment and an adjacent, distal portion of affected urethra. The proximal segment is excised and a dorsal or ventral stricturotomy performed on the distal portion. The floor strip or roof strip is primarily anastomosed and an oral mucosal graft placed on the opposite wall as a "complex" augmented anastomotic repair

Preoperative Evaluation

The preoperative evaluation for bulbar urethroplasty is discussed in Chap. 5 in this textbook and will not be reviewed here. Suffice it to say that a recent high-quality retrograde urethrogram delineating all features of the stricture should be available and cystoscopy may be performed if correlation is felt necessary. Ideally, there should be no recent urethral dilations/incisions prior to urethroplasty to ensure the maximum extent of the diseased urethra can be identified at the time of urethroplasty. We routinely wait a minimum of 3 months from the most recent calibration. A suprapubic cystostomy tube to allow for urethral rest may be placed prior to surgical repair as needed (see Chap. 29 in this book).

Surgical Technique

Exposing the Urethra

The augmented anastomotic urethroplasty is performed with the patient in dorsal lithotomy position with the thighs just cephalad of vertical. We use padded Allen stirrups, and all patients wear lower extremity sequential compression devices. A table-fixed Bookwalter retractor, a surgeon's headlight, and 2.5× magnification loupes are advantageous in allowing for maximal exposure/visualization (Fig. 15.6).

Before a perineal incision is made, undiluted methylene blue is instilled per urethra to differentially stain normal from scarred mucosa. Staining of the mucosa also assists in the accurate placement of closure sutures. A 22-French red rubber catheter is passed per urethra and advanced to (but NOT through) the level of the stricture to

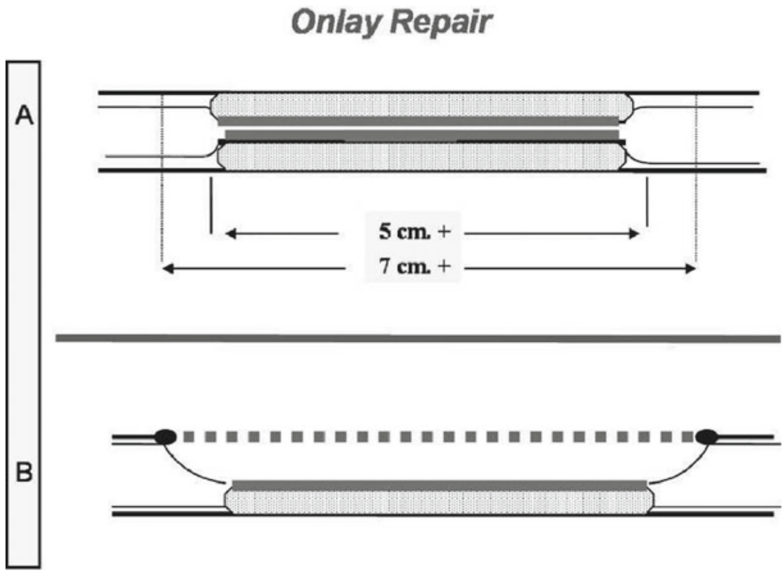

Fig. 15.5 Dorsal onlay repair. In some long strictures, disease is uniform and a discrete area is unable to be identified (*line A*). In these cases a segment of stricture is not excised and the entire stricture is onlayed with graft (*dashed line*) extending 1 cm into healthy urethra proximally and distally (*line B*)

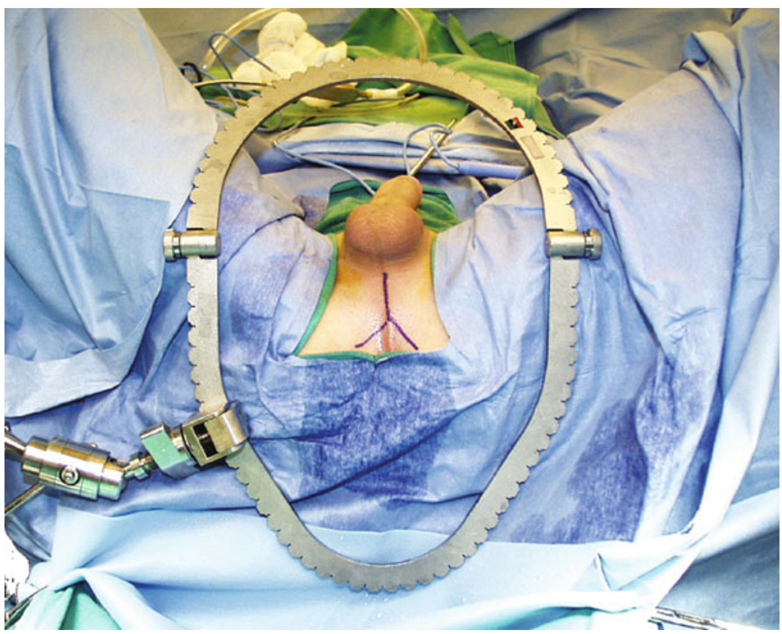

Fig. 15.6 Patient in lithotomy position with table-fixed Bookwalter retractor in place. Note the marking for a midline perineal incision with posterior bifurcation

identify its distal limit and to guide location of the incision.

For a bulbar urethral stricture, we utilize a midline perineal incision with posterior bilateral bifurcation. An electrocautery is used to carry the incision down to level of the bulbospongiosus muscle. The bulbospongiosus muscle is incised in the midline and dissected off the underlying bulbar urethra.

(A) For a tight/dense stricture that is felt to require excision based on aforementioned characteristics, the strictured urethra, as well as 2 cm of proximal and distal healthy urethra, is circumferentially mobilized. Ventral dissection is taken proximally through the central perineal tendon in order to adequately mobilize the urethra, if needed.

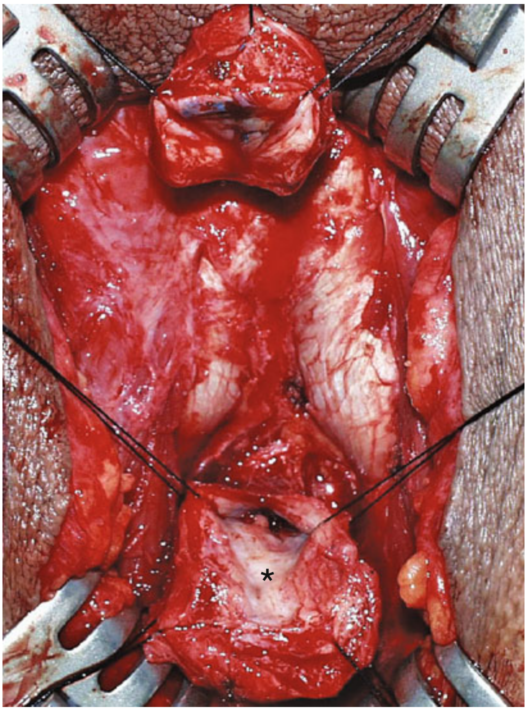

Fig. 15.7 The proximal urethra is placed on traction and dorsal stricturotomy is performed into healthy proximal urethra. Two centimeters of afflicted urethral tissue in the foreground (*) will be excised

With guidance from the red rubber catheter, the urethra is transected at the distal level of the obstructing stricture. The severed urethral ends are tagged with several 4-O silk sutures. The strictured urethra is opened either dorsally or ventrally until healthy urethra is identified proximally. As the urethra is opened, 4-O silk suture tags are placed on the bulbospongiosum to assist with traction and exposure (Fig. 15.7). A change in color of the previously injected methylene blue and appearance of the spongy tissue help clarify when the proximal limit of stricture is reached. Bougie à boule calibration to 26 French ensures that the proximal limit of the diseased urethra has been reached. Cystoscopy is performed to ensure the unspatulated proximal urethral tissue is healthy and that no bladder pathology (i.e., stones) exists. We routinely place a percutaneous suprapubic tube at this time.

The diseased urethral length is measured. Factors including urethral length and elasticity are assessed to determine the most appropriate repair (primary anastomosis vs. augmented anastomosis). Although preoperative retrograde urethrography and periurethral ultrasonography may provide some guidance [12], the final determination for type of repair is based predominantly on the intraoperative findings of stricture length and overall urethral/periurethral appearance. If complete stricture excision and primary anastomosis is felt to be feasible, it is done.

When excessive stricture length prevents complete excision with a simple anastomotic repair, one determines if there is an excisable segment that would still allow for tension-free floor- or roof-strip reapproximation. As mentioned previously, roof-strip anastomoses have been favored by some for the proximal bulbar urethra and floor-strip anastomoses for the mid- to distal bulbar urethra. In the case of a planned floor-strip anastomosis, the scarred mucosa and spongy tissue can often be excised leaving behind the "raw" healthy underlying bulb as a posteriorly based flap to ultimately cover the anastomosis ventrally (Fig. 15.8). For roof-strip anastomoses, the spongiosum tends to be thinner due to the more dorsal location of the bulbar urethra. As a result, full-thickness excision is more likely required. Important considerations at this juncture are whether one can approximate healthy urethra to healthy urethra and if the dorsal/ventral urethrotomy has extended far enough into the healthy urethra such that all adjacent spongiofibrosis will be encompassed by the graft. If tension-free reapproximation is not possible, further distal/proximal urethral mobilization is performed.

(B) When the initial RUG suggests that a "complex" approach is required (e.g., a long stricture with a "tight" area that might need excision) (Fig. 15.4), a decision must be made whether to approach it ventrally or dorsally based on the aforementioned variables and

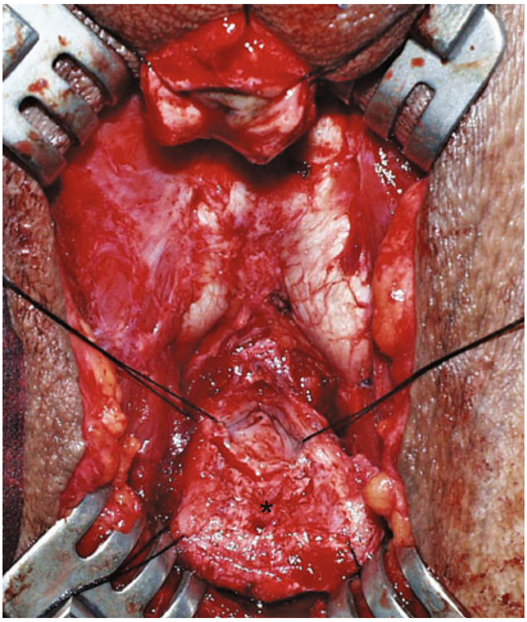

Fig. 15.8 The proximal, ventral urethral stump is on traction, and 2 cm of strictured urethra has been excised. The residual, "raw," healthy spongiosum (*) is a posteriorly based flap that will be used to cover the ventral urethral anastomosis

surgeon preference. For a dorsal approach, the urethra is circumferentially mobilized. A long dorsal urethrotomy is performed and the urethra assessed for partial or full-thickness excision. For a ventral approach, particularly in the mid to distal bulbar urethra, a ventral urethrotomy may be made without initial urethral mobilization. The urethra is assessed to determine if excision of a "tight" mucosal segment is feasible. If full-thickness excision is required, then the urethra will need to be circumferentially mobilized proximally and distally for a few centimeters. In either approach if excision is deemed unfeasible, a long dorsal/ventral onlay is performed.

After urethral preparation is complete, one must determine the length of graft required to complete the urethroplasty. The proximal and distal stumps are brought together and the urethrotomy length is measured to determine the needed length of graft. Measurement includes spatulation of 1 cm into the healthy proximal and distal urethral segments.

Placing the Graft

The types of graft material as well as the technique of graft harvest for urethroplasty are discussed in Chap. 12 (buccal mucosal grafts) and Chap. 14 (lingual grafts) in this textbook.

1. Dorsal Onlay

   After appropriate tailoring, the graft is placed dorsally and spread fixed onto the corporal bodies as originally described by Barbagli [7]. The graft can be affixed to the underlying corporal bodies with bilateral as well as central quilting sutures that include tunica albuginea of the corpora and/or fibrin glue [13]. After graft anchoring to the corporal bodies, starting with the proximal graft apex, interrupted 4-0 or 5-0 absorbable sutures are placed incorporating graft, tunica albuginea, and dorsal spatulated urethral wall. Incorporation of the underlying corporal body helps secure the graft in position (Figs. 15.9 and 15.10). When the apical suture is at the bulbo-membranous region, this and the adjacent sutures are hemostatic as they tamponade the midline veins exposed and opened during dorsal urethra mobilization. Once these apical interrupted sutures are placed, suturing of the lateral urethral walls to each edge of the graft is performed in a continuous fashion but stops short of reaching the cut edge of urethra.

   After securing the proximal aspect of the spatulated urethra to the dorsally placed, spread-fixed graft, the distal portion of the graft is anastomosed to the spatulated distal urethra in a similar fashion. Once again, centrally placed quilting sutures and/or fibrin glue are used to secure the graft to the underlying corporal bodies. Then the urethral floor strip (i.e., ventral wall) is primarily reanastomosed in two layers (urethral mucosa and spongiosum) with interrupted 5-0 (for urethral epithelium) and 4-0 (for spongiosum) absorbable suture (Fig. 15.11). Additional sutures securing the lateral aspects of the outer urethral wall to corpora cavernosa may be placed at the discretion of the surgeon. If desired, fibrin glue may be thinly applied over the ventral closure to minimize urinary leakage [13].

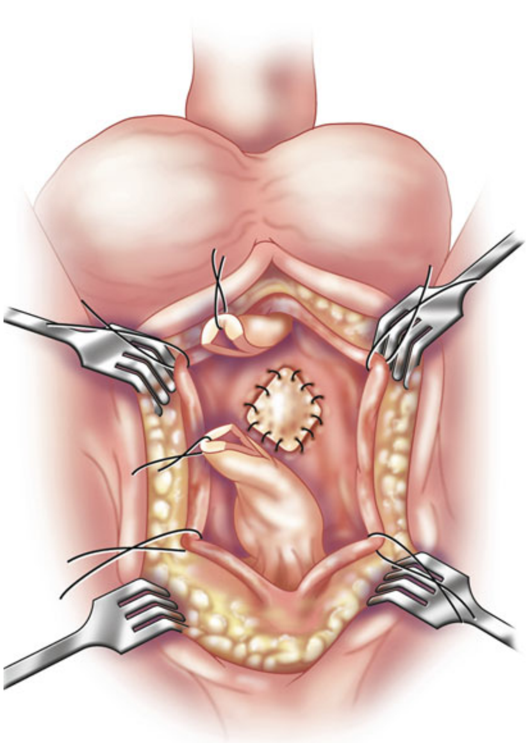

Fig. 15.9 The buccal graft is spread fixed to the corporal body and anastomosed to the dorsal, proximal urethra

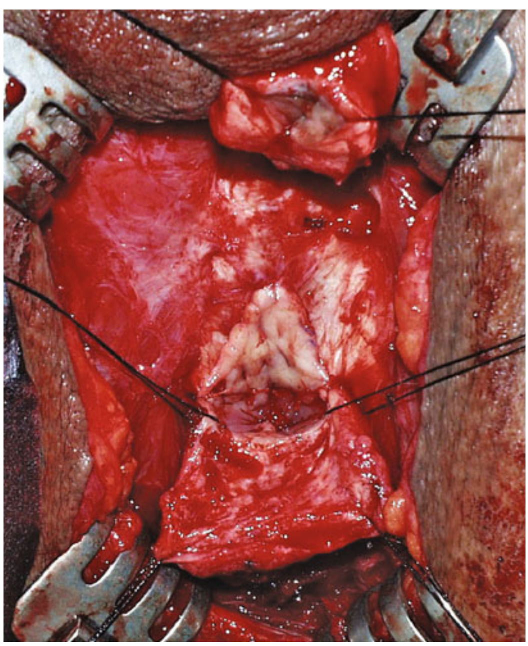

Fig. 15.10 The buccal graft is spread fixed to the corporal body and anastomosed to the dorsal, proximal urethra

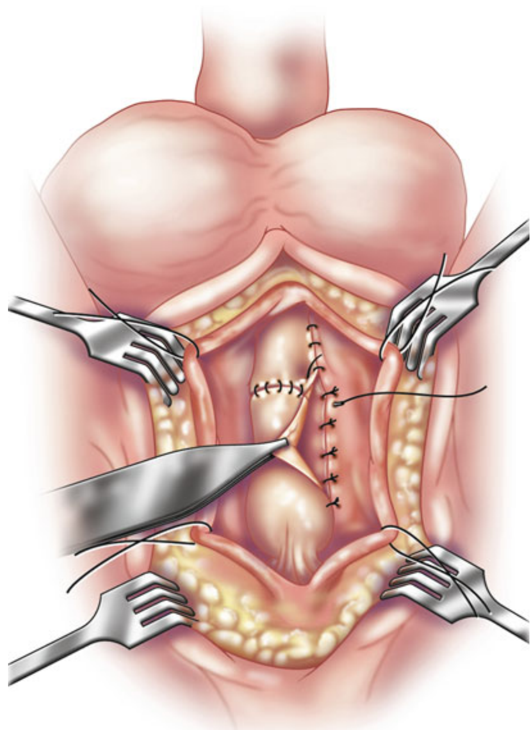

Fig. 15.11 Ventral walls (floor strip) anastomosed and final lateral sutures placed

2. Ventral Onlay

The dorsal walls of the two urethral ends are anastomosed (roof-strip anastomosis) with full-thickness, single layer interrupted 4-0 absorbable suture. Our preference is to also incorporate tunica albuginea of the underlying corporal bodies. Laterally, the urethral anastomosis can be performed in two layers (urethral mucosa and spongiosum). Following dorsal end-to-end anastomosis, a spatulated ventral defect remains (Figs. 15.12 and 15.13). The tailored oral mucosal graft is secured to the urethral mucosal edges with interrupted 5-0 sutures at the apices and continuous sutures laterally (Fig. 15.14). Spongioplasty is performed by closing the thick ventral spongiosum in the midline over the graft using 4-0 sutures (Figs. 15.15 and 15.16). Fibrin glue may be injected over the repair to minimize urinary leakage.

Once the urethral anastomosis is completed, a Foley catheter sized per surgeon preference (we use 14–18 Fr; larger catheter size for ven-

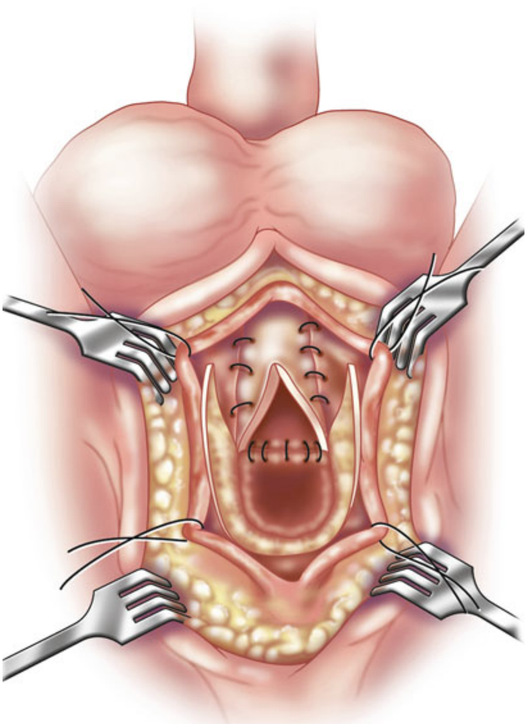

Fig. 15.12 The dorsal urethral walls have been anastomosed as a roof strip leaving a spatulated ventral defect to which the graft will be onlayed

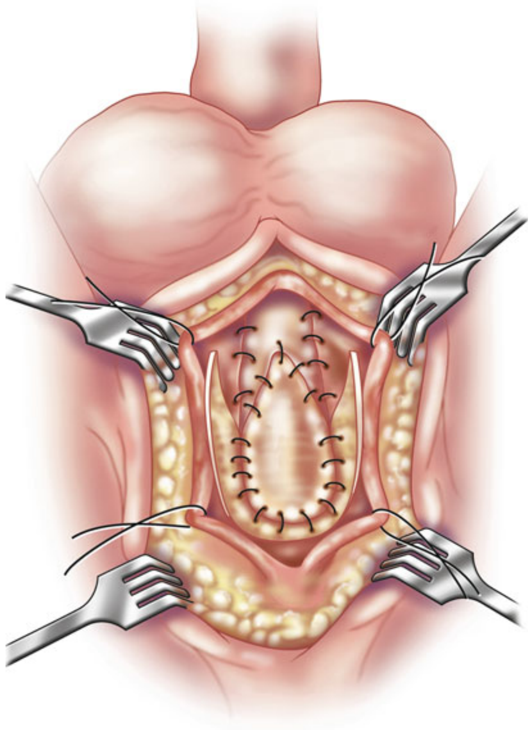

Fig. 15.14 Tailored graft is sutured to the ventral urethral defect

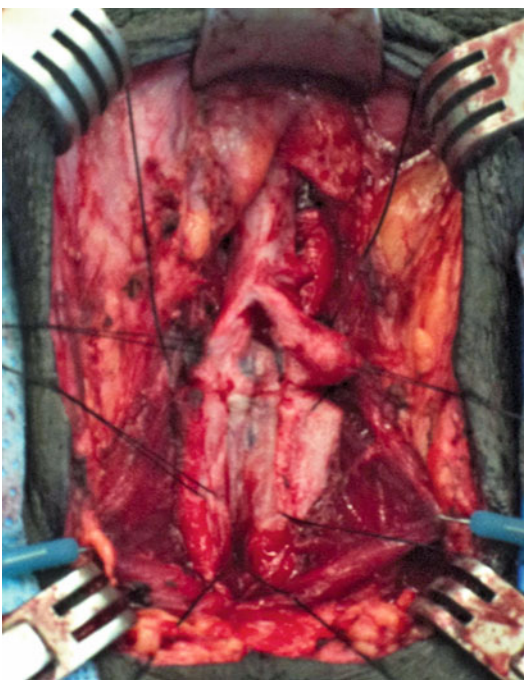

Fig. 15.13 The dorsal urethral walls have been anastomosed as a roof strip leaving a spatulated ventral defect to which the graft will be onlayed

tral onlays) is inserted. The bulbospongiosus muscle is reapproximated over the repaired bulbar urethra. Similarly, Colles' fascia and the skin are closed in multiple layers using absorbable suture. Closed, suction drain placement is based on surgeon preference but not necessarily required. The incision is dressed with fluffed gauze and a scrotal support.

Postsurgical Follow-Up

Following dorsal onlay grafts, we do not restrict ambulation or reasonable activity. Patients are usually discharged home on postoperative day #1. The dorsally located, spread-fixed graft is secured to its vascular bed and protected from dislodgment. For ventral onlay grafts, a period of bed rest (usually 24–48 h) has been recommended [4]. At 3 weeks, the urethral catheter is removed and a combined antegrade/retrograde urethrogram is performed (Fig. 15.17). If the study is negative for extravasation, the suprapubic tube is capped and the patient is instructed to void per urethra. Once the patient con-

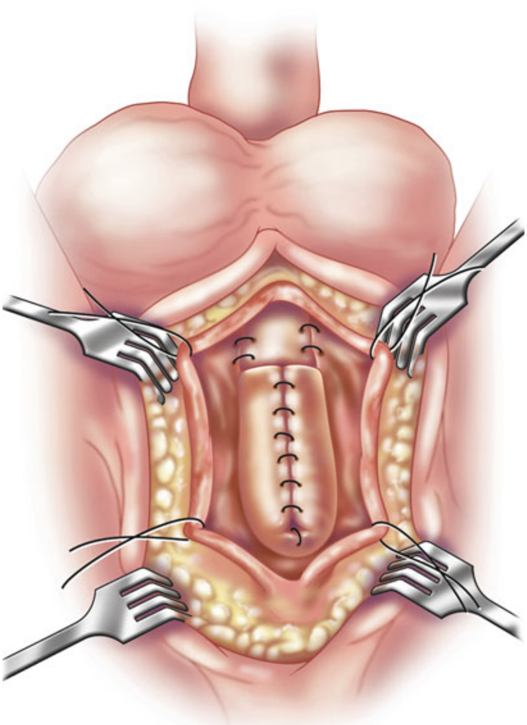

Fig. 15.15 Spongioplasty reapproximates the ventral spongiosum over the graft

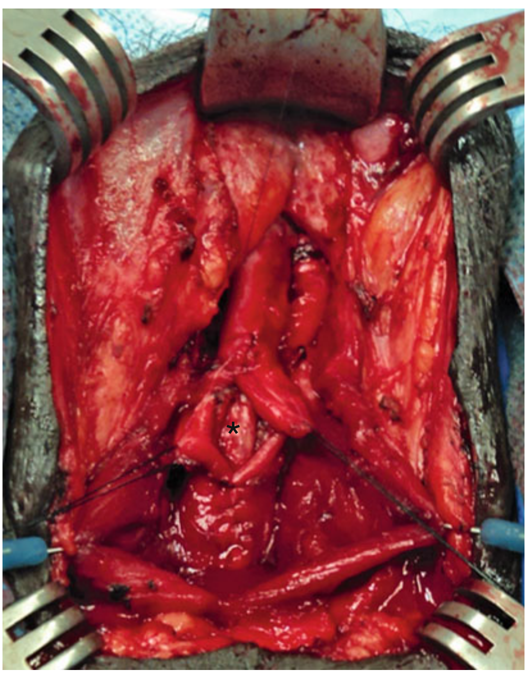

Fig. 15.16 Spongioplasty reapproximates the ventral spongiosum over the graft (*)

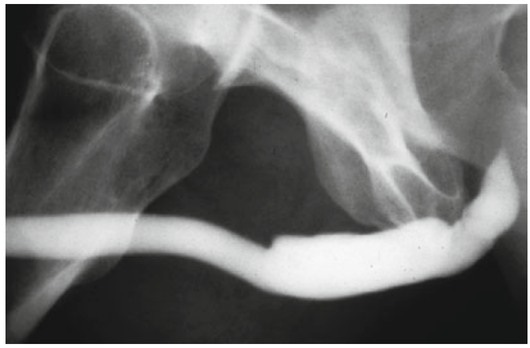

Fig. 15.17 Postoperative urethrogram with patent bulbar urethra after an augmented anastomotic urethroplasty with dorsal onlay of buccal graft. Note typical "mesa" like shape

sistently demonstrates adequate bladder emptying, the suprapubic catheter is removed. If extravasation is present, the suprapubic tube remains to gravity drainage and the study is repeated in 1–2 weeks. A repeat urethrogram is performed at 3 months, by which time future durability of the repair is likely to be evident. At 12 months postoperatively, a noninvasive uroflow study and post-void bladder ultrasound are performed. RUG is repeated as indicated to evaluate for recurrent stricture disease. Abnormal RUG findings prompt a flexible cystoscopy to rule out recurrent strictures. Follow-up thereafter is then dictated by patient symptomatology.

Results

In 2001, Guralnick and Webster reported the outcomes on a series of urethral stricture patients treated with augmented anastomotic urethroplasty [14]. With a mean follow-up of 28 months, 93 % of patients were stricture-free. Similar results (~90 % success at medium term, 3-year follow-up) have been reported by Abouassaly and Angermeier [4] and El-Kassaby et al. [15]. In cases of recurrent stricture formation, a short ring stricture is often located at either the proximal or distal anastomotic ends [4, 14–16]. Possible reasons for recurrent strictures include failure to extend the repair far enough into healthy urethra (especially at the proximal end) and poor inosculation due to inadequate graft bed vascularity (particularly at the distal end with ventral onlays where the distal spongiosum is less robust) [17].

Postoperative Complications

Complications following bulbar urethroplasty are generally infrequent and minor and are discussed in Chap. 21 of this textbook. The most common complaint is post-void dribbling, likely due to disruption of the natural closing mechanism of the bulbar spongy tissue and its surrounding muscle [1]. This is best managed by instructing the patient to manually milk the urethra from the perineum to the meatus after each void [14]. Stricture recurrence, while uncommon, represents a failure of the procedure. As previously discussed, although it is possible for the entire graft to obstruct, a postoperative stricture usually occurs at one of the anastomotic suture lines [16]. When failures occur, a variety of management options are available. Initial treatment with internal urethrotomy or dilations is frequently all that is necessary. Strictures that encompass the entire graft area are typically treated with redo-urethroplasty [18]. Utilization of other graft types (i.e., lingual mucosa) may be necessary in patients with a history of extensive previous buccal mucosa urethroplasty. Other complications such as oral mucosal graft donor site complications (sensory changes, effects on salivary flow, or contracture) and alterations in sexual function may occur. Fortunately, most cases are transient. These are discussed in detail herein by Shenfeld in Chap. 21.

Surgical Pearls and Pitfalls

Pearls	Pitfalls
If possible, try to excise only scarred mucosa and spongiosum leaving behind intact healthy spongiosum (i.e., partial thickness excision). This may be easier to accomplish with dorsal approaches	Complete transection of urethra in a patient with deficient proximal or distal urethral blood supply may result in fibrosis of the deficient segment. Try to identify urethras at risk for this (e.g., distal hypospadias or extensive distal stricture) and rather than completely transect the urethra, perform dorsal or ventral urethrotomy and determine if partial thickness excision is feasible, leaving behind intact spongiosum. Then anastomose the edges of urethral mucosa and place onlay graft on opposite wall
Ensure spatulation is into healthy pink urethra (instillation of methylene blue at start of case may help differentiate healthy from unhealthy epithelium). Repeated intraoperative cystoscopy can help determine if adequate spatulation has been performed	Failure to onlay the graft across unhealthy wide-caliber spongiofibrosis will risk stricture recurrence at this level. If possible, excise this unhealthy spongiofibrotic tissue until healthy tissue is identified. However, if the segment is thought to be too long for excision, then ensure the spatulation extends at least 1 cm into healthy appearing urethra
Attempt to preserve the bulbospongiosus muscle as much as possible – use Lone-star hooks as opposed to the Bookwalter rake retractors for this	Ventral onlays into the distal bulbar urethra risk an insufficient corpus spongiosum for spongioplasty to cover the graft (to serve as the graft bed). In this case, one may mobilize the bulbospongiosus muscle and use it to cover the graft and serve as the graft bed
Spread fixing the dorsal onlay graft to the corporal bodies will help keep it secured to its graft bed (either with sutures, including central quilting sutures, or with fibrin glue)	A hematoma under the graft may lead to poor graft take. For dorsal onlays, central quilting sutures with graft fenestration can help mitigate this. Alternatively, use of fibrin glue to attach the graft to the corporal bodies (without graft fenestration) will usually suffice
When placing the roof-strip anastomotic sutures, include bites of the tunica albuginea of the corporal bodies to anchor the anastomosis in place	

Pearls	Pitfalls
Determine based on preoperative imaging the need for complete urethral transection (e.g., total/subtotal obliterative stricture). If complete transection is thought to be not necessary, decide in advance whether a dorsal or ventral approach will be taken. If a dorsal approach is preferred, then circumferentially mobilize urethra in order to make a dorsal urethrotomy. If a ventral approach is preferred, one need not circumferentially mobilize urethra prior to ventral urethrotomy. However, if full-thickness excision is required, then circumferential urethral mobilization will be needed	
Bed rest for 24–48 h after a ventral onlay graft may help with graft take. This does not appear to be necessary with dorsal onlay grafts	
Use 4-0 and 5-0 absorbable sutures (Vicryl, Monocryl, or PDS) when performing the urethral anastomosis	

Preferred Surgical Instruments of M.L. Guralnick

Jordan retractor system (C&S Surgical, Slidell, LA) for Bookwalter retractor system (Codman, Raynam, MA)
Lone-star hooks
Wagenstein forceps
7-in. Power Cut Black delicate Metzenbaum scissors (Sontec Instruments)
4-0, 5-0 synthetic absorbable sutures (Vicryl, Monocryl) on SH and RB-1 needles
Loupe magnification

Editorial Comment

This is a comprehensive chapter detailing the vast experience of the author with the method of the augmented anastomotic urethroplasty. The author is an acolyte of George Webster and thus of Turner-Warwick, and thus my surgical technique is somewhat different in many respects. I will speak to such differences below.

1. I do not use a Lambda incision and do not feel it really adds much to improving exposure. A midline perineal incision is almost always sufficient for good surgical exposure
2. The indications where I utilize the technique of augmented anastomotic urethroplasty are:
   (a) Obliterative or near obliterative bulbar strictures (with a traumatic etiology), less than 3 cm in length, where we preoperatively planned a stricture excision and primary anastomosis. The dilemma comes when the stricture has been excised (up to 3 cm) and, despite adequate urethral mobilization, the urethra is found to be very in elastic and the two ends of the urethra cannot come together without tension. This happens more often than you think – and most when the stricture is located in the mid to distal bulb – so we cannot take full advantage of the natural elasticity of the whole bulbar urethra.
   (b) Bulbar strictures that are good candidates for a buccal graft urethroplasty but that also have concomitant short segments of a very narrow caliber and scarred stricture. I am often surprised that despite the pre-op urethrography showing a very narrow short segments, oftentimes after the urethrotomy, the plate is surprisingly much wider than expected (>5 mm) – and thus does not need any excision. In general, I follow the rule that if the urethral plate is >5 mm wide, I

just do a graft, and if the plate is <5 mm, I will either augment the plate with double overlapping buccal grafts (after Palminteri) or excision and graft. Thus, unless the stricture has a true obliterated segment, I generally make the decision for graft v. excision plus graft, on the fly – at the time of the surgery. For that reason, I always start off with the urethrotomy and look at the plate and then decide if a segment needs to be excised. I do not like transecting the urethra first – unless the stricture is obliterated. Moreover, if the patient is young and the stricture is of a nontraumatic etiology, I have concerns for creating the rare postoperative complication of impaired erection and glans sensation. For this reason, I have been doing lately more of the Palminteri technique (See Chap. 33).

3. Liberal use of cystoscopy intraoperatively is key. More often than not, the urethra spatulates to 24 Fr, but visually the proximal urethral still looks all wide and friable. In these cases, I will extend the urethrotomy length to be grafted.
4. I do not use a suprapubic tube routinely for bulbar urethroplasty. I find it just adds to the morbidity of the procedure. Where I do place a SP tube is only for penile urethral reconstruction, especially if the meatus is involved. In these circumstances, I place a 12-Fr urethral Foley that I plug – and in so doing avoid possible tugging and tension to the suture line. I have had my fair share of iatrogenic hypospadias by patients who stepped on their urethral catheter bag or fell asleep with the Foley tugging on the meatus.
5. I have found no real advantage to using fibrin glue for bulbar urethroplasty, except to decrease the operative time needed to spread fix the buccal graft to the corpora (rather than suturing). Fibrin glue, in my hands, has not helped shorten the time till Foley removal. It still seems to always take 2–3 weeks till the extravasation on urethrography resolves.
6. For long proximal and mid bulbar urethral strictures that require a short segment of urethra to be excised, I prefer a dorsal mucosal anastomosis and a ventral graft onlay. I have found this to be technically easier for me to sew and allows for ample tissue for a good spongioplasty. Also, from a commonsense view, when you look at a race track, the circumference of the outer lanes is longer than the inner lanes. This is the reason they stagger the start lines of Olympic runners on the race track – with the starting line for the outer lane runners placed well ahead of the inner lane runners. It just makes sense then to make the urethral anastomosis dorsal, for this is the shortest distance, and to place the graft ventral – where the circumference (distance) is longer.

For distal bulbar strictures that require a segmental excision, however, I prefer a dorsal graft and ventral excision – as the spongiosum is inadequate distally for good coverage and the host bed of the corpora is still very reliable.

–Steven B. Brandes

Acknowledgements The authors wish to thank Dr. George Webster, one of the authors of this chapter in the 1st edition, for his guidance, mentoring and friendship. We would also like to acknowledge his invaluable contributions to the art of urethral surgery

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Penile Skin Flaps for Urethral Reconstruction

16

Benjamin N. Breyer and Jack W. McAninch

Summary

The penile skin flap can provide single-stage reconstruction of strictures from the bulbar urethra to the meatus. An understanding of the patient comorbid disease status, penile tissue quality, and stricture length and location are critical for preoperative planning. The ideal flap will be hairless, accustomed to the aqueous environment, adaptable, and cosmetic. This versatile and technically challenging technique calls for a thorough understanding of penile vascular anatomy and the fascial layers. All penile flaps share a common blood supply from the external pudendal artery, and all involve the isolation of an island of skin. Penile flaps are best described by their anatomic characteristics such as the orientation and location of the harvested skin island, the origin of the pedicle, and how the penile flap is utilized to treat the stricture. Details regarding our operative approach to performing penile skin flaps are provided.

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Patient Selection

The aim of anterior urethral reconstruction should be to provide unobstructed voiding from a glandular meatus, ideally in a single stage. The penile skin flap can provide an excellent option for repair of strictures of varying lengths and locations. The approach can be technically challenging and appropriate patient selection is critical for success.

First, consider patient comorbid disease status. Conditions that compromise blood flow and wound healing may increase penile skin flap failure rates (e.g., smoking history, peripheral vascular disease, diabetes, radiation therapy) [1]. Local wound pathology such as concurrent fistula or periurethral abscess can affect outcomes.

Second, consider patient age. Several reports have demonstrated that complex urethroplasties, including penile skin flaps, can be performed in men older than 65 years of age with similar outcomes to younger men [1–3]. However, elderly men may prefer periodic urethral dilation or a permanent first stage urethroplasty to gain excellent voiding status and avoid complex surgery; these options may not suit younger men.

Third, consider whether lichen sclerosis (LS) caused the stricture. No one advocates using penile skin flaps involved with LS, however good long-term flap results have been reported in patients with LS when the flap itself was uninvolved [4]. Others believe only a two-stage repair is appropriate using extragenital skin [5].

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Current Clinical Urology, DOI 10.1007/978-1-4614-7708-2_16,

Fourth, length and location often dictated technique employed. Penile skin flaps work best for penile urethral strictures located in the meatus through the distal bulb. With rare exceptions, anastomotic urethroplasty and buccal mucosal graft onlay in the bulbar urethra provided excellent results and are the technique of choice in this location.

Desirable Flap Characteristics

Being hairless, accustomed to the aqueous environment, adaptable, and cosmetic are the four main desirable flap characteristics. Flap hair leads to chronic bacterial urethral colonization, stone formation and obstruction, and inflammation. The distal penile shaft and prepuce are hairless and the proximal and mid penile shaft contain variable amounts of hair. Hair is more prominent ventrally.

Skin not accustomed to the aqueous environment becomes inflamed, soggy, and undergoes squamous metaplasia went chronically exposed to urine. Distal penile skin and notably the inner prepuce are better accustomed to a moist environment than its proximal counterpart.

A desirable flap must be adaptable to treat strictures in varying locations and of varying lengths. Most flap techniques allow for good mobility to treat diverse locations. The transverse island flap technique provides up to 15 cm of length.

Most penile skin flaps provide excellent cosmesis by creating a suture line along natural skin markings. For example, longitudinal penile flaps create an incision along the median raphe, while transverse penile flaps recreate the circumcision scar.

Soft Tissue, Fascia, and Vascular Anatomy of the Penis

Penile anatomy is described in detail in Chaps. 1 and 2 in this volume. Here, we highlight anatomy relevant to penile skin flaps (Fig. 16.1). Some inconsistency with anatomic terminology exists. Throughout this chapter, we will utilize the terminology of Dr. Quartey [6].

The superficial layers of the penile and scrotal soft tissue are composed of skin that contains dartos muscle which can contract in response to

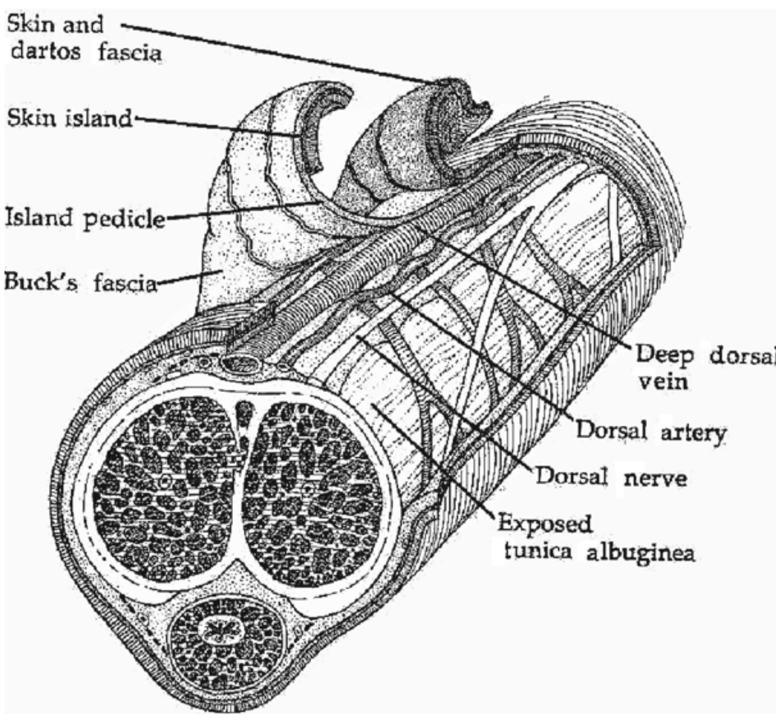

Fig. 16.1 The fascial anatomy of the penis

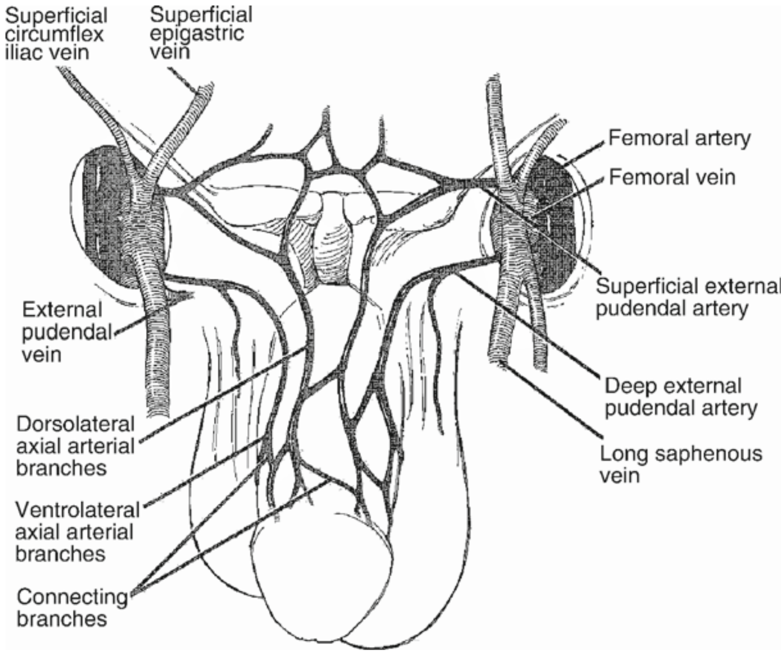

Fig. 16.2 Arterial supply and venous drainage of the penis

stimuli. Below the skin and dartos muscle lies a subdermal vascular plexus. This vascular plexus is supported by dartos fascia (also known as Colle's fascia) which is continuous with Scarpa's fascia on the anterior abdominal wall. Below the dartos fascia lies the tunica dartos which is a loose areolar tissue that contains the axial arteries of the penis. Penile skin flaps are an example of an axial flap based on the subcutaneous plexus of vessels traveling in the tunica dartos. Below the tunica dartos lies Buck's fascia. Buck's fascia surrounds the neurovascular bundle of the penis dorsally and splits ventrally to wrap around the corpus spongiosum.

Understanding the penile blood supply is critical to performing penile skin flaps. The superior (superficial) and inferior (deep) external pudendal arteries branch from the femoral artery to supply the penile skin. The venous system parallels the arterial supply (Fig. 16.2). The external pudendal artery at the base of the penis divides into the ventral lateral and dorsolateral axial penile arteries. From these axial penile arteries, the fine superficial branches to the subdermal plexus arise. The subdermal plexus runs superficial to the dartos fascia.

Types of Flaps

Penile skin flap nomenclature can be unclear and confusing. For clarity, it is best described based on intuitive anatomical classification. The anatomic classification will take into account (1) the orientation of the penile skin flap (longitudinal versus transverse), (2) where on the penis the penile skin flap came from (proximal versus distal penile skin), (3) where the flap pedicle blood supply is derived (dorsal versus ventral versus lateral pedicle), and (4) how the flap is integrated to repair the stricture (ventral onlay versus tube flap versus combined tissue transfer).

Longitudinal Versus Transverse

Longitudinal is the most intuitive direction for penile flap construction, running parallel to the urethra for easy placement, and offering the ability to tailor length and width in a straightforward manner. The flap is harvested from ventral skin and minimizes the amount of dissection required to cover the urethra. The suture line created from closing this dissection recapitulates the median raphe to provide a good cosmetic result. A major disadvantage of this approach is that in longer strictures, proximal penile skin with hair must be used. As mentioned earlier, this can lead to infection, stone, and obstruction. Another disadvantage of longitudinal penile skin flaps is that flap length is contingent on penile length.

The transverse penile flap runs perpendicular to the long axis of the penis. As such, it is less intuitive and requires a greater degree of pedicle dissection to allow the flap to rotate 90° to cover the urethra. It provides a greater range of flap length and width options. A ring of distal penile skin typically provides 15 cm of flap. Less can be harvested for use in shorter defects and a "hockey-stick" or Q-flap extension can be used when more than 15 cm is needed [7]. The transverse flap suture line recreates the circumcision scar producing excellent cosmesis. Another advantage of the transverse flap is a more broad-based blood supply compared to longitudinal flaps. The longitudinal flap must be divided on one side in order to roll the skin over the urethral defect. On the other hand, the transverse flap allows for circumferential dissection of the tunica dartos pedicle providing a robust blood supply. One criticism of the transverse flap is that the dissection is more challenging.

Proximal Versus Distal Penile Skin

The distal penile skin is strongly preferred for urethral reconstruction than its proximal counterpart. One should harvest the transverse skin flap as distally as possible. As mentioned earlier, it is preferable for penile skin flap to be hairless and accustomed to a moist environment. Distal penile skin is essentially hairless, while proximal skin has hair. In addition, the distal penile skin and prepuce are accustomed to a moist environment.

Dorsal Versus Ventral Versus Lateral Pedicle

As outlined earlier, all penile skin flaps receive blood supply from the superficial and deep external pudendal arteries regardless of construction. Penile skin flaps are differentiated on whether they utilize the ventrolateral or dorsolateral branches of the external pudendal artery. As the anatomically derived name suggests, a dorsally based flap utilizes blood supply from the left and right dorsolateral branches. The converse is true for a ventrally based flap. A lateral flap derives the majority of its blood supply from both the ipsilateral ventrolateral and dorsolateral branch of the external pudendal artery.

Flap type helps determine from where the pedicle is derived. A longitudinal skin flap from the ventral penile skin must be supplied by a ventral-based or lateral pedicle, not a dorsal-based pedicle. As described by Turner-Warwick (citation), when developing a ventral pedicle, a plane over the urethra at the distal end of the flap is developed and the dissection is carried proximally and laterally to produce a broad base. Orandi described creating a lateral pedicle by dissecting the skin island off the urethra from medial to lateral and continuing the dissection out laterally along the corporal body (citation). When constructing a transverse penile skin flap, blood supply is maximize by circumferentially dissecting the tunica dartos from the underlying shaft. The skin island and flap can then be divided longitudinally either ventrally or dorsally, and based on a dorsal or ventral pedicle, respectively.

Ventral Onlay Versus Tube Flap Versus Combined Tissue Transfer

Ventral onlay of a penile skin flap is performed after ventral urethrotomy given an adequate, intact dorsal urethral plate is present. The flap is isolated and fashioned to the appropriate length and then sewn as an augment to the ventral urethrotomy.

For short (<2 cm) obliterative strictures with an inadequate dorsal plate an excision and anastomotic urethroplasty can be performed. For longer (>2 cm) obliterative strictures, the dorsal plate needs to be reconstructed. An augmented anastomotic urethroplasty may be possible (see chapter 15 by Guralnick) or a two-stage repair where the first stage recreates the dorsal plate can be undertaken (see chapter 20 by McClung and Wessells).

One-stage operations to repair obliterative strictures that are too long for an augmented anastomotic urethroplasty include the tube flap or combined tissue transfer with a dorsal graft followed by a ventral penile skin island flap. Tube flaps are created by transforming the island skin flap into a cylinder, using it to replace the diseased urethra. The tube flap can be used to treat long obliterative strictures. Overall results have been poor, and the technique has been replaced by combined tissue transfer. Typically, a graft is employed in one part of the urethra and the flap and another. For long-segment urethral disease with obliteration, a dorsal graft can recreate the urethral plate followed by a ventral onlay flap [8].

Results

While the overall success rate for fasciocutaneous penile skin flaps is high, this rate diminishes with time [1]. Overall success rates for anastomotic or graft-aided urethroplasty is likely higher [3]. Given the variety of surgical techniques employed by reconstructive urologists, it is difficult to compare success rates for different techniques of penile skin flap urethroplasty. Stricture length and the location, etiology of disease, mechanism of patient referral, indications for surgery, surgical technique, and quality of follow-up in the definition of failure may differ in each of these institutions. At our institution, at 1, 3, 5, and 10 years the overall estimated stricture-free survival rates were 95, 89, 84 and 79 %, respectively. On multivariate analysis smoking, history of hypospadias repair, and stricture length 7–10 cm were predictive of failure [1].

Technique

Preoperative Preparation

Stricture length and the quality of the dorsal plate should be assessed with retrograde urethrogram, voiding cystourethrogram, and sonourethrogram. Careful attention should be paid to patient comorbid disease status, surgical history, and penile skin quality.

Patient Positioning

Stricture length and location dictate patient position (supine, low lithotomy, or high lithotomy). Given the technically challenging nature of penile flap surgery, operative times can be lengthy. The patient should be properly padded and placed in the supine position as much as possible to minimize positioning-related complications. Pendulous urethral strictures are all performed in the supine position. More proximal strictures require lithotomy; here, the flap can be harvested in supine, with the patient repositioned in lithotomy to place the flap.

Flap Harvest

The glans penis is placed on stretch with the aid of a 2-O silk stay stitch in the midsagittal plane. Hair-bearing penile shaft skin is spared during patient shaving to avoid incorporation during flap harvest. One must employ meticulous surgical technique: handle tissues carefully with fine instruments to remain in the proper tissue plane and to avoid vascular pedicle compromise. Bipolar electrocautery can be used to control bleeding vessels. Hematoma formation can compromise the vascular pedicle by compression.

A flap is crafted to match the length and width of the urethral defect. Measurements are made after complete stricturotomy. While the measurement of length is intuitive, width is less so. The width should equal the expected circumference of the urethra at that location. The urethral plate plus the flap width should equal the expected circumference. For example, a dorsal plate of 4 mm +20 mm wide flap will provide a 24 mm circumference and a 24 Fr lumen.

Longitudinal Ventral Penile Skin Flap with a Lateral Pedicle (Technique of Orandi [9])

As described above, placed the penis on stretch. Make a ventral vertical penile shaft incision over the area of the stricture, approximating the stricture length. This initial incision will serve as

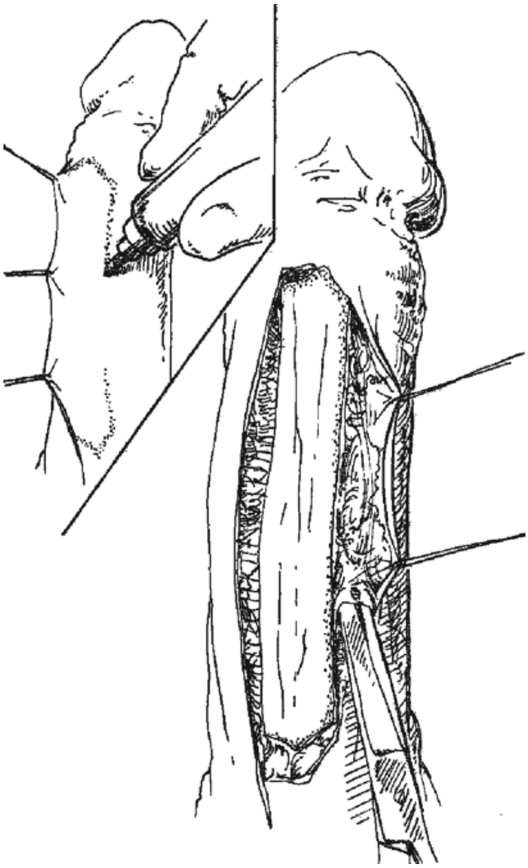

Fig. 16.3 Technique of harvest of the Orandi flap

the deep incision and should be carried to the lateral border of the corpus spongiosum. Create a lateral urethrotomy contralateral to the side of the initial skin incision. Extensive urethrotomy until normal urethra is encountered proximally and distally. The lateral urethrotomy minimizes the amount of flap dissection necessary to gain a tension-free anastomosis. A hexagon shaped skin island is crafted to match the length and width of the urethral defect (Fig. 16.3). A second long incision is made on the skin island superficially and is carried down to but not through the pedicle and developed laterally. The flap is sutured onto the urethrotomy in a tension-free manner (Fig. 16.4).

Longitudinal Ventral Penile Skin Flap with a Ventral Pedicle (Technique of Turner-Warwick [10])

The bilateral pedicle island penile skin flap described by Turner-Warwick is a ventral-based pedicle derived from the right and left ventrolateral branches of the external pudendal artery. This flap is most useful in bulbar urethral reconstruction. Similar to the Orandi flap, a hexagonal longitudinal patch of ventral skin is utilized. Marked out the skin island preoperatively based on imaging of

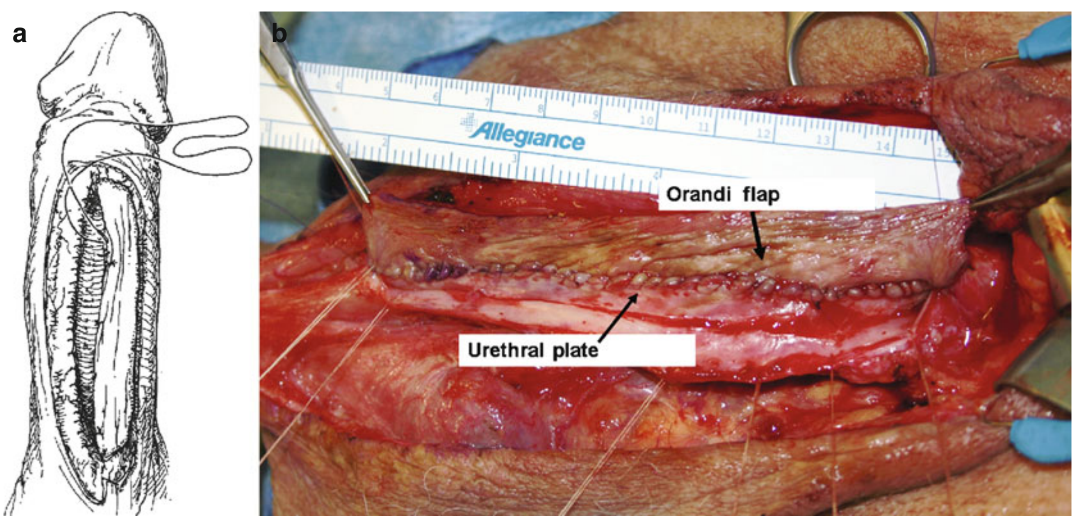

Fig. 16.4 (**a**) Rotation and onlay anastomosis of the Orandi flap. (**b**) Orandi skin flap sewn to urethral plate. Foley catheter then placed and contralateral side of flap anastomosed (Image courtesy SB Brandes)

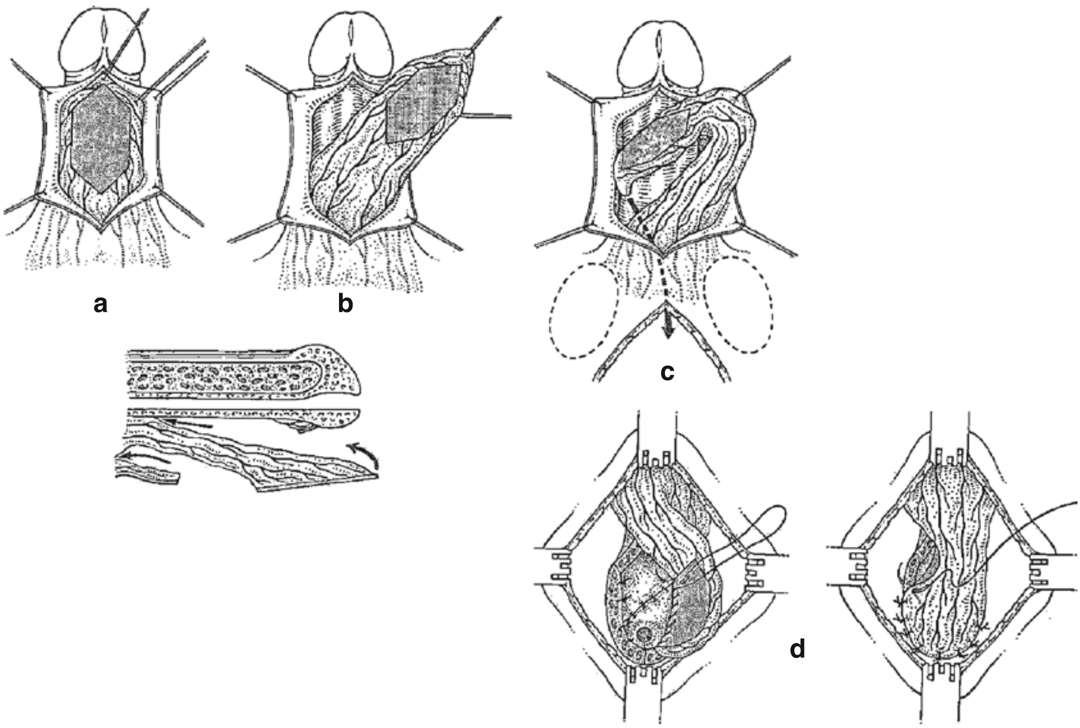

Fig. 16.5 Technique of harvest of the Turner-Warwick flap (**a**–**c**) development of pedicled skin flap, (**d**) sewing the flap to the urethral plate

the stricture. If the stricture is located in the bulbar urethra, the skin island can be marked out after the urethra has been exposed via a separate perineal incision. The deep plane is developed below the level of the pedicle around the distal apex of the island while the superficial layer is developed around the proximal apex of the island (Fig. 16.5). The island and its pedicle are elevated off the underlying penile urethra and overlying proximal penile shaft skin and scrotal skin. The pedicle is further developed down into the scrotum. The flap is inverted through a scrotal tunnel and brought out through a separate perineal incision and sewn to the bulbar urethrotomy.

Transverse Circular Penile Skin Flap with a Primarily Dorsal Pedicle (Technique of McAninch [11, 12])

The penis is placed on stretch, and the flap is marked out with calipers and brilliant green dye. The width of the flap varies between 2.0 and 2.5 cm, depending on the caliber of the stricture (Fig. 16.6). If the penis is uncircumcised, then the inner prepuce is chosen for the flap, whereas if the penis is circumcised, then the distal penile skin is used, for reasons described earlier.

The distal incision is carried down deeply beneath the pedicle, leaving the pedicle with the proximal penile skin (Fig. 16.7). Once a satisfactory plane is established, the dissection is continued proximally, degloving the entire penile shaft. The proximal/superficial incision is then made and the pedicle dissected off the proximal penile skin, circumferentially all the way to the base of the penis. This leaves a very mobile circular ring of penile skin supported by a circumferential pedicle. The flap and pedicle are generally divided ventrally as we feel the dorsal branches of the pedicle are more robust (Fig. 16.8). The flap is then rotated 90° and brought around ventrally (Fig. 16.9). The skin island is trimmed to meet the length of the stricturotomy and sutured to the urethral edge (Fig. 16.10).

Fig. 16.6 Skin markings for flap harvest (Figure copyright Jack W. McAninch, MD, illustration by Stephan Spitzer)

Urethral Closure with Ventral Onlay Island Skin Flap

All penile skin flaps are sutured to the urethral plate in a similar fashion. A meticulous watertight epithelium to urethral edge anastomosis is performed. The use of loupe magnification, fine suture, and delicate instruments is recommended (see appendix). It is at the discretion of the surgeon

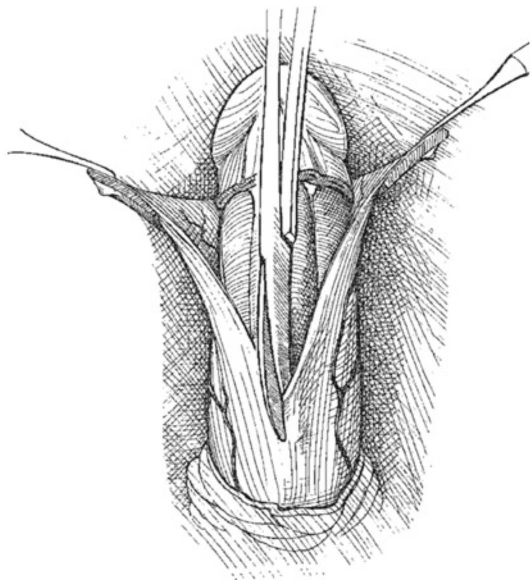

Fig. 16.8 Ventral division of the skin island and pedicle in the midline (Figure copyright Jack W. McAninch, MD, illustration by Stephan Spitzer)

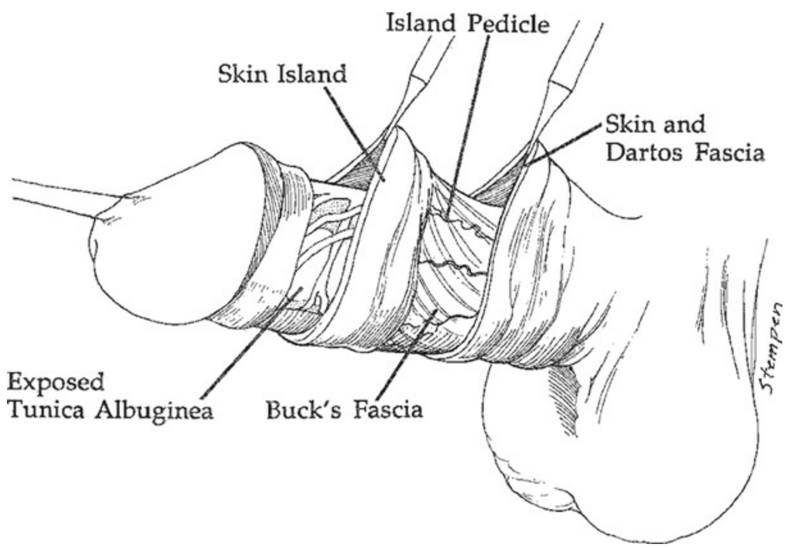

Fig. 16.7 Technique of harvest of the McAninch flap (Figure copyright Jack W. McAninch, MD, illustration by Stephan Spitzer)

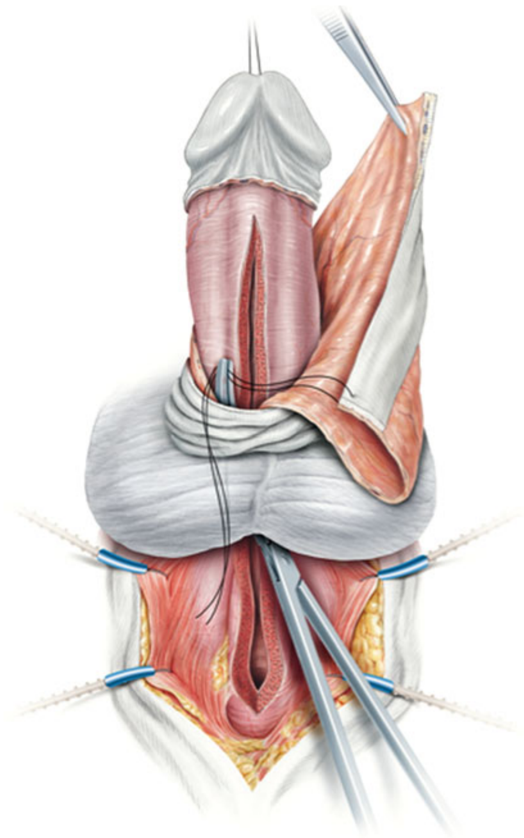

Fig. 16.9 90° flap rotation and ventral transposition (Figure copyright Jack W. McAninch, MD, illustration by Stephan Spitzer)

whether to perform a running or interrupted suture anastomosis; neither approach has proven better than the other. The closure is aided by placement of a 14–18 French catheter. Problems of poor bladder drainage arise when the catheter is too small; problems of tissue necrosis and ischemia arise when the catheter is too big. The catheter is typically left in place for 1–3 weeks depending on the surgeon's preference.

Urethral Closure in Combined Tissue Transfer

As mentioned previously, combined tissue transfer techniques are used as one-stage solutions to obliterative long anterior urethral strictures [8, 13]. Typically, a dorsally placed buccal mucosal graft is employed in combination of the penile skin flap.

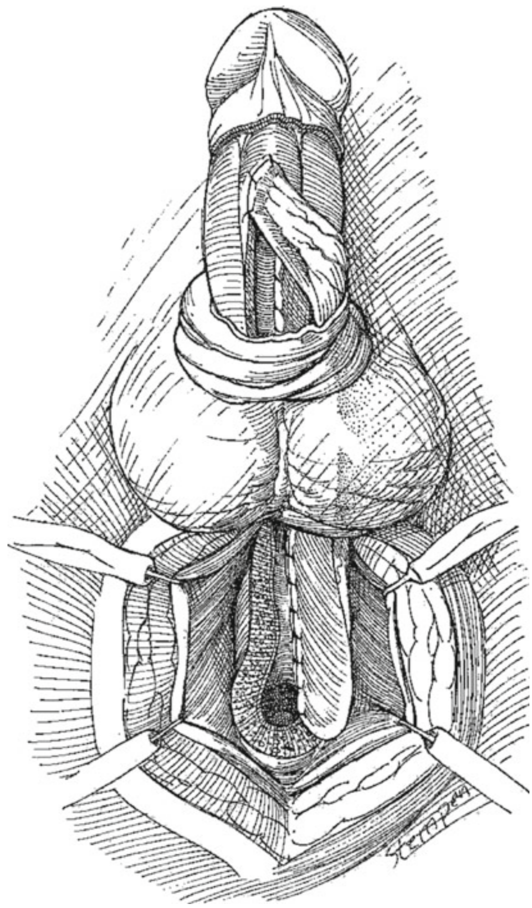

Fig. 16.10 Onlay anastomosis of the McAninch flap (Figure copyright Jack W. McAninch, MD, illustration by Stephan Spitzer)

The stricture must be completely excised exposing the corporal bodies. The buccal graft is then attached on stretch to the corporal bodies and the dorsal aspect of the native urethral lumen. After tapering the flap to the appropriate length and width, place sutures in the proximal and distal apices of the flap suturing to the ventral aspect of the native urethra. Interrupted sutures should also be placed at the apices to complete the anastomosis to the native urethra. A running suture can then be placed to secure the lateral edges of the flap to the underlying buccal mucosal graft while concurrently securing the graft to the tunica albuginea.

Surgical Pearls and Pitfalls

Key intraoperative surgical points	Potential intraoperative surgical problems
Place penis on stretch during initial flap measurement (ideal width 20–25 mm)	Skin necrosis: too thin on the skin side/wrong dissection plane, will likely need local wound care postoperatively
When elevating Buck's fascia support, the tunica dartos superficial to the neurovascular bundle	Ventral bowing of the urethra: Incomplete flap mobilization/dissection requires taking dissection more proximally
Provide sufficient mobilization of the skin and pedicle flaps	Diverticulum formation: caused by flap redundancy, requires appropriate tapering intraoperatively
Make a watertight epithelium to epithelium anastomosis	Fistula formation: caused by epithelial breakdown, can be prevented by avoiding overlying suture lines
Completely in size stricture to healthy tissue	Stricture recurrence: either technical error in suture placement or inadequate scar incision
Taper flap to stricture length	

Preferred Surgical Instruments and Suture of Authors

(a) Castroviejo Caliper
(b) Bayonet bipolar cautery forceps
(c) Bougie-a-Boule
(d) Forceps
  (i) Gerald forceps with teeth
  (ii) DeBakey forceps
  (iii) Bishop-Harmon forceps
  (iv) McAninch blue titanium forceps (Sontec #2600-582)
(e) Scissors
  (i) Supercut curved endarterectomy Scissors, 6¾ in. (Jarit #102-315)
  (ii) Supercut straight Mayo Scissors, 5½ in. (Jarit #102-100)
  (iii) Supercut curved Jamison Scissors, 5½ in. (Jarit #102-300)
(f) Needle Holders:
  (i) Euphrates-Pasque (2300-661)
(g) Suture
  (i) 2-0 silk pop-off (glans stitch)
  (ii) 5-0 chromic (to repair holes in the corpus spongiosum)
  (iii) 4-0 Dexon RB-1 (for holding stitches and wound closure)
  (iv) 5-0 or 6-0 Maxon, RB-1 (for urethral anastomosis)

Editorial Comment (1)

The McAninch circular penile skin flap is the most versatile and reliable choice for long segment urethral substitution. Caution is advised in hypospadiacs, smokers, and those with lichen sclerosus or otherwise unhealthy foreskin. The circular flap may be easily divided into multiple separate flaps or brought up and down the urethra as needed for synchronous strictures. Combining this flap with a dorsal buccal graft is a sound strategy for segmental urethral replacement when needed.

I tend to limit this technique to the penile urethra, where tissue transfer is easy; grafts are greatly preferred over flaps in strictures of the deep perineum. Tunneling a skin flap through the scrotum is tedious and may tether the penis during erections; for this reason, flap tunneling should be avoided in young, sexually active patients. Covering all suture lines with redundant pedicle provides a waterproofing layer that virtually eliminates the risk of fistula. Fibrin sealant is also helpful to provide hemostasis, reinforce suture lines, and prevent edema. I recommend completion of circumcision in uncircumcised men since the neighboring distal foreskin may be prone to ischemic slough. A gentle compressive dressing with Coban prevents hematoma and edema but must be removed with 24–48 h to prevent ischemic complications.

–Allen F. Morey

Editorial Comment (2)

I generally prefer to use the McAninch circular skin flap, because it is hairless, can be mobilized to any area of the anterior urethra, and is long

(10–15 cm) and versatile. Proper and extensive mobilization of the dartos pedicle to the penoscrotal junction with the penis on stretch will help avoid the complications of penile torsion or flap tension. I also longitudinally split the pedicle dartos on the dorsal aspect, in order to transfer the skin flap to the urethra. This prevents the need for wrapping the pedicle around the penile shaft, as needs to be done if the dartos is opened on the ventral side.

Ventral-longitudinal (Orandi) flaps require less mobilization and are easier to construct, but hair is often present at the proximal aspect – so the limit of such flap length is generally 6 cm and usually confined to the mid penis. To help prevent fistula formation, I suggest you place the Orandi flap via a dorsal urethrotomy, after rotating the mobilized urethra, rather than place it ventrally. If you place the flap ventrally, I prefer harvesting and interposing a tunica vaginalis flap. Make sure the penis is on stretch when you tack down the vaginalis flap, so as to prevent a high riding testis with erection. Although I have generally moved away from the use of flaps to almost exclusively buccal graft urethroplasty, they still have an important role in the armamentarium. Flaps are particularly useful for reconstructing a prior graft failure, long (near panurethral) strictures, or the obliterated urethral plate where a combination of ventral onlay flap and dorsal graft (replacing the urethral plate) is used in one stage.

In general, we try to mobilize flaps with the patient in the supine position, and if the stricture extends into the bulbar urethra, we subsequently redrape and prep the patient in the lithotomy position. In this way, the morbidity of excessive time in the lithotomy position can be avoided. From a technical viewpoint, when dissecting out the pedicle of the flap, we will typically error on the skin side in our attempt to make the dartos pedicle as thick as possible. My feeling is that if we make it a little thin on the skin side, the skin may slough in a small area, but this is something that with dressing changes will granulate in nicely with time and leave little long-term morbidity. If we skimp on the pedicle side out of fear of devascularizing a small segment of skin, we potentially compromise the success of the urethroplasty (which is a much bigger problem to deal with). For this reason, we typically first start with the distal skin incision that extends deep, to mobilize the sub-dartos plane, and then make the more proximal skin incision (usually 2 cm proximal) that extends only into the subepithelial avascular plane. When dissecting out the subepithelial plane, we typically keep an index finger under the dartos pedicle (and periodically palpate with a thumb) to insure that we are keeping the pedicle as thick as possible.

–Steven B. Brandes

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Panurethral Strictures

17

Carlos Guidice

Summary

Panurethral strictures (PUS) are complex and long strictures that affect the entire anterior urethra. Such strictures are a challenge for the urethral surgeon and require the use of the entire surgical armamentarium. An accurate diagnosis is important to design a proper surgical plan. Surgical methods for reconstructing these long strictures are bilateral buccal mucosal grafts, "Q" penile skin flaps, McAninch flap (circular penile skin), Orandi flap (longitudinal penile skin), or a combination of such onlay flaps and grafts. For one-stage reconstructions, the graft is typically placed proximally to benefit from spongiosal blood supply, and the flap is placed on the distal bulb or penile urethra. In patients with inadequate skin, a combination of oral grafts may be used. In some PUS, one- or two-stages surgeries may be combined in the same patient. The absence of the urethral plate requires the creative combination of different tissue transfer techniques.

Introduction

Panurethral strictures (PUS) are complex and long strictures that involve both the penile and bulbar urethra (Fig. 17.1). Such strictures are difficult to reconstruct and require the creative combination of different tissue transfer techniques for successful urethral reconstruction.

A careful evaluation of patients by physical exam, endoscopy, and urethrography is critical before scheduling surgery. It is also important to take into comorbidities such as cigarette smoking and diabetes, which may effect overall graft take

Fig. 17.1 VCUG showing a panurethral stricture

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S.B. Brandes, A.F. Morey (eds.), *Advanced Male Urethral and Genital Reconstructive Surgery*, Current Clinical Urology, DOI 10.1007/978-1-4614-7708-2_17,

and flap survival [1]. When reconstructing the panurethral stricture, we prefer two surgical teams (oral and genital teams), as it helps to reduce the anesthesia time and allow the surgeon to be focus on intraoperative decision making in the main surgical area.

The initial surgical steps include exposure of the entire anterior urethra, longitudinally urethrotomy for visual inspection of the epithelium and spongiofibrosis, followed by intraoperative bougienage of the spatulated edges and urethroscopy to assess the mucosa and lumen of the proximal urethra.

Evaluation

The first step to evaluate patients with long stenosis is a genital skin inspection, mainly the penile skin. Patients with healthy normal penile skin have major advantages over those with inadequate skin, as is common for patients with penile surgery, hypospadias surgery, or presence of lichen sclerosus (LS). A normal appearing penis with adequate healthy skin means that a significant portion of the stenosis and, sometimes all the stenosis, can be repaired with a local skin flap.

The first common surgical pitfall is to not properly diagnose the stricture as being panurethral. On urethrography, the narrowing of the lumen can be fairly uniform, with only short areas of more severe stenosis. Such a panurethral stricture can be misread as just a short stricture and the other less narrow areas underestimated as being of "normal" caliber. Some of the ways to avoid this error in diagnosis is that, no matter how uniform the urethra may look, if it does not expand to >8 mm in diameter on imaging then it is probably stenosed.

On urethrography, the urethra proximal to the stenosis may appear normal in patients who are still able to urinate slowly yet spontaneously. At times, here the proximal urethra may actually be scarred and just kept open by the proximal hydraulic distention of the urethra. In such patients, we prefer to the urethra at rest and place a suprapubic (SP) tube. By putting the urethra at rest (diverting the urine proximally) gives the affected urethral areas a chance to declare themselves – the strictured areas to possibly worsen, while the healthy areas will stay healthy. Urethral rest thus helps avoid underestimating the full extent of unhealthy urethra and helps confirm stenosis severity [2]. With an accurate and precise knowledge of the full extent of stricture, a better preoperative surgical reconstructive plan can be formulated.

If the preoperative urethrography is confusing as to stricture length and location, we typically perform an examination under anesthesia, combining cystoscopy and repeat imaging. We do not recommend taking the patient to surgery for a urethroplasty, until an accurate diagnosis has been performed.

Patient Positioning

Usually, we start with the patient in the supine position and open and repair the penile urethral stricture. We then reposition the patient lithotomy and work on the more proximal strictures that involve the bulbar urethra. By following this order of positioning, the morbidity of keeping the patient in prolonged lithotomy position is minimized. We typically place our patients with PUS in adjustable "Allen or "Yellofin" stirrups, initially in the low lithotomy position, almost supine, with the patient's buttocks at the edge of the bed. Thus, when the penile aspects of the urethral stricture are completed, the legs can be easily placed into lithotomy without repositioning or redraping.

Surgical Reconstruction Methods

In this chapter, we combine the different concepts of tissue transfer techniques, in order to improve the treatment success rates of long and complex stenoses [3, 4].

Bilateral Buccal Mucosal Grafts

In some cases, patients with PUS do not have adequate penile skin to be used for its reconstruction. Therefore, the solution is to use a combination of

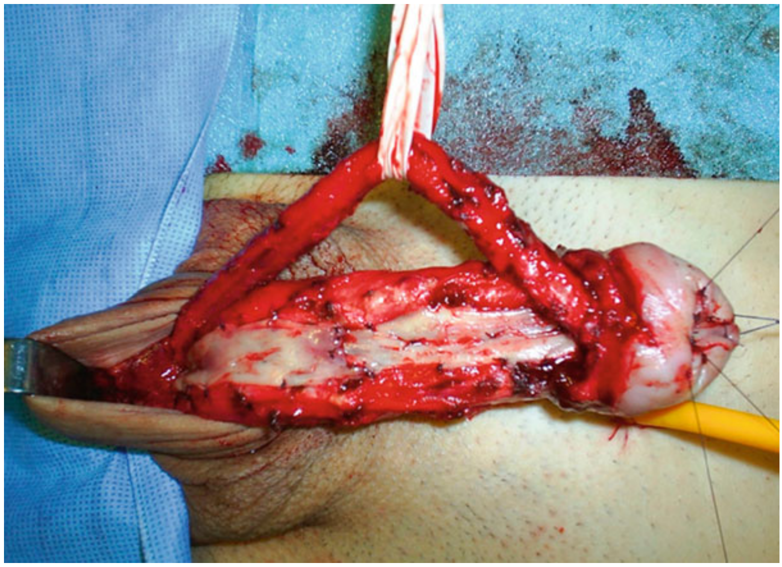

Fig. 17.2 Sub-coronal approach. Two buccal grafts are used to reconstruct the penile urethra. The grafts are quilted to the corpus cavernosum. In this case, the fossa navicularis is also repaired

oral grafts to perform a one-stage reconstruction [5]. Bilateral buccal mucosal grafts harvested from the cheeks typically will be a maximum of 6 cm in length each (depending on the oral anatomy) and thus can be used to repair strictures up to 12 cm long. When phallic length is short, two buccal grafts are usually of sufficient length for penile urethral substitution reconstruction.

The surgical exposure of urethral can be either through a circular sub-coronal incision or through a ventral longitudinal incision. We prefer the sub-coronal approach because it avoids two overlapping longitudinal suture lines and thus helps prevent possible urethrocutaneous fistula formation. Technically, once the penile urethra is exposed, we circumferentially mobilize the corpus spongiosum, separating it from the penis (corpus cavernosum). The penile urethra is then rotated and the urethra opened on its dorsal aspect. The buccal grafts are then spread fixed and quilted to the corpora (Fig. 17.2). As the penile spongiosum is small and thin, there is insufficient tissue for a ventrally placed graft to achieve adequate coverage (spongioplasty). Unsupported and inadequate “spongioplasty” to ventral grafts are prone to ischemic failure and sacculation. If the fossa navicularis and meatus are also stenosed, it can also be repaired as with a ventral buccal graft (Fig. 17.2).

Once the penile urethra has been repaired, the patient is repositioned into the lithotomy position in order to approach the bulbar urethra. The bulbar urethra is then mobilized, detached from the corpus cavernosum, and rotated 180°. The buccal graft is then dorsally spread fixed to the corpus cavernosum and sewn end to end to the same graft that was used to repair the penile urethra (Fig. 17.3). Most of the times, the two grafts harvested from the cheeks are not sufficiently long enough to repair the entire PUS, and therefore, we prefer to harvest a lingual mucosal graft for the additional graft material.

If there is a desire to avoid a penile incision, the penile urethra can still be exposed and repaired all through the perineal approach by a unique surgical technique [6]. In summary, after a conventional perineal incision approach, the bulbar urethra is mobilized circumferentially and detached from the tunica albuginea of the corpus cavernosum. The corpus spongiosum is then mobilized all the way up to the glans penis, invaginating the penis down through the perineal incision. This is essentially the same technique that is used when performing a urethrectomy for urethral cancer. The grafts are placed into a lateral urethrotomy and quilted to the corpora. The rest of the procedure is identical to the one previously described (Fig. 17.4). See Chap. 34 in this textbook for more details of this technique.

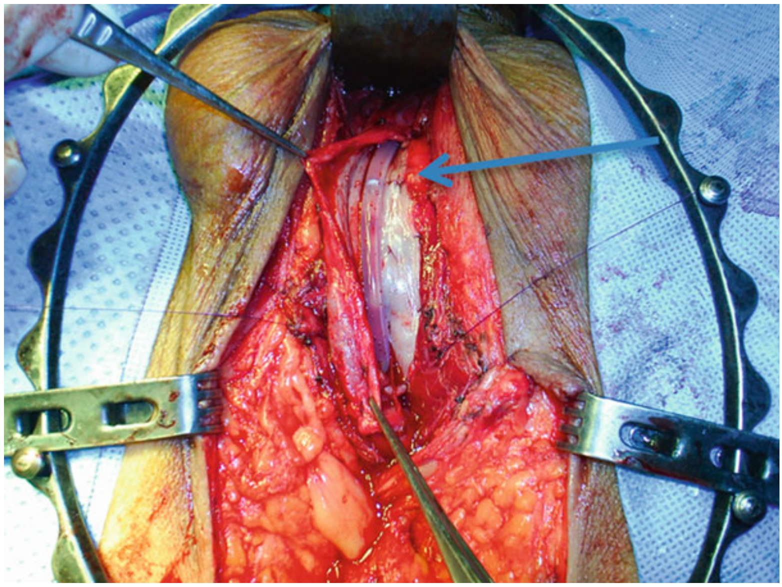

Fig. 17.3 Perineal approach for the bulbar stricture. Note the dorsal fixation of the graft. Also note the anastomosis between the graft repairing the bulbar urethra and the graft repairing the penile urethra (*arrow*)

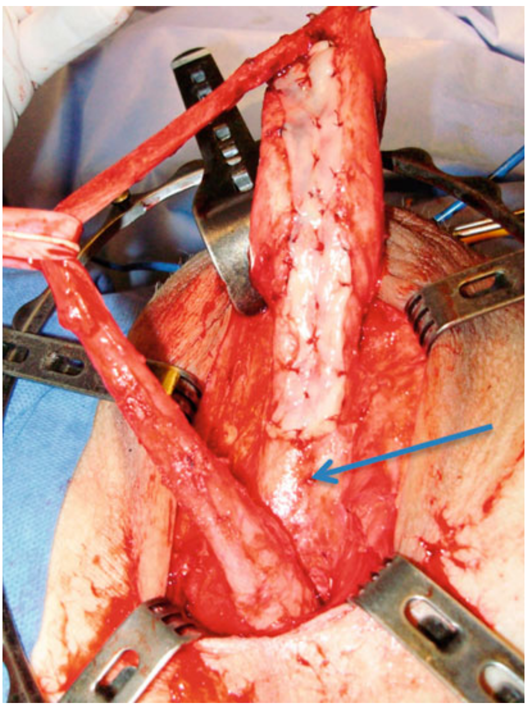

Fig. 17.4 Panurethral stricture repaired via a perineal incision with three oral dorsal grafts (two buccal mucosa grafts and one lingual graft, *arrow*)

The suture we typically use for the graft fixation is polydioxanone 5/0. We also use it for the anastomosis between the graft and the healthy urethra, as interrupted sutures (Fig. 17.5).

Although it is well known that the running suture is a water-tight suture, we believe it is also more prone to ischemia failure and it would favor restenosis. Therefore, we only recommend running sutures for the sides of the reconstruction and interrupted sutures for the ends. Aside from a silicone urethral Foley catheter (16–18 Fr), we also usually place a SP tube as part of the reconstruction. We generally evaluate the patient 3 weeks after surgery with VCUG. If no contrast extravasation is observed, the SP tube is removed. In contrast, extravasation is detected; we leave the SP tube in place and perform another VCUG in 1 or 2 weeks. In this additional time of urethral rest, the bulbar urethra will normally spontaneously heal (Fig. 17.6).

Circular Fasciocutaneous Onlay Flaps: “McAninch” and “Q-Flaps”

Some penile skin flap designs provide adequate skin quantity and quality for the reconstruction of patients with PUS with a unique tissue transfer technique.

It is well known the flap vascularity can be compromised in cigarette smokers, and therefore, the urethroplasty failure rate and complications may be greater in these cases. Diabetes disease

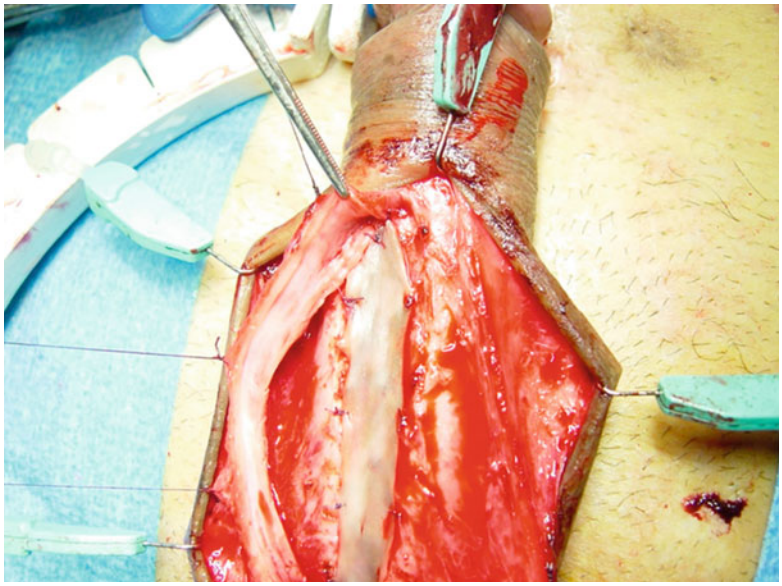

Fig. 17.5 Detailed picture showing anastomosis by interrupted sutures between the healthy urethra and a buccal mucosal graft

Fig. 17.6 Normal postsurgical VCUG after urethral reconstruction using three dorsal grafts (same patient Fig. 17.1)

induces microangiopathy and endothelial dysfunction that will also cause an increase flap complications [1].

McAninch Flaps

For select patients who have adequate and sufficient elastic penile skin, an option for reconstructing PUS is the circular fasciocutaneous flap, popularized by McAninch. Overall stricture-free rates are good and durable with penile skin flaps [7]. McAninch and Morey [8] reported a 79 % success rate at an average follow-up of 41 months (range 1–7 years). Most authors describe the majority of recurrences to occur at the proximal and distal ends – where the flap joins with the spatulated native urethra. For the onlay flap urethroplasties that fail, they can be salvaged, however, by additional urethral reconstruction surgery. For stricture recurrences >1 cm long, anastomotic urethroplasty was successful in 5 out of 7 patients. For strictures <1 cm in length, urethrotomy was effective in 6 out of 7 patients. The authors emphasized the importance of minimizing the high lithotomy position in order to avoid compartment syndrome and sacral and perineal nerve injuries. According to their experience, a maximum of 5 h high lithotomy position was recommended to avoid positioning complications.

Q-Flaps

Another option for reconstructing PUS is the Q-flap. The Q-flap is a modification of a circular fasciocutaneous skin flap procedure (McAninch flap). It is so-called because it incorporates an additional midline ventral longitudinal penile extension, thus resembling the letter Q. Morey et al. [9] reported their experience with 15 men undergoing

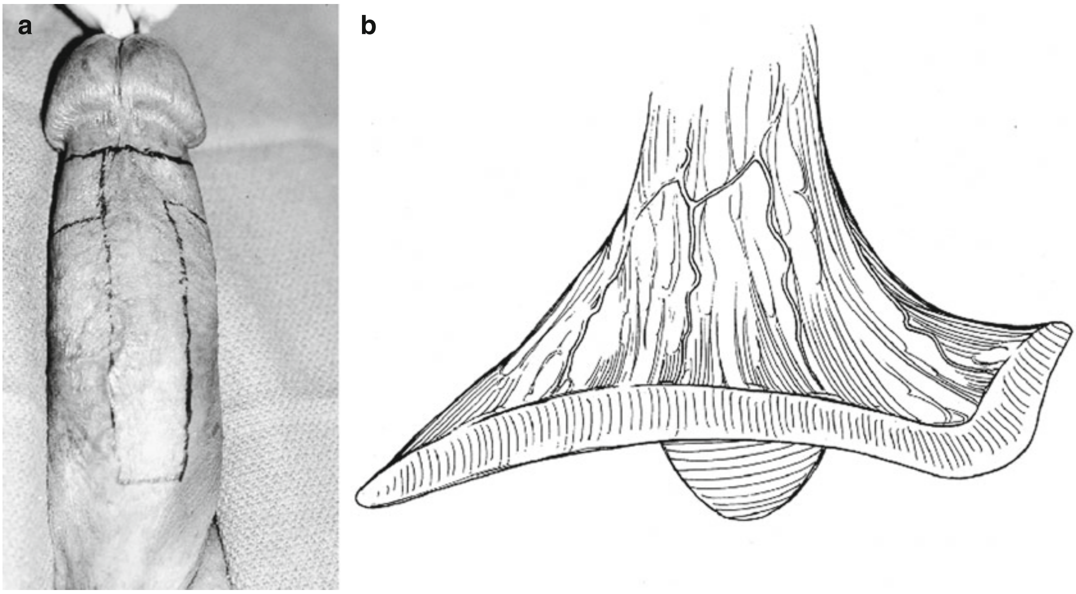

Fig. 17.7 Q-flap. (**a**) Circular fasciocutaneous skin flap with ventral longitudinal extension, as outlined on the penis. (**b**) Illustration of a fully mobilized hockey stick-shaped flap (i.e., Q-flap). (**a** Courtesy Allen F Morey, **b** From Quartey JKM [18])

single-stage urethral reconstruction with distal circumferential penile skin flap incorporating a ventral midline extension (i.e., Q-flap). None had undergone previous urethroplasty and all still had a prepuce. Mean stricture length was 15.5 cm (range 12–21 cm). The Q-flap provided a pedicle strip of penile skin with a mean length of 17 cm (range 15–24 cm). Operative times averaged 5 h. The Q-flap provides an abundant hairless penile skin flap that enables single-stage panurethral reconstruction while eliminating the additional time and morbidity of harvesting further grafts. No proximal grafts were necessary for stricture repair. Excellent results were obtained in 10 of 15 (67 %) of patients. Complications included recurrent stricture (in 2 patients) and urethrocutaneous fistula, meatal stenosis, femoral neuropathy, and prolonged catheterization for local extravasation (in 1 patient each). Of the 15 patients, 13 were followed for a mean of 42, 6 months (range 12–102 months) and the remaining 2 for only 6 months. Of the former, 11 void standing and have excellent cosmetic results. Focal failure occurred 5 years after surgery, in 1 patient. Moderate skin edema and ecchymosis occurred routinely for several days after surgery.

The flap is outlined with the penis on stretch and the penis degloved, carefully preserving the vascular pedicle of the tunica dartos (Fig. 17.7). A ventral urethrotomy is then made into the stricture. In the uncircumcised patient, the outer sleeve of the prepuce is then mobilized carefully from the tunica dartos skin flap pedicle. The Q-flap is typically 2 cm wide, depending on the width of the urethral "plate," to create a urethra of normal caliber (24 French). The ventral and longitudinal extension typically adds an additional 3–6 cm. Hair-bearing skin from the proximal penile shaft is avoided whenever possible. Once the pedicle is dissected back to the penoscrotal junction, the flap pedicle is divided ventrally along the edge of the Q-extension and then further to the penoscrotal area. Relaxing incisions can be useful along the lateral margins of the flap to allow a tension-free transfer to the perineum and prevent penile torsion. The Q-flap is sewn into the ventral urethrotomy as an onlay flap. The fossa navicularis typically is reconstructed with the use of either a glans wings or a glans-preserving technique. Anastomosis of the flap to the urethral plate is performed with running 4–0 polyglactin or polydioxanone sutures. It is important to keep the flap on stretch while it is sewn into place to prevent redundancy and sacculations, which can result in bothersome post void dribbling. Redundant pedicles should also be loosely advance over the contralateral suture line to help prevent fistula formation.

Once the penile aspects of the onlay flap are sewn in, the patient is repositioned into the lithotomy position. To transfer the flap to the perineum with no tension, a scrotal tunnel roughly 4 cm wide in diameter is made. Redundant distal prepuce, if present, is excised at the end of the reconstruction. Most patients are kept in the hospital for 1–2 days postoperatively. A 16–18 F silicone urethral catheter is maintained for 3–4 weeks, followed by a VCUG. For comfort and to prevent inadvertent pulling on the urethral catheter, we typically also place an SP tube and plug the urethral Foley catheter. The major advantage of the Q-flap is that it offers a one-stage reconstruction of difficult and long strictures and eliminates the need for additional, potentially morbid and time-consuming tissue transfer techniques, which otherwise would be necessary for PUS reconstruction.

Flap Combined with Grafts

In other situations, if the patient has an adequate penile skin, but not enough to bridge the entire stricture length, then a buccal mucosal graft should be added to the bulbar urethra. Usually, we begin with the patient in the supine position to mobilize a circular fasciocutaneous onlay flap to treat the penile stricture. The distal incision of the penile skin circular flap is made deep to include the pedicle of dartos and the anterior lamella of Buck's fascia. For the proximal margin of the skin flap, the skin is sharply incised with a scalpel, until the skin separates open, separating the dartos into a superficial and deep layer. The penile shaft skin can then be mobilized to deglove the penis by separating the dartos away from the vascular pedicle to the skin flap within an avascular, areolar-like plane.

The circular fasciocutaneous flap will typically be 15 cm in length and 2 cm in width (Fig. 17.8). If the pedicle of dartos and anterior lamella of Buck's fascia is adequately mobilized,

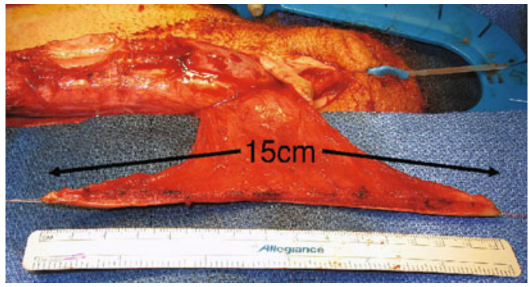

Fig. 17.8 Circular fasciocutaneous onlay flap, fully mobilized and rotated vertically for use as an onlay flap. Note skin flap length of 15 cm (Courtesy SB Brandes)

the flap can be transposed even to the proximal bulbar urethra, through a window underneath the scrotum. By adequate mobilization, we mean that when the penis is placed on full stretch there should be no tension on the vascular pedicle (Fig. 17.9). Inadequate pedicle mobilization will cause the penis to rotate during erection towards the direction the pedicle has been dissected.

A ventral urethrotomy is made until the healthy urethra is found and can be bougied to 24 Fr. The edges of the urethral plate are sewn to the corpus spongiosum with a running suture for hemostasis. The flap is then sutured to the lateral margins of the urethral plate with running sutures with 4/0 polyglactin or polydioxanone sutures (Figs. 17.10 and 17.11). The rest of the bulbar stenosis is treated with a buccal mucosal graft harvested from one or both cheeks, if necessary. The grafts are then placed in ventral position and covered by the spongy tissue (spongioplasty). The reason the buccal graft is placed proximally is because the corpus spongiosum is thicker and will provide good host bed for the graft. In order to repair the entire stenosis, we suture the proximal end of the flap to the distal end of the graft with interrupted sutures (Figs. 17.12 and 17.13a, b).

In order to decrease the surgical time of this perineal approach, we use two surgical teams (oral and genital teams). This flap design has some possibility of skin necrosis of the donor site. However, in our experience, the few skin necrosis cases we have had will heal by secondary intention and have not required any surgical repair (Fig. 17.14).

Other authors [3] prefer the Orandi flap [10] combined with two proximal grafts. Even though

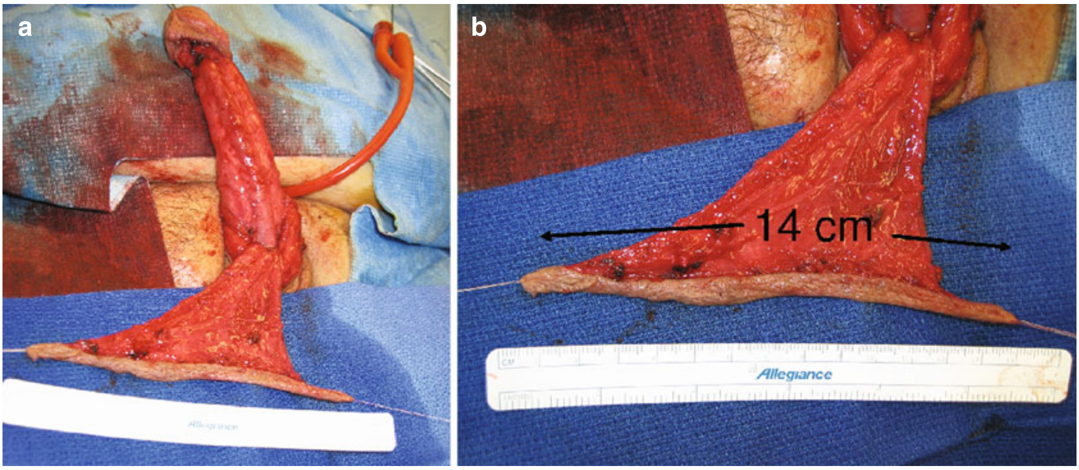

Fig. 17.9 (**a** and **b**) Circular fasciocutaneous onlay flap fully mobilized till the penoscrotal junction. Note the length of the skin flap (14 cm) and the versatility of its long vascular pedicle of dartos for reconstruction of any aspect of the anterior urethra (Courtesy SB Brandes)

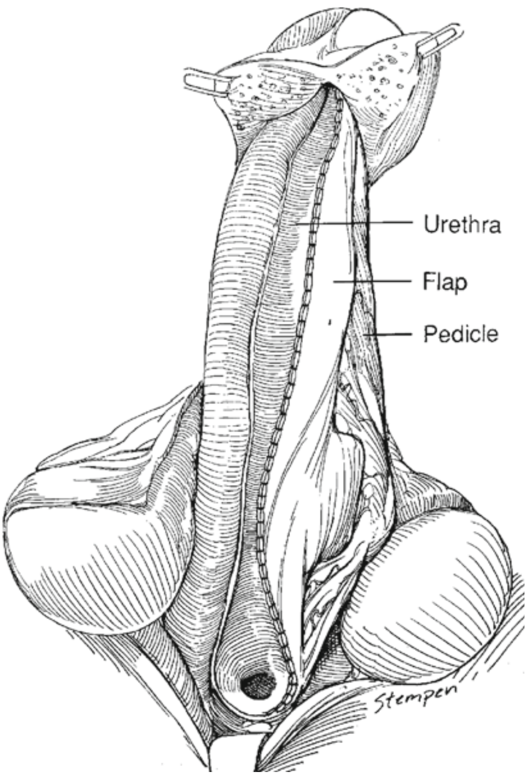

Fig. 17.10 Circular fasciocutaneous flap rotated vertically and sewn to the urethral plate as an onlay

the Orandi flap is technically less demanding than the McAninch flap, the skin quantity for the reconstruction is also less (normally 8–9 cm in length). In the penile urethra, the corpus spongiosum is not well developed. Therefore, the graft must be placed in the dorsal, against the corpus cavernosum. Since the flap is placed in the ventral aspect and the graft is placed in the dorsal aspect, it is recommended that the flap's proximal end and the graft's distal end overlap 0.5 cm. This help prevent an annular ring-like restenosis (Fig. 17.15a–c).

Berglund and Argenmeier [4] observed that in 18 patients they were able to reconstruct PUS with a combined graft and flap. Of the 18 patients, 3 had recurrent strictures (16.7 %). Mean stricture lengths were 15.1 cm (range, 9.5–22 cm). Etiology of their PUS was hypospadias 22 %, instrumentation 22 %, pelvic trauma 17 %, lichen sclerosus (LS) 17 %, and unknown 22 %. The author combined the Orandi flap (mean length 8.5 cm), extending the incision to the scrotum that was previously depilated, with a buccal mucosal graft (mean 6.3 cm). This flap design has less (almost none) possibility of skin necrosis of the donor site, but the quantity and quality of the adequate skin for reconstruction are also less.

Proximal Buccal Grafts and Distal Staged Urethroplasty

When the patient has a penile urethral stricture that has a failed multiple prior reconstructions

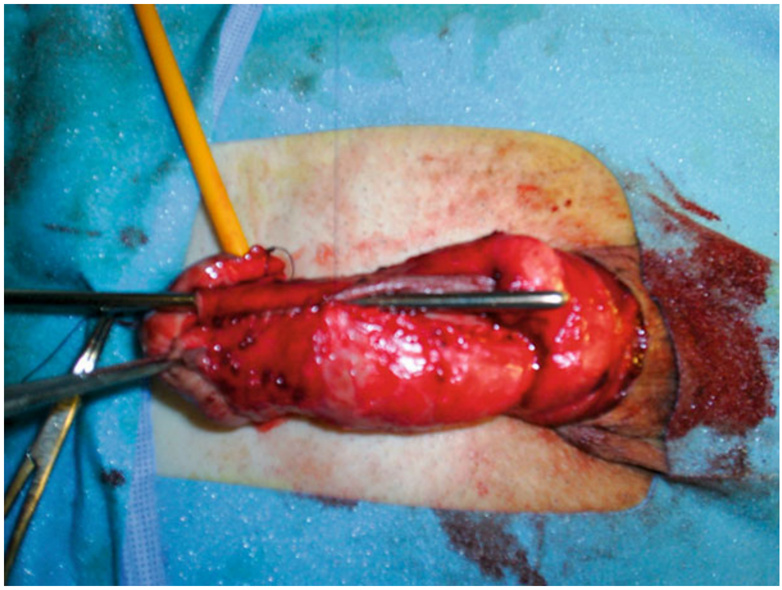

Fig. 17.11 The flap is sutured to the opposite lateral margin of the urethral plate recreating the urethral circumference

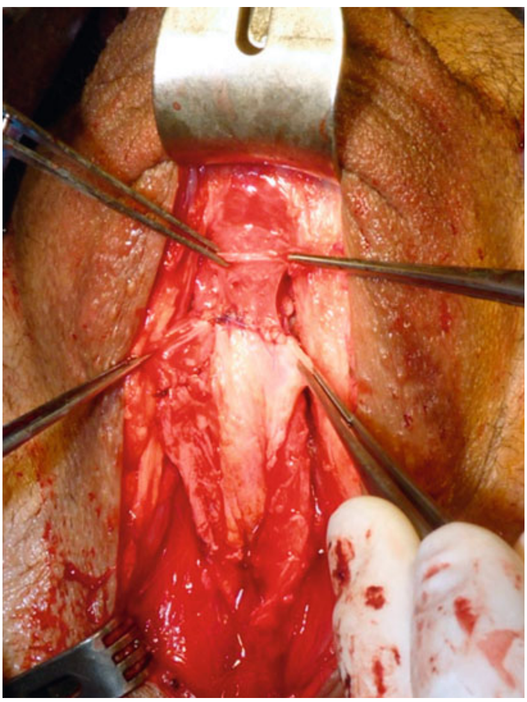

Fig. 17.12 Distal end of the ventral buccal mucosal graft sutured to the proximal end of the flap. Note the rich vascularization provided by the corpus spongiosum

by hypospadias surgery or LS surgery and there is an associated bulbar urethral stricture, then such patients can often be successfully managed by combining a staged urethroplasty to the pendulous urethra with a one-stage urethroplasty with a buccal mucosal graft to the bulbar urethral stricture.

For the bulbar urethral stricture, we perform a perineal approach in the lithotomy position and repair the stricture with a buccal mucosal graft placed either ventrally or dorsally, based on surgeon preference. The patient is then repositioned to the supine position (Fig. 17.16). The ventral midline penile incision is made to expose the corpus spongiosum, followed by a ventral urethrotomy extending up to the glandular stenosis and glans wings are developed. The tunica dartos of the penis is then sutured to the side of the urethral plate, to act as a host bed for the subsequent graft. In cases where the meatus and/or the fossa strictures are near obliterative, we favor removal of the urethral plate, followed by complete grafting due to the abundant fibrosis usually found. If it is possible the rest of the penile urethral plate is preserved (Fig. 17.17). Depending on the length of the stricture, a split-thickness skin graft (STSG) from the thigh or a buccal mucosal graft is fenestrated with a No. 11 blade and then quilted to the corpora with multiple 5/0 polydioxanone sutures. The buccal mucosal

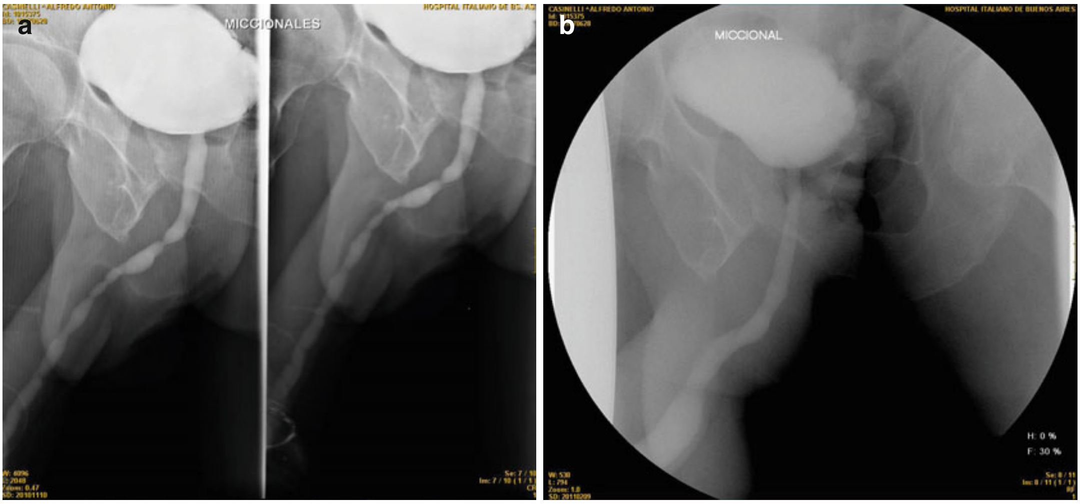

Fig. 17.13 (**a** and **b**) Pre- and postsurgery urethrography after PUS reconstruction combining a circular skin flap and ventral buccal mucosa graft

Fig. 17.14 Donor site skin necrosis after the mobilization of a circular fasciocutaneous flap. Note edema of the residual prepuce

graft should be oversized by 20 % and the split-thickness skin graft (STSG) by 50 % to allow for graft contracture as it matures.

A neomeatus is then made at the proximal aspect of the pendulous urethral stricture. A 16–18 silicone Foley is placed and a typical bolster dressing of Xeroform, cotton batting soaked in mineral oil, and fluff bolster tied into place with purple dyed 2-0 polydioxanone sutures placed at the edges of the grafts. The dressing and bolster are taken down after 3–5 days. After the grafts have matured and the tissue is supple, which typically takes 6 months, the second stage is performed (Figs. 17.18, 17.19, and 17.20). At the time of the staged tubularization, we prefer to interpose a tunica vaginalis flap or a dartos flap, to act as a second layer to prevent fistulization (Fig. 17.21).

In some cases, the opposite situation takes place and we perform a single-stage reconstruction of the penile urethra with a penile skin flap or with a dorsal buccal mucosal graft, as was previously described. For bulbar urethral stricture, we perform a staged surgical reconstruction with buccal mucosal grafts or split-thickness skin graft (STSG) (Fig. 17.22a–d). A key technical aspect for the first stage is to place the grafts completely around the proximal meatus. This will help prevent subsequent meatal stenosis.

LS-Induced PUS

PUS that are LS induced typically start as meatal stenosis and meatitis. The high pressure voiding and infected urine, lead to secondary littritis, which then results in corresponding annular (band-like) strictures at the level of each of the glans. The stenotic bands that developed are typically multiple and throughout the bulb and pendulous urethra. LS is a good example of how

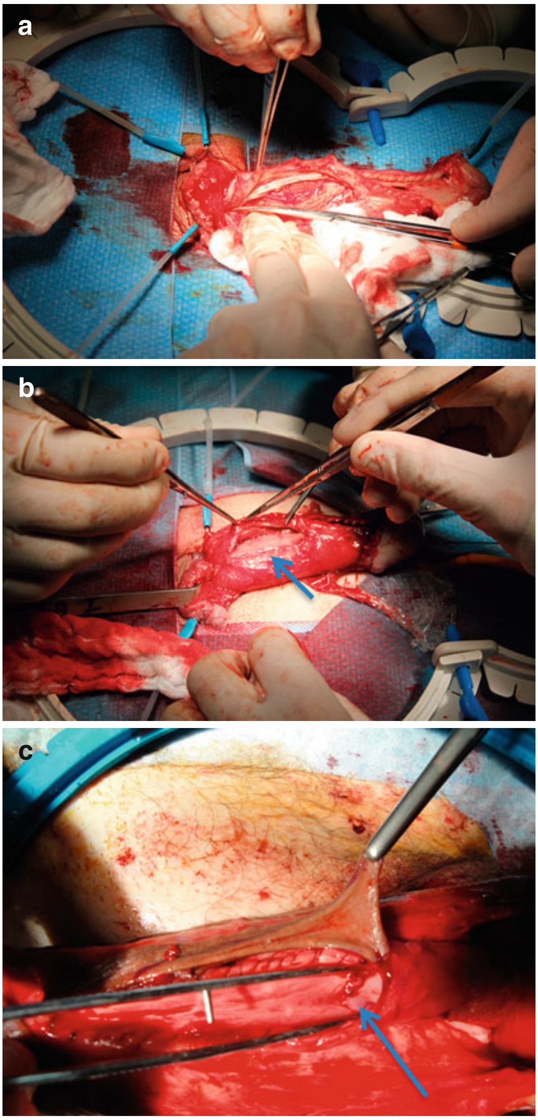

Fig. 17.15 (**a**) Penile urethra opened along its ventral and dorsal aspects. (**b**) Buccal mucosal graft placed dorsally (*arrow*). (**c**) Ventral longitudinal skin flap (Orandi flap) and dorsal buccal mucosal graft (*arrow*). Note the overlap (0.5 cm) between the ventral flap and the dorsal graft

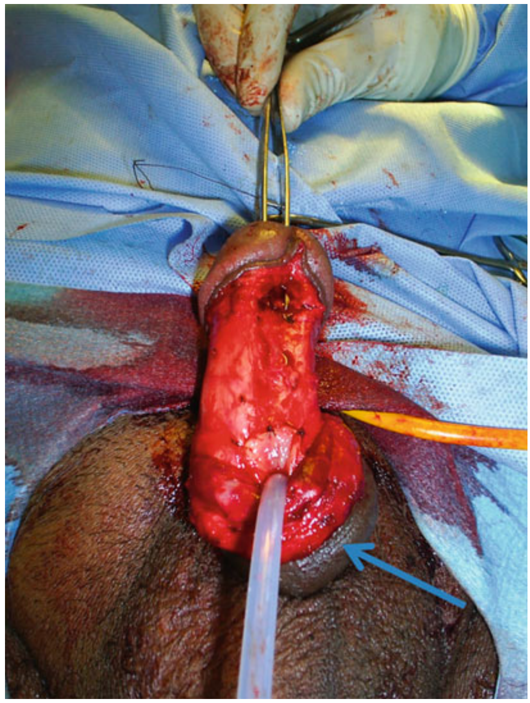

Fig. 17.16 Dorsal buccal mucosal graft (emerging through the scrotal tunnel) repairing the bulbar urethra in a one-stage surgery. Note that at this stage the penile urethral plate was removed and that a stage surgery will be performed to complete the penile urethral reconstruction

untreated and ignored meatal stenosis can progress to the complex and difficult to repair PUS. Because the epithelium is infected with LSA, in our experience, over prolonged follow-up, such onlay flap or grafts eventually become infected and restenosed. Avoiding the use of local skin makes sense because the LS often affects all genital skin fairly diffusely and, thus, nonvisible, subclinical disease will often just manifest later.

The treatment of LS-induced PUS is somewhat controversial. Some authors [11] in order to achieve durable results favor staged urethroplasty. One-stage reconstruction, however, is possible in patients with a reasonably wide residual urethral plate. A urethral plate >0.5 cm can typically be saved, according to our experience. Two buccal mucosal grafts placed in the dorsal position are usually effective (Figs. 17.23 and 17.24). Even the fossa navicularis can be repaired and leave the meatus at the tip of the glands. Using bilateral mucosal grafts, Kulkarni et al. [12] reported in a multicenter international paper 90 % success in 80 patients with PUS secondary to LS, with an average follow-up of 58 months (range 12–115 months). Additionally, Dubey [13] reported in 21 patients with PUS secondary to LS reconstructed with two dorsal buccal

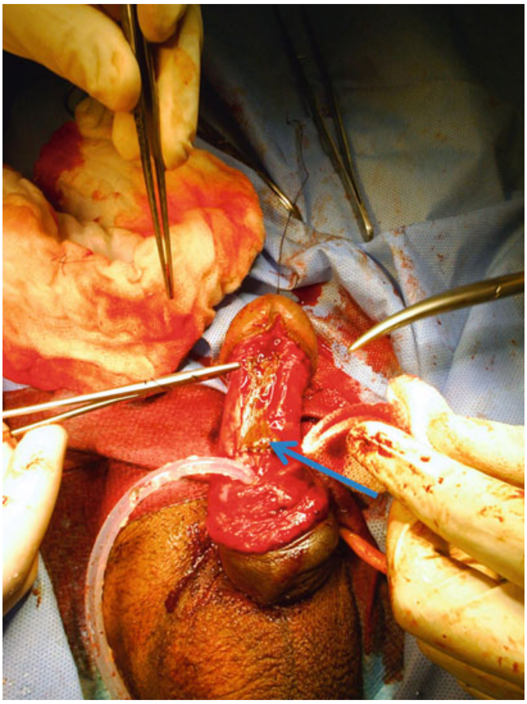

Fig. 17.17 Dorsal prepuce skin graft to the absent urethral plate. Note the interrupted sutures between the dorsal skin and the buccal graft (note arrow)

Fig. 17.19 Mobilization of lateral flaps

Fig. 17.18 Second-stage reconstruction of the penile urethra at 6 months after the first stage. Note the buccal mucosal graft in the dorsal aspect of the neomeatus (see arrow)

Fig. 17.20 Running suture over a Foley catheter to complete the second-stage reconstruction of the penile urethra

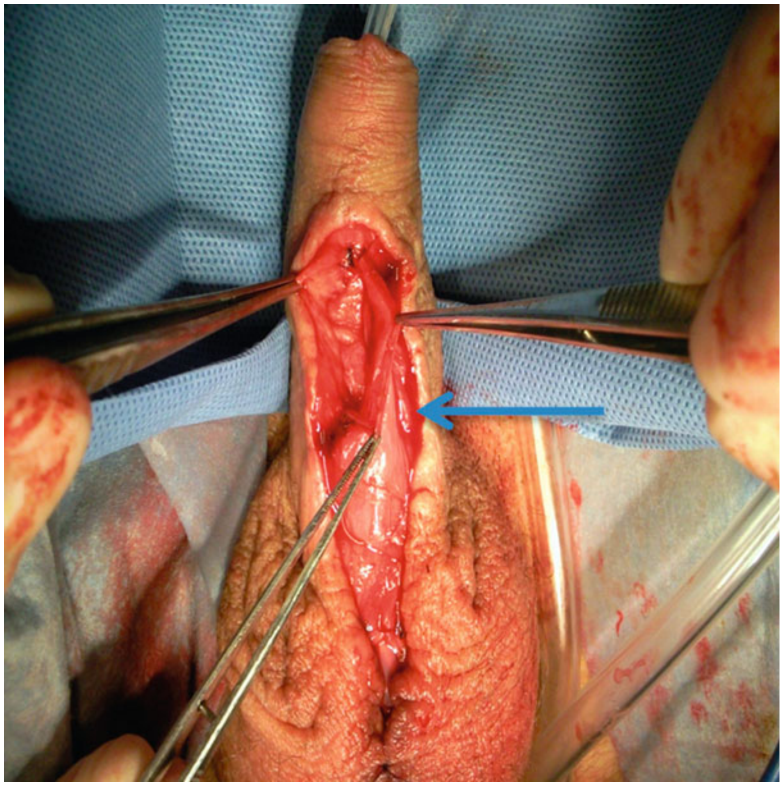

Fig. 17.21 Tunica vaginalis flap (*arrow*) covering the first suture line. Note the skin will close over the tunica vaginalis flap

mucosal grafts, an 88 % success rate, at a mean follow-up 33 months.

PUS with Areas of Complete Lumen Obliteration

In some cases, PUS have areas of the corpus spongiosum with severe fibrosis, luminal obliteration, and damage of the urethral mucosa. In such cases, the residual urethral plate must be removed and replaced. If these urethral plates are preserved, the risk of reconstruction failure would be higher. It is difficult to determine when a urethral plate should be replaced or extended. Wessels et al. [14] stated that in some cases they have removed sections of thick fibrosis tissue without resecting the corpus spongiosum. According to Dubey et al. [15], if the stenosis accepts a pediatric cystoscope (6 Fr), it would then have a sufficient urethral plate to graft to. We believe that it is reasonable to preserve urethral plates which are at least 0.5 cm wide; Urethral plates <5 mm in width should be removed and replaced.

If both ends cannot be re-approximated to recreate the urethral plate, there are typically two options: the first option is a staged reconstruction, as we described previously, with buccal mucosal grafts or STSG [16]. The second option is to reconstruct the urethral plate gap in a one-stage surgery with a tubularized skin island flap. In general, tubularized flap reconstruction of the urethra has over a 50 % failure rate [8]. An alternative option, according to Morey [17], is to replace the narrow urethral plate with a buccal mucosal graft in the dorsal position combined with a ventral onlay penile skin flap. This combination creates a tubular structure that has a more durable success rate. Once the urethral section most affected has been removed, it should be replaced with a buccal mucosal dorsal graft. This is then quilted to the tunica albuginea, as previously described, with 5/0 polydioxanone sutures and anastomosed with interrupted sutures,

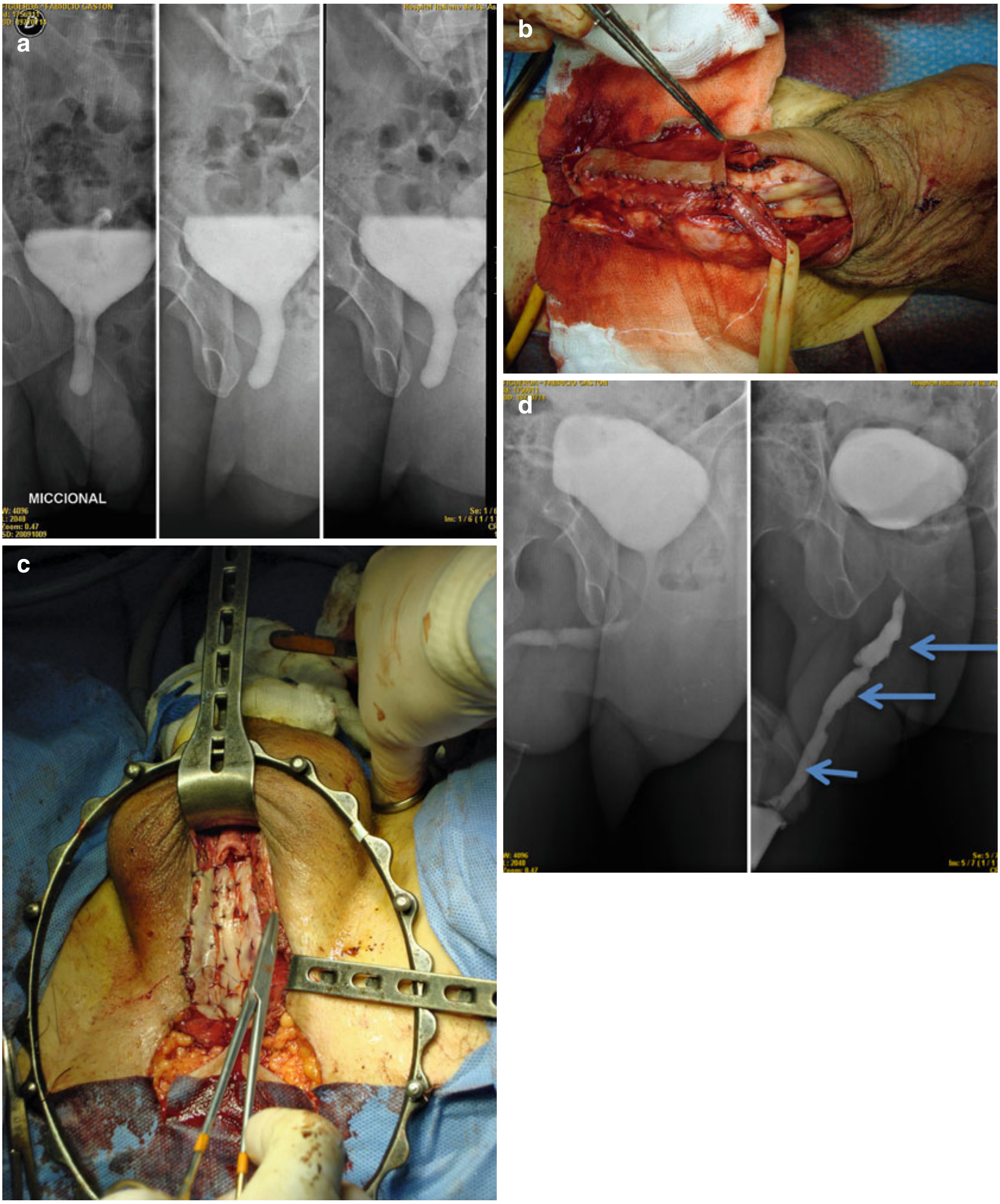

Fig. 17.22 (**a**) Preoperative VCUG showing an obliterative membranous stricture in a patient with a PUS. (**b**) One-stage penile urethral reconstruction combining ventral skin flap with dorsal graft. (**c**) Two stage bulbar reconstruction (same patient) with oral grafts. (**d**) Postsurgical retrograde noting the three tissue transfer techniques used in this case: the flap (*short arrow*), the graft (*intermediate arrow*) and the staged reconstruction (*long arrow*)

to the ends of the preserved urethral plate. A circular or longitudinal fasciocutaneous flap, following the preferences of the surgeon, is mobilized (Fig. 17.25). The lateral edges of the flap are then sutured with a running suture of PDS 4/0 to the entire urethral plate to be reconstructed, including the urethral neo-plate of buccal mucosa (Fig. 17.26).

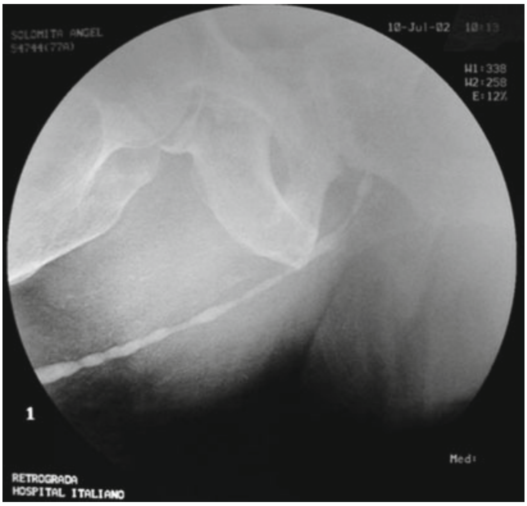

Fig. 17.23 Retrograde urethrogram showing PUS secondary to LS

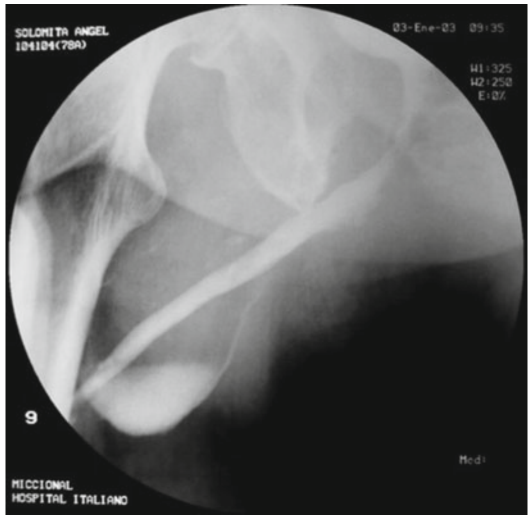

Fig. 17.24 Normal postsurgery VCUG after a one-stage reconstruction with combined oral grafts (same patient)

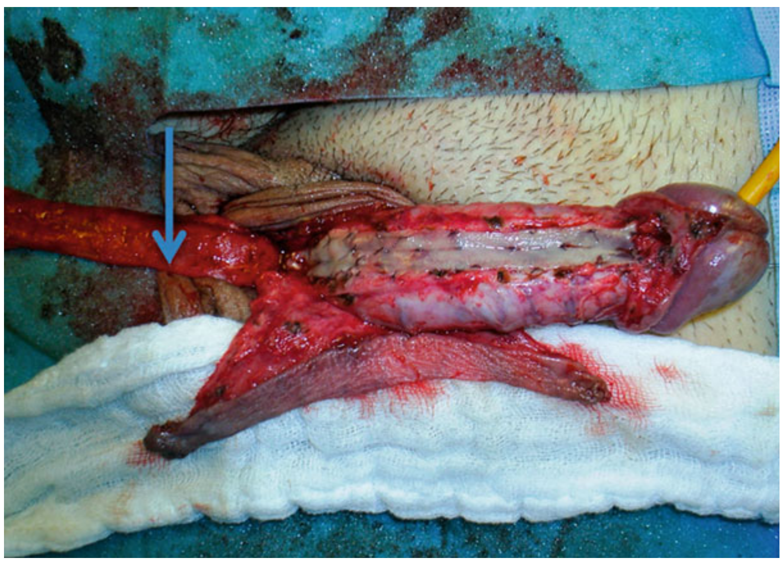

Fig. 17.25 Two dorsal buccal mucosal grafts replacing the urethral plate and a circular fasciocutaneous flap to completing reconstruction. Note the corpus spongiosum has been removed (*arrow*)

The combination of tissue transfer is normally used in the penile urethra. However, in PUS we have used it with good outcomes in the bulbar urethra. These cases are more time consuming because the penile skin flap must be brought to the bulbar urethra through a trans-scrotal tunnel (Fig. 17.27). Here, urinary diversion is with a silicone urethral Foley catheter (18 Fr) and a 16 Fr SP tube for 3 or 4 weeks, followed by a void cystourethrogram.

Surgical Pearls and Pitfalls

Key Surgical Points

- Adequate surgical table and adjustable stirrups to reposition the patient during the surgery are key.
- The first step should be to reconstruct the penile urethra with a penile fasciocutaneous flap. The patient should be in the supine position to decrease the time in lithotomy.

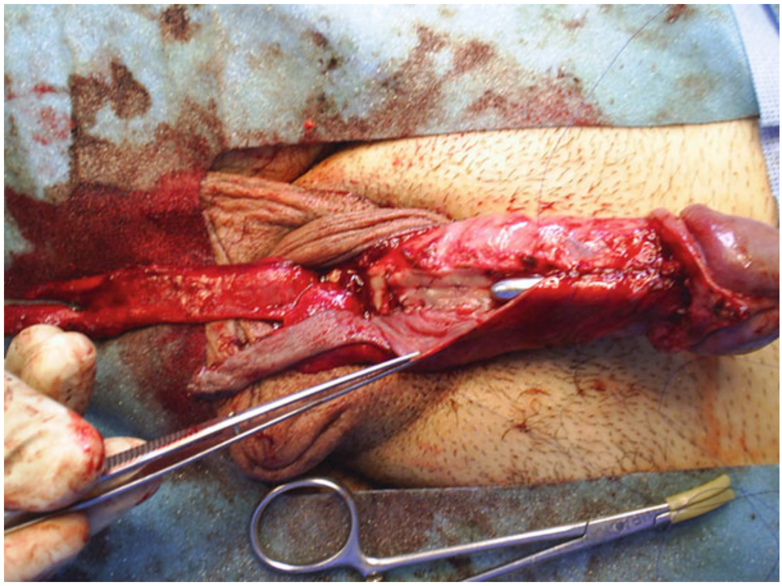

Fig. 17.26 The skin flap is sutured over the urethral neo-plate of buccal mucosa

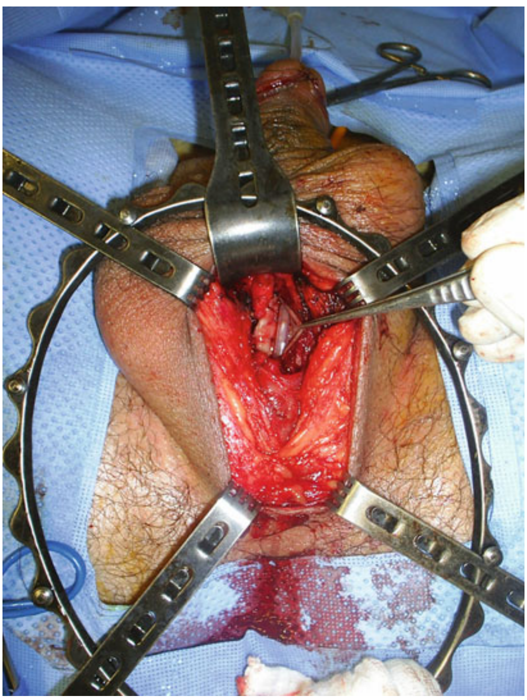

Fig. 17.27 Perineal approach to repair the bulbar component of the stenosis. Note the flap, the dorsal graft, and the Foley catheter

- Carefully dissect the penile skin flap pedicle based on the tunica dartos.
- Skin flaps should not be more than 2 cm wide to avoid sacculations.
- For a ventral buccal graft to take, it must be covered with sufficient corpus spongiosum (spongioplasty).
- Overestimate buccal mucosal grafts by 20 % and the STSG by 50 %, to avoid retractions and stenosis recurrence.
- Remove any inadequate urethral plate and replace it with a buccal mucosal graft. Performing a reconstruction to a poor urethral plate will increase the possibility of stricture relapse.

Potential Problems

- Neuropraxia and compartment syndrome can be minimized by limiting the time in lithotomy
- Penile rotation during erection can be avoided by adequate mobilization of the pedicle when the penile is on full stretch.
- Skin necrosis can be avoided by careful dissection of the subdermic tissue.
- Flap complications are more common in smokers and vasculopaths.
- Re-strictures usually occur in at the junction lines between the transferred tissues and native urethra.
- Place interrupted sutures at the ends of the grafts or flaps to reduce the risk of ischemia.
- To prevent a urethrocutaneous fistula, interpose healthy tissues between the suture lines, like tunica vaginalis or dartos fascia.

Editorial Comment

Pan urethral strictures are highly complex and very difficult to treat. The entire armamentarium of surgical tricks is required for a successful and durable reconstruction. Many patients have unrealistic expectations, and it is essential to educate patients as to the complex nature of this problem and that reconstruction typically requires more than one surgery. Penile skin flaps still have a role in urethral reconstruction – especially when the urethral plate is very narrow and near obliterative and a combined dorsal buccal graft is needed. Penile flaps have higher potential complication rate than grafts. When developing the dartos vascular pedicle to the skin flap, periodically palpate the pedicle and skin to make sure that either is not getting too thin. I tend to error on keeping the dartos to the skin flap thick and take a chance for some skin necrosis. The skin necrosis is typically not severe and granulates in with local care and no long-term sequelae. To prevent penile torsion, it is essential to mobilize the dartos pedicle to the penoscrotal junction while keeping the penis on manual stretch. To prevent urethrocutaneous fistula formation, interposition of a tunica vaginalis flap from one of the testis is always useful. Make sure to mobilize the tunica to the external ring and place the penis on stretch while tacking the tunica in place. Inadequate mobilization will result in the testis being pulled up into the penis with erection. The other way to prevent a fistula is to place the flap dorsal rather than ventral. This works well for penile strictures that involve the mid or proximal penis (not the fossa or meatus).

For LS-induced urethral strictures, I prefer a staged urethroplasty with a combination of buccal oral graft and or lingual grafts. I have limited experience with the one-stage technique detailed here-in chapter 34, by Kulkarni. However, his technique, if it bares out to be a successful and durable technique at long-term follow-up, it is then a great addition to the armamentarium – avoiding the morbidity of a staged urethroplasty and a penile skin incision.

Lastly, as reconstructive urologists, we all want our urethral stricture patients to ideally have a completely reconstructed and 24 Fr urethra. However, complete reconstruction is sometimes heroic and not really necessary. What patients want is good quality of life while minimizing the morbidity of surgery. Not every patient needs to have a 24 Fr urethra. To void normally all one needs is a urethra >14 Fr. So many times, to get a patient to void relatively normally and void standing, all we need to fix is the most stenotic part of the urethra and not have to reconstruct the whole urethra. Moreover, for many panurethral stricture patients or hypospadias cripples, a properly constructed perineal urethrostomy might be a better solution, rather then that multiple aggressive surgical reconstructions. Perineal urethrostomy should be considered much earlier in the decision making, rather than as a last resort and a sign of failure.

–Steven B. Brandes

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18 The Application of Muscular, Myocutaneous, and Fasciocutaneous Flaps as Adjuncts in Complex Refractory Urethral Disorders

Leonard N. Zinman and Jill C. Buckley

Summary

Simple wounds, fistulas, strictures, and tissue loss can be readily managed by appropriate tension-free approximation of unaltered wound edges with or without local random flaps. A number of local and systemic factors, however, transform these readily managed wounds into complex challenging conditions with poor outcome. Size, location, infection, radiation, reoperative hypovascular fibrosis, steroids and immunocompromising drugs, and vascular disease impact on wound care. With the advent of the axial muscle and fascial flaps, regional transpositions of peninsular flaps have dramatically changed our ability to restore the stability of wounds and the rescue of an anatomic region. These tissue transfer techniques have been underutilized in genitourinary reconstruction over the past two decades in the care of refractory radiation and inflammatory and reoperative pathology of the urethra, bladder, rectum, and perineum. This chapter reviews our experience with gracilis, gluteus, rectus abdominis, and Singapore flaps in refractory stricture and fistulas that defy conventional options. Experimental and clinical studies have confirmed the role of muscle surface in wound healing demonstrating superior resistance to bacterial inoculation in the presence of viable muscle, compared to random flaps and altered wound edges. These appropriately selected muscular and fascial flaps separate suture lines, support hypovascular fibrotic wound edges, protect grafts in adverse settings, and fill dead space injuries adjacent to wound. The adjuncts of axial muscular and fascial flaps in challenging complex perineal wound and fistulas closure have had a profound impact on outcome in our experience.

Introduction

The ability to achieve a long-term, stable, stricture-free, and hairless urethral lumen in patients with complex strictures, fistulas, and separation defect in the presence of adverse wound settings is one of the ongoing challenges of reconstructive urologic surgery. Genital fasciocutaneous penile and scrotal island flaps, oral mucosal (buccal and lingual) grafts, or some combination of the two in a one-stage or multistage fashion is presently the standard of surgical care for strictures not suitable for anastomotic repair. There is, however, a unique subset of patients with complex pathology and refractory fistulas that have undergone multiple failed previous procedures, prior radiation therapy, skin loss from trauma, or decubitus, and

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impaired wound healing associated with steroids and immunosuppressive drugs. With the advent of the axial flap and increasing insight into the understanding of neurovascular flap anatomy, a select group of reliable muscle, musculocutaneous and fasciocutaneous tissue constructs, is uniquely accessible for this challenging pathology as either peninsular or free flap constructs [1–4].

Muscle-Assisted "Full-Thickness" Buccal Mucosal Graft Urethroplasty

Oral mucosa has now become a well-established tool in the resolution and repair of anterior urethral stricture disease [4]. The advantages of buccal mucosa include ease of application, readily retrievable, wide versatility, hairless donor site, and the ability to construct a conduit that most closely resembles a normal-functioning urethra with rare sacculation. It has proven to be an invaluable addition to the reconstructive paradigm as a one- or two-stage procedure for the complex post hypospadiac, the patient with BXO, or the radiated or reoperated urethra. Its unique anatomy includes a thin, highly vascular lamina propria and a thick epidermal cover, the probable basis for its highly reliable record of graft take [5].

In spite of this impressive record of success, an adverse fibrotic, hypovascular, and inflamed periurethral tissue bed with a compromised wound may result in partial or total graft loss.

This troublesome clinical setting will require a change in graft recipient site vascularity to ensure reliable inosculation, a concern that has been solved by transferring a number of trunk or thigh muscle flaps to buttress the graft subdermal or lamina propria surface.

Skeletal muscles with or without their skin components have an established place in resolving complex wounds, osteomyelitis, prosthetic graft sepsis, and repair of tissue defects and fistulas that develop under unfavorable conditions [6, 7]. They provide coverage, obliterate dead space, separate suture lines, improve vascularity, and enhance white cell function [8]. The skeletal muscular surface with its dense microcirculation, when intimately secured to the dermal side of a skin graft or the lamina propria of a buccal mucosal undersurface with proper immobilization, will promote a consistently predictable and rapid inosculation and prevent seroma formation and subsequent contracture. The optimal muscle flaps available for urethral and perineal reconstruction include the gracilis muscle in four variant forms, the rectus abdominis, the inferior gluteus maximus, rectus femoris, semitendinosus, and free latissimus dorsi. The most versatile and readily retrieved muscle is the gracilis, which can be transferred simply as a support for a skin or buccal graft in either a dorsal or ventral position. Three additional variations of transfer of the gracilis muscle include a short version of the flap, which offers more muscle volume for preventing dead space; the myocutaneous technique, which is the incorporation of a potential skin paddle for defect coverage in an island or peninsular form; or the prefabrication of a skin graft and subsequent transfer of the muscle, which carries with it an established neovascularized skin graft island.

Gracilis Flap: Anatomy and Retrieval for Urethral Stricture Disease

The gracilis muscle remains the reconstructive workhorse of the perineum, groin, genitalia, and anal musculature. As a free flap, it has widespread application in coverage of the head, neck, and extremities, as well as functional muscle in facial reanimation, and can play a major role in the salvage of high-risk urethral pathology burdened by wound healing adversities. Its anatomy has been reliably defined by numerous studies that have identified its blood supply (Fig. 18.1), innervations, and functional characteristics [8, 9]. This muscle has played an early role in urologic reconstruction with Deming's use in 1922 in an attempt to resolve urinary incontinence by a circumferential urethral cuff and Garlock's successful repair of a recurrent vesicovaginal fistulas in 1923 at the Mount Sinai Hospital in New York City, clearly noting the absence of this concept from our repertoire for a century [12, 13].

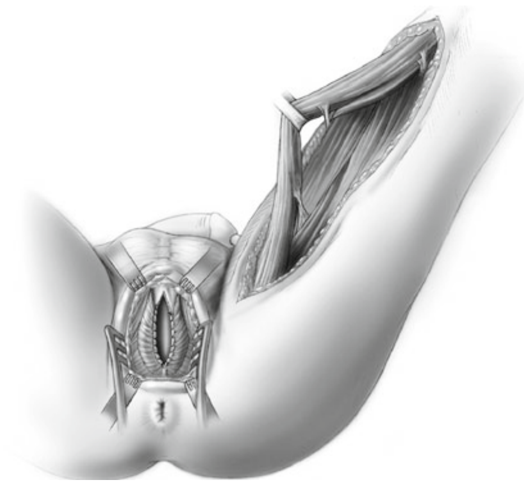

Fig. 18.1 The gracilis muscle with proximal dominant pedicle and two distant minor pedicles is a Mathes type II pattern of muscle circulation, the commonest muscle vascular anatomy

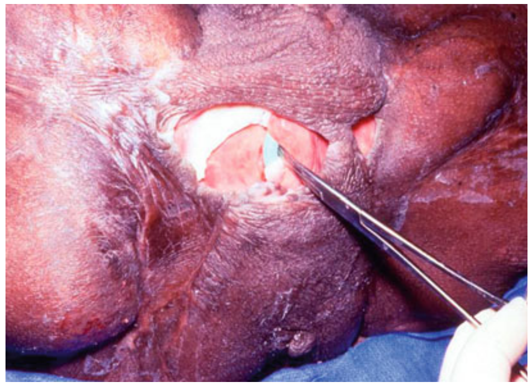

Fig. 18.2 This 57-year-old paraplegic with a perineal decubitus and bulbar urethral cutaneous fistula required a repair by an onlay graft of buccal mucosa with a muscle and skin cover to allow graft take, wound coverage, and bulk to prevent recurrent decubitus

Technique of Buccal Mucosal Graft Onlay with Gracilis Support

The proper sequence for this procedure is (1) prepare the urethra, (2) mobilize the muscle, and (3) harvest the buccal graft after a suprapubic diverting cystotomy is established (Figs. 18.2, 18.3, 18.4, 18.5, 18.6, 18.7, and 18.8). The urethra is prepared ventrally with exposure through a midline perineal incision extending into the midscrotal raphe. The bulbocavernosus muscle is divided and carefully preserved because it will be sutured to the edges of the applied gracilis. A urethrotomy is started distally and extended for 2–3 cm beyond both ends of the stricture. Hemostasis from the spongiosal edge is achieved with locked running 5-0 chromic catgut sutures along the urethrotomy margin. Extensive, severely fibrotic, or radiated corpus spongiosa should not be excised unless there are obliterated segments since the traditional expected elasticity is often absent in the presence of a severe spongiosis so that ventral penile tethering may develop.

A buccal graft is preferably obtained from the inner cheek, where a 6- to 10-cm × 2- to 2.5-cm strip of mucosa can be harvested with minimal morbidity, depending on the contour and shape of the mouth, the length, and the width of the urethral defect being measured over a 28-French template. The head and neck are hyperextended, and the face and jaw are draped with antiseptic preparation. A self-retaining

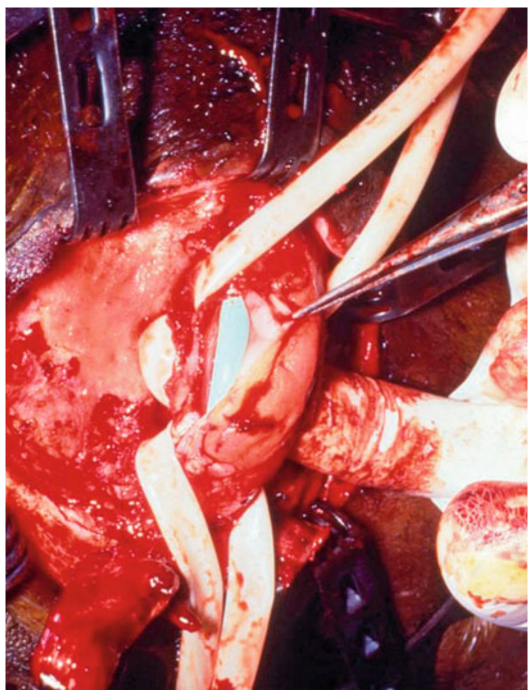

Fig. 18.3 The urethral defect was mobilized, debrided, and closed with a lateral onlay of oral mucosa

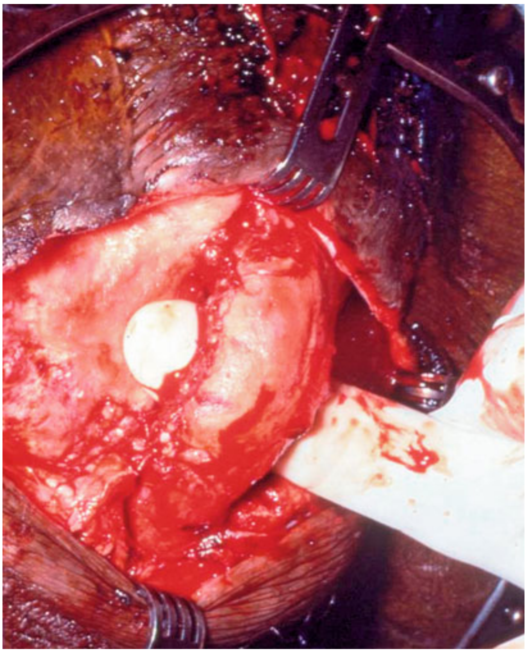

Fig. 18.4 Restoration of the urethral lumen with mobilization of perineal wound edges to permit transfer of the rectus abdominis myocutaneous flap

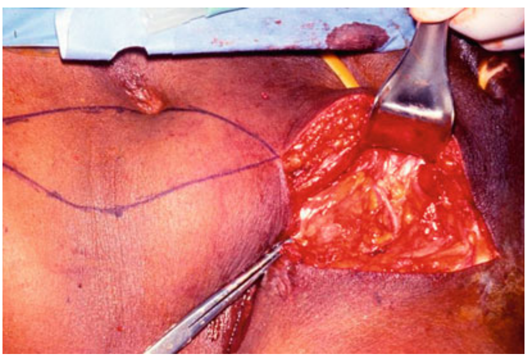

Fig. 18.5 Outline of a vertical island of overlying skin juxtaposed at midpoint (VRAM). The muscle is retracted medially exposing the inferior deep epigastric vessels without dissecting them out

(Jensen) retractor or a small Weitlaner is placed in the lateral edge of the mouth opposite the site of retrieval, after a transoral endotracheal tube has been inserted. Two short, right-angle retractors are placed under the lips, along with 4-0 Vicryl traction sutures placed in the lateral lip edge, and a rectangle of mucosa measuring

Fig. 18.6 Transected right rectus abdominis muscle with skin and rectus fascial components ready for transfer to its deep epigastric pedicle

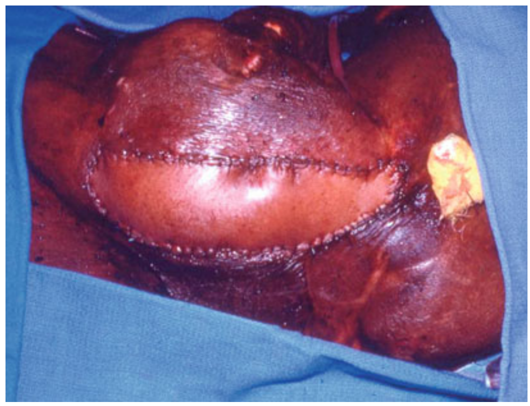

Fig. 18.7 Muscle in place with skin cover protection in a well-padded wound

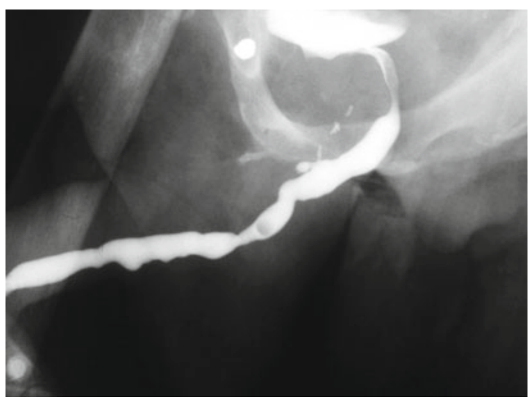

Fig. 18.8 The result of the reconstruction is a patent urethral lumen with continence and a return to self catheterization

2–2.5 × 6–10 cm just inferior to Stensen's duct is retrieved after submucosal infiltration with adrenalin 1:100,000 dilution (Fig. 18.9). The graft is transected at the level of the anterior tonsillar pillar and placed in a saline-soaked sponge, while the donor site is closed. If a lower lip retrieval donor site is used, it should be left open. A lower lip donor site is best avoided if possible because of the complication of contraction of the lip and perioral numbness which are not uncommon complications of this donor site. The graft is meticulously defatted on the surgeon's forefinger until a thin, white surface is obtained. The measured graft is fixed into the urethrostomy with three stabilizing apical sutures of 5-0 Monocryl at each end followed by a running suture along the margins. Excess graft length is managed by extending the urethrotomy distally until there is a proper fit (Fig. 18.10).

Harvest Description

The gracilis muscle is transferred into the perineum through a capacious tunnel to prevent compression ischemia. The muscle surface is placed over the graft anchored firmly to periurethral tissues. The bulbocavernosus muscle is sutured to the lateral surface of the gracilis (Fig. 18.11). If there is residual dead space or a larger perineal defect than expected created by the repair, then both gracilis muscles are transferred for muscle bulk. The muscle needs to be fixed and buttressed against the graft lamina propria.

Short Gracilis Flap

The classic traditional version of the gracilis muscle may not always be suitable for some patients when the mobility is limited by the

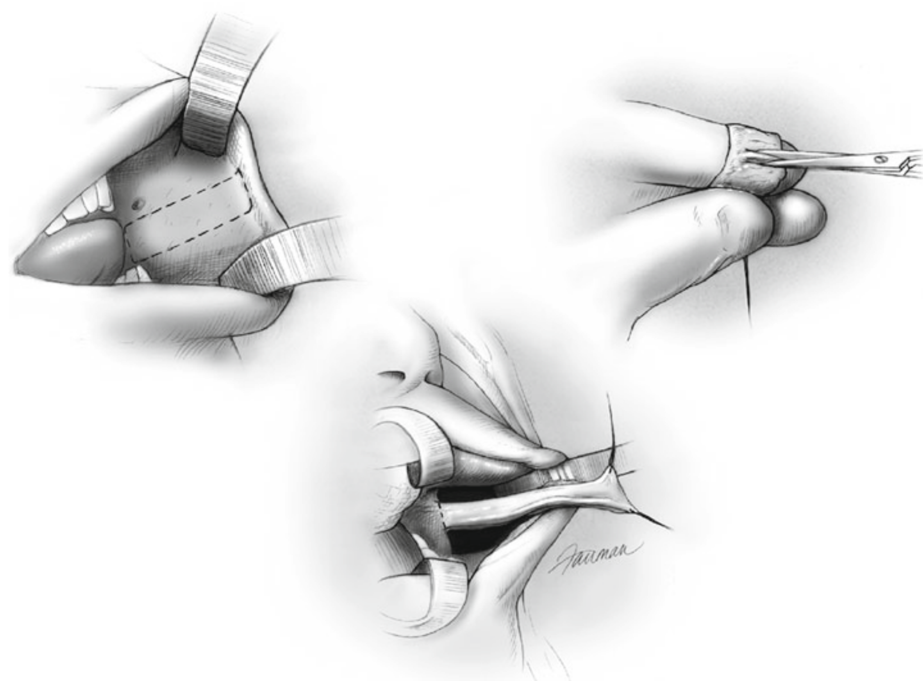

Fig. 18.9 There are occasionally some adductor branches that augment the obturator. Buccal mucosa graft can be retrieved from one or both cheeks. The opening to Stensen's duct is identified opposite the second molar. The lower lip should be avoided as a donor. A 2.5 × 6–10-cm graft can be potentially harvested if the mucosal dissection is extended from the tonsillar pillar to the lip edge. The graft is carefully cleaned and thinned by placing it on the forefinger under tension, removing the fibroglandular surface until a white, shiny surface is obtained. One should avoid any graft retrieving material beyond the vermillion border of the lip

location of the vascular pedicle and the defect is not adequately covered. The short version of the muscle offers a very useful alterative with more mobility, a larger bulk of muscle mass to fill a large defect, and prevents the appearance of a bulky deformed upper medial thigh, which can easily abduct without tension [10]. To achieve this kind of mobility for more extended coverage, the main proximal vascular pedicle is first occluded with a vascular clamp and an intact axial circulation from the obturator artery confirmed by a Doppler probe (Fig. 18.12). It is then divided, and the muscle dissected proximally to its origin on the inferior pubic ramus dividing the fascia and rotating it through a previously created wide tunnel. This fully mobilized muscle with cutaneous component can also consistently survive on circulation from the terminal branches of the obturator artery, which enters the muscle at its origin [10, 11].

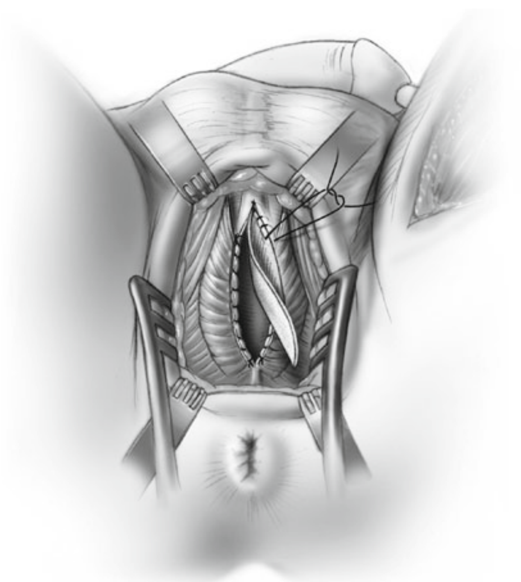

Fig. 18.10 A full-thickness buccal mucosa graft is sutured into the urethrotomy over a no. 24 catheter

Dorsal Placement of Buccal Graft and Gracilis Muscle

In the paraplegic patient with a bulb stricture, a traumatic fistula secondary to erosion of the dorsal surface of the urethra from pressure against the pubic arch or a central decubitus, a dorsal approach to the urethra with a muscular buttress

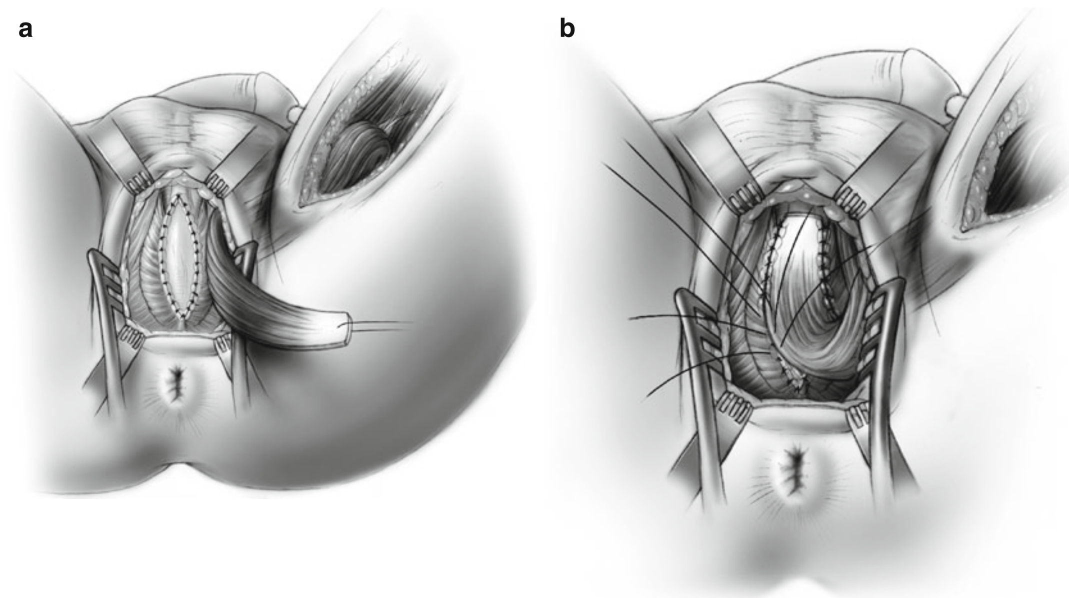

Fig. 18.11 The gracilis muscle is detached distally, and the muscle flap is transferred through a capacious subcutaneous medial thigh tunnel. It is applied securely to the dermal surface or lamina propria undersurface of the buccal graft by suturing its margin to the periurethral fascia

on either surface may be the optimal reconstructive procedure (Fig. 18.13). The bulbar urethra is widely mobilized, and a dorsal urethrotomy is created by rotating the spongiosa to gain access for a 12 o'clock urethrotomy in a relatively avascular site. The graft onlay is completed with interrupted 5-0 Monocryl sutures, and the muscle is transferred to the perineum in the long form and placed between the dorsal graft bearing surface and corpora cavernosa. The muscle edges are sutured to the periurethral fascia, and a perineal artery or posterior thigh fasciocutaneous flap can be transferred for a perineal cover (Fig. 18.11).

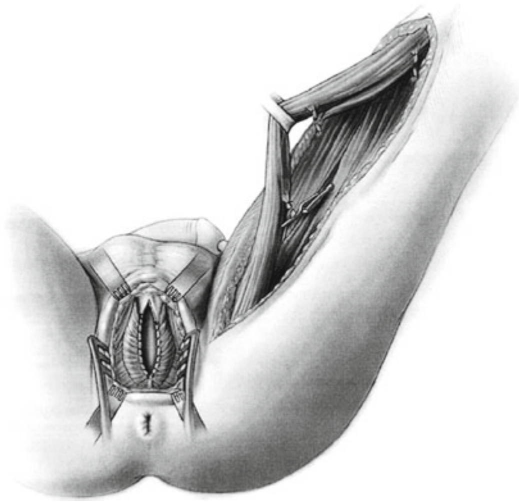

Fig. 18.12 The use of a "short" gracilis muscle with the proximal dominant medial circumflex femoral vascular pedicle divided permits a larger mass of muscle for transfer when more extensive coverage is needed

Prefabricated Combined Skin and Gracilis Flap Reconstruction

The concept of establishing a vascularized skin graft by initially securing its vascular support before tissue transfer offers a selectively useful maneuver [14, 15] in the management of strictures with periurethral beds compromised by extensive hypovascular fibrosis, fistulas, and radiation by prefabricating a skin or buccal graft at a distant site in the medial thigh creating an axial flap to establish a reliable circulation to the graft and transferring it to the urethra as an onlay. The uncertainty of precarious, unpredictable inosculation can thus be avoided. This permits a skin component or buccal graft without excessive bulk in a more distal site on the muscle flap. The gracilis muscle is first exteriorized through a 10- to 12-cm incision over its distal third, suturing it to the graft edge (Fig. 18.14). The graft is sutured to the edges of the exposed anterior muscle

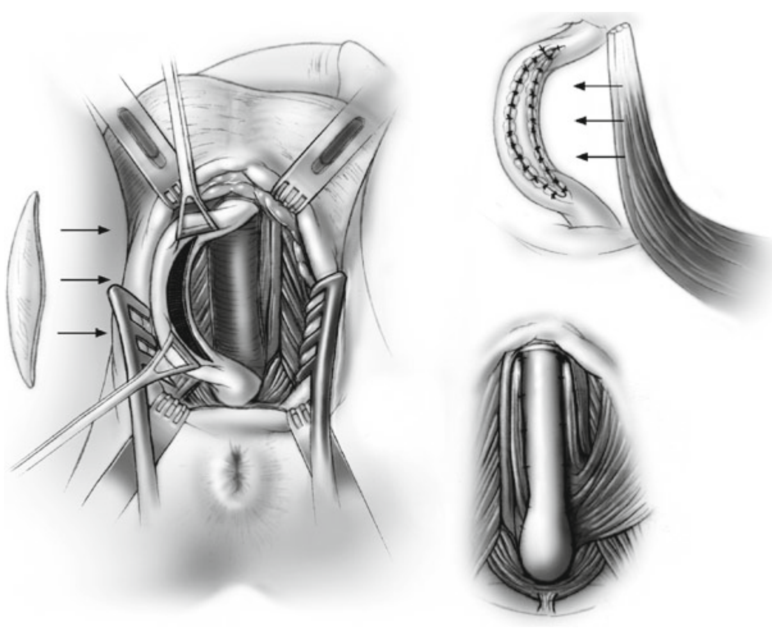

Fig. 18.13 Dorsal wall injuries can be repaired by making a dorsal urethrotomy and fixing a buccal onlay at both apices followed by a muscle flap interrupted between the graft and the ventral corpora

surface, and pie is crusted and quilted to the muscle with 5-0 Monocryl sutures. It is then supported with a large stent-like compression bolster dressing. These grafts develop new vascular patterns that have been observed experimentally to appear in a stable reliable manner at a 3- to 4-week interval and offer the advantages of a custom-created neovascularized skin flap [16]. This type of flap then avoids the use of a large, bulky myocutaneous skin paddle. When the graft maturity is established (4–6 weeks) and the maximum contracture is noted, the muscle and skin are retrieved with a circumferential incision around the graft including a 3-mm margin of thigh skin. The graft, which is now a flap by definition, is tailored to fit the urethral defect, including a redundant margin (Fig. 18.15). The distal gracilis tendon is transected, and the long muscle flap with the adherent graft composite is transferred on its proximal pedicle into the perineum for a proximal urethral repair (Fig. 18.16).

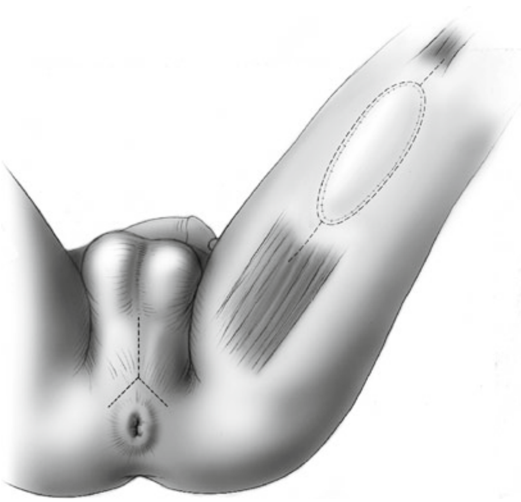

Fig. 18.14 The muscle is exteriorized through a 12-cm incision over its distal third suturing it to the buccal graft. The graft is sutured to the edge with interrupted 5-0 Monocryl sutures completely covering the exposed muscle surface. The graft is then pie crusted and quilted against the muscle

The Gracilis Myofasciocutaneous Flap

The gracilis muscle with a cutaneous component has a more limited application in urologic reconstruction but can be an invaluable adjunct when a supportive muscle and a skin cover are required. The perineal decubiti with a urethral or prostatic defect, the radiated prostatoperineal fistula

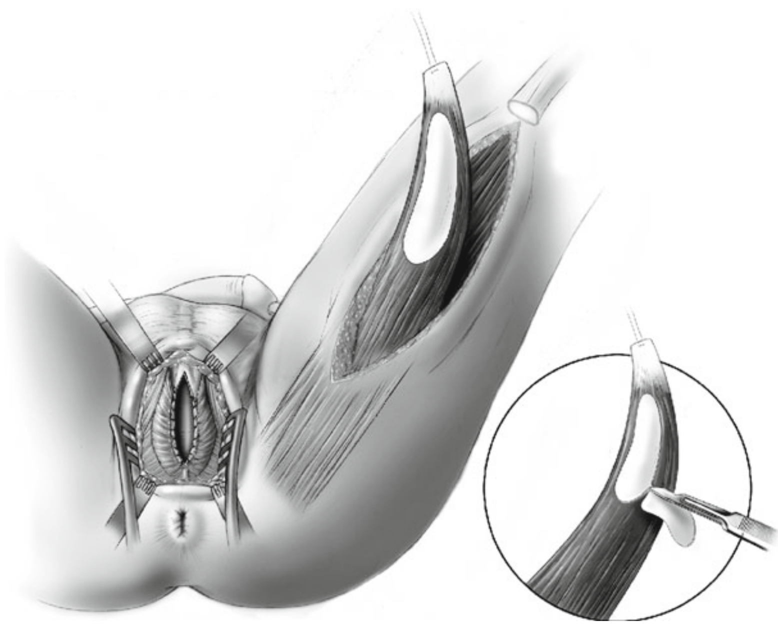

Fig. 18.15 When the graft is secure, the muscle is explored through a circumferential incision around the graft margin extending distally and proximally to expose the entire flap

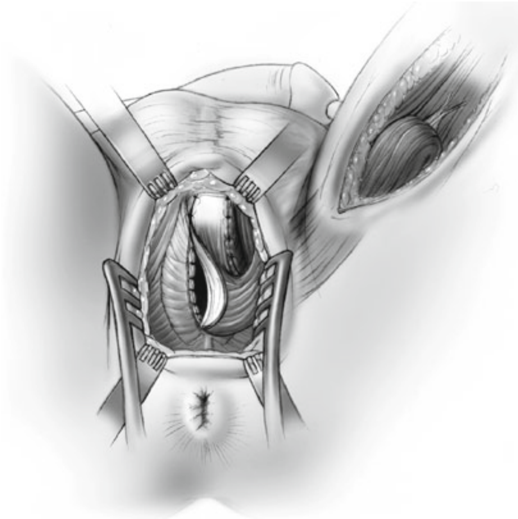

Fig. 18.16 The urethral stricture is first exposed and the appropriate stricturotomy is performed. The thigh incision is extended proximally and distally, dividing the gracilis tendon near its insertion. The urethroplasty is completed by transferring the gracilis muscle with its newly added graft component through a generous medial thigh and perineal tunnel. The buccal patch is sutured to the urethral edge

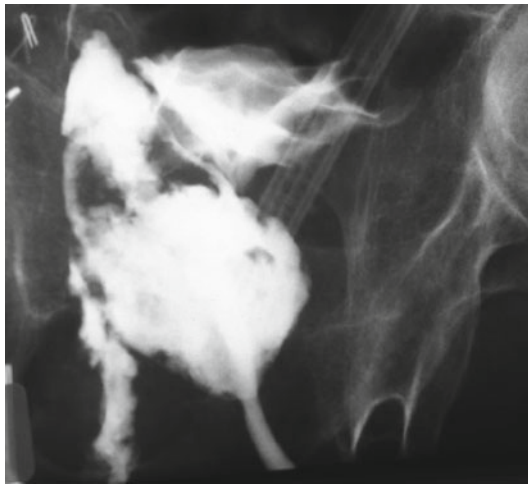

Fig. 18.17 Retrograde urethrogram in a 67-year-old patient with a radiation prostatocutaneous fistula 11 years after rectal incision

following abdominoperineal rectal excision, the inflammatory bowel disease with multiple urethrocutaneous fistulas, and the genital and perineal defect following debridement for necrotizing fasciitis are some indications for this flap combination (Fig. 18.17). Because partial and total necrosis of the cutaneous portion of the flap occur in 13 and 6.8 % of this combined tissue transfer [17] using the classic flap, a modified harvesting technique has been described by Whetzel [18] to avoid overlying skin segment that has an absent cutaneous vascularization derived directly from the muscle surface. During elevation of the muscle, the deep investing perigracilis septal fascia, including fascia of the adductor longus, vastus medialis, adductor magnus, semitendinosus, and sartorius, is included so that no gracilis muscle fibers are seen. The proximal end of the greater saphenous vein can be left in situ and mobilized with the flap. The approach is based on the observation that blood supply to this skin over the gracilis muscle comes primarily from vessels traveling around it, rather than through the muscle. The anterior border is the predominant route for blood vessels on their way to the skin, so the flap is designed with its center based on the anterior edge of the muscle rather than on the midline. This concept is in opposition to the original description where the blood supply was consistently and directly through the muscle by the perforators to the surface [18]. This vascular pattern accounts for both muscular and fasciocutaneous vascular concepts in the gracilis environment. The fasciocutaneous component needs to be integrated into the planning of a viable musculocutaneous flap, because the vascular basis is primarily by means of the septocutaneous vessels within the septum between the gracilis and the adductor longus muscles most of which originate from the main gracilis pedicle and travel around the muscle rather than through it to the overlying skin [19]. This anastomotic approach to the vascular anatomy of the cutaneous paddle has been validated by Chuang et al. [20] in head and neck reconstruction, where the gracilis has been transferred as a free flap.

Operative Technique for Transfer of the Gracilis Myofasciocutaneous Flap

The patient is placed in the lithotomy position for flap transfer to the perineum, the vagina, or the inguinal location with the legs in adjustable and flexible multijoined yellowfin stirrups. This position permits the patient's knees and thighs to be flexed or straightened for the transfer after flap dissection. Cutaneous flap size is determined by the measurement of the defect to be covered or the size of the space that will require the appropriate volume of muscle and deepithelialized skin for replacement and fistula closure (Fig. 18.18). Cutaneous vascular perfusion is more reliable when the size of the skin paddle is reduced to an 8×20-cm measurement along with excision of the distal gracilis muscle when a "short" gracilis flap is used after ligating the medial circumflex femoral pedicle. A guideline is drawn initially on the unflexed thigh from the pubic tubercle to the medial femoral condyle. A large oval vertical skin island is outlined with its center over the anterior edge of the muscle in its proximal two-thirds (Fig. 18.19). The distal tendon is then mobilized anterior to the semitendinosus muscle tendon. A wider flap tends to be more secure with regard to blood supply since the critical perforators have a more likely chance of being included in the flap (Fig. 18.20). The anterior flap margin is dissected deep into the subcutaneous tissue to the fascia (Fig. 18.21). The medial fascia of adductor longus and vastus medialis, adductor brevis, and semitendinosus is included with the gracilis along with all of the sartorius and all of the gracilis fascia so that no gracilis muscle should be seen. This includes all the tissue between the adductor longus and the gracilis. The saphenous vein segment is included. Because partial and total necrosis of the cutaneous portion of the flap occur in 13 and 6.8 % of this combined tissue transfer [17] using the classic flap, a modified harvesting technique has been described by Whetzel and Lechman [18] in an attempt to overcome and avoid the hazards of retrieving an overlying skin segment that has an absent cutaneous vascularization derived directly from the muscle surface. During elevation of the muscle, the deep investing perigracilis septal fascia, including fascia of the adductor longus, vastus medialis, adductor magnus, semitendinosus, and sartorius, is included so that no gracilis muscle fibers are seen. The proximal end of the greater saphenous vein can be left in situ and mobilized with the flap. The approach is based

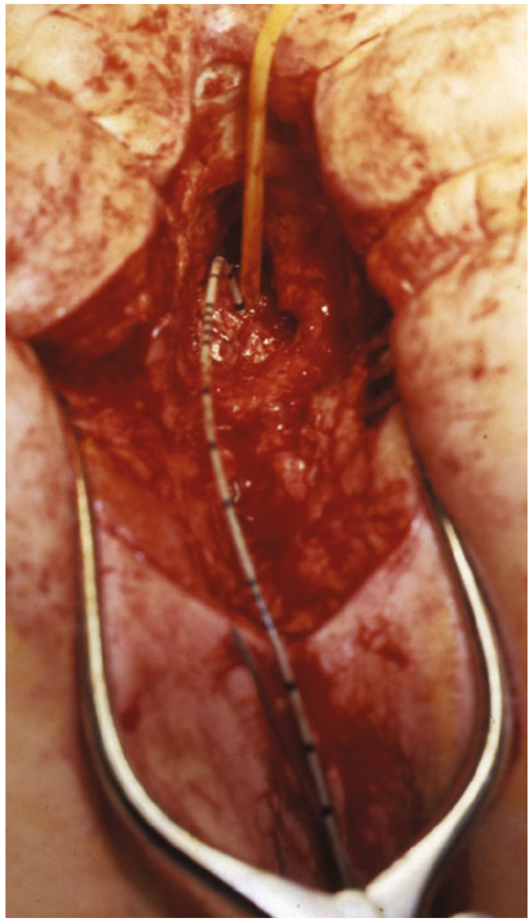

Fig. 18.18 Exposure of prostatic radiation fistula and excision of radionecrotic intergluteal skin surface in the prone position

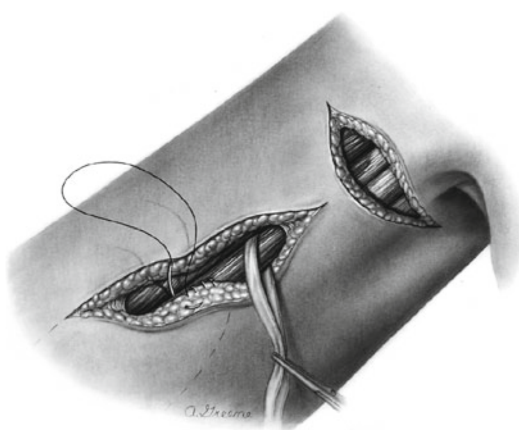

Fig. 18.19 Gracilis myofasciocutaneous flap with skin paddle centered over borders of the proximal two-thirds of the muscle

Fig. 18.20 The skin margin of the flap is sutured to the fascial underside of the muscle to avoid shearing disruption of the muscular and septocutaneous perforators during elevation

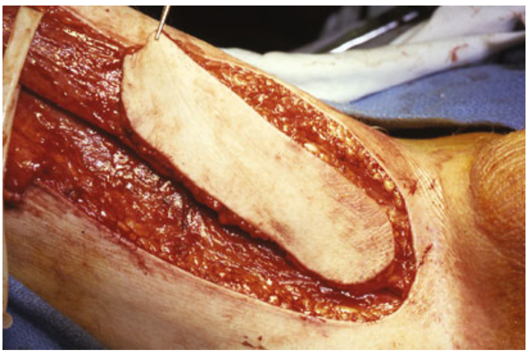

Fig. 18.21 The distal tendon medial to the semitendinosus is divided, and the flap is elevated after the skin flap is prepared

on the observation that blood supply to this skin over the gracilis muscle comes primarily from vessels traveling around it, rather than through the muscle. The anterior border is the predominant route for blood vessels on their way to the skin, so the flap is designed with its center based on the anterior edge of the muscle rather than on the midline. This concept is in opposition to the original description where the blood supply was consistently and directly thought to be through the muscle by the perforators to the surface [17]. This vascular pattern accounts for both muscular and fasciocutaneous vascular concepts in the gracilis environment. This anastomotic approach to the vascular anatomy of the cutaneous paddle has been validated by Chuang et al. [20] in head and neck reconstruction, where the gracilis has been transferred as a free flap.

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The patient is placed in the lithotomy position for flap transfer to the perineum, the vagina, or the inguinal location with the legs in adjustable and flexible multijoined yellowfin stirrups. This position permits the patients the maximal rotation for vaginal and any deep perineal spaces. The skin margin of the flap is sutured to the fascial underside to avoid disruption of the muscular septocutaneous perforating vessels by shearing of the skin off the muscles during further elevation of the proximal incision. The distal tendon is divided and the flap elevated with the skin island attached proximally (Fig. 18.22). The distal two minor pedicles from superficial artery are ligated and divided. The relation of the skin to the muscle is again confirmed as it is elevated and changed if not correctly centered over the muscle. The dominant pedicle will be seen by retracting the adductor longus medially as it passes over the deeper adductor magnus. The flap is rotated on its pedicle to the defect by making a wide superficial subcutaneous tunnel to accommodate the flap without tension or compression.

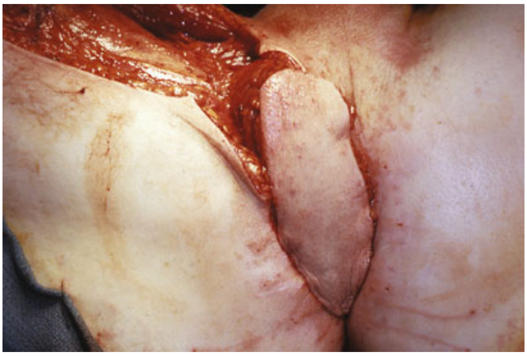

Fig. 18.22 The flap is rotated on its pedicle without tension in the defect after dividing the groin skin bridge

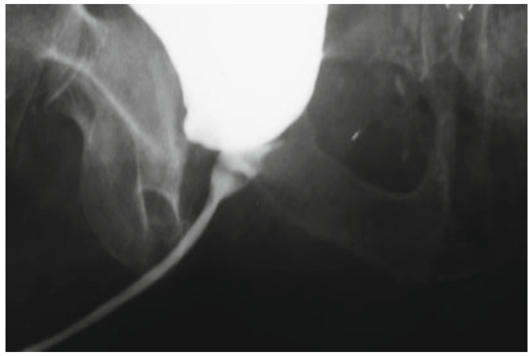

Fig. 18.23 The postoperative urethrogram reveals fistula closure following the closure of the prostatocutaneous radiation injury patched with a penile preputial skin FTSG

If compression potential exists, from the overlying tunnel, then the skin is divided. If further skin paddle rotation or advancement is required at the recipient site, the legs are then brought down with some adduction and muscle shortening which can provide additional 3–6 cm in length. The thigh and perineal incisions are closed with a suction drain (Blake) that is left in for 72 h. The leg is firmly wrapped, and the patient is immobilized for 72 h, and subcutaneous heparin is administered for 7 days. If any of the surface demonstrates necrosis, then early debridement with a stented skin graft is instituted (Fig. 18.23).

The anatomical approach to the harvest of this myofasciocutaneous flap with aggressive inclusion of the perigracilis fascia creates the most reliable vascular inflow to the middle third of the skin island (Fig. 18.24).

Fig. 18.24 The perigracilis septocutaneous perforators that come around the muscle result in a well-perfused viable myocutaneous axial flap

Perineal Artery Fasciocutaneous Flap (Singapore)

The perineal artery medial thigh fasciocutaneous flap is another concept in tissue transfer that has the potential of salvaging the complex proximal prostato-membranous and bulb stricture. It is particularly suited for the repair of radiation prostato-membranous strictures, the recurrent failed post-anastomotic urethral distraction defects, and the rare rectourethral fistula associated with a proximal stricture. The flap can be a valuable adjunct in the initial perineal and thigh coverage of defects following necrotizing fasciitis. The radiation vesicovaginal fistula has also been successfully closed by using this skin cover to replace the ischemic vaginal wall. Its robust blood supply, predictable measurements, minimal donor site morbidity, and prior reported success in vaginoplasty make this flap an ideal alternative option for complex proximal urethral reconstruction. The proximal portion of the medially rotated flap increases the safety and security of the perineal cover in patients with overlying perineal skin loss, prior surgery, or radiation therapy in conjunction with the urethral replacement. It belongs to the class of axial fasciocutaneous flap constructs consisting of skin, subcutaneous tissue, and a well-developed fascial undersurface.

The flap has a defined skin territory supported by an identifiable vascular pedicle, the perineal artery which is a distal branch of the internal pudendal. The perineal artery penetrates the fascia at its base and develops a superficial plexus, which arborizes with the subdermal plexus and reliably perfuses the skin [21]. The flap has the advantages of a simple dissection, minimal bleeding, no loss of function, and minimal bulk, making it more suitable for a smaller defect such as those seen in urethral, vaginal, and scrotal reconstructions. It can be transferred to the urethra using three different techniques of flap rotation. The onlay patch is the most commonly used for urethral repair and best designed in a transverse direction [22].

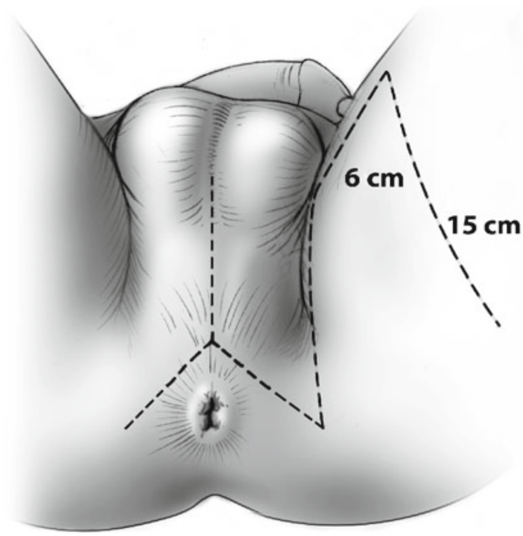

Fig. 18.25 Perineal artery medial thigh flap measurements are consistently 15 × 16 cm with its proximal base located at the level of the mid-perineum. The medial border is the groin crease lateral to the edge of the scrotum

Flap Design and Technique of Elevation for Onlay Patch Urethroplasty

The perineal artery, or Singapore flap, is a vertically oriented composite of skin with an underlying deep fascia and adductor epimysium measuring 6 × 15 cm with its proximal base located at the level of the mid-perineum 3 cm distal to the anal margin (Fig. 18.25). The perineal artery arises just medial to the groin crease with branches to the scrotum and medial thigh skin. This circulation is richly enhanced by its arborization with the deep external pudendal, the medial circumflex femoral from the profunda femoris, and the anterior branch of the obturator artery. This is a partially sensate flap innervated by the pudendal and the posterior cutaneous nerve of the thigh with good sensory perception in the mid-perineal portions of the transferred flap. The perineal artery entrance site can be best identified by a Doppler probe before flap design. The urethral stricture is exposed by a thorough ventral urethrotomy, which is started distally with an indwelling 5-French Fogarty vascular balloon catheter as an intraluminal guide and carried proximally to a point 2 cm beyond the balloon to establish a 30-French proximal lumen and a 26-French distal lumen. This flap is outlined initially with a skin marker defining the measurements with a skin on stretch and extending it, if needed, an extra 2 cm into the femoral triangle, where random circulation-based skin extension occurs.

The incisions are started in parallel vertical lines down to the fascia on both sides, raising the epimysium with the fascia and suturing it to the dermis to prevent shearing injury to the segmental vessels. The flap is then lifted back to its proximal transverse margin after completing the distal transverse incision. Effective blood flow is confirmed by deepithelializing a 2- to 3-mm area at the distal margin to identify a bleeding dermis. The tissue bridge between the base of the flap and the urethral exposure is divided to prevent tunnel pressure effect and the potential comprise of flap circulation. This procedure permits ease of transfer to the deep proximal urethra and a lateral rotation of the scrotal and perineal tissues to help close the donor site [23].

A 6- to 8-cm transverse island is outlined at the distal edge of the flap by deepithelializing a 3- to 4-cm strip of skin just proximal to the island onlay segment, leaving a thin layer of dermis to prevent ischemic injury to the transverse island (Fig. 18.26). If the urethrotomy is greater than 6 cm in length, it will require an additional segment of buccal mucosa in a combined composite to repair the entire stricture. The buccal mucosa graft is always placed in the more distal portion to avoid the trans-spincteric site where flaps are more likely to succeed than grafts. The flap is then rotated medially and inferiorly, and the island patch is sutured by initially placing the apical sutures at each end to establish a good fit without folds or bunching. If the proximal apex is in the prostatic floor then six 4-0 Monocryl sutures are initially placed at the site, rearmed and inserted into the inferior edge of the skin flap (Fig. 18.27). The donor site is closed by advancing the thigh incision toward the scrotum and transferring the scrotal bridge laterally (Fig. 18.28). A small suction drain exiting through the thigh incision is removed in 3 days. The urethral catheter and suprapubic cystotomy are left in for 3 weeks pending a normal voiding cystourethrogram.

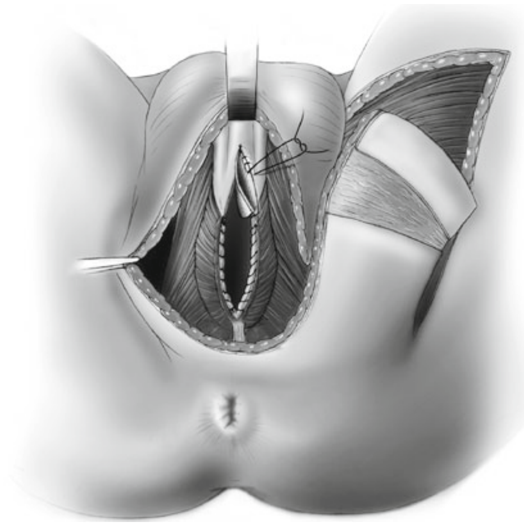

Fig. 18.26 A proximal urethrotomy is performed from the distal bulbous urethra across the trans-sphincter segment to the prostatic apex. A buccal mucosal graft can be utilized to repair the distal portion of the bulbar stricture if the suture is longer than 6–8 cm. A distal transverse island is outlined at the distal margin of the flap, and a 3-cm wide strip of skin is deepithelialized just proximal to the island leaving a thin layer of dermis

Gluteus Maximus Muscle Flap

Gluteal Flaps for Bulbomembranous Urethral Reconstruction

Prostatocutaneous and proximal bulbomembranous urethral fistulas and strictures may occur from surgical trauma after abdominoperineal resection of rectum for cancer and inflammatory disease, as a delayed phenomena associated with adjunctive radiation therapy or the result of a pressure-induced decubitus with associated perineal skin loss. This recalcitrant problem requires

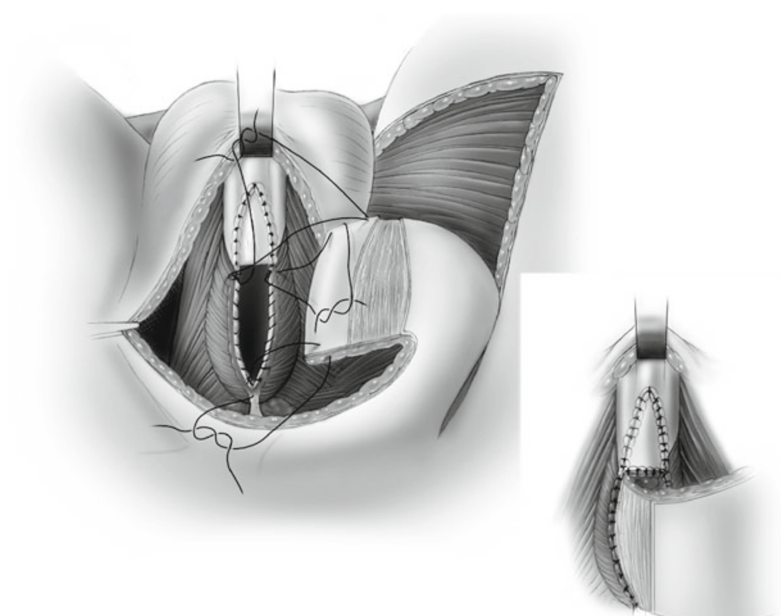

Fig. 18.27 A transverse island is rotated medially and inferiorly, and the island of skin is applied to the urethrotomy defect and sutured with running 4-0 Monocryl sutures. The distal edge of the island flap is approximated to the proximal margin of the buccal graft completing the combined reconstruction

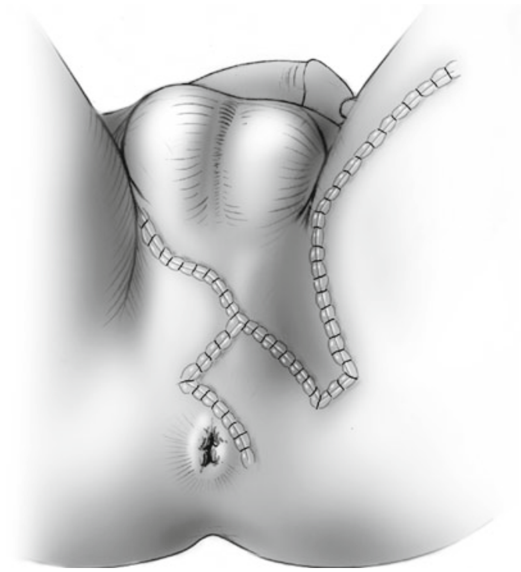

Fig. 18.28 Closure of the perineum and donor site is accomplished by rotating the inguinal and scrotal bridge laterally into the thigh defect and advancing of the inferior margin of the thigh incision toward the groin. No donor site morbidity has been noted

a large, reliable muscle flap that will buttress the repair, fill in the noncollapsible retrovesical dead space and tissue loss surrounding the fistulas, and offer a good blood supply to a rigid fibrotic tract and a buccal graft onlay.

There needs to be a sufficient tissue bulk for covering the perineum and intergluteal space and a well-vascularized surface to assist the closure of the defect in the face of impaired wound healing. This can be accomplished by a number of muscle flaps including transabdominal transfer of the rectus abdominis, bilateral coapted gracilis muscle flaps combined with a semitendinosus, a gracilis myofasciocutaneous flap, or a free latissimus dorsi flap. Our use of unilateral or bilateral inferior gluteus maximus has been the most effective for this pathology, but often a neglected option. The anatomical insights gained over the past two decades have resulted in the development of a number of gluteus maximus muscle flap designs which permit preservation of function and the ability to transfer a large muscle bulk to the deep perineum and presacral space [24]. The inferior gluteus maximus or a lower segment of this muscle based on the inferior gluteal artery vascular pedicle permits rotation of the muscle into an intergluteal, sacral, and perineal space without incurring impaired function or contour deformity of the buttocks [24].

Gluteal Anatomy and Clinical Applications

The gluteus maximus is a large, quadrilateral muscle that forms the prominence of the buttocks. It measures 24×24 cm on average and arises from the posterior gluteal line of the ileum and the sacrum, the side of the coccyx, the aponeurosis of the sacrospinalis, the sacrotuberous ligament, and the fibers from a diffuse origin course laterally and inferiorly to the fascia over the gluteus medius muscle, inferiorly to insert into the iliotibial tract and the gluteal tuberosity of the femur (Fig. 18.33). The muscle is nourished by the superior and inferior gluteal arteries, which are branches of the internal iliac arteries (Fig. 18.29b). There are two minor vascular pedicles, which anastomose freely with the gluteal vessels. These are the first perforators of the profunda femoris artery and vein and the intramuscular branches of the lateral circumflex femoral artery from the profunda. The first perforator enters the muscle adjacent to its insertion, and the two or three intramuscular branches enter beneath the inferior gluteus muscle insertion. The superior and inferior gluteal nerve (L5–S1) courses through the sciatic foramen, accompanies the inferior gluteal artery medial to the sciatic nerve, and enters the gluteus maximus muscle on its deep surface at the level of the piriformis muscle, where it supplies motor innervations to the entire muscle.

Loss of muscle function does not become evident in casual activities such as easy walking or standing because other muscles will compensate for its loss. The gluteus maximus extends and rotates the thigh laterally and is important for more forceful activities such as running, climbing, and jumping. The superior or inferior half of the muscle may be elevated as a flap without loss of function if the other half is intact. The muscle segment can be rotated to cover the sacrum where the dominant pedicles enter the muscle very close to the fibers of origin from the sacral

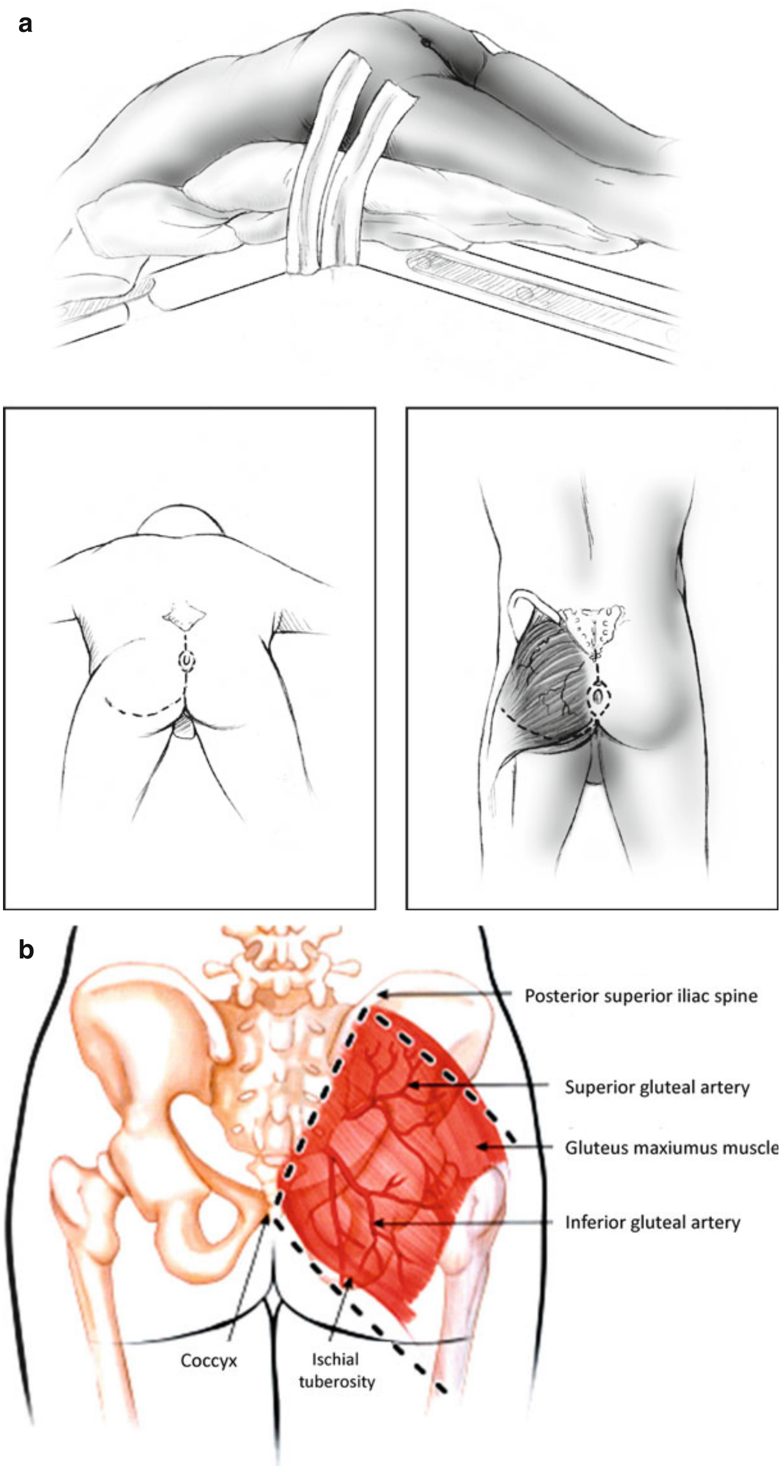

Fig. 18.29 (**a**) The patient is placed in the prone position with the waist and pelvis flexed. The legs and feet are protectively padded, and chest rolls are placed under the chest and pelvis to prevent pressure point injury. The fistulous tract is excised with the indwelling stent. The incision is extended in the *mid-perineal line* in both directions and laterally to expose the surface of the inferior gluteus maximus. The inferior segment of the muscle is identified after the horizontal component of the incision is made. (**b**) Anatomical landmarks of the gluteus maximus muscle (Image courtesy M. Zinn)

edge. The muscle is split into two segments, and the inferior portion is used primarily for perineal and vaginal reconstruction. The lower distal portion is adjacent to the intergluteal and perineal space, making it an optimal skeletal muscle flap for repair of this portion of the urethra and for obliteration of the pelvic space.

Techniques of Gluteal Maximus Repair of a Perineal Urethral Stricture (and Fistulas)

The patient is initially cystoscoped in the lithotomy position, at which time any fistulous tracts are cannulated with a ureteral catheter and the bladder drained with a urethral catheter. The patient is then placed in the prone position with the waist flexed and the legs separated (Fig. 18.29a). Protective padding is then used for the legs and feet, and chest rolls are placed to prevent pelvic and breast compression. The lateral edge of the sacrum and greater trochanter is initially identified and marked as respective origin and insertion of the gluteus maximus muscle. The fistula tract is excised by making the circumferential incision and extending in cephalad and caudal along the perineal midline in the intergluteal groove. The intergluteal midline cleft is incised from the scrotum to the coccyx deep to the ventral urethral and prostatic surface. The incision is extended horizontally along the inferior gluteal crease to expose the superficial surface of the muscle. The dissection proceeds cephalad under the coccyx and laterally down the pelvic sidewall. More exposure can be achieved by extending the incision parasacrally. The urethra is identified and the lateral fibrous and radiated tissues are excised. The overlying skin on the gluteus muscle is retracted upward and lateral. The lower sacrum and coccyx are resected and the prostatic surface exposed. More sacral bone is removed if there is poor exposure or obvious radionecrotic bone involvement. A prostatic fistula is closed with a buccal mucosa graft following exposure and lateral retraction of the levator ani muscle. A proximal urethral stricture can also be repaired with a buccal mucosal onlay in a ventral position followed by support to both grafts with a muscle surface. This well-vascularized muscle will overcome completely the adversity of the radiated pelvis.

Table 18.1 Gluteus maximus anatomy: summary table

Origin:	Gluteal surface of ilium, lumbar fascia, sacrum, sacrotuberous ligament
Insertion:	Gluteal tuberosity of the femur, iliotibial tract
Blood supply:	Superior gluteal artery 2–3 mm, pedicle 2 cm; inferior gluteal artery 2–2.5 mm; and vein 3–3.5 mm, pedicle 6 cm
Innervation:	Inferior gluteal nerve (motor), (L5, S1, S2 nerve roots), no sensory nerve with flap
Action:	External rotation and extension of the hip joint
Advantages:	Available donor site in most patient, hidden donor scar, minimal functional deficit if < 1/3rd of muscle harvested
Disadvantages:	Donor site seroma common, thigh numbness may result from injury to the posterior cutaneous nerve with inferior gluteal flap harvest

To elevate the inferior half of the gluteus maximus after exposure of its superficial surface, the muscle is split at its midportion. The inferior half of fibers of insertion is divided and separated from the iliotibial tract, and the gluteal tuberosity and the muscle is mobilized from lateral to medial, identifying the inferior vascular pedicle (see Table 18.1 for anatomical summary). The origin can be completely detached from the sacrum without endangering the blood supply, if needed. The piriformis muscle is the key reference point in locating the sciatic nerve deep to the gluteus maximus. With the sciatic nerve carefully preserved and the location of the gluteal vessels confirmed, the muscle can be split to the level of the sacrum in preparation for transfer (Fig. 18.30). A 10 × 20-cm flap can be retrieved based on the inferior gluteal artery. Gradual detachment of the inserting fibers of the muscle on the iliotibial tract, intermuscular septum, and the lesser trochanter of the femur can be readily performed once the underlying

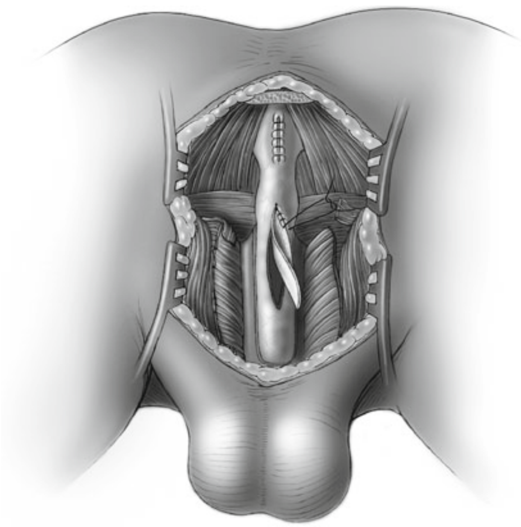

Fig. 18.30 The prostate and proximal urethra are exposed through an intergluteal dissection following excision of the fistula tract. A buccal mucosa patch onlay is placed ventrally to repair a proximal stricture and prostatic fistula

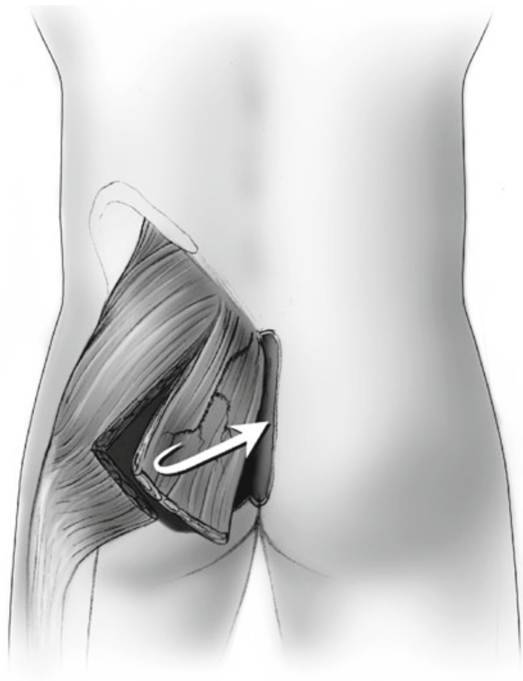

Fig. 18.31 To elevate the inferior half of the gluteus maximus, the muscle is split at its midportion and mobilized initially from the lateral to medial identifying the inferior gluteal vascular pedicle. The inferior half of the fibers of insertion is divided, and the remainder of the muscle splits to the level of the sacrum preparing it for rotation to the perineum

structures are identified. Partial release of the gluteus origin from the sacrum will facilitate further flap transposition, which can be easily moved an additional 5–7 cm.

The distal flap is then advanced into the perineal defect from the buttock and fixed to the periurethral fascia, completing the buttress effect over the urethral and prostatic graft and fistula (Fig. 18.31). With adequate mobility, the muscle can also be placed under the sacral roof to completely obliterate the entire rectroprostatic and urethral compartment (Fig. 18.32). The donor site can be closed by mobilizing the contralateral skin edge and turning the skin and subcutaneous tissue over in a medial direction and suturing it to the contralateral skin edge. It is rarely necessary to place a skin graft for this exposed muscle because lateral buttock and inferior subcutaneous thigh skin dissection will allow closure without tension [25]. If the muscle does not reach the buccal graft surface, a gracilis or semitendinosus muscle can be retrieved in the prone position and transferred in the space under the inferior gluteus maximus. The gluteus maximus muscle or musculocutaneous flap provides reliable support and buttressing of recalcitrant prostatic and urethrocutaneous fistulas and urethral strictures in

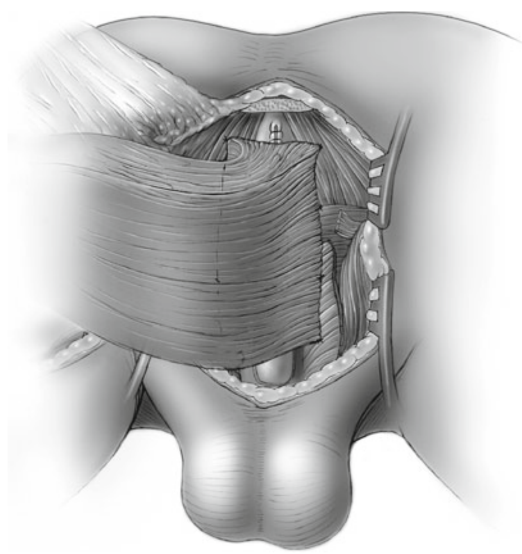

Fig. 18.32 The distal muscle flap edge is advanced medially into the perineal defect obliterating the rectourethral and prostatic space from the sacrum to the perineal edge where it is fixed to the periprostatic and periurethral fascia

patients who have undergone a prior proctocolectomy. The technique advances a large bulk of well-vascularized muscle, which permits complete obliteration of perineal and intergluteal spaces that have been injured by a prior radiation or tissues loss. This is not an expendable muscle, but proper mobilization of the inferior gluteal segment with preservation of the superior segment, loss of strength in extension, and abduction of the hip can be prevented permitting the use of a local muscle flap with minimal donor site morbidity. The anatomy of the retro-gluteal space containing the inferior gluteal artery, the piriformis muscle, and the sciatic nerve is well protected by mobilizing the inferior gluteus from the gluteal tuberosity medially to the sacral edge.

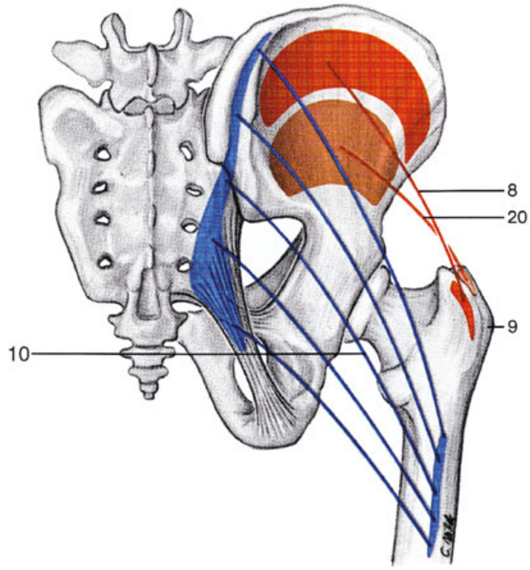

Fig. 18.33 Course of gluteal muscles as to origin and insertion. *8* gluteus medius, *9* greater trochanter, *10* gluteus maximus, *20* gluteus minimus [30]

Rectus Abdominis Muscular and Myofascial Flap

The rectus abdominis muscle and myofascial flap with or without a cutaneous component were first described by Mathes in 1977 for use in abdominal wall defects. It has been a valuable adjunct in repairing complex pelvic and perineal pathology with its robust size and shape and its simplicity and versatility [26].

The muscle originates in the pubic crest laterally and the anterosuperior symphysis pubis medially connected by two tendons (Fig. 18.33). The proximal three tendinous fascicles are inserted into the fifth, sixth, and seventh costal cartilages. Two to five tendinous insertions cross the muscle transversely and adhere intimately to the anterior aponeurotic rectus fascial sheath. The anterior and posterior laminae of the rectus sheath are fused medially (linea alba) and laterally. Below the umbilicus and above the arcuate line, the posterior sheath is formed by the aponeurosis of the internus abdominis and transversus muscles, although the aponeurosis of the latter usually terminates a short distance before the arcuate line.

The blood supply to the rectus abdominis muscle is essentially from both the superior and inferior deep epigastric arteries (Fig. 18.34). The latter originates from the external iliac, ascends obliquely anterior to the transversalis fascia and laterally, and enters the lateral border in the surface under the rectus muscle approximately 5 cm above the pubis at the same level as the 12th spinal nerve. The artery penetrates the deep surface of the muscle approximately at the level of the umbilicus before anastomosing with the superior epigastric artery, which is a branch of the internal thoracic or mammary and the subclavian. Other anastomotic branches come from intercostals and lumbar arteries [27].

The rectus has two standard arcs of rotation. When based on its inferior pedicle, the inferior epigastric artery, the rotation occurs at the level of the pubis, and the muscle will reach the groin, perineum, and inferior trunk. The inferior arc can be extended by division of the fibers of origin and mobilization of the inferior epigastric artery to the level of the inguinal ligament. The margins of the muscle can be identified during active muscle contraction by placing the patient in the supine position and requesting a straight leg-raising maneuver while the abdomen is palpated. The muscle length average is 25 cm with a width of 6 cm depending on body habitus. The inferior pedicle is located deep to the lateral half of the muscle 5 cm above the pubic edge.

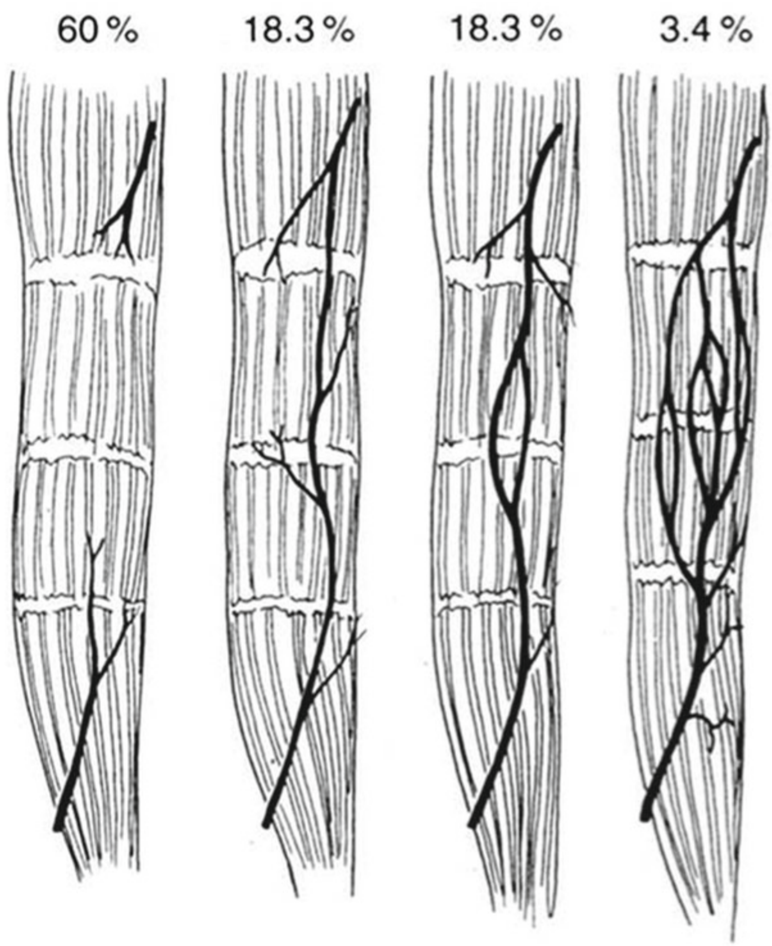

Fig. 18.34 The rectus abdominis is a bipedal flap Mathes Type III muscle arising from the fifth, sixth, and seventh costal cartilage and inserting into the lateral pubic symphysis. It has four vascular patterns based on the inferior deep epigastric and superior epigastric artery and vein

Vertical Skin Island

The vertical skin island is the most useful when coverage is an essential component of the transfer to the perineum and groin. It receives perforator vascular communications from the paired rectus muscle surfaces. The greatest concentration of perforators is around the umbilicus. The skin island may be designed over the entire muscle, and its limitation is primarily related to the ability to close the donor site. Closure in the vertical direction is within the constraints of a defect width of 6–8 cm. In the nulliparous female or young male, the skin island dimensions can extend to generally 21 × 8 cm. In the older male or multiparous female, the width may be extended to as much as 14 cm.

The ideal incision for flap elevation is a paramedian into the rectus sheath which is then dissected off the muscle surface preserving the rectus sheath at each tendinous intersection. The dense adherence to the tendinous intersection usually occurs above the umbilicus while the lower ones are separated with ease.

When a skin island is used, its edges are elevated 1–3 cm lateral and medial to the cut rectus sheath to preserve as much sheath as possible for direct closure while maintaining the critical musculocutaneous perforating vessels extending through the central rectus sheath between the muscle and skin island. It is useful to place a series of Vicryl 3-0 sutures between the skin island, anterior sheath, and muscle at both the medial and lateral aspects of the island to avoid disruption of the musculocutaneous perforators during flap elevation below the semicircular line of Douglas or the linea semicircularis. At a fairly constant point midway between the umbilicus and pubis, the aponeurotic fibers of the external oblique and transversus muscles pass anterior. Below this, the posterior sheath consists only of transversalis fascia and persistent fibers of the transversus muscle. After posterior sheath separation, then divide the distal muscle at the desired length [28].

In the inferior-based flap, transect muscle by dividing the superior epigastric at the deep medial surface of the muscle. The muscle is elevated off the posterior sheath. When closure of the donor site approaches the flap base, care is taken to avoid compression of the flap base by a tight tunnel. The selection of patients for this flap should carefully avoid those patients with prior abdominal incision, history of scleroderma, radiation, smoking, or obvious vascular disease. If closure of the anterior rectus sheath results in tearing of the remaining fascia, the adjunctive use of synthetic mesh or biological substitute (allodem) should be added to the repair of the fascia. The attachment of the rectus muscle to the symphysis pubis should be left intact to add support to the vascular pedicle and prevent twisting and tension of these vessels.

Hernias are a potential complication of this muscle transfer which can best be avoided by limiting the amount of rectus fascia removed. By leaving at best 40–50 % of the lateral fascia intact, use of the Prolene figure-of-eight fascial closure sutures, and selective reinforcement of the donor site with mesh sandwiched between the anterior and posterior rectus sheath, hernia development will be minimal. Most incisional hernias and dehiscences occur when a skin component and large fascial defects are created with a reported incidence of 0–11 % [29].

Conclusion

For refractory urethral strictures and fistulas, skin and buccal graft muscle flap composites, such as with the gracilis muscle, the Singapore medial thigh flap, the inferior gluteus maximus muscle flap, and the rectus abdominis muscle, are reliable and successful techniques for reconstruction. These flaps are all particularly valuable resources in the management of recalcitrant pathology or the presence of wound healing impairment such as radiation or other adverse conditions that would jeopardize genital skin graft and flap survival. These expendable muscle-and-tissue covering flaps will not result in impaired motor function if careful attention is paid to the details of their retrieval. Other axial flaps that are available as an enhancing support system in genitourinary reconstruction include the posterior thigh fasciocutaneous, rectus femoris, semimembranosus, semitendinosus, and latissimus dorsi free flap, all of which require more complex retrieval techniques. The only consistently successful option for repair of the complex urethral stricture pathology in patients who have undergone numerous failed prior procedures in the proximal and posterior urethra is the combined use of a ventral buccal mucosal, posterior auricular Wolfe, or penile skin graft supported by a transferred muscle surface.

Preferred Surgical Instruments in Transfer of Axial Flaps

1. Modified Denis Browne self-retaining blackened ring retractors
2. Adson-Beckman retractor
3. Isolated hooks of the Lone Star ring retractor
4. 6 and 8 cm Stille tooth forceps
5. 6 and 9 cm Tenotomy scissors
6. Strully dural scissors
7. 4-0 and 5-0 Monocryl for graft application: 6-0 PDS for graft quilting 4-0 and 3-0 Vicryl sutures for wound closure

8. Doppler Probes for dominant axial vascular pedicle location
9. Skin marker

Editorial Comment

Urologists can and should learn to harvest fasciocutaneous, muscular, and myocutaneous flaps and graft onlays. They should be part of the surgical armamentarium of all urologists who choose to perform urethroplasty and urinary fistula surgery. The harvest of such flaps and muscles can be easily learned and mastered and should not be relegated or deferred to the plastic surgeon. Developing flaps is easier than you think; it just takes patience and good knowledge of the vascular anatomy. I learned how to do such flaps, not in fellowship or residency training, but rather on my own – first by doing a few cadaveric dissections and then by doing combined case with an open-minded plastic surgeon. This is a well-detailed chapter that will serve you well as a surgical atlas. Keep it handy at the surgical bedside.

–Steven B. Brandes

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19 Posterior Urethral Strictures

A.R. Mundy and Daniela E. Andrich

Summary

Posterior urethral strictures are not common, and in the context of this chapter, they are not really strictures—they are best called pelvic fracture-related urethral injuries. They are generally repaired transperineally with very satisfactory results, but some injuries can be technically very challenging and the consequences of inadequate or inexpert surgery of even straightforward cases can be devastating. This is not an area for amateurs.

Introduction

The male urethra is traditionally divided into the anterior urethra, which is surrounded by the corpus spongiosum, and the posterior urethra, which is surrounded by the sphincter mechanisms and the prostate. The posterior urethra is subdivided into the bladder neck (or preprostatic urethra), the prostatic urethra, and the membranous urethra. Bladder neck strictures and strictures of the prostatic urethra are largely a consequence of the treatment of carcinoma of the prostate and of benign prostatic hyperplasia with the use of the "new technology" and are considered elsewhere in this volume. Posterior urethral strictures affecting the membranous segment are most commonly caused by instrumentation of the urethra and by transurethral resection of the prostate. As a consequence of this, not only are the epithelium and the subepithelial vascular tissue strictured, probably as a result of ischemia, but the same fibrotic process infiltrates the urethral sphincter mechanism. Treatment is largely directed toward the preservation of urethral sphincter mechanism, and these so-called sphincter strictures are best treated by urethral dilation for this reason. Relatively common as they are, these will not be considered further in this chapter. Posterior urethral strictures otherwise are uncommon and are most commonly caused by pelvic fracture-related urethral injury. It is these "strictures" that are the subject of this chapter.

As a result of the (well-justified) pronounced influence of Richard Turner-Warwick on the assessment and management of these "strictures," they have come to be termed pelvic fracture urethral distraction defects rather than strictures proper. Such thinking is largely based on the concept that injury leads to a shearing force that plucks the prostatic urethra from the membranous urethra or, more probably, the membranous urethra from the bulbar urethra and that this is more commonly a complete injury rather than a partial injury, leading to distraction of the two ends. Recent evidence suggests otherwise on both counts.

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Recent evidence [1] suggests that most pelvic fracture-related injuries are partial injuries rather than complete injuries. It also suggests that although "switchblade" transection of the urethra, partial or complete, by a bone fragment can occur, most commonly urethral injury depends on what happens to the soft tissues of the pelvis rather than the bones and particularly on what happens to the perineal membrane and puboprostatic ligaments. Most commonly, it is argued, the injury that causes disruption of the pelvic ring causes a rupture of the perineal membrane and the other supporting ligaments of the lower urinary tract "midsubstance," that is, to say at a point between the bony attachments laterally and the visceral attachments medially, and as a result of this, the urinary tract is preserved unless it is damaged by a switchblade mechanism as described above. It is only when the injury causes the perineal membrane to avulse a part or the whole of the urethral circumference, rather than to rupture midsubstance, that urethral injury results. Because it is the perineal membrane that "does the damage" when this happens, it is the bulbomembranous junction that is the most common site of urethral injury. This most commonly occurs with disruptions of the pelvic ring injuries that are both vertically and rotationally unstable, but even then, urethral injury is not particularly common. It is in this same category of pelvic ring injuries that bladder neck injuries and other more complicated injuries to the lower urinary tract occur. Switchblade injuries more commonly injure the proximal bulbar urethra, sometimes extensively.

The incidence of pelvic fracture has been estimated at 20 per 100,000 population. The male-to-female incidence ratio is about 1.8–1, although this varies considerably with age. The mortality of such trauma is about 10 %, and the incidence of urethral injury is variably reported at about 5–10 %, which means that the annual incidence of pelvic fracture-related urethral injuries per million population is approx. 5–10. Not all of these urethral injuries require surgical treatment, and some may respond just to a simple occasional urethral dilation. Thus, the number of those coming for urethroplasty is few. In the United Kingdom, this is approx. 1 per million population as compared with about 12 per million population requiring urethroplasty for anterior urethral stricture disease. This frequency is lower than it might be if some surgeons with no experience of urethroplasty did not persist with dilatation or urethrotomy rather than refer a patient on to a surgeon with such expertise. The incidence, of course, depends on how well the original injury is handled as well, and the current standard of care is suprapubic catheterization followed by urethroplasty 3 months or so later when the patient has recovered from his or her other injuries [2].

Assessment

If a patient has a partial or a complete obstruction to the urethra 3 months or so after their injury, the investigations of choice are a flow rate study, if the patient is able to void, together with an ascending urethrogram (retrograde urethrogram) and micturating cystogram to define both the upper and lower limits of the stricture (Fig. 19.1). A retrograde urethrogram alone may show the distal limit of the obstruction with great clarity but not the proximal limit. The deformity in most instances is characteristic: the posterior urethra is displaced posteriorly and there is a characteristic S-bend deformity at the site of injury.

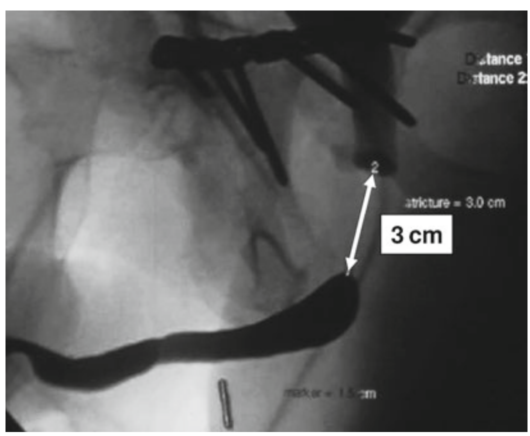

Fig. 19.1 Combined ascending urethrogram and micturating cystogram helps to define the proximal and distal limits of the stricture (Image courtesy SB. Brandes)

It is common to see an apparently long gap between the distal limit of a complete obliteration on ascending (retrograde) urethrogram and the bladder neck on a cystogram (through a suprapubic catheter). This does not mean that the stricture extends all the way up to the bladder neck, only that the detrusor is unable to contract and open the bladder neck and so allow contrast down to the upper end of the obliteration [3].

It is also quite common to see an apparently incompetent bladder neck in association with a complete obstruction but this is usually misleading. The reason for this appearance (of a so-called "beaked" bladder neck) is not clear, but the vast majority of such patients have a perfectly competent bladder neck postoperatively. When the bladder neck has been damaged, it produces an altogether different appearance; indeed, it looks as though it has been damaged rather than simply being beaked open.

A flexible cystoscopy may be helpful in determining the nature of an apparently obstructed or incompetent bladder neck and indeed might be helpful in the overall assessment of the urethra on either side of the obstruction. Clinically, it is important to document clearly, objectively, and subjectively whether the patient has normal erections or erectile dysfunction, for obvious medicolegal reasons and also because those patients with complete erectile dysfunction, particularly if associated with a cold numb penis, are likely to have a more profound disruption of the local blood supply and may therefore be more prone to recurrent stricturing after urethroplasty. Assessment of the pelvic and perineal vasculature may be advisable, and in some instances revascularization of the pudendal and penile blood supply might be considered both for the erectile dysfunction and to improve the chances of a successful urethroplasty by improving the local blood supply [4].

It is also important to check that the patient can abduct his hips to allow access to the perineum. Without easy perineal access, urethroplasty may be extremely difficult. Other investigations might be helpful in certain circumstances, and some surgeons seem to recommend them almost routinely, most notably magnetic resonance imaging. We have often found the use of magnetic resonance imaging interesting, but we have rarely found it to be helpful. Where it has been helpful has been in circumstances in which patients have had more than usually severe injuries, causing more than usually severe anatomical distortion, or when they have had previous surgery creating complications such as fistulae or false passages. Even then, good-quality contrast radiography of the bladder and urethra is usually more helpful. In those who have sustained rectal injuries, the patient will usually have a covering colostomy, in which case a barium enema study will be important.

Preparation

The patient is admitted on the day of surgery and requires no special preparation. It is sensible to know the patient's blood group, although blood transfusion is rarely necessary except in complicated cases. It is also sensible to have an up-to-date urine culture, although prophylactic antibiotics will almost always be given with the premedication or with the anesthesia.

Urethroplasty for posterior urethral strictures requires a lithotomy position to give access to the perineum. There should also be access to the suprapubic area. Most patients have an indwelling suprapubic catheter because they have complete obstruction. This provides a channel for passing a urethral dilator through the track and into the bladder neck to demonstrate the upper level of the obstruction by palpitation during the course of the procedure. When this is not available, it may be necessary to do a suprapubic cystostomy through a short vertical stab incision just above the pubic symphysis to allow this maneuver. In a few patients, most notably those with complex injuries, an abdominoperineal approach may be necessary, in which case the whole abdomen will need to be prepared for a long anterior midline incision.

Some experts like to use the so-called exaggerated lithotomy position to give access to the perineum [5]. We find this unnecessary and more prone to complications and use what is call "social lithotomy," which speaks for itself. Articulated leg supports are necessary in either case. It is also useful to have inflatable leggings to provide intermittent compression of venous thromboembolism and of the legs during the course of the procedure to reduce the risk of compartment syndromes. These are rare but can be a devastating complication when they occur. With social lithotomy this is in any case less likely.

Principles

The general principles of urethroplasty for posterior urethral strictures were worked out many years ago. Those principles are that it is almost always possible to define the healthy urethra above and below the site of the injury of the surrounding fibrosis and perform a spatulated end-to-end anastomosis. Indeed, substitution urethroplasty should never be performed, except in very exceptional circumstances, usually as a consequence of previous surgery or of neglect. Second, it is almost always necessary to reduce tension of the anastomosis to reduce the risk of recurrent stricturing. In some instances, tension is relieved simply by a full mobilization of the bulbar urethra depending on the retrograde blood flow down the bulbar urethra to maintain its vascularity. When mobilization of the urethra alone is insufficient to reduce tension of the anastomosis, tension can be further reduced by straightening out the natural curved course of the bulbar urethral from the penoscrotal junction to the apex of the prostate. This curve may be as much as a half or five-eighths of a circle, and the curve is produced by the fusion of the corpora cavernosa over the inferior aspect of the pubic symphysis. Thus, the urethra can be straightened out by separating the crura of the penis, as far as this is possible, and by performing a wedge resection of the inferior pubic arch. Unfortunately, the degree to which the crura can be separated is variable, and it may not be possible to completely straighten out the urethra by crural separation alone, in which case the urethra must be rerouted in some patients around the shaft of the penis rather than between the two component parts of the shaft of the penis [6]. This point is controversial and some surgeons believe that rerouting of the urethra is never necessary [7]. Those against rerouting argue that they are always able to get a tension-free anastomosis without it [8]. To me this suggests that there is a finite limit to the gap between the two ends of the traumatized urethra which seems to me nonsensical. I suppose it all depends on how a surgeon assesses tension and what his or her casemix is.

This sequence of mobilization proceeding to crural separation when necessary, proceeding to inferior wedge pubectomy when necessary, and proceeding ultimately to rerouting of the urethra around the shaft of the penis when necessary is known as the "transperineal progression approach" and was first referred to as such by Webster. The various component parts of the progression approach had been described decades beforehand by Marion, Waterhouse, and Turner-Warwick amongst others. Webster's particular contribution was to rationalize their innovations in one approach [8].

Occasionally, the proximal urinary tract—the bladder and prostatic urethra—is displaced anteriorly rather than posteriorly and stuck on to the back of the pubis is inaccessible from below. Occasionally there is bladder neck injury, or simultaneous rectal injury, or a false passage. These all require an abdominoperineal approach rather than a purely perineal approach. This is more common in children in whom the corpus spongiosum is less well developed and therefore is less elastic.

Procedure

The urethra is exposed by a midline perineal incision, about 10 cm long, along the line of the raphe from the posterior aspect of the scrotum to just short of the anal margin. Some surgeons prefer to use a curved or S-shaped incision or to extend the incision on one or other or both sides of the anal margin, but we find this unnecessary.

The incision is deepened through the subcutaneous tissue down on to the bulbospongiosus muscle (Fig. 19.2). At the anterior margin of the bulbospongiosus, there is a layer of fascia called Gallaudet's fascia. Incising Gallaudet's fascia puts you into a plane between that fas-

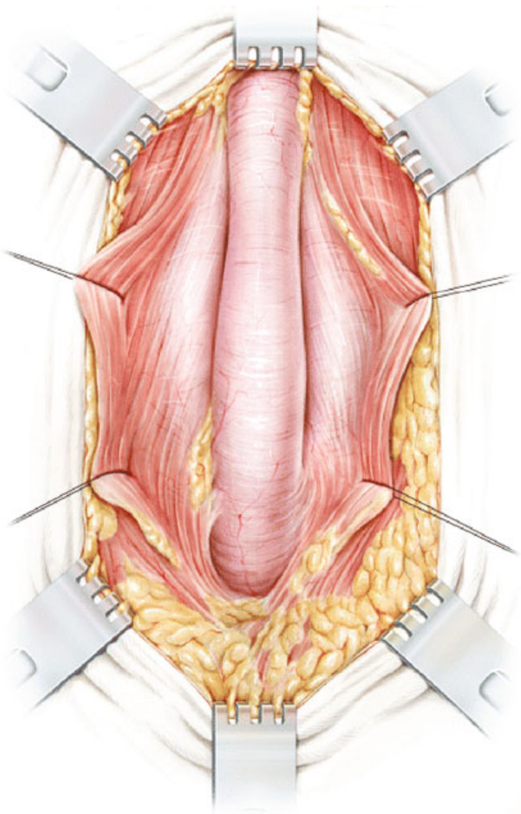

Fig. 19.2 Exposure and mobilization of the bulbar urethra from within the bulbospongiosus muscle [6]

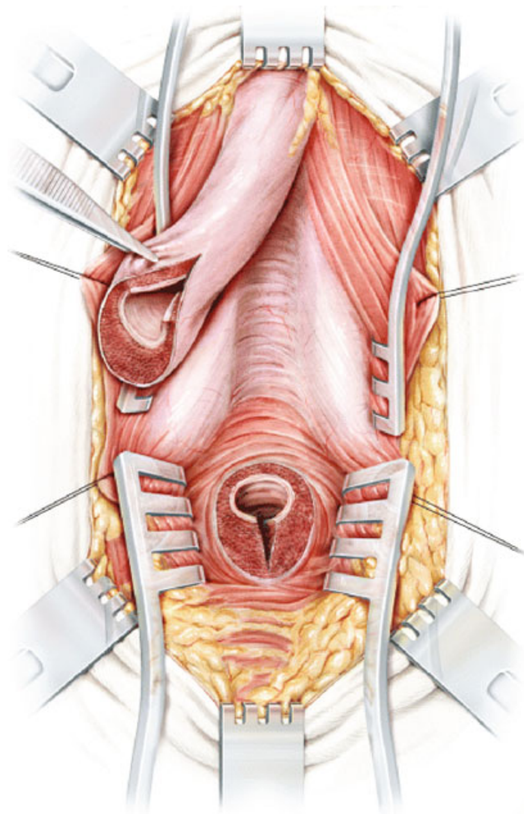

Fig. 19.3 The urethra is then transected through the site of obliteration to free it. It is then trimmed back to healthy tissue and spatulated on its dorsal aspect, then lightly clamped with an atraumatic vascular clamp and retracted out of the way [6]

cia and Buck's fascia as you dissect distally and allows you to get into the plane between bulbospongiosus and Buck's fascia more proximally [9]. The bulbospongiosus muscle can be divided along the line of its raphe all the way back to the perineal body and can then be reflected off the surface of the corpus spongiosum on both sides. Buck's fascia is then divided on both sides where the corpus spongiosum lies against the ipsilateral corpus cavernosum. By dividing Buck's fascia and deepening this toward the midline on each side, the corpus spongiosum can be freed up from the corpora cavernosa as far distally as necessary and as far proximally as the site of the obliteration. Posterolaterally, at the site of obliteration or thereabouts are the short stout arteries to the bulb which may bleed impressively if they are divided. They are often thrombosed by the original injury but should be looked for and sutured-ligated if they can be identified. Anteriorly on the surface of the urethra as the bulbar segment becomes the membranous segment, there is a urethral artery on each side at 11 o'clock and 1 o'clock, which may bleed irritatingly if it is not secured by diathermy first. In the midline there are commonly venous sinuses that may ooze a little but are rarely troublesome. These are best dealt with by suture-ligation if necessary.

The site of the obliteration of the urethra is easily defined by passing a Foley catheter up the urethra until it can pass no further, and at this site the urethra is transected (Fig. 19.3). If the bulb of the urethra has not been fully mobilized, then this transection will be through the remaining stump of the bulb, and instead of dividing the arteries to the bulb as described above, their branches will be divided in the substance of the spongy tissue and bleeding can be profuse. A bit of pressure for a couple of minutes with a swab will reduce this to the level where the bleeding is easily secured with diathermy or a stitch.

Having mobilized and divided the bulbar urethra, the fibrosis around the margins of the transection can be trimmed back to healthy tissues and the urethra itself spatulated. The corpus spongiosum can then be retracted out of the operative field by means of a lightly applied vascular clamp.

Occasionally, there is still a lumen through the site of the transection to the healthy posterior urethra above but this is rare. More commonly the posterior urethra above the site of the fibrosis and obliteration is best defined by passing a metal sound such as a Van Buren in the United States, a Clutton's sound in the UK, or a Benique sound in Europe, through the suprapubic catheter track, if there is one, or through a suprapubic cystostomy if there is not (Fig. 19.4). This allows the tip of the sound to be palpated in the upper end of the wound usually posterior to the point at which the bulbar urethra was mobilized and transected. It is then usually just a simple matter to cut down onto the posterior urethra, trim away sufficient fibrosis to expose the upper end, and then spatulate it open. Surgeons vary in the degree in which they profess to excise fibrotic tissue from the apex of the proximal urethra, but all will be careful anterior-laterally on either side of the proximal urethra where the neurovascular structures to the corpora cavernosa responsible for erection will be vulnerable. At this point the verumontanum should be clearly visible within the posterior urethra—a useful point for distinguishing the urethra proper from a false passage. It is very unusual for the verumontanum to have been damaged by the injury.

If the proximal urethra is not identifiable by palpation, in this way an abdominoperineal approach may be necessary as described to follow.

Having cleared the two ends of the urethra of fibrosis and spatulated them back into healthy tissue, it is a simple matter to see whether they will come together without tension or not. If so, they can be sutured together with six or eight 5-O absorbable sutures (Figs. 19.5 and 19.6).

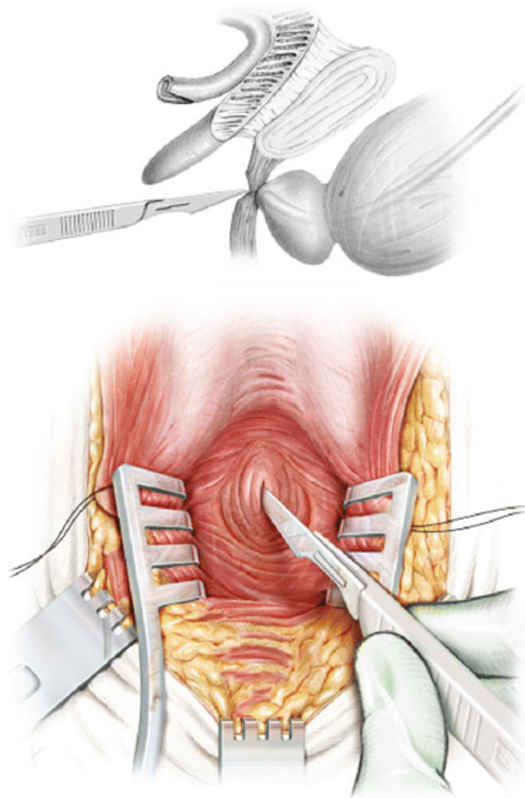

Fig. 19.4 Identification of the proximal urethra when the lumen is obliterated and incision onto a sound passed antegrade [6]

Again, opinions vary as to which suture material is best, but this probably means that it makes not the slightest difference what you choose. We prefer Vicryl (for no very good reason). It is important to approximate the epithelium with each stitch and to take an adequate bit of the surrounding tissue to make sure the sutures hold. It is obviously important that this should be healthy epithelium. This is not always easy to discern with the naked eye and magnification may be helpful.

Working in a confined space in the posterior urethra, it is often easier to place sutures if the needle is bent into a J shape then held in the needle holder so that it emerges end on. Rotation of the wrist then maneuvers the needle through a significantly smaller axis of rotation rather than

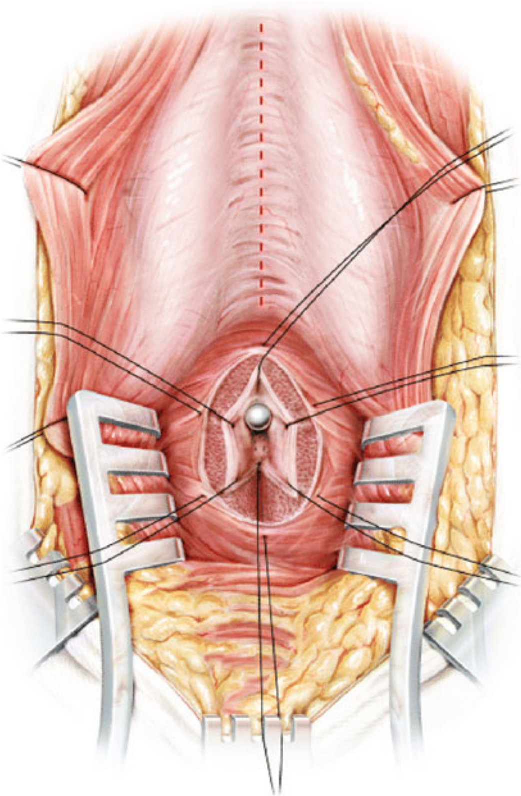

Fig. 19.5 Six 5-O polyglactin sutures are placed through the full thickness of the proximal urethra at 2:4, 6:8, 10, and 12 o'clock positions as a preliminary move to the anastomosis, so as to spatulate open the posterior urethra and to make sure that this is clearly visible and healthy [6]

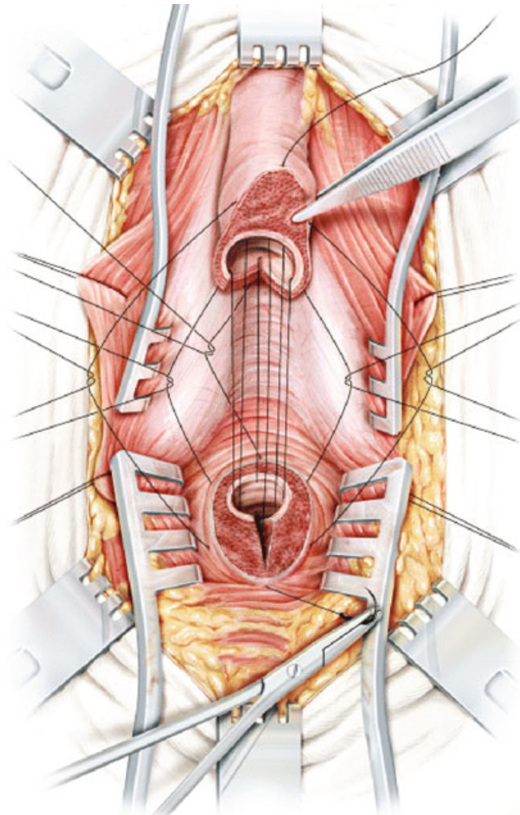

Fig. 19.6 The sutures are then passed through the distal end of the urethra and tied "parachute" style [6]

when the needle is held in the traditional way at right angles to the jaws of the needle holder. A gorget facilitates suture placement and also protects the inside of the urethra.

If there is tension of the anastomosis, which there usually is after urethral mobilization alone, then the natural curve of the urethra can be straightened out, as alluded to above, in stages: firstly, by incising the tunica albuginea that binds the two crura of the corpora cavernosa together in the anterior midline (Figs. 19.7 and 19.8). Opening this intercrural plane allows the urethra to lie between the crura rather than on the surface of the crura and reduces tension quite considerably. Indeed, in more than 50 % of patients, this will be sufficient to allow a tension-free anastomosis. If it is not, it may be seen that the urethra is being curved over the inferior pubic arch on its way to the anastomosis in which case a wedge pubectomy of the inferior pubic arch can be performed (Figs. 19.9 and 19.10). Having fully opened the intercrural plane and taking great care not to damage the dorsal arteries and nerves of the penis on either side of the inner aspects of the separated crura (as well as the nerves of the corpora cavernosa on either side apex of the prostate and the membranous urethra), the pubic periosteum can be incised with diathermy down to bone, and the bone can then be removed either using a Capener's gouge or a bone punch, or some similar instrument. In about another 10 or 15 %, this

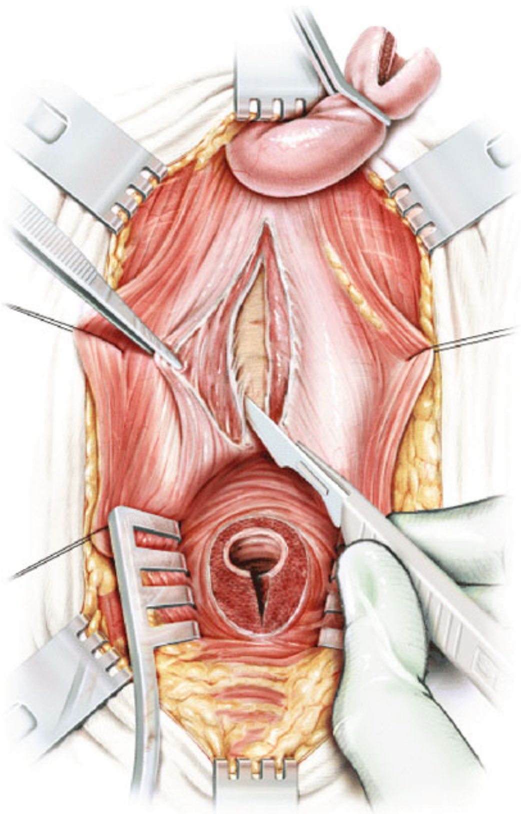

Fig. 19.7 Ventral midline incision made between the corpora in an avascular plane to separate the corporal bodies [6]

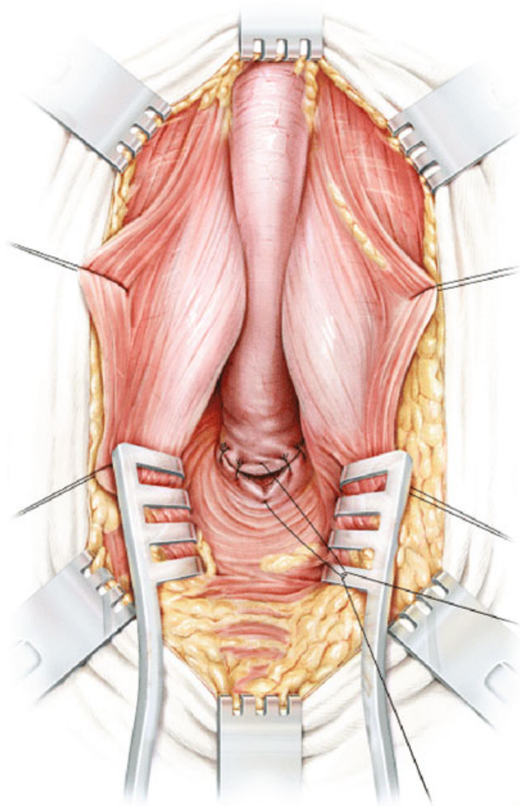

Fig. 19.8 The reconstructed urethra lies within the intercrural plane, thus creating a tension free anastomosis [6]

will allow a tension-free anastomosis. For some surgeons, there will still be a group of patients for whom there is still unacceptable tension at the anastomosis despite both a crural separation and an inferior wedge pubectomy. In such patients those surgeons will mobilize the urethra further distally off the corpora cavernosa beyond the point where possible. Then, by exposure of the anterior aspect of the pubic symphysis at the anterior limit of the skin incision, a bony channel can be created through to the wedge pubectomy already created, and the urethra can be passed through this channel for anastomosis to the proximal urethra (Figs. 19.11, 19.12, and 19.13). It is obviously important during this to make sure that there is an adequate bony channel and that there are no sharp bony spikes to damage the urethra.

Having completed the anastomosis, a 14- or 16-French silicone Foley urethral catheter is passed up into the bladder, and if there was a preexisting suprapubic catheter, then this is replaced as well. The wound is then closed in layers taking care to obliterate all the dead space as far as possible to reduce the risk of hematoma formation. If there is a space left behind that cannot be obliterated by suture, then a wound drain should be left in place, but this is usually only necessary in those patients who have had a wedge pubectomy or rerouting of the urethra.

Postoperative Follow-Up

The wound is usually healed and the urethra intact after 2 weeks. We arrange for our patients

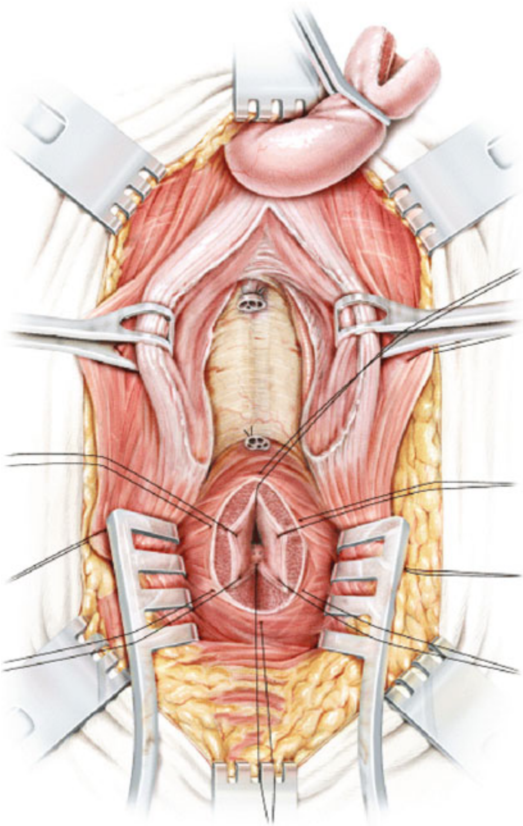

Fig. 19.9 Maximum separation of the crura to expose the inferior pubic symphysis [6]

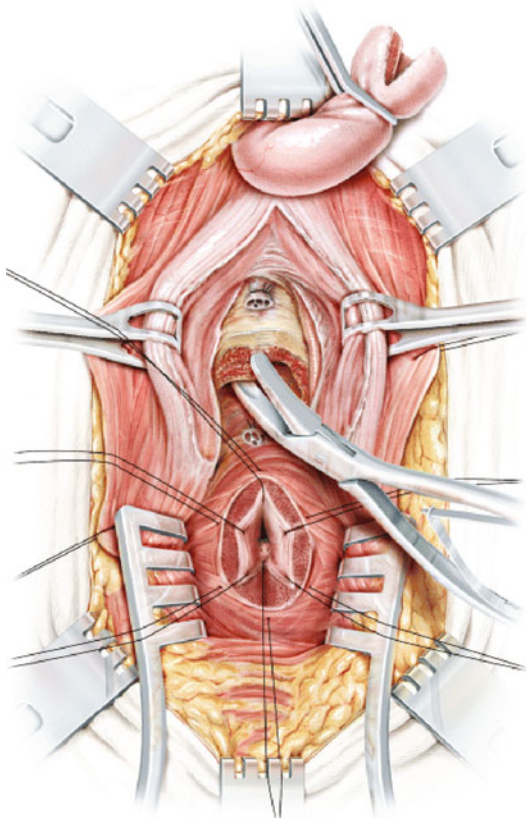

Fig. 19.10 Wedge resection of the inferior part of the pubic symphysis [6]

to have a pericatheter urethrogram at this point to make sure that there is no extravasation in which case the catheter can be removed and the patient can start normal voiding. If there is any irregularity, we leave the catheter in for a further week and then repeat the x-ray, by which time it is almost always satisfactory. We get a baseline flow rate study at this stage. We then see the patient 6 months or so later and repeat the flow rate study and the ascending urethrogram and micturating cystogram. Although there are occasional instances of patients who deteriorate with time, we have yet to see a patient with a widely patent urethra on urethrography and a normal flow rate 6 months postoperatively who shows signs of deterioration thereafter. We therefore do not follow up such patients unless there is some other reason. If the urethrogram is unsatisfactory, for whatever reason, then however good the flow rate might be, we will follow those patients up with an annual ascending urethrogram and micturating cystogram and flow rate study as it is in this group of patients that the occasional long-term recurrent stricture occurs.

Complications

However, much of the most common presentation of a recurrent stricture is that the patient runs into trouble within hours or days of having their postoperative catheter removed. This is because such problems are as a result of ischemia of the anastomosis because the blood supply is insufficient to sustain adequate vascularity

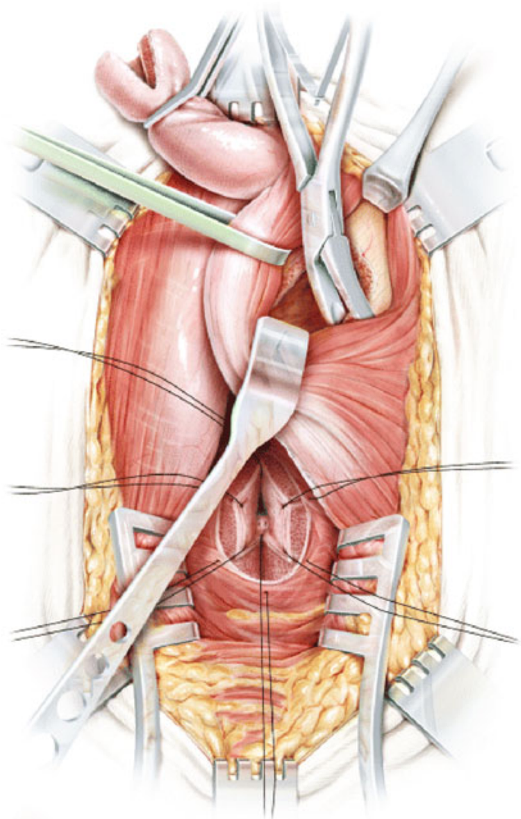

Fig. 19.11 Medial retraction of the left crus of the penis and resection of a bony channel [6]

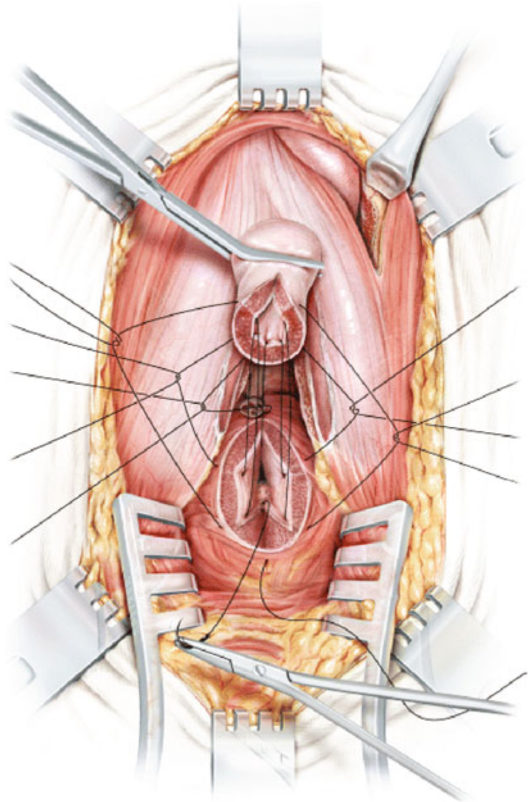

Fig. 19.12 "Parachute-style" anastomosis [6]

of the anastomosis, or because fibrotic tissue was left behind or, more commonly, because there was tension at the anastomosis. If the procedure was performed technically and competently, then almost always the patients who show this early failure also have complete erectile dysfunction supporting the concept that this recurrent stricture is vasculogenic and ischemic in origin. In such cases the suprapubic catheter must be replaced (if it has been removed), and the patient must wait another 3 months and the procedure is repeated. This is usually successful because the length of the ischemic segment is usually short.

When the proximal urethra cannot be identified by a sound in the apex of the prostate and membranous urethra or if there is some other indication that requires it, then an abdominoperineal approach is necessary [10]. Through a long lower midline incision, the apex of the prostate is exposed by dividing the hematoma-fibrosis that plasters the bladder, bladder neck, and prostatic urethra to the pubic bone and symphysis. This is easier said than done and will often require a wedge resection of the posterior aspect of the pubic symphysis to allow the apex of the prostate to be exposed. Once it has been exposed, a channel is created through to the perineal incision and the procedure continues as described previously (Fig. 19.14). When rerouting the urethra is necessary during an abdominoperineal repair, it is usually easier to reroute it through a superior wedge pubectomy rather than an inferior wedge pubectomy, particularly in children and teenagers (Fig. 19.15).

Bladder neck injuries are a particular problem. They never heal spontaneously, they are always associated with more severe injuries to the urinary tract, they are almost always associated with injury to the bulbomembranous urethra as well, and they are commonly associated with infected cavities and fistulation of those cavities through to the perineum or into the adductor compartment to the leg. When a bladder neck injury is identified, it should be repaired as early as possible to reduce the risk of the latter complications. More minor bladder neck injuries may appear to heal in the first instance, but they always give rise to problems later on: incontinence, persistent or recurrent bleeding, or recurrent cavitation and infection. The longer they are left, the more difficult they are to repair. Fortunately, most ruptures are in the anterior or anterolateral midline, and they can be carefully identified and reconstructed with reconstruction of the urethra as well, although such repairs may be difficult, lengthy, and tedious.

After abdominoperineal reconstruction of the urethra, with or without bladder neck reconstruction, mobilization of the omentum to fill the dead space, line the raw bony areas, and wrap around the reconstruction seems sensible. Postoperatively such patients are managed in exactly the same way as after transperineal bulboprostatic anastomotic urethroplasty.

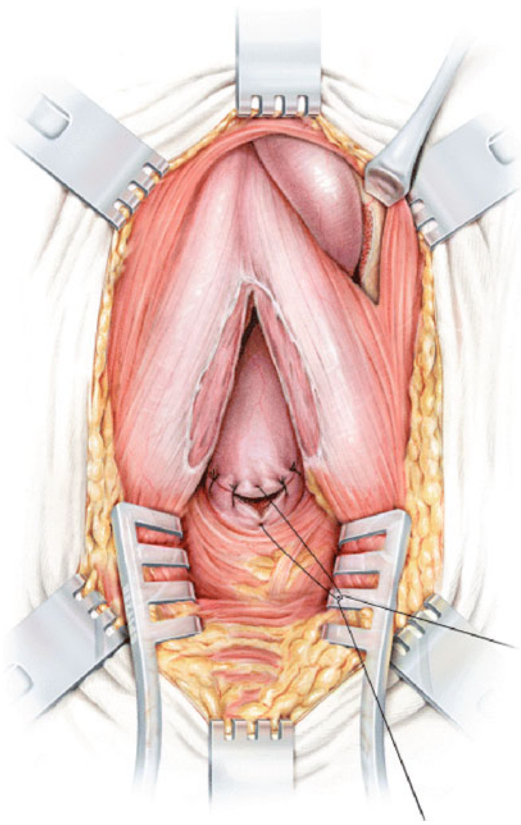

Fig. 19.13 The completed anastomosis [6]

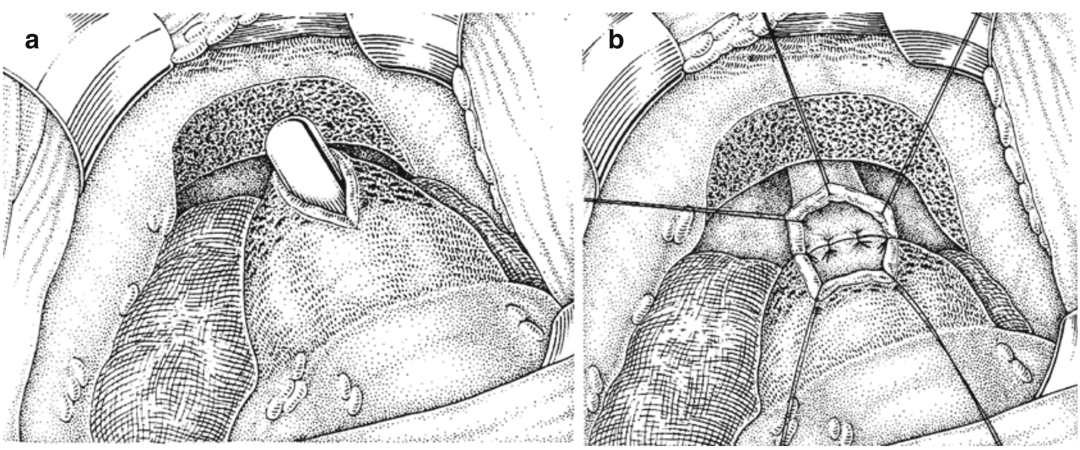

Fig. 19.14 Abdominoperineal approach. (**a**) Exposed prostate apex after pubis wedge resection and incision onto sound passed antegrade. (**b**) Completing the primary anastomosis [2]

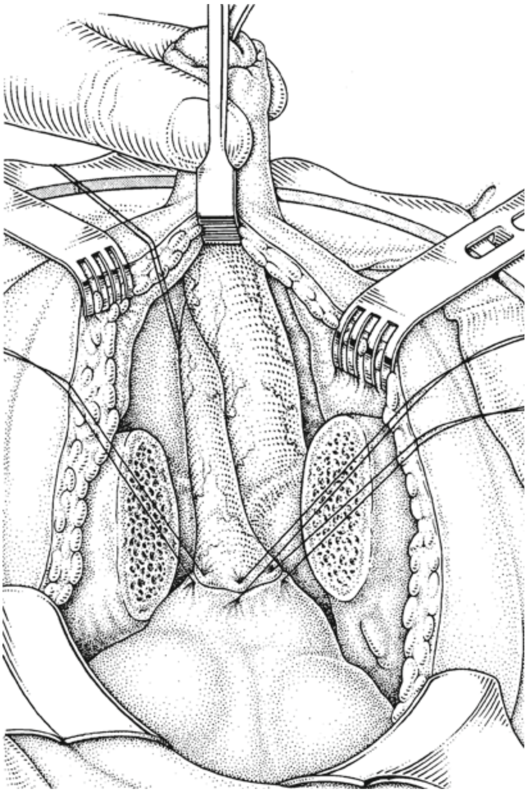

Fig. 19.15 Abdominoperineal approach. Pubectomy and primary anastomosis [2]

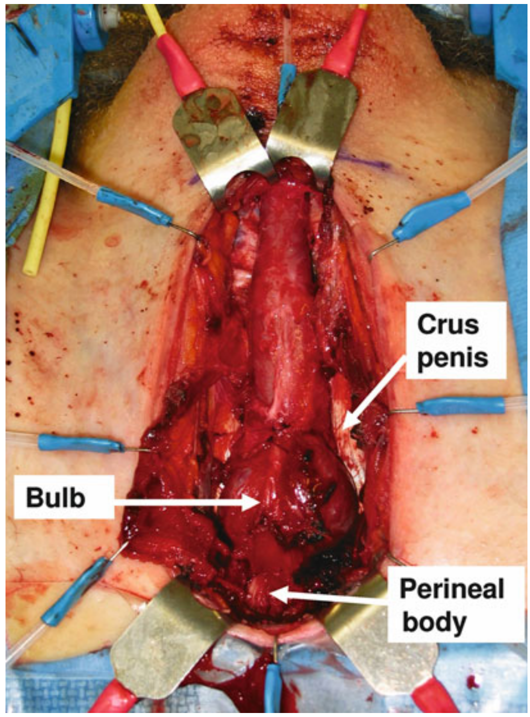

Fig. 19.16 Excellent exposure of the entire bulbar urethra via a midline incision and Lone Star retractor

Surgical Pearls and Pitfalls

- Perineal ring retractor
- Gorget
- DeBakey forceps, Mcindoe scissors and needle holder (generally 7″)
- If inferior pubectomy and crural rerouting are required, a 1/2 in. and 1 in. angled Capener's gouge and hammer and double-action bone nibblers
- 5/0 Vicryl for the anastomosis
- 16 F Silicone Foley urethral catheter

Editorial Comment

This chapter by Mundy and Andrich is a masterful summary of posterior urethroplasty. Therefore, I have detailed below some of the differences in technique that we like to perform. First, we make a midline perineal incision from 1 cm anterior to the anus up to the scrotal margin. We can typically achieve excellent exposure of the urethra and do not consider a lambda incision necessary (Fig. 19.16). Although we have had good success with just the Lone Star retractor system, the Jordan perineal retractor for the Bookwalter provides superb exposure, and thus is our go to retractor for all posterior urethroplasties. When using this system, mobilize the urethra from the perineal membrane till the penoscrotal junction. Do not mobilize the urethra distal to suspensory ligament; otherwise, you risk creating iatrogenic chordee. Mobilize the entire bulb and separate the bulb from the perineal body and rectum posteriorly. We typically use bipolar electrocautery liberally here to control pesky bleeding from small perforating vessel branches or from the bulbospongiosus muscle. We try to avoid using monopolar electrocautery out of concern of electrical scatter and potential injury to the nervous and

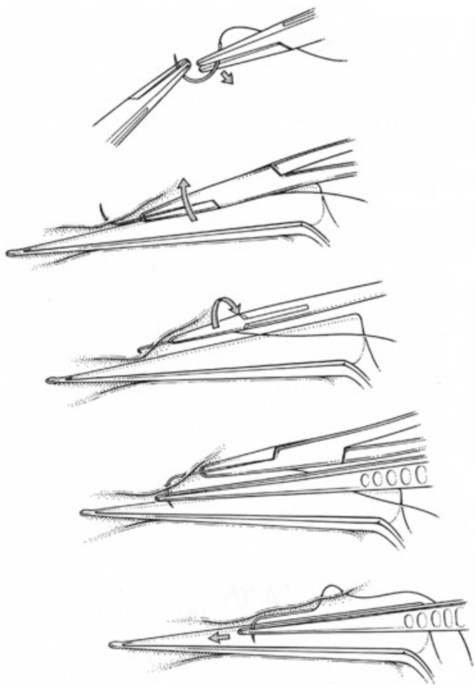

Fig. 19.17 The "ski" needle and DeBakey forceps (alternative, gorget) are useful to facilitate proximal sutures placement From Ref. [12])

vascular supply to the penis for tumescence. Then, place a hard 18-Fr Rob-Nel catheter and palpate the proximal end of stricture. Transect the urethra just proximal to the palpable end of the Rob-Nel with Mayo scissors. The urethra should not bleed too much if the cut is made through the scar. The bulbar arteries are usually obliterated already from the prior pelvic fracture. However, the bulbar urethra can bleed quite briskly, if the cut is not through the scar or if the bulbar arteries are intact. Once the urethra is transected, pack the fossa to temporarily control bleeding and then oversew any bleeding bulbar arteries. Place a 24-French Van Buren sound via the SP tract and into the prostatic fossa and incise onto the palpable end of sound (use a scalpel). If the sound cannot be felt confidently, we typically perform antegrade cystoscopy or open the bladder. When the sound cannot be felt, it generally suggests that the stricture is long or the prostate is displaced off the midline. A useful trick to confirm you are cutting onto the prostatic urethra, is to place a spinal needle through the center of the scar and then cystoscope antegrade via the SP tract. If you can see the needle in the prostatic urethral lumen, you are dissecting in the right place.

Scar tissue around the sound is then excised sharply until the tissue is supple and the antegrade placed sound can be easily rotated in all directions. This is the key to the success of the operation—judicious and adequate excision of the scarred tissue. Spatulate the prostatic/membranous urethra at 6 o'clock till the back handle of a DeBakey forceps or nasal speculum can fit easily into the urethra. The verumontanum can usually be easily seen at this time. To perform the anastomosis, I typically place eight sutures in the proximal urethra. A long armed nasal speculum will facilitate suture placement; I first place sutures at 12, 6, 3, and 9 o'clock and then place another four sutures in between. I prefer 4-O PDS and will often bend the RB needle into a J-shaped "ski" needle to facilitate suture placement (Fig. 19.17). I serially place numbered labeled mosquitoes on all the sutures to enable proper orientation (Fig. 19.18). I then place the left half of the sutures in its corresponding location of the spatulated urethra starting from dorsal to ventral (clockwise). I then place a 16-French silicone Foley catheter, followed by placing the right side of sutures into the distal urethra in numerical order in clockwise fashion. The sutures are then serially tied in numerical order in the same order the sutures were placed (posterior to anterior).

In 1983, Webster and colleagues popularized an elaborated perineal approach for reconstruction of pelvic fracture-related urethral distraction injuries wherein urethral mobilization is augmented as needed by progressing through the additional steps of corporal splitting, inferior pubectomy, and urethral rerouting to bridge long urethral defects. In a 2003 update of their experience, Flynn and Webster noted a more elaborate repairs: urethral mobilization (8 %), corporal splitting (34 %), inferior pubectomy (12 %) and urethral rerouting (38 %). In contrast, we have not found urethral rerouting to be necessary and instead think that liberal urethral mobilization and corporal splitting alone are usually sufficient

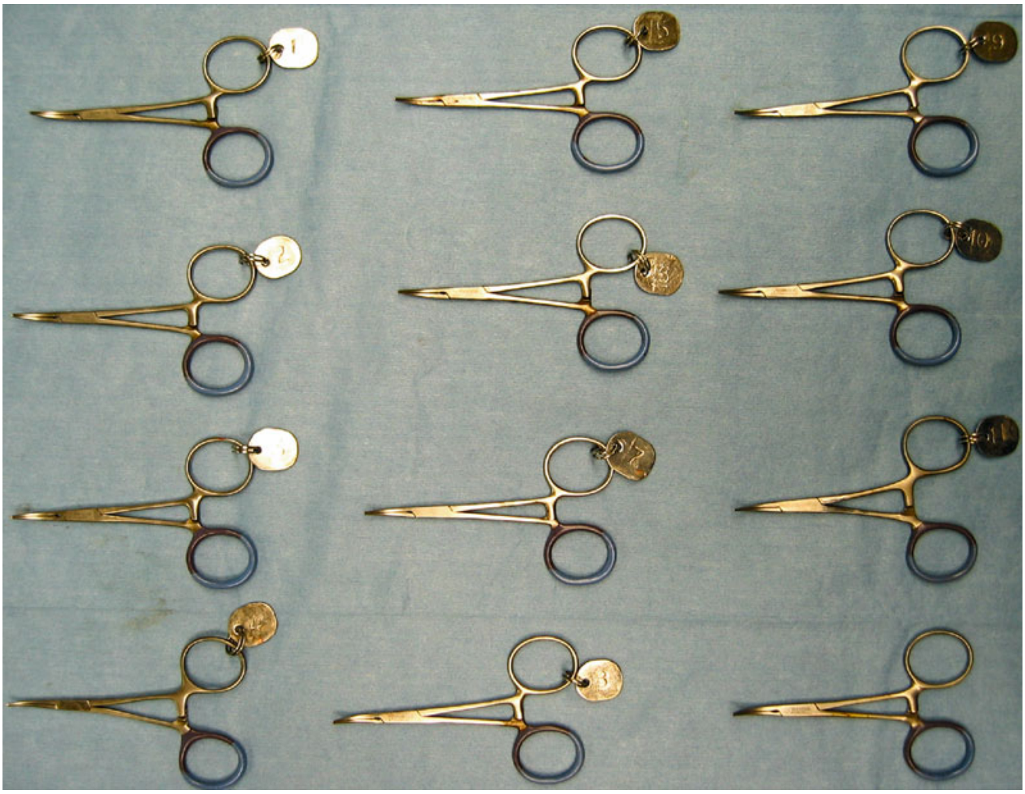

Fig. 19.18 Serially numbered mosquito clamps (1–12) to facilitate suture orientation

in most patients. Moreover, most posterior urethral strictures are typically no more then 2–3 cm in length, and thus, the limits of the progressive approach are usually not required. In our retrospective analysis [11] of 142 posterior urethroplasties, we have found that in our hands, supracrural urethral rerouting has a limited role in posterior urethroplasty. It is rarely necessary for success and appears to be inferior to an abdominoperineal approach as a salvage maneuver for complex cases. Ancillary maneuvers such as corporal splitting or inferior pubectomy, however, are useful for facilitating proximal urethral exposure.

The abdominal perineal approach is typically useful as a salvage procedure for prior failed perineal urethroplasty and as a first-stage procedure for children or for patients with orthopedic deformities preventing perineal access, distorted pelvic anatomy, extensive heterotopic bone formation, associated urethral or bladder urinary fistula, and extreme long urethral defects (>6 cm). Practically, the AP approach requires a wedge resection of either the posterior aspect of the symphysis pubis (Fig. 19.14) or a total pubectomy (Fig. 19.15). From the prior pelvic fracture, much of the tissue surrounding the prostate apex and pubic symphysis is only callous that can be easily removed with a mallet and osteotome. From the prior accident the dorsal venous complex of the prostate has been disrupted and thrombosed—so opening up the retropubic space, although being very adherent and tissue planes obliterated, should not be very vascular. For total pubectomy, what gives the pelvic ring stability are the ligaments. Therefore, taking a 2-cm swath out of the pubic symphysis is of no structural or functional consequence. Total pubectomy requires a distal midline incision, almost onto the penis to expose the caudal aspect of the pubic bone. The suspensory ligament needs to be taken down and the corpora cavernosa separated from the caudal surface of the pubic ramus. Once the penis has been displaced caudally, a mallet and osteotome can be used to resect the tissue. Classically, a Gigli saw or an orthopedic power drill has been described, but in our experience, we have not found the need. Once the apex of the prostate has been exposed, a large metal sound (we prefer a 24-French Van Buren) is placed antegrade (via the bladder) and an incision made onto the tip of the sound. The tissue is spatulated and excised till a fresh and palpably soft edge. The proximal urethral, which has been mobilized extensively by the typical perineal approach, is also spatulated and a primary anastomotic urethroplasty performed. Because of the bony gap and open space created by a pubectomy, omentum is mobilized into the pelvis to wrap the anastomosis, fill the dead space, prevent tissue herniation, and promote surgical success.

Part of all surgical planning is an informed consent discussion with the patient about the risks and benefits of the procedure. When it comes to posterior urethroplasty, we tell each of our patients that the potential surgical side effects are: minor stress urinary incontinence ([up to 36 %], bothersome to more severe incontinence [only 2 %]), urgency to void [up to 66 %], temporary impotence [up to 26 %], permanent impotence-very rare [0–7 %, depending on the series], and positioning complications-such as perineal nerve palsy and sacral nerve stretch [12]. We also quote to our patients that long-term, durable success with posterior urethroplasty is roughly 85 %.

–Steven B. Brandes

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Staged Urethroplasty

20

Chris McClung and Hunter Wessells

Summary

Staged urethroplasties are characterized by a planned repair involving more than one surgery to fix a urethral stricture, obliteration, diverticulum, fistula, or combination of the above. Common indications for a staged urethroplasty included failed hypospadias surgery, multiple prior urethroplasty failures, and strictures associated with lichen sclerosus. Because excision and primary anastomosis has a significant potential to produce postoperative chordee, staged procedures are more commonly used in the penile urethra relative to the bulbar urethra. Free tissue transfer is inherent to staged urethroplasties; common donor sources include buccal mucosa and split thickness skin. Preservation of the native urethral plate in selected cases allows maximization of donor graft with limited availability. A technical description of the staged urethroplasty is followed by a review of published success rates, which range from 73 to 100 %. Common complications of a staged repair include need for additional revisional surgery, fistula, postoperative curvature, and recurrent stricture.

Introduction

Technical advances have allowed reconstructive surgeons to repair, in a single stage, long strictures that previously required a multistaged stage approach. Strategies to accomplish this include excision and primary anastomosis to bridge longer strictures, composite procedures using dorsal buccal graft and a ventral penile skin flap, and simultaneous dorsal and ventral double buccal mucosa grafts [1–3]. Despite these advances, however, certain challenging clinical indications still require excision of large portions of the urethra with complete replacement using multistaged techniques.

For this reason, staged urethroplasty is an important tool for the reconstructive urologist to have in his or her arsenal. Staged urethroplasties are characterized by a planned repair involving more than one surgery to fix a urethral stricture, obliteration, diverticulum, fistula, or combination of the above. Staging the procedure affords the reconstructive surgeon an interim inspection prior to closure, more robust engraftment of tissue transfer, and, if necessary, the opportunity to revise focal areas of fibrosis. Although such repairs are generally thought to require two separate surgeries, in reality they may require more, and thus the term *staged urethroplasty* is preferred over “two-staged” urethroplasty [4]. This

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chapter reviews the indications, historical overview, technical description including choice of graft, and outcomes of staged reconstruction of anterior urethral stricture disease.

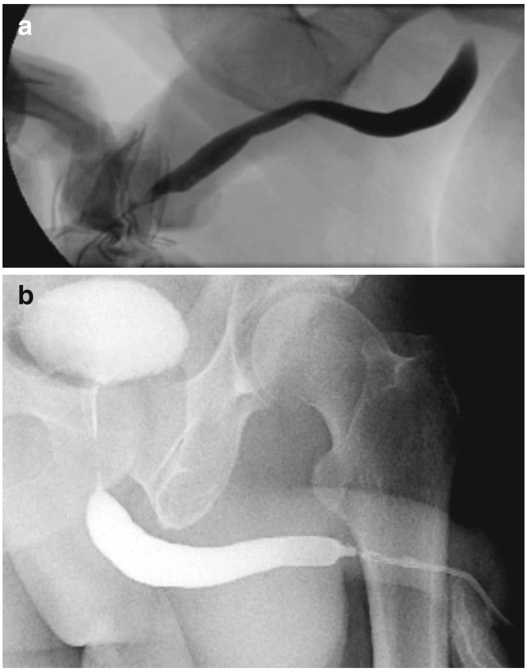

Fig. 20.1 Retrograde urethrograms showing a distal fossa navicularis stricture (**a**) and a longer penile urethral stricture (**b**) treated with staged urethroplasty

Indications

The primary indication for staged urethroplasty is a complex long stricture of the anterior urethra for which single-stage reconstruction is inadvisable. The presence of voiding complaints, involvement of the glans skin, penile curvature with erection, prior instrumentation and surgery, as well as comorbid medical conditions should be elicited by a careful history. Physical examination focuses on the appearance of the glans penis, urethral meatus, skin redundancy and elasticity, and detection of any palpable abnormalities of the corpus spongiosum or penile shaft. Strictures of the penile and bulbar urethra are typically delineated on retrograde urethrogram as shown in Fig. 20.1. Use of bougie à boule for calibration and narrow (8 Fr) flexible endoscopes enhances the accuracy of diagnosis. Skin punch biopsy to diagnose lichen scelrosus may allow preoperative topical therapy in selected cases (Fig. 20.2).

Failed hypospadias surgery is the most common indication for staged urethral reconstruction. Poor tissue vascularity and fibrosis, presence of hair-bearing skin, and penile urethral anatomical location of stricture are common factors in patients with a childhood history of hypospadias repair. Although some surgeons approach post-hypospadias strictures in a single stage, the paucity of excess skin and problems associated with previously mobilized genital skin cause most

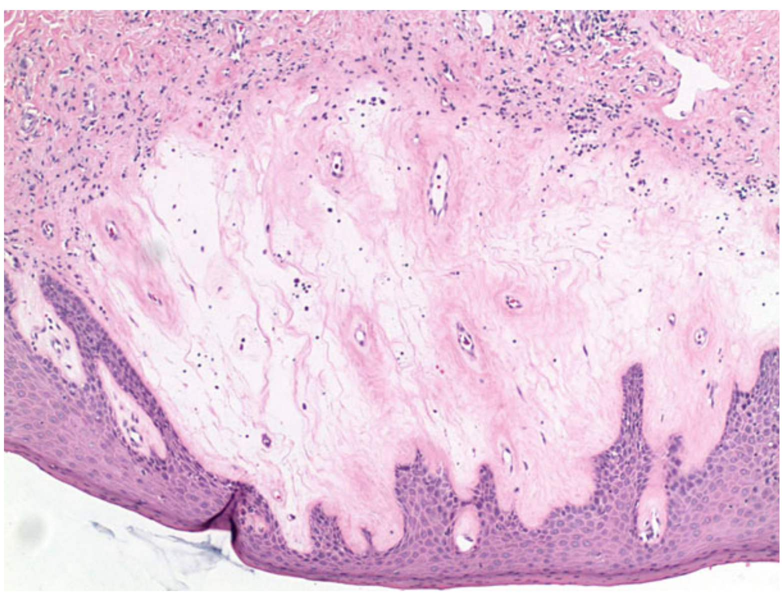

Fig. 20.2 Photomicrograph demonstrating collagenization of dermis in lichen scelrosus

groups to favor a staged repair [5]. As a corollary, it is the authors' preference to use a staged repair in adults with multiple prior urethroplasty failures, in whom grafting, stenting, or urethral mobilization reduces the likelihood of successful single-stage repair.

Primarily involving glans skin and the urethral meatus, LS also affects the penile urethra causing strictures. LS spares no segment of the anterior urethra and can cause pan-urethral stricture disease. Strictures related to lichen scelrosus (LS) frequently require staged repairs due to the location of the strictures and progressive nature of the disorder. Fasciocutaneous flaps using genital skin to repair LS-related strictures in one stage have been show to have a high failure rate [6]. The cause of the high failure rate is hypothesized to be disease progression in the genital skin of the flap, and for this reason certain authors advocate staged repairs using non-genital skin such as buccal mucosa for LS-related strictures [6].

Staged repairs can be utilized on any segment of the anterior urethra, although the most common application of staged urethroplasty is to the penile urethra as a result of etiological and anatomical considerations. Because excision and primary anastomosis has a significant potential to produce postoperative chordee, strictures in the penile urethra are commonly approached via a dorsal onlay patch graft or staged procedure. The decision to proceed with dorsal onlay as opposed to a staged repair usually relies upon the residual lumen of the stricture. An onlay graft urethroplasty relies on augmenting a narrowed lumen. For this reason, we approach obliterated or nearly obliterated strictures via a staged repair so as to avoid creation of a tubularized buccal mucosa graft. Tubularization of a buccal graft for a single-stage reconstruction is associated with high failure rates, which have been reported to be as high as 45 % [7].

History

The earliest modern staged urethroplasty was introduced by Johanson in 1953 [8]. He marsupialized the urethra to the overlying skin allowing exposure of the urethral plate. The patient voided via a proximally based urethrostomy. Six months later, a 1.5 cm strip of skin containing the urethral plate as well as adjacent perineal or genital skin was outlined demarcating the neourethral plate. The lateral skin edges were undermined, and the neourethral plate was buried as a skin strip and a catheter were left in place. The buried skin strip would tubularize by "secondary intention," and the catheter was removed 2–3 weeks later. Leadbetter modified the procedure 7 years later to include tubularization of the neourethral plate by primary closure at the time of second-stage repair [9], akin to modern staged procedures (Fig. 20.3). The final contribution to modern two-stage urethroplasty arose from Bracka's work on hypospadias repair [10]. His contribution focused on urethral plate substitution with full thickness grafts. In contrast, the Johanson-Leadbetter urethroplasty preserved the urethral plate and incorporated adjacent hair-bearing skin into the second-stage closure. Not infrequently, with a severely inflammatory or obliterative stricture, resection of the entire affected segment of stricture is required, thus favoring full thickness grafting per Bracka's technique. Taken together, the three aforementioned studies have laid the groundwork for all variations of the modern two-stage urethroplasty.

Modern Surgical Variations of Staged Urethroplasty

The initial description of a staged urethroplasty by Johanson and Leadbetter did not utilize free graft tissue transfer for urethral reconstruction. Perineal and scrotal skin surrounding the urethral plate was used in the second stage to augment the width of the urethral plate and hence the neourethra. This same technique has been used in modern adult urethroplasty series. Moradi et al. reported 1- and 5-year success rates of 71.4 and 57.1 %, respectively, utilizing the Johanson technique [11]. Success in this study was defined as "proper voiding," lack of fistula development, and "uneventful" retrograde urethrography [11]. Complications documented included fistula and diverticulum formation at 8.6 and 5.7 % respectively.

The Johanson-Leadbetter urethroplasty is rarely used in practice today. Hair-bearing skin from the perineal and scrotal tissues can lead

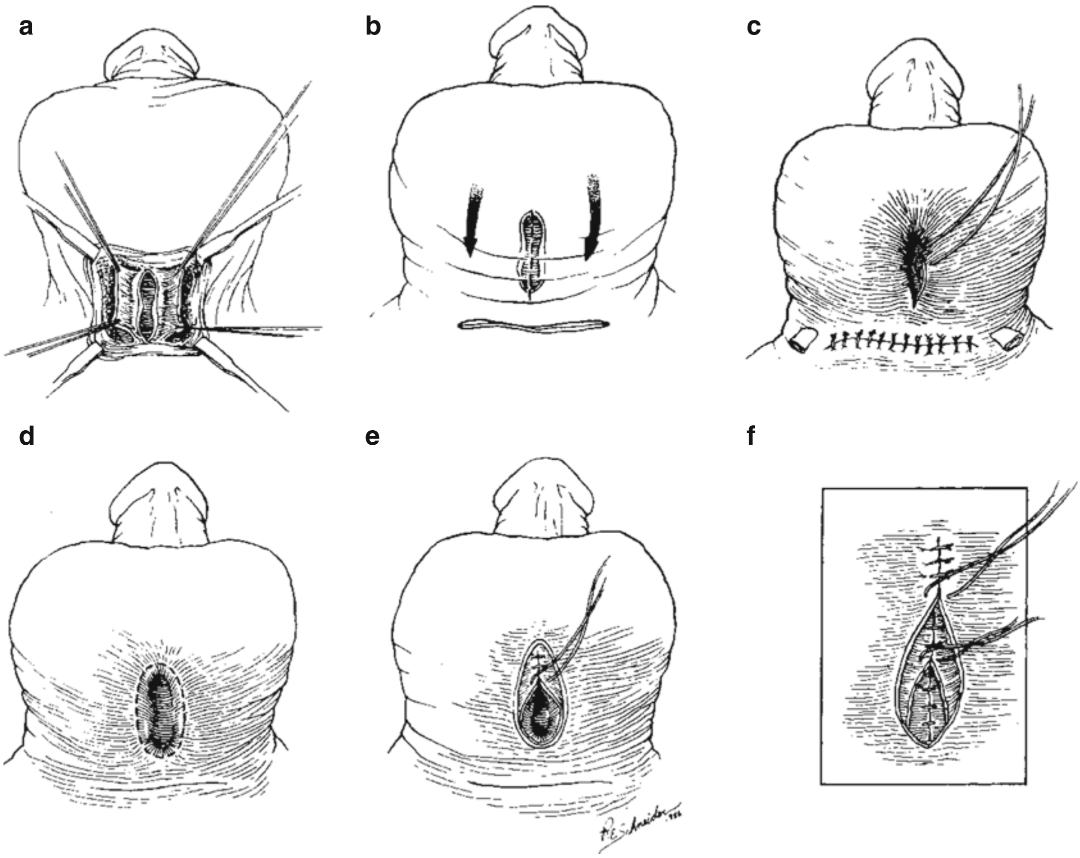

Fig. 20.3 Two-stage repair as described by Turner Warwick. (**a**–**c**) 1st stage of scrotal flap sewn to ventral urethrotomy; (**d**–**f**) 2nd stage and tubularization of urethra

to problems with obstruction within the newly constructed urethra, sacculation, and eczematoid changes. Therefore, free grafts are preferred to augment or replace the native urethra. Graft options for non-hair-bearing free tissue transfer include buccal mucosa, split-thickness skin grafts, and full thickness skin grafts. We avoid the use of bladder mucosa because when exposed to the external environment, it becomes friable and difficult to tubularize.

Schreiter et al. described outcomes of 2-stage urethroplasty utilizing meshed split (thigh, $n=23$) and full thickness (foreskin, $n=73$) skin, placing the graft lateral to the preserved and marsupialized native urethral plate (Fig. 20.4) [12]. Only one failure was documented in the meshed, foreskin graft group. Success was defined by a "visualization of a wide urethra with radiography, uroflow rates exceeding 15 ml per second peak flow rates as well as absence of residuals on voiding cysto-urethrography" [12]. Seven patients between both cohorts required interim revision for graft loss. Fistula was seen in 4.2 % of the patients.

Carr et al. published an updated case series of meshed graft urethroplasties of which the majority had preservation of the native urethral plate. Split-thickness skin grafts and foreskin grafts were used in 17 and 3, respectively [13]. Interim revision prior to stage two closure was required in six patients for ostial stenosis, chordee, or adhesions to the graft. Success was defined as normal urethrography and normal voiding history. At a median follow-up of 38 months, their success rate was 80 %. The only complication reported after stage two repair was a urethrocutaneous fistula in one patient.

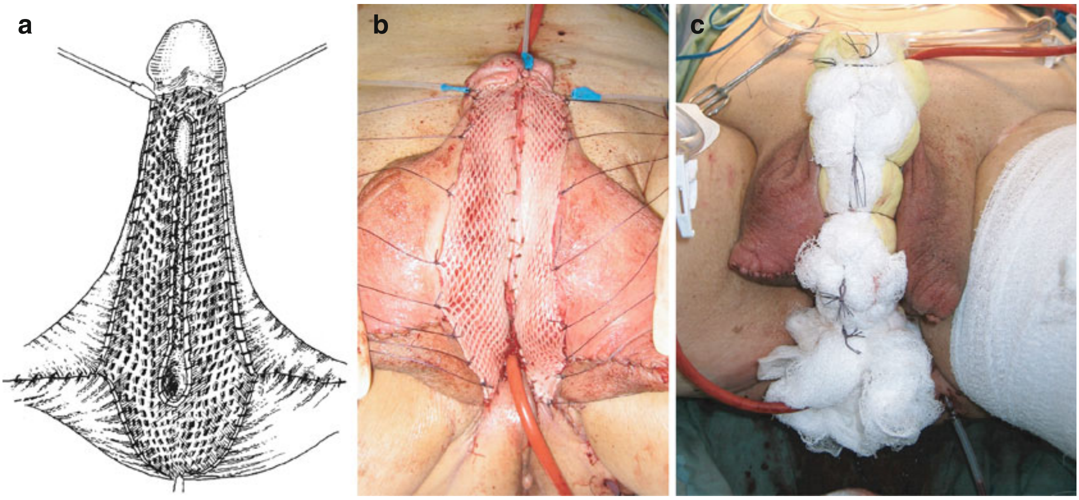

Fig. 20.4 Mesh graft urethroplasty as described by Schreiter et al. (**a**) Cartoon of meshed skin graft. (**b**) Meshed skin graft quilted to host bed. Note bolster sutures at edges. (**c**) Bolster dressing (Images courtesy SB Brandes)

For obliterated or significantly inflammatory strictures, the urethral plate is commonly completely removed. In this setting, free graft (or skin flap) substitution to create a neourethral plate is required. The use of BMG in staged urethroplasties mirrors its adoption in one-stage procedures. Andrich et al. described both of these advances in one of the largest series of staged procedures to date. In their study of 103 staged repairs [4], 63 repairs were in the penile urethra, 11 were in the bulbar urethra, and 29 were pan-urethral. Grafts used were buccal mucosa and full thickness skin (posterior auricular). Their series showed a high revision rate after both first- and second-stage repairs, with approximately 50 % of the patients requiring a "3-stage" procedure. Of note, all revisions were on penile or pan-urethral strictures. Their re-stricture rate at 6 months was 4/103 patients. Although this success rate is relatively high, the follow-up was short. Longer-term follow-up after staged penile urethroplasty shows durable success rates of 73.3 % at 56 months in a small series, indicating that the success appears to decrease over time [14].

Based on the author's literature review, no randomized controlled trial exists comparing the success of different graft types in staged urethroplasties (i.e., meshed skin vs. buccal mucosa). In general most reconstructive urologists, including the authors, prefer buccal mucosa when adequate supply exists. Pfalzgraf et al. reviewed urethroplasties performed at their institution between 1993–1999 and 2000–2004 [15]. The rate of BMG over meshed skin grafts increased from 12 to 50 % during these two periods. Although the success rates between the two grafts were relatively equal, erectile dysfunction and chordee were only seen in the meshed graft groups with rates of 4 and 9 % respectively [15].

As buccal mucosa has become the graft of choice for staged repairs, a dilemma occurs when an adequate supply of buccal graft does not exist. One option to use a split-thickness meshed graft is described above. An advantage of a full thickness graft over a thin split graft is less postoperative contraction. Meeks et al. published a method of using full thickness abdominal skin with limited morbidity [16]. At a mean follow-up of 28 months, the failure rate with this graft in their small case series was 12.5 %.

Another option for maximizing the available supply of buccal mucosa is by preservation of the urethral plate. This can be done in the fashion of Schreiter's work, by placing grafts lateral to the urethral plate. In 2001 Asopa et al. presented a novel one-stage urethroplasty utilizing ventral sagittal urethrotomy with dorsal inlay of buccal mucosa graft [17]. Wessells et al. modified this

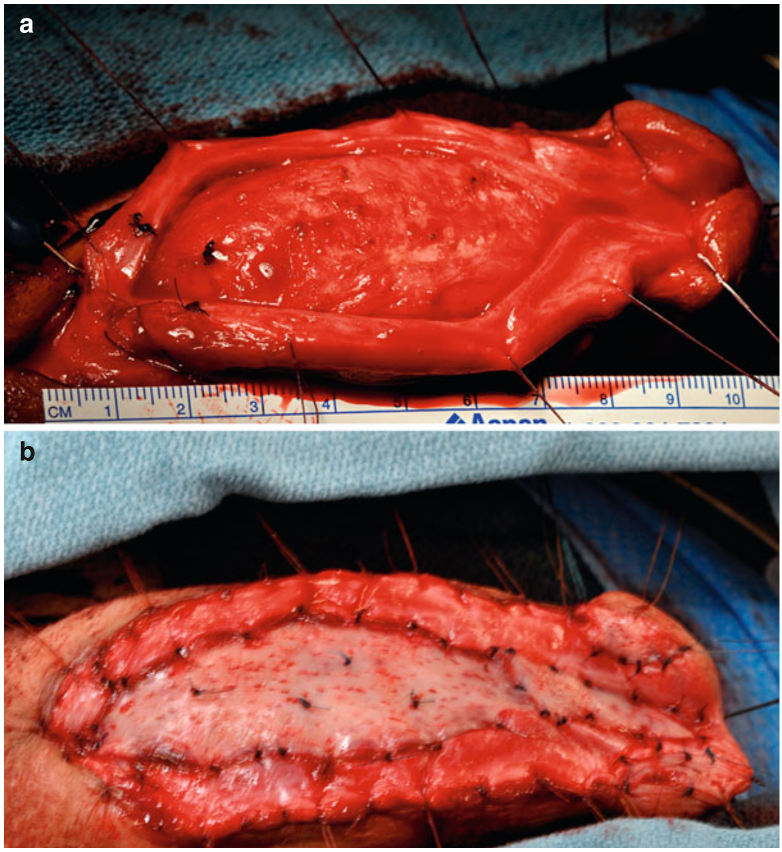

Fig. 20.5 Staged Asopa procedure. (**a**) Split halves of the native urethral plate lateralized and preserved during a first-stage urethroplasty. (**b**) Inlay of buccal mucosa between the split halves of the native urethral plate

procedure to be used in a two-stage approach [18]. In this method the strictured urethral segment was mobilized in a circumferential fashion and then split ventrally and dorsally, resulting in two halves of the urethral plate. The halves of the split urethral plate were lateralized, and buccal mucosal graft was secured between with split urethral plates (Fig. 20.5). This allows easier tubularization of the laterally placed spongiosum and urethral halves in a second stage, leaving the graft on its bed. However, the residual luminal diameter necessary to carry out this approach is probably 10 Fr.

Technical Description, First Stage

Patient positioning depends on the location of the stricture. Penile urethral strictures allow the patient to be placed in the supine position, whereas bulbar strictures require the lithotomy position. Mobilization of the strictured urethra and transection then follow. For distal strictures involving the fossa navicularis, a ventral urethrotomy is extended from the meatus proximally until healthy urethral tissue is seen. The urethral plate is then mobilized off of the underlying corporal bodies, allowing resection of the strictured urethral segment distally to the glans. Buccal mucosa is harvested in the standard fashion, defatted, and fenestrated with an 18-gauge needle. The dimensions of the graft are tailored to the length of the defect, allowing a minimum width of 25–30 mm. The graft is spread and fixed laterally to the tunica albuginea of the underlying corporal bodies using 5-0 absorbable sutures. Additional sutures approximate the lateral graft to the skin edges in an interrupted fashion, and the graft is quilted to the tunica albuginea as well (Fig. 20.6a). A nonadherent dressing bolster is gently tied down to the base of the graft (Fig. 20.6b). Postoperatively, the graft is immobilized for 5 days; after which time the surgical bolster is removed. During this next 5 days,

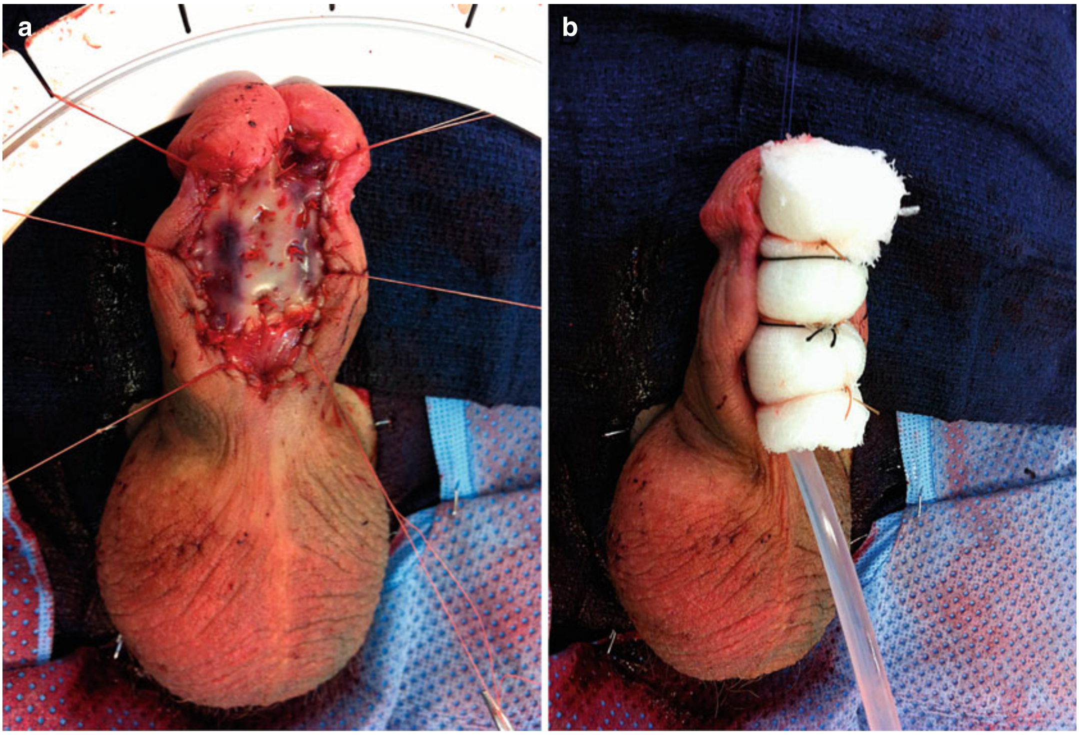

Fig. 20.6 Completion of first-stage urethroplasty. (**a**) Graft is quilted onto the surface of the corporal bodies. The skin is approximated to the edges of the graft. (**b**) The surgical bolster dressing is applied to the base of the graft

antibiotic-impregnated fine gauze provides protection and coverage of the grafts, and catheter drainage is continued for another 5 days. Once the urethral catheter is removed on day ten, local application of an antibiotic ointment continues for 1–2 weeks. In the interval between the first- and second-stage procedures, daily application of a fragrance-free barrier emollient (e.g., Eucerin) keeps the skin protected and moisturized.

Technical Description, Second Stage

The neourethral plate is allowed to heal for at least 9 months prior to proceeding with retubularization. During this time, the patient is seen intermittently to examine graft quality and suitability for reconstruction. Once the graft, and adjacent skin, has adequate pliability and vascularity, the patient is scheduled for second-stage repair. Graft contracture, graft loss, stenosis of the proximal urethrostomy, or other complications indicate the need for revision (*vide infra*).

The neourethral plate is mapped out in order to allow adequate width of the retubularized urethra (Fig. 20.7a). Typically, this will be at the junction of buccal graft and native skin; with very wide buccal grafts, excess graft may need to be removed. The marked perimeter of the neourethra is incised sharply with a scalpel. The plane between native skin and Buck's fascia is developed laterally. The lateral edges of the graft are sharply elevated off of the tunica albuginea of the underlying corpora cavernosa, preserving as much supporting tissue as possible, until adequate mobility exists to tubularize the graft plate. Holding sutures can be placed to loosely re-approximate the edges over a 20-Fr catheter and confirm the adequacy of the diameter (Fig. 20.7b). The graft is tubularized with a running 5-0 polyglactin horizontal mattress suture. Additional coverage with tunica vaginalis or dartos flaps is advisable when available, particularly along the penile urethra and at the

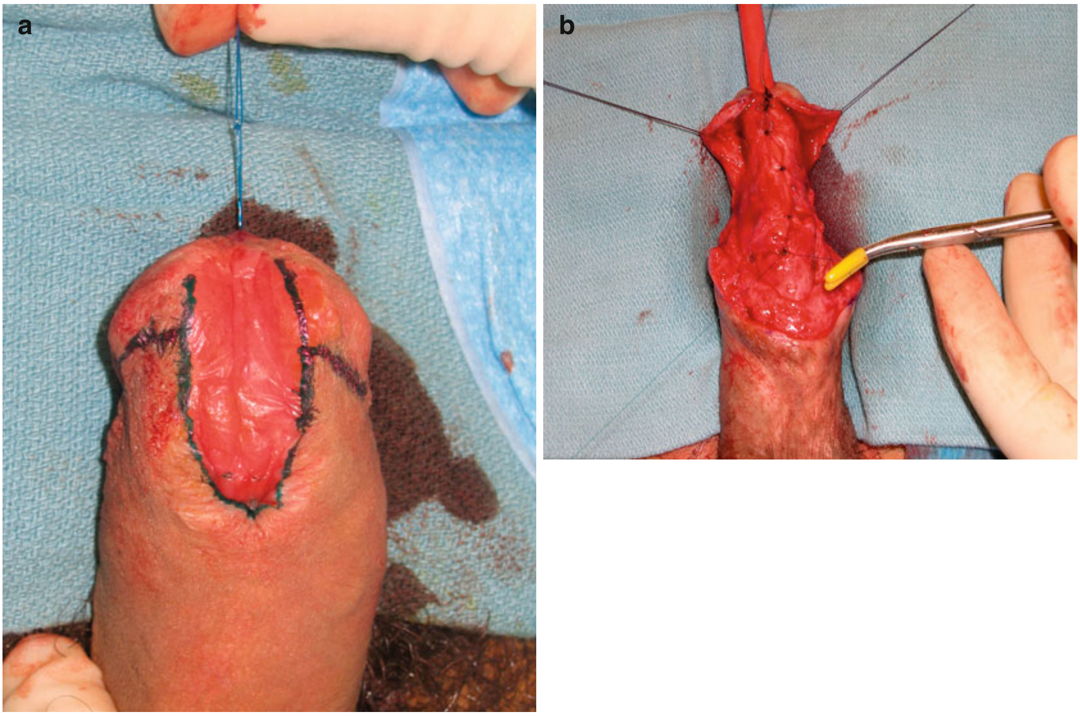

Fig. 20.7 Second-stage closure. (**a**) Mapping of incisions. (**b**) After creation of glans wings, mobilization of urethral plate, and approximation of neourethral tube over 20-Fr catheter

subcoronal margin below the glans. The skin is closed in an interrupted fashion with an absorbable suture (Fig. 20.8). The urethral catheter is removed 10 days after surgery.

An intraoperative challenge exists when the urethral plate does not have adequate elasticity or width to easily tubularize over a large-bore catheter. If the adjacent skin lacks hair follicles, it can be incorporated into the neourethra as necessary. In other cases, if the urethral plate is not wide enough, adjunctive measures include addition tissue transfer of small ventral grafts (Fig. 20.9) or skin flaps (Fig. 20.10). When the tubularization is not possible, placement of additional lateral buccal grafts is required, delaying closure for another 6–9 months.

Fig. 20.8 Appearance of penis 10 days after second-stage closure

Bulbar and Pan-Urethral Strictures

Staged approaches can be applied successfully to more proximal strictures of the bulbar urethra as

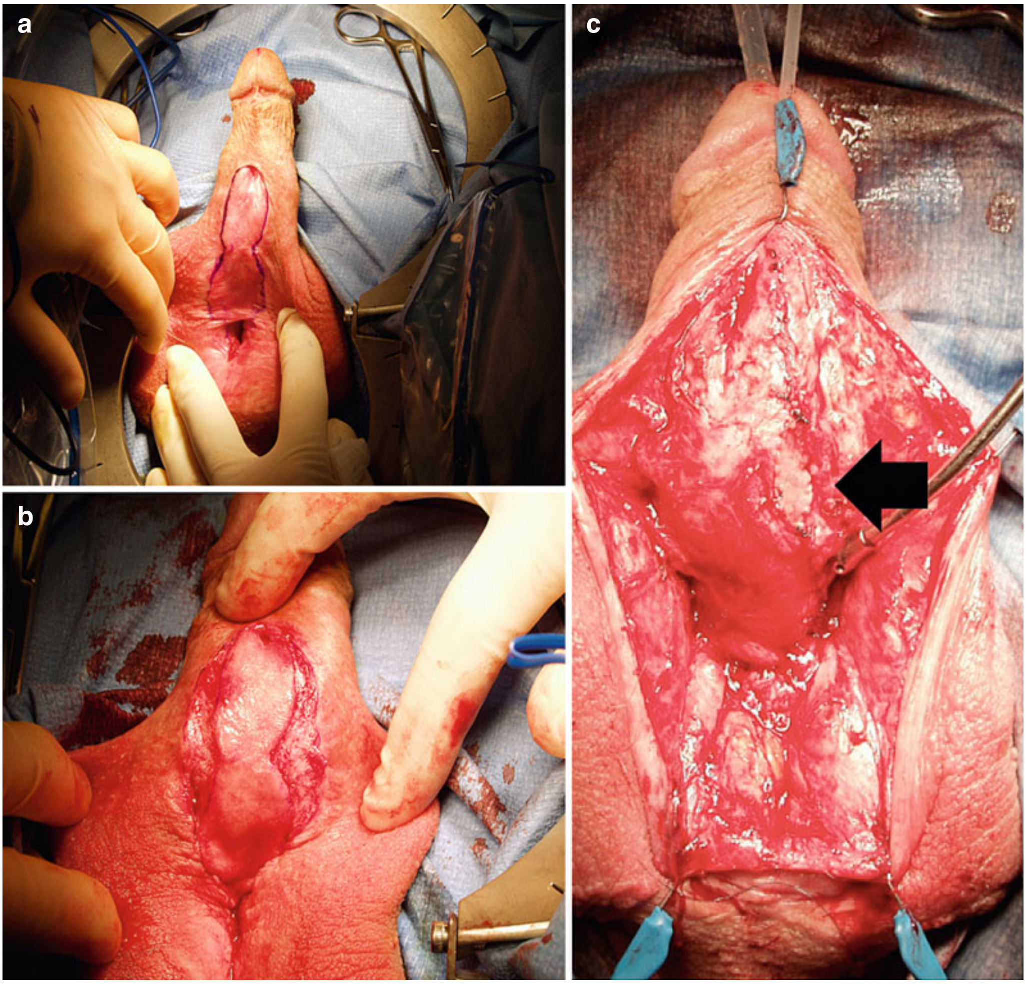

Fig. 20.9 Augmentation of second-stage closure with ventral buccal graft. (**a**) Appearance of plate at second stage. (**b**) Paucity of skin at midgraft. (**c**) Placement of small buccal graft (*arrow*). A flap of dartos fascia was quilted onto the graft to serve as a vascularized bed

well as pan-urethral anterior strictures. In these cases the scrotum may need to be split in the first stage, requiring positioning in lithotomy, more extensive dissection, and larger amounts of buccal mucosa or full thickness skin. A second-stage procedure for such a stricture is shown in Fig. 20.11.

Success Rates and Complications

The reported success rate of staged urethroplasty varies as a function of institution, cohort size, and follow-up time. The authors consider success to be urethral patency, a cosmetically acceptable orthotopic meatus (Fig. 20.12), and absence of chordee or fistula. Table 20.1 summarizes success rates for staged repair. Success at each individual stage should be quoted when possible, with the combined final rate of patency ranging from 78 to 96 % in several large series. The longest-term follow-up documented in the literature is 56 months [14]. In general, the success rate of staged urethroplasty decreases with time.

Complications can occur after staged urethroplasty. Revision rates after first-stage grafting are not uncommon and range between 7 and 37.8 % [4, 5, 13, 19]. Indications for revision after first stage repair include graft loss, stomal stenosis,

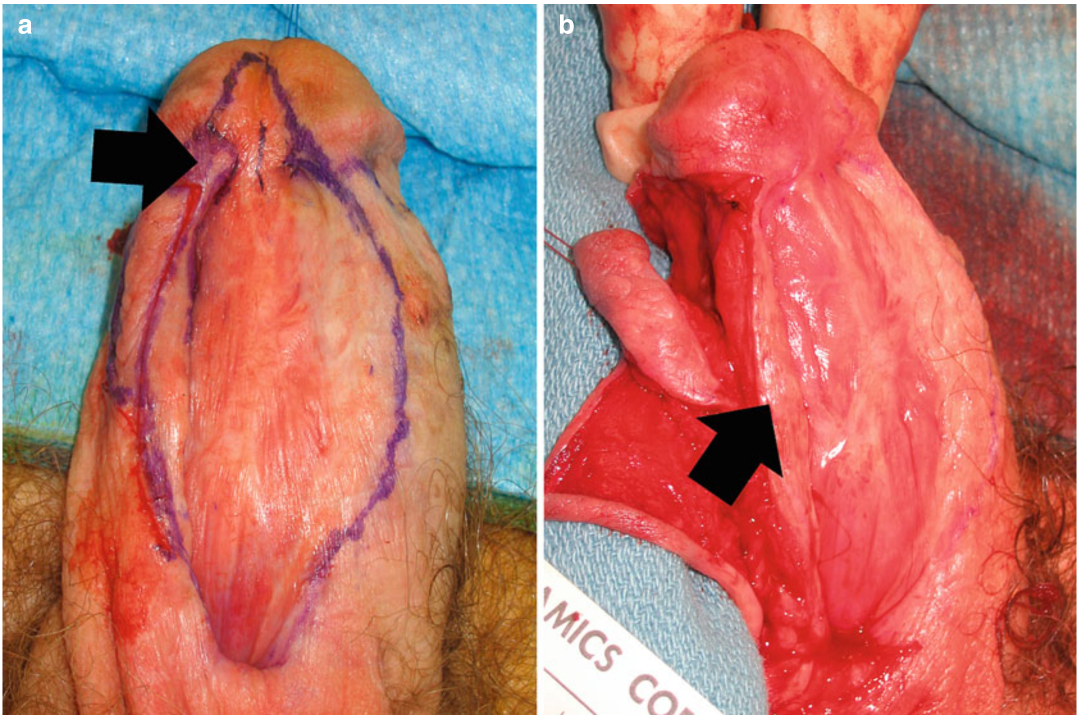

Fig. 20.10 (**a**) Narrowed plate (*arrow*) during second-stage closure. (**b**) Small Orandi-type skin flap (*arrow*) augmentation at the coronal margin

deepening of the glans cleft, and management of skin bridges or synechiae [4]. Complications after final-stage repair are less common. Documented complications after final-stage repair include stricture recurrence, fistula formation (2.6–10 %) [4, 5, 7, 13, 16, 24], wound dehiscence (10 %) [4, 16], and wound infection or abscess (5 %) [16, 24]. Fistula closure should follow standard principles of reconstructive surgery, namely, delaying repair until the tissues become soft and pliable. Fortunately, with good urethral caliber being the norm with staged procedures, the fistula closure can be simple (Fig. 20.13).

Erectile dysfunction has been cited to occur 4 % of the time after staged urethroplasty [15], and chordee rates range between 5 and 10 % [13, 15, 16]. In our experience penile curvature may occur after either first- or second-stage procedures but generally resolved without need for surgical correction.

Patient-Driven Considerations

It is not uncommon for a patient to present for follow-up after a first-stage urethroplasty who decides not to proceed with a final-stage repair. Elliott et al. reviewed a series of 38 men who had a first-stage urethroplasty, only 9 (24 %) of whom opted to proceed with second-stage repairs [25]. Of the nine patients opting to proceed with second-stage repair, seven patients had a neo-meatus at the penoscrotal junction. This paper highlights several patient-driven aspects in staged repairs. First, patients are often extremely happy after a first-stage repair and will often not proceed with second-stage repair. Second, patients with a penoscrotal junction neo-meatus are often not satisfied after a first-stage repair, as they cannot generate a good stream. In summary, it is not uncommon for patients not to proceed with a second-stage repair, and many authors believe that some patients may be better served with a perineal urethrostomy over a staged urethroplasty.

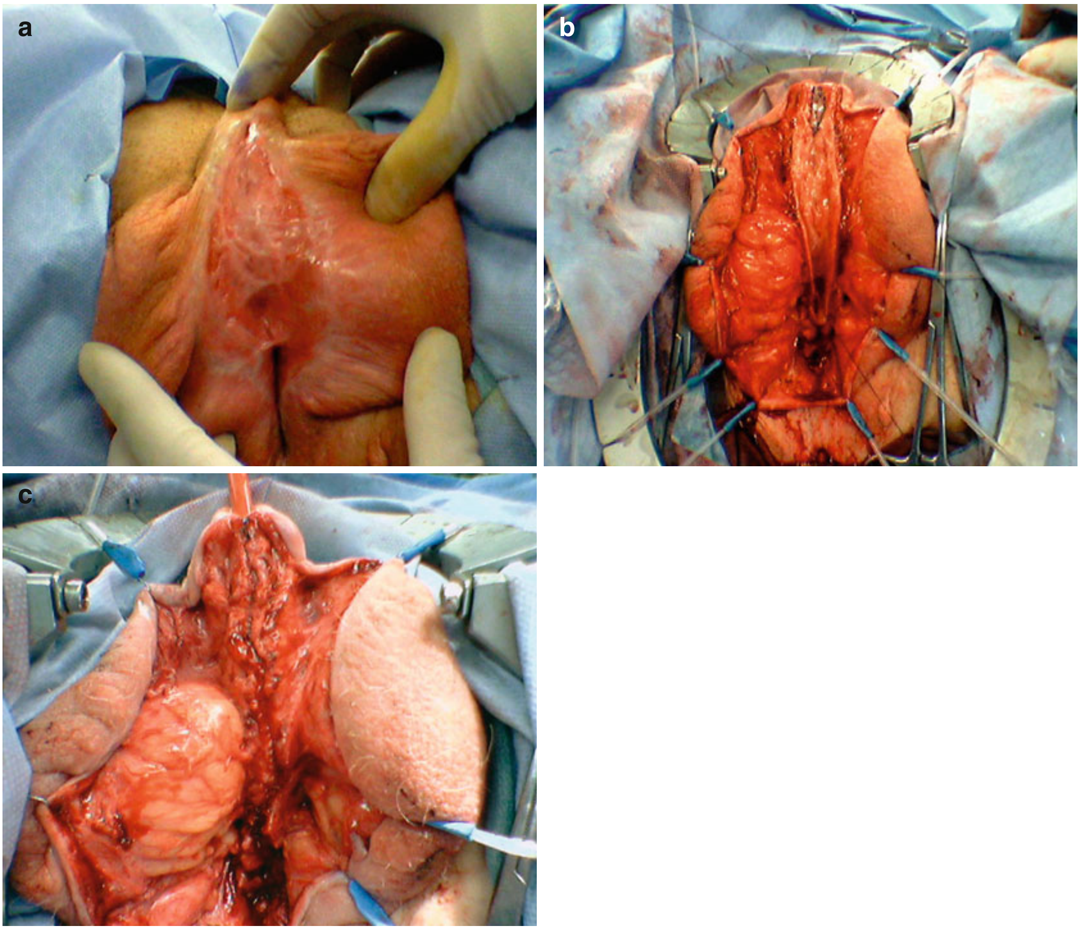

Fig. 20.11 Second-stage closure of pan-urethral stricture. (**a**) Appearance immediately before closure. (**b**) Dissection of urethral plate with addition of small dorsal graft to augment distal urethral plate. (**c**) Closure extending all the way to the glans

Fig. 20.12 Orthotopic urethral meatus after second stage, with minimal pink buccal mucosa visible at the margins

Table 20.1 Success rates of stages of urethroplasty with sample size and follow-up duration

Series	Sample size	Follow-up (months)	Success rates (%)
Venn and Mundy [6]	16	36	93.8
Andrich et al. [4]	103	6	96
Dubey et al. [19]	15	24.2	86.7
Dubey et al. [20]	14	32.5	78.6
Levine et al. [21]	7	36	86
Meeks et al. [22]	6	17	100
Kulkarni et al. [14]	15	56	73
Authors cohort (unpublished)	46	12	78

Adapted from Mangera et al. [23]

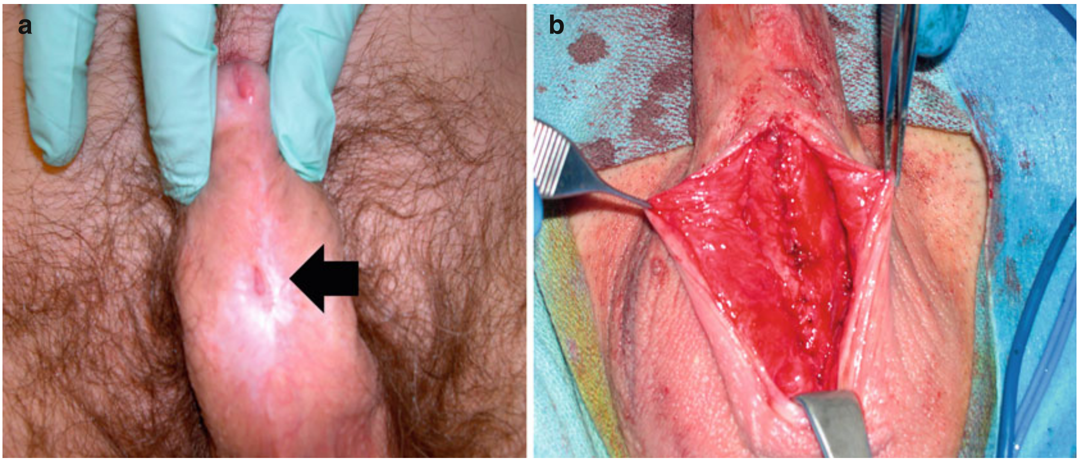

Fig. 20.13 (**a**) Fistula at base of penis after second-stage closure (see *arrow*). (**b**) Successful repair showing primary closure of urethra in layers

Posterior Urethral Reconstruction

Two-stage urethroplasty for the repair of membranous strictures is largely of historical consideration. In modern times, the sequential use of urethral mobilization, corporal splitting, inferior pubectomy, and corporal rerouting to gain urethral length has replaced the need for staged repairs of membranous urethral defects. Historical documentation of staged repairs for posterior urethral reconstruction exists in the writings of Blandy and Turner-Warwick [26, 27]. Both of these procedures utilized a perineal urethrostomy as part of the first-stage repair, followed by tubularization of scrotal or perineal skin in the second-stage repair.

Conclusion

Indications for staged urethroplasty exist in modern reconstruction, including obliterated pendulous strictures, inflammatory states such as lichen sclerosus, and tissues with poor vascularity such as strictures occurring after childhood hypospadia repair. Choices of free grafts include buccal mucosa, split-thickness skin grafts, and full thickness skin grafts. Buccal mucosa has limited availability, and composite grafts are often required for the two-stage repairs of long urethral strictures. Patients should be counseled of the potential need for revisional surgeries at the outset of a staged repair. A select group of patients will choose not to proceed with a second-stage repair. Therefore, a perineal urethrostomy should be discussed as a management option at the time of initial consultation for a patient requiring staged procedures for definitive repair. With perseverance and use of adjunctive measures and procedures, the majority of men undergoing staged urethroplasty will achieve a satisfactory outcome.

Surgical Pearls and Pitfalls

Key Points "First Stage"

- The strictured urethral segment is mobilized in a 360° fashion and resected.
- Proximal and distal ends of the urethra are spatulated and fixed to the tunica albuginea taking care to widely lateralize the spatulation.
- Buccal mucosa is harvested, defatted, and fenestrated with an 18-gauge needle.
- The graft is spread, fixed, and quilted to the tunica albuginea of the underlying corporal bodies.
- Additional sutures re-approximate the lateral skin edges and the native urethra to the buccal graft.

- A nonadherent bolster dressing is applied.

Key Points "Interim Period"
- Local care continues postoperatively with use of emollients.
- Quality and consistency of neourethral plate are assessed at intervals.
- Calibration of proximal and distal urethrostomies assessed.
- Revisions performed as needed to ensure adequate width of plate.

Key Point "Second Stage"
- The neourethral plate is allowed to heal for at least 9 months prior to proceeding with retubularization.
- The marked perimeter of the neourethra is incised sharply with a scalpel.
- The lateral edges of the graft are sharply elevated off of the tunica albuginea of the underlying corpora cavernosa.
- The graft is tubularized with a running 5-0 polyglactin horizontal mattress suture.
- Additional coverage with tunica vaginalis or dartos flaps is used as available.

Potential Problems
- Early graft loss: Immobilization with a bolster is important in the first 5 days when the processes of imbibition and inosculation occur. This will help prevent early graft loss.
- Poor graft pliability: A common pitfall is to proceed with second-stage repair too early. Waiting until adequate pliability and vascularization occur is essential.
- Narrow neourethral plate: Incorporate non-hair-bearing native skin with the buccal graft for tubularization of the neourethra.

Favorite Surgical Instruments of H. Wessells

Jarit SuperCut black handled scissors
Curved iris scissors for defatting graft and glans dissections
Gerald forceps (smooth and with teeth)
Jennings mouth gag (for buccal harvest)
Lone Star retractor for penile urethral and meatal strictures
Perineal Bookwalter retractor for bulbar urethral strictures
Fine needle drivers (Ryder)
Bougies à boule for calibration
Precise caliper for measurement of urethral plate width
Beaver blade #69 for creation of neourethral margins in glans

Sutures
4-0 polyglycolic acid
5-0 polyglycolic acid
4-0 chromic
5-0 chromic
5-0 glycolide and trimethylene carbonate copolymer

Editorial Comment

When the ideal tissue (local or distant) for urethral reconstruction is deficient or not available (from either prior failed urethral surgery, hypospadias, infection, or trauma), then it is best to fall back on the technique of a staged urethroplasty, rather than a single stage. It is important to do proper informed consent with your patient in that a staged urethroplasty can often be more than two stages. In 30 % or more of cases, three or more stages are needed to complete the urethral reconstruction. Johanson's surgical principles that he introduced in the 1950s are still in use today, directly and indirectly. His original article is one of the seminal articles in the field of reconstructive urology because he introduced a novel method for reconstructing the urethra that was simple, straightforward, and successful. I urge you to get a copy and read Johanson's original manuscript.

Over the years, I have found that the patients most willing to do a staged urethroplasty are married and in a supportive and loving relationship. Married men are also able to have intercourse after the first stage – and these frequent erections help keep the grafts stretched and prevent them from contracting. Single men are self-conscious and typically want a one-stage reconstruction. The other group of patients willing to undergo staged reconstruction is hypospadias cripples. They are typically exhausted from multiple failed surgeries over the years. After the first stage, many hypospadias cripple patients are so delighted with their open proximal urethral meatus, that over a third never come back for tubularization (second stage). The technique by Schreiter, a modification of the original two-stage urethroplasty by Johanson, uses a ventral urethrotomy to marsupialize the urethra and a meshed skin graft to the dartos and urethral edges. Today, most surgeons use oral buccal grafts, rather than skin as the first stage, as it is resistant to LS and does not contract as much. If there is insufficient dartos on the penis to graft to for the first stage, there will not be a plane to mobilize the graft for the second stage. In such rare instances, mobilize the tunica vaginalis off one of the testes and bring it onto the penis through a scrotal window and tack to the corpora – and then place the grafts onto the tunica. In this way there is a tissue plane to develop for the second stage.

After 6–12 months (the longer the better) of graft maturation, the urethra is tubularized in a standard Thiersch-Duplay fashion. The key to a successful staged repair is waiting long enough after the first stage until the grafts are supple and elastic. I like patients to have erections often after the first stage in order to stretch and soften the graft. If they are able to have natural erections, I encourage frequent intercourse. If they are impotent, I encourage the daily use of a vacuum erection device. The common error here is to perform the second stage too early. At the time of the tubularization, it is important not to make the neo-meatus too tight and too distal. Resist the temptation to get the meatus exactly anatomical. Also at the final stage, if a layer of dartos is not available to close over the tubularized urethra, I also like to interpose a flap of tunica vaginalis on top of the urethral suture line – this will help prevent urethrocutaneous fistula formation.

–Steven B. Brandes

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21 Complications of Urethroplasty

Ofer Shenfeld

Summary

Complications of urethroplasty are directly related to the location of stricture, surgical technique, type of substitution tissue, length of stricture, skills of the surgeon, and patient selection. Complications range from mild and temporary to severe and complicated. Aside from recurrent stricture, postoperative complications are erectile dysfunction, post void dribbling and urethral sacculation, ejaculatory dysfunction and issues with glans sensation, skin sloughing, urethral fistula, and oral graft harvest side untoward results. Limitations in current published papers are the lack of a standardized definition of treatment failure, surgeon underreporting, and reports of complications being from single surgeon's case series of heterogeneous urethroplasty techniques, with short to intermediate-term follow-up and nonstandardized follow-up.

Introduction

Urethroplasty is considered the gold standard treatment of urethral stricture disease. Though these surgical procedures are significantly more complex than the simpler means of urethral dilation or visual internal urethrotomy, in expert hands urethroplasty holds the promise of significantly higher long-term success rates. There are many described techniques for urethroplasty, and selecting the appropriate technique is based on urethral stricture location and length, urethral elasticity, availability of local healthy tissues, and the preference of the reconstructive surgeon, usually based on his experience with these varied techniques.

In discussing the complications of urethroplasty, one finds the literature lacking in standardized definitions, when even the definition of success and its opposite, failure, is not widely agreed on. Also because of the aforementioned range of available reconstructive techniques, it is difficult to reach generalized conclusions concerning surgical complications, as the reported series often consist of single surgeon's case series of various urethroplasty techniques with short- to intermediate-term follow-up and unstandardized reporting of complications. Additionally, common side effects that may be bothersome to the patients may not be considered significant complications by the surgeons, causing underreporting of these conditions. All these difficulties may be overcome, in time, by the adoption, by reconstructive surgeons, of more standardized reporting methods, better definitions of surgical success or failure, and patient-reported outcome measures (PROMS).

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Recurrent Stricture

Risk Factors

When discussing urethroplasty complications, the most significant is surgical failure or recurrent stricture. The best definition for surgical failure and the methods for screening urethroplasty patients for recurrent stricture are still not clear [1, 2], making it difficult to reach definite conclusions about the chances for recurrence. Using various evaluative means including imaging and cystoscopy and the report of symptoms requiring additional surgery or urethral dilatation, one systematic literature review [3] found strictures to recur in 15.6 % of urethroplasty patients. Reviews of urethroplasty series show that the chance for stricture recurrence is influenced by many factors including the stricture length and location, previous urethral manipulations, patient obesity [4], the technique used, and the surgeon's expertise. Smoking and diabetes may also adversely influence the success of urethroplasty [5]. Several studies have demonstrated that previous multiple urethral manipulations (DVIU and dilatation) and previous urethroplasty are both risk factors for recurrent stricture after urethroplasty. Thus, most patients would be better served by early urethroplasty, forgoing repeated ineffective urethral manipulations. Also since prior failed urethroplasty may adversely affect the success of subsequent urethroplasty, referral to experienced urethral surgeons at centers of excellence should be performed.

Incidence

The technique used for urethroplasty is an important determinant of the chance for restricture. While in the short- and midterm (6.5 years) anastomotic urethroplasty and flap techniques achieve similar results [6], anastomotic urethroplasty results in more durable success rates of 86 % at 15 years' follow-up compared to 42 % for substitution urethroplasty (grafts or flaps), with most failures in the anastomotic group occurring early [7] and probably reflecting surgical technical problems. This may reflect selection bias since longer strictures [5], more complex strictures, and strictures involving the penile urethra [8, 9] are all associated with higher restricture rates and are more likely to require a substitution rather than anastomotic urethroplasty.

Restenosis Characteristics

When using grafts, oral mucosa grafts may result in lower restricture rates then skin grafts [10]. Though the location of the graft placement, dorsal or ventral or lateral, seems not to affect success [11], ventral grafting may be associated with more complications such as post micturition dribbling and ejaculatory dysfunction [12]. Strictures after graft or onlay flap urethroplasties tend to occur as short rings at the proximal or distal extent of the repair, a condition named "fibrous ring" [13]. Anastomotic strictures after excision and primary anastomosis urethroplasty are also usually short stenotic rings. Short recurrent strictures may be treated successfully by visual internal urethrotomy; longer strictures resulting from graft or flap failure may require repeated urethroplasty or perineal urethrostomy [14].

We believe that a common reason for urethroplasty failure is underestimation of the true extent of the urethral stricture disease leaving parts of the diseased urethra untreated. We use several measures to minimize the chance of urethroplasty failure. These include careful preoperative assessment of the urethra with urethrography and cystoscopy to better plan the surgery in advance. Intraoperatively, the urethra proximal and distal to the stricture is assessed by flexible urethroscopy and calibrated to 30 Fr with bougie a boules. Suspicious areas (white and blanched mucosa) are incorporated into the repair. When performing urethroplasty, the urethra should be opened generously proximally and distally into apparently healthy urethra to minimize the chance of missing a region of occult urethral disease. Another potential intraoperative problem is performing an anastomotic urethroplasty under tension. When in doubt, an anastomosis on tension should be converted to an augmented anastomosis using an oral mucosal graft. The proximal and distal extents of graft or flap onlays should be fixed to the urethra with several interrupted sutures, as running sutures may cause bunching up of the tissue and ischemia and add to the risk of "fibrous rings"; the rest of the onlay may be closed using running sutures. Since recent dilatation of urethral strictures prior to surgery may hide the true extent of the stricture and cause underestimation of the stricture length, it is our practice to avoid such manipulations and advocate suprapubic drainage of up to 3 months if the patient is dependent on such dilatations [15] or if the preoperative urethrogram reveals a dilated irregular urethra proximal to the stricture [16], since these dilated areas may also hide occult stricture disease. See Chap. 29 for details of the concept of "urethral rest."

Restenosis Treatment

Patients presenting with recurrent strictures after urethroplasty should be carefully assessed in order to be able to carefully plan their subsequent treatment. As previously mentioned, short anastomotic strictures or fibrous rings at the proximal or distal ends of an onlay may be treated by visual internal urethrotomy. This should not be done aggressively so as not to extend the spongiofibrosis into healthy segments of the urethra. Recurrent stricture after this can be managed by redo urethroplasty or by patient self-dilatation with 14 or 16 Fr catheters, if the patient prefers. When we are presented with long recurrent strictures, we believe that these are best managed by redo urethroplasty. Obviously this is more difficult than primary urethroplasty, as tissue plains have been obliterated by previous surgery making dissection more difficult and tissues previously available for reconstruction may not be available for use a second time. We tend to delay redo reconstructions for at least 6 and preferably 12 months after the previous reconstruction, to allow the tissues to settle down and increase the chance for success. The choice of reconstructive technique is dictated by available tissues and the location and extent of the stricture. When an onlay has been previously used, we will place the second onlay on the contralateral side of the urethra (ventrally if the previous onlay was placed dorsally and vice versa). Patients that have undergone multiple previous reconstructions, mainly hypospadias cripples, will usually require a staged buccal or mesh graft urethroplasty. See Chap. 25 herein by Hudak and Morey, for a more detailed description of reconstruction of failed urethroplasty.

Sexual Complications of Urethroplasty

Since urethral reconstruction may involve extensive mobilization of the corpus spongiosum and, in cases of bulbar and posterior urethral strictures, dissection into the intra-crural space, these surgical procedures may have a negative impact on patients sexual function in general and erectile function in particular. It has been shown that patient satisfaction with urethral reconstructive surgery is significantly influenced by the effects on sexual function [17], making the study of these effects even more important. It is interesting to note though that even conservative measures, such as visual internal urethrotomy, may also lead to erectile dysfunction [18].

Factors that may affect erectile function after urethroplasty include stricture location and length, patient's age, reconstructive technique used, as well as the time that may have passed since surgery. These factors are interrelated since stricture location and length will affect the choice of surgical technique.

Stricture Location

When considering the possible effects of stricture location on postoperative erectile function, one must consider the potential differences between bulbar and penile urethral surgery. Theoretically bulbar urethral surgery, especially that requiring dissection of the intra-crural space, may cause injury to the erectile neurovascular structures. Penile urethral surgery may adversely affect penile aesthetics and cause chordee, penile torsion, or tethering.

Bulbar Urethra

In a study by Anger et al. of 25 patients undergoing urethroplasty for bulbar urethral strictures [19] using anastomotic, augmented anastomotic, or buccal grafting techniques, there was no significant change in erectile function. A trend towards worse postoperative sexual outcomes was shown for older patients and those with lower preoperative IIEF scores. The authors suggested that keeping the dissection to the midline of the intra-crural space away from neurovascular structures and minimizing the use of electrocautery may help avoid erectile dysfunction after surgery. Although this study was prospective and used a validated questionnaire (IIEF), it was underpowered to draw any conclusions concerning possible differences between different surgical techniques. In a study by Erickson et al. [20], bulbar urethral reconstruction was twice as likely to cause postoperative erectile dysfunction, as was penile urethral reconstruction. The significance of this observation is not clear, since the vast majority of the patients recovered their preoperative erectile function within 6 months of surgery.

Penile Urethra

Though the previously mentioned study suggested a higher risk for erectile dysfunction following bulbar urethral reconstruction, another study by Coursey et al. [21] suggested that longer strictures mostly of the penile urethra requiring genital skin flap procedures resulted in a higher erectile dysfunction rate.

Patient Age

As previously mentioned, Anger et al. found a trend for worse sexual outcomes in older patient undergoing reconstruction for bulbar urethral strictures. This was further demonstrated in a similar prospective study by Erickson et al., of 52 men [22] undergoing anterior urethroplasty by a variety of methods. Using the validated BMFSI questionnaire, they reached similar conclusions. Though looking at all the men together, no significant changes in erectile function occurred after surgery; there was a significant decrease in erectile function in the older patients (over 50 years). Interestingly, this study showed an improvement in ejaculatory function in younger patients. Again the study was underpowered to address possible differences between surgical techniques.

Time Since Surgery

As in other urogenital surgical procedures known to adversely affect sexual function, such as in the case of radical prostatectomy, one may expect the time since surgery to have an impact on the recovery of sexual function, if it was negatively impacted by urethral reconstructive surgery. Erickson et al. noted a relatively high rate of erectile dysfunction (66 % of those with normal preoperative erectile function). The vast majority of them (98 %) regained normal erectile function after a mean of 190 days (range 92–398). Similarly Andrich et al. [7] showed a 10 % incidence of erectile dysfunction after substitution urethroplasty, which decreased to 2 % over 2–3 months.

Reconstruction Technique

Any conclusions concerning what effects different surgical techniques may have on postoperative erectile quality must be drawn from a paucity of literature. Nearly all the studies are retrospective reviews of the results of surgical series, and not specifically designed to address questions concerning sexual function or to compare surgical techniques, and their effect on sexual function.

Anastomotic Urethroplasty (Excision and Primary Anastomosis, EPA)

In the anterior urethra, this is almost exclusively used for shorter bulbar urethral strictures. Most case series of EPA for bulbar urethral strictures report a very low incidence of erectile dysfunction (1–2.3 %) [23, 24], Barbagli et al. [25] reported their experience in 153 cases of anastomotic bulbar urethroplasty that sexual complaints were common, with ejaculatory dysfunction in 23 %, changes in glans sensitivity in 20 %, and decreased glans engorgement during erections in 12 %. One should note that these reported sexual side effects, though interesting and important, have not been reported by others and that the study was a retrospective survey using a nonvalidated questionnaire to assess the patients postoperative sexual function. Such side effects in their patient population have prompted these authors to use a muscle-sparing and corpus spongiosum-sparing (nontransecting) techniques for urethroplasty.

Graft Urethroplasty

The most commonly used graft material in urethral reconstruction is buccal mucosa. This is used mainly for longer bulbar urethral strictures but may also be used for the more complex penile urethral strictures, particularly for hypospadias cripples. The use of buccal grafts for urethroplasty carries a minimal risk for erectile dysfunction [26, 27], though patients may report ejaculatory problems related to semen pooling in the reconstructed segment [28]. As has been previously mentioned, this is more likely to occur when the graft is placed ventrally as opposed to dorsally. This is probably due to the higher chance of outpouching of the graft, than in dorsal graft placement, where it is supported by the tunica of the corpora cavernosa. Careful tailoring of ventral graft width to a urethral lumen size less than or equal to 30 Fr is essential. The use of a buccal mucosa graft in combination with partial excision of the stricture (augmented anastomosis technique) for bulbar urethral strictures carries a low risk of erectile dysfunction (3 %), yet slightly higher risk of penile shortening (17 %) [29].

Flap Urethroplasty

Penile skin flaps are used mainly to repair long complex penile urethral strictures. Initial reports made no mention of sexual dysfunction following their use [30]. As previously mentioned, Coursey reported that the use of penile skin flaps for the repair of long penile urethral strictures was associated with a higher incidence of sexual dysfunction. Sexual dysfunction in these patients may be due not only to erectile dysfunction but also to penile tethering or torsion (Fig. 21.1) as well as to ejaculatory dysfunction due to semen pooling in the reconstructed urethra. Kesler et al. [17] noted in their series of 225 patients that 32 % of those patients that underwent flap urethroplasty reported erectile

Fig. 21.1 Penile torsion with erection after inadequate pedicle mobilization of a penile skin flap (Image courtesy G. Barbagli)

deterioration, additionally 18 % complained of penile shortening, 21 % curvature, and 28 % dissatisfied with their postoperative sexual outcomes. In another analysis of various urethroplasty techniques, Al-Qudah et al. [27] noted a 2 % chance of chordee after fascio-cutaneous flap urethroplasties. The same principles concerning dorsal or ventral placement of grafts hold true for island flap onlay urethroplasty. Aggressive mobilization of the flap's pedicle to the base of the penis may help avoid penile curvature and torsion. It is also important, when reconstructing the penile skin at the end of surgery, to carefully plan the distribution of the remaining skin to avoid scrotalization of the penis, which results in perceived penile shortening.

Staged Graft Urethroplasty

Staged techniques are warranted in complex long strictures, in patients lacking enough genital skin to complete one-stage urethroplasty. These procedures carry a relatively high risk of postoperative sexual dysfunction such as ejaculatory and erectile dysfunction as well as penile shortening, tethering, and scarring [27]. Barbagli et al. [31] noted that even completing only the first stage of a staged procedure (perineal urethrostomy) caused sexual problems in 22 % of 173 patients. Of these about 40 % reported difficulty with penetration.

It is apparent that though major sexual sequels of urethroplasty such as severe ED are relatively uncommon, surgeons may underreport other changes in sexual function such as ejaculatory sensory and aesthetic factors. This may be due to the perceived low importance of these changes, though patients themselves may consider these to be significant. Better instruments for patient-reported outcome measure must be developed and validated to be able to better explore these sexual complications in urethroplasty patients. Until this happens one must be careful when counseling patients prior to urethroplasty giving the patients the best available information. It is our standard of practice to actively question our patients after urethroplasty about changes in sexual function and to offer appropriate support and treatment. Careful tissue handling, minimal use of monopolar cautery during surgery, as well as the use of muscle sparing [32] techniques (to help avoid ejaculatory dysfunction) and vascular sparing [33, 34], techniques (to help reserve bipedal urethral blood flow) may help minimize the chances for these sexual complications.

Penile Rehabilitation

Erectile Dysfunction

Six to eight weeks after urethroplasty, we encourage all our patients to resume sexual activity. At that time, the surgical wounds have stabilized and postoperative erectile pain has subsided. Patients reporting decreased erectile function are encouraged to initiate a daily PDE5 inhibitor treatment (we prefer tadalafil (Cialis) 5 mg daily). The majority of patients will not need treatment beyond 3–6 months and will stop it on their own when they note that normal erections have returned. Very infrequently, a patient has significant erectile dysfunction that is not responsive to PDE5 inhibitors. For such patients we initiate 3-day-a-week intracavernous injection treatment with vasoactive drugs (we prefer "Trimix" – prostaglandin E1, phentolamine, and papaverine). We believe that penile prosthesis should be avoided in such patients because the aggressively mobilized corpus spongiosum, especially if it was transected proximally during EPA urethroplasty, may be overly dependent on distal blood flow from corporal perforators. This potentially important cavernosal blood flow may be abolished after a penile prosthesis is implanted. We do not routinely investigate patients with nocturnal penile tumescence sleep studies nor penile Doppler, as we have not found this helpful in tailoring our patient's treatments.

Penile Shortening, Tethering, or Torsion

Patients with penile shortening, tethering, or torsion are advised to start twice-daily treatments with a vacuum erection device (VED) applied for 10 min each time. Another alternative is to use penile traction devices, though these tend to cause the patients more discomfort, especially if they just had penile urethral surgery. Most patients will notice an improvement within 6 months of initiating treatment. In most cases these penile deformities have no functional significance, and reassurance is all the patient needs. Occasionally patients with significant torsion or curvature may be offered surgery to correct the deformity by redistribution of the penile skin or by corporoplasty. This is preferably postponed for at least 12 months after surgery, as most stricture recurrences also occur within this time frame. If surgery is performed after an island flap onlay urethroplasty, care should be given to preserving the vascular pedicle. The previous surgery's operative report may supply invaluable clues, when planning to avoid the pedicle, as this pedicle may come around the right or left side of the penile shaft.

Post Micturition Dribbling and Urethral Sacculation

Post micturition dribbling is likely underreported in the literature, as many authors do not consider it as a real complication or even attempt to query their patients about it. Some patients, however, perceive post micturition dribbling and associated semen sequestration as bothersome. Many patients complaining of urinary incontinence after surgery actually have instead significant post micturition dribbling, as actual stress urinary incontinence is very uncommon after urethral surgery. There are various explanations for post micturition dribbling. Normally the elasticity of the urethra and contractions of the surrounding corpus spongiosum wring out the urethra at the end of micturition. Other possible reasons for post micturition dribbling and semen sequestration, after urethroplasty, may be loss of urethral elasticity, loss of continuity of the corpus spongiosum, urethral diverticula or sacculation, and loss of the efficiency of the bulbospongiosus muscle contraction. It is important to note though that the appearance of dribbling some time after urethroplasty may also indicate recurrence of a urethral stricture.

The type of surgical technique selected may affect the incidence of bothersome dribbling:

Buccal Graft Urethroplasty

Post micturition dribbling occurs in 8–21 % of patients after buccal graft onlay urethroplasty [35]. When comparing ventral to dorsal placement, Andrich et al. [28] noted dribbling in 100 % of the patients, yet no significant difference in bothersome dribbling for ventral (21 %) versus dorsal (17 %). Urethral sacculation is sometimes present after buccal graft urethroplasty, but only rarely does it result in bothersome post micturition dribbling or be large enough to be labeled a urethrocele or diverticula [11, 36], (Fig. 21.2). Sacculations, however, are less common after dorsally placed BMG. Elliot et al. emphasized the importance of proper tailoring of ventrally placed buccal grafts. Furthermore, proper closure of the adventitia of the corpora spongiosum ("spongioplasty") over the graft will provide backing and further decrease this complication [36].

Island Flap Urethroplasty

When island flaps are used for urethroplasty, the reported rate of post micturition dribbling is 10–50 % and seems to be more common when compared to similar graft techniques [7, 27, 37]. It is possible that urethral sacculations increase the incidence of dribbling, especially after ventral onlay [38] (Fig. 21.3). It is significantly less common with dorsally placed flaps [12].

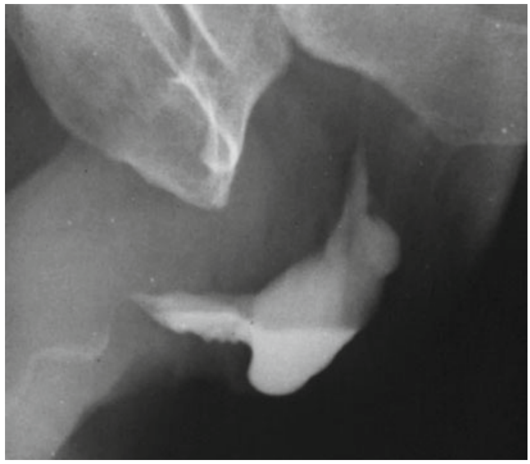

Fig. 21.2 Sacculations after ventral buccal graft urethroplasty (Image courtesy G. Barbagli)

Anastomotic Urethroplasty

One may expect less post micturition dribbling after anastomotic urethroplasty compared to substitution techniques, but when patients are questioned specifically about this complication, it appears to occur just as frequently [27].

Summary and Treatment

In our experience, post micturition dribbling initially occurs in the majority of urethroplasty patients, no whatever urethroplasty technique is used, and decreases in incidence to 15 % within a year of surgery. Tailoring of the grafts or flaps to an acceptable urethral caliber, spongioplasty and careful closure of the corpus spongiosum over ventrally placed grafts, preferential use of dorsal placement of grafts and flaps, and avoiding unnecessary trauma to the bulbospongiosus muscle may all help to reduce this complication. Patients should be made aware of this possible complication during preoperative informed consent. Initial treatment consists of manual self-compression of the perineum after each void and pelvic floor training (Kegel exercises), to improve bulbospongiosus muscle contraction. We have not, however, found Kegel exercises to be useful in our patients. Patients with very troublesome post micturition dribbling or de novo dribbling that has started some time after

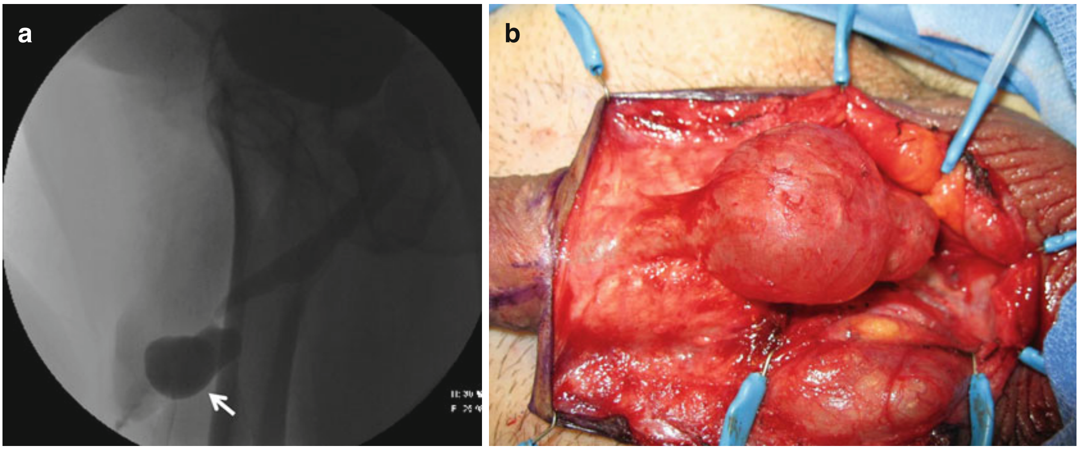

Fig. 21.3 Diverticulum after onlay flap urethroplasty to a penile urethral stricture. (**a**) Voiding cystourethrogram (*arrow*). (**b**) Surgically exposed diverticulum (Images courtesy S.B. Brandes)

urethroplasty should be investigated with retrograde and voiding cystourethrography. Indications for operation on these patients are presence of a distal stricture or recurrent urinary tract infections. Patients with a very large diverticula are typically patients that have had proximal hypospadias. These hypospadias cripples may also have hair or stones in their urethral diverticula and usually require revision of their urethroplasty, most commonly by a staged buccal graft technique.

Oral Complications

Oral mucosa, in particular buccal mucosa, has become the most widely used graft material for urethroplasty – replacing skin grafts and greatly decreasing the use of skin island flaps. Oral mucosa's biophysical properties, such as ease of harvest, resistance to infection, reduced graft shrinkage, and high rate of take by the host bed, make it an ideal graft material. These seem to result in better urethroplasty outcomes compared to skin grafts [10, 39] and fewer complications compared to skin island flaps [37].

Oral mucosa grafts are most commonly harvested from the inner cheeks (buccal mucosa). Cheek harvesting is reported to have less early and late complications than lip harvesting [40]. Early complications include pain and discomfort, which usually disappear or decrease to mild in 90 % of cases in 5–7 days, self-limited oral numbness (30–65 %), and mouth tightness (50–75 %) which usually disappear by 6 months [10, 41]. Late complications include persistent oral numbness (2–26 %) or persistent oral tightness in (9–32 %) 6–20 months after surgery [42, 43], Change in salivation occurs in 1–11 % [27, 44]. Rare complications include intraoral bleeding, hematoma, infection, cheek granuloma, and Stensen's duct damage. Lip contracture is a devastating complication reported in 3–5 % of patients after lip graft harvest [44–46] (Fig. 21.4). Although it is a rare complication, it is best to avoid use of lip mucosa grafts when possible. A better alternative to buccal mucosa grafts is lingual mucosa grafts harvested from the undersurface of the tongue. Potential complications of lingual graft harvest are tongue numbness, taste disturbances, and slurred speech, which are usually only transient in nature [47].

Some have reported that leaving the cheek wound open and allowing it to heal by secondary intention decreases pain and tightness postoperatively [44, 48]. However, others have not found pain and tightness to be problematic after closure of the buccal graft site.

When necessary, we prefer to harvest buccal mucosa grafts over other oral grafts, as it is easy to harvest with fewer complications. We use a one-team approach where the same reconstruc-

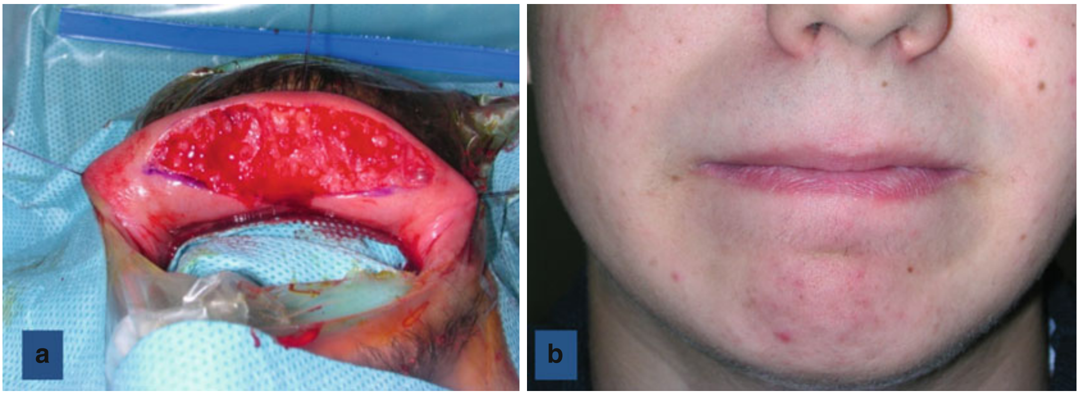

Fig. 21.4 (**a**) Oral mucosal harvest from the lower lip. (**b**) Lip contracture and poor aesthetic result from the harvest (Images courtesy of G. Barbagli)

tive surgeon obtains the graft, though some surgeons prefer a two-team approach to decrease surgical time. When it is obvious, before surgery, that a buccal graft will be needed, due to stricture length or unavailability of local tissue for reconstruction, we prefer to harvest the grafts before placing the patient in the lithotomy position, in order to minimize the chance for positioning-related complications. Monopolar cautery is to be avoided in the mouth. We use bipolar and manual compression for hemostasis. We prefer to leave the harvest site open and place an epinephrine-saturated gauze in the cheek till just before the patient is extubated. The future holds the promise of tissue-engineered graft materials that may obviate the need for oral graft harvesting and its associated patient discomfort and possible complications.

Infection, Skin Necrosis, and Fistula

UTI

Urinary tract infection and urosepsis are to be expected occasionally after urethroplasty as after any other urological procedure requiring postoperative catheter drainage. The same principles, consisting of removing the catheters as early as possible and the appropriate use of antibiotic prophylaxis, hold true for urethroplasty patients.

Penile Skin Necrosis

Penile skin necrosis has been reported in 0–15 % of patients after penile skin flap urethroplasty [30]. Penile skin necrosis usually occurs in the penile skin proximal to the flap because during harvest of the flap, the skin vascular supply via the subdermal plexus may be disturbed (Fig. 21.5). Although this complication usually heals spontaneously [12], it can result in a temporarily alarming appearance of the penis for both patient and doctor. It is very important to reassure the patient that this condition will usually resolve without significant sequela. The patient should be instructed to wash his penis several times a day with soap and running water, after which a moist-to-dry gauze dressing is applied. This will result in rapid granulation followed by epithelization.

Urethral Fistula

Fistulae occur very rarely after bulbar urethroplasty, as the bulbospongiosus muscle and thick perineal subcutaneous layers intervene between the bulbar urethra and the perineal skin. Urinary extravasation at the time of the postoperative urethrography after removing the urethral catheter has been reported after anastomotic l urethroplasty in 1–4 % of patients [23, 27] and in 0–25 % of buccal graft urethroplasties [42, 43, 49] (Fig. 21.6). These "leaks" typically resolve after

Fig. 21.5 Skin necrosis after onlay flap urethroplasty (Image courtesy of G. Barbagli)

Fig. 21.6 VCUG image of a urethral fistula after bulbar ventral buccal graft urethroplasty (Image courtesy of G. Barbagli)

an additional time of catheter urinary drainage. In our experience, we have found this problem to occur in 4 % of patients undergoing bulbar urethroplasty, mostly after ventral buccal mucosa graft urethroplasty, and always resolves by leaving the suprapubic catheter drainage in place for an additional week or two.

Fistulae are much more common after reconstructions involving the penile urethra. This is obviously due to the thin or even lack of tissue layers between the penile urethra and penile skin. Two techniques frequently used for penile urethral reconstruction are the fascio-cutaneous flaps (skin island flaps) such as the circular island

Fig. 21.7 Urethrocutaneous fistula and acute necrosis after penile skin flap urethroplasty (Image courtesy S.B. Brandes)

flap and the staged graft urethroplasty (buccal mucosa or split thickness skin grafts). Fistula can happen in up to 20 % of cases of fascio-cutaneous onlay urethroplasty [7, 27] (Fig. 21.7) and in up to 10 % after one- or two-stage buccal urethroplasty [9] (Fig. 21.8). Care must be used when developing the vascular pedicle. Delicate handling of the flap is important to avoid devitalization and fistula formation. Avoid overlapping skin and urethral suture lines as much as possible. Postoperative erections may also play a role in fistula formation. Some have reported fewer fistulas when monofilament sutures (PDS) were used [50], though others have failed to show this advantage [51]. Fistula formation is thought to be less common if extra layers of tissue can be interposed over the suture line, such as Dartos or tunica vaginalis flaps [52]. Fistulae are thought to be the result of necrosis of the skin, the graft, and the intervening tissue [53, 54]. Wound infection or dehiscence may also cause fistulae (Fig. 21.9). Fistulae are significantly less common in dorsal compared to ventral patch urethroplasty [38]. Initially small fistulae may resolve spontaneously with additional catheter drainage and meticulous skin wound care. Established fistulae often require multilayer fistula closure, usually delayed for 6–12 months. Strictures distal to the fistula must be aggressively looked for and treated.

Fig. 21.8 Urethrocutaneous fistula after staged tubularization of an oral graft urethroplasty (Images courtesy of G. Barbagli)

Complications of Patient Positioning

Though these do not directly compromise urethroplasty success rates, patient-positioning complications may severely impact on patient's quality of life, and efforts must be made to prevent them as much as possible. It is our belief that the urethral surgeons should personally position the patient to ensure optimal surgical visualization and proper padding of bony prominences.

Nerve Injury

In a review of 177 patients [55] operated in the exaggerated lithotomy position, transient neuropraxia of the common peroneal nerve was noted in 15.8 % of the patients. Statistical analysis failed to show a correlation between this compli-

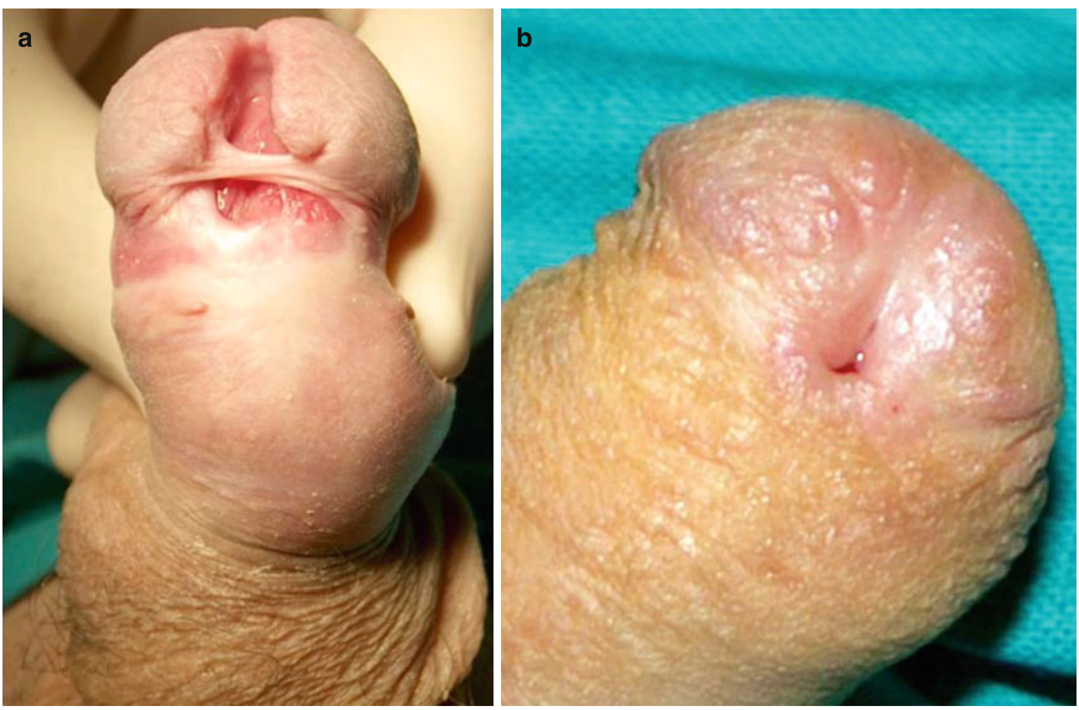

Fig. 21.9 (**a**) Glans dehiscence and (**b**) meatal stenosis after a second-stage urethroplasty (Images courtesy of G. Barbagli)

cation and patient's age, weight, height, or time spent in lithotomy. A latter study of 185 patients undergoing urethroplasty in the high lithotomy position found 10 % of lower limb complications, of which 4 patients had severe complications [56]. Stricture length and duration of lithotomy correlated with complications. Patients in lithotomy for less than 5 h were found to be at low risk for these complications. In a prospective study of 995 patients undergoing various surgical procedures in different lithotomy positions, 1.5 % developed lower limb neuropathies causing paraesthesia, dysesthesia, or pain. Nerve injuries involved the obturator, lateral femoral cutaneous, sciatic, or peroneal nerves and resolved in all but one patient within 6 months of surgery. Duration of surgery and lithotomy were the only significant factors affecting the risk of neuropathic complications [57]. A review of urethroplasties performed in elderly patients found no increased risk of neurovascular lower limb complications in these patients despite prolonged lithotomy position [58].

Treatment of Nerve Injury

We treat our patients, with neuropraxia after high lithotomy positioning, with physical therapy including passive and active mobilization of the lower limbs. Neurological consultation is usually not needed as this is a self-limiting condition. Patients presenting with atypical neurological conditions such as those with motor deficits are assessed by a neurologist; these may have more complex conditions such as cord hematoma (after regional anesthesia), acute disk, or cerebrovascular accident.

Compartment Syndrome

Compartment syndrome is another possible complication of the high lithotomy position. A survey of British urologists [59] found 65 cases of compartment syndrome associated with the lithotomy position, most commonly after cystectomy. Various positioning parameters have been associated with the risk of compartment syndrome [60] including the degree of leg elevation and hip angulations, Trendelenburg position, foot dorsiflexion, the type of leg holders used (calf support as opposed to heel support), and prolonged surgery; all decreased leg perfusion and increased the chance for compartment syndrome. Use of external compression devices helps decrease the incidence. Early diagnosis of compartment syndrome is of great importance, as prompt fasciotomy will help avoid permanent limb disability.

We position our patients using a short table extension under the patient's pelvis. This is elevated 45°, and the feet are placed in modified, lift assist, Allen stirrups with padded boots, elevated an additional 30°. This brings the perineum nearly parallel to the floor while keeping the legs and thighs in as neutral a position as possible with minimal contact or pressure of the calves within the stirrups. To minimize lithotomy time, we harvest grafts or prepare flaps at the beginning of surgery with the patients supine. Using this setup we have had minor complications (transient sensory neuropraxia) in 23 % of our patients, yet all resolved quickly within a week. We did have one patient with calf compartment syndrome and one with a permanent peroneal neuropraxia – making our major complication rate at 0.3 %.

Conclusions

The urethral surgeon should be experienced in a wide variety of reconstructive techniques and should know how to apply them when choosing the best reconstructive technique for his patient. This together with good surgical visualization (loupe magnification, proper positioning, and retraction), meticulous surgical technique, and careful tissue handling will help decrease the complications of surgery. Even in the best of hands, complications are sometimes unavoidable. The patients should be made well aware of this in advance when preoperatively discussing the reconstruction. The surgeon should be well versed in the management of these complications as many of them can be successfully managed.

Editorial Comment

This is a wonderful chapter summarizing the potential complications of anterior urethroplasty and the possible methods for management. I have simplified the conclusions into two tables – one on surgical pearls and the other on pitfalls.

Surgical Pearls

- Avoid dissection of the intercorporal septum if possible – to minimize ED
- Minimize use of monopolar energy and maximize use of bipolar
- For anastomotic urethroplasty, avoid dissecting the urethra distal to the suspensory ligament (to avoid penile foreshortening and chordee)
- While sewing in a graft or skin flap, keep the penis on full stretch
- When developing an onlay penile skin flap, mobilize the Dartos pedicle proximal enough to prevent any penile torsion or tension with subsequent erection
- Tailor ventral onlay grafts and flaps to no larger than 30 Fr
- Do not harvest oral mucosa from the lower lip. Use buccal or lingual grafts instead
- Properly pad bony prominences and limit time in lithotomy to <5 h
- Avoid unnecessary trauma to the bulbospongiosus muscle
- Preferentially place flaps and grafts dorsally if possible

Surgical Pitfalls

Complication	Treatment
Penile torsion	After 12 months, consider skin redistribution or Dartos flap
Penile tethering/ foreshortening	Vacuum erection device (VED)
Chordee	VED; persists >6 months, consider penile plication
ED	Daily Cialis; consider cavernosal injection therapy and VED
Cutaneous fistula	After 6 months, repair in multiple layers
Postvoid dribbling	Manually compress perineum; consider Kegel exercises
Penile skin necrosis	Reassurance; wet-to-dry dressings
Stricture recurrence	Annular ring, urethrotomy; long stricture, repeat urethroplasty

Complications after anterior urethroplasty are vexing and difficult problems. The best way to manage complications is to avoid them in the first place. I cannot emphasize enough how important the proper selection of the patient and the proper surgical reconstruction method will help you to avoid untoward events. Selection is the silent partner of the surgeon. In other words, no matter how good a surgeon you are and how good the tissue and reconstruction looks at the time of surgery, if it all falls apart postoperatively, it was all for naught. In other words, if the patient has poor protoplasm, has many comorbidities, smokes cigarettes, or has a very scarred and tenuous urethral vascular supply, any method at a one-stage urethroplasty, no matter the skill of the surgeon or technique utilized, will plainly just not work. One size does not fit all. In other words, each urethral reconstruction does not fit all situations, and the management must be tailored to the individual patient – taking into account not only stricture characteristics but his comorbidities, social situation, and desires.

Lastly, I feel that the overall potential for erectile, glans sensation, and ejaculatory dysfunction after urethroplasty is generally underreported and understudied in the literature. While the basis of my experience is my own and somewhat anecdotal, I have tailored my surgical indications in the attempt at minimizing the potential for complications. I have for late, limited my use of anastomotic urethroplasty to select group of patients – namely, young patients with short strictures of the bulbar urethra (<3 cm) that are of traumatic etiology and near or totally obliterative lumens. I have also been more liberally utilizing the new reconstructive techniques of the one-sided dissection, bulbar artery preservation, and the nontransecting anastomotic urethroplasty and stricturoplasty (as detailed in this text in Chaps.

34 and 38). For hypospadias cripples and for LS etiology strictures, I have moved to an exclusive staged urethroplasty technique, to not only improve stricture-free rates but to reduce potential morbidity. Moreover, for the refractory and recurrent stricture patient, I have more liberally utilized perineal urethrostomy, as a way to improve initial success and quality of life. When it comes to assessing the incidence and degree of complications from urethroplasty, we are still in our adolescence as a profession. We are still in dire need of standardized definitions of surgical success or failure, as well as validated and accurate patient-reported outcome measures for urethroplasty.

–Steven B. Brandes

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22 Postprostatectomy Strictures

Margit Fisch, Daniel Pfalzgraf, and C. Phillip Reiss

Summary

Complications of open and transurethral prostate surgery are the most common cause of iatrogenic posterior urethral strictures.

Treatment of these strictures can be troublesome and has a considerable risk of recurrence. Individualized therapy is required based on etiology, local tissue factors, and incontinence risk. This chapter reviews the epidemiology, mechanisms, and optimal treatment of acquired postprostatectomy strictures of the posterior urethra and bladder neck.

The incidence of bladder neck contracture (BNC) after endoscopic surgery for BPH is reported to be 0-9.7%. Although the number of radical prostatectomies (RP) is rising, the incidence of BNC after RP is considered to be decreasing due to modified surgical techniques. In contemporary studies the likelihood of BNC after RP is reported to be 0.2 -20.5 %.

Numerous risk factors for postprostatectomy strictures are described, such as multiple previous interventions, excessive blood loss, urinary leakage, obesity and narrow bladder neck reconstruction. All these risk factors seem to have a compromised wound healing in common. As to treatment options, no general, widely accepted concept exists. To ensure an optimal treatment outcome a meticulous preoperative workup is of utmost importance. However, first line treatment should be endoscopic. In highly recurrent strictures resistant to endoscopic intervention open reconstruction can be performed with good results. In select patients urinary diversion can be a reasonable treatment option.

Introduction

Postprostatectomy strictures are an infrequent but troublesome complication after prostatic surgery for benign hyperplasia as well as for prostate cancer. This chapter reviews the epidemiology, mechanisms, and risk factors. Furthermore, treatment options are discussed.

Background and Epidemiology

Generally, two different forms of postprostatectomy strictures should be differentiated – anastomotic strictures after RP and sclerosis of the bladder neck after endoscopic treatment of benign prostatic hyperplasia (BPH). Although the location of these types is similar, often lumped together as bladder neck contracture (BNC), the etiology and therapy of the two subsets are diverging.

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Table 22.1 Reported incidences of BNC after treatment of BPH

Reference	Year of publication	No. of patients	Surgical approach	% stricture
[18]	1985	646	TUIP	0.4
[19]	1985	388	TURP	0.8
[20]	1986	84	TURP	7.1
[21]	1989	1,180	TURP	0.1
[22]	1991	1,471/71	TURP/OPE	8/7
[23]	1993	2,266	TURP	0.9
[24]	1994	623	TURP	2.8
[25]	1998	446	TURP	2.6
[4]	2004	1,211	TURP	2.4
[6]	2004	120	HoLEP	0
[26]	2004	900	TURP	3.4
[16]	2005	552	HoLEP	1.3
[7]	2005	1,135	TURP	9.7
[15]	2006	4,031	TURP	2.8
[27]	2008	98/112	TURP/PVP	3.1/1.8
[5]	2009	376	TURP	1
[13]	2009	246	PVP	1.2
[17]	2010	1,065	HoLEP	6.0
[28]	2010	202	OPE	0.4
[14]	2010	54	PVP	7.4
[3]	2011	550	PVP	1.1
[12]	2011	400	PVP	4
[2]	2011	3,589	TURP	3.2

TUIP transurethral incision of the prostate, *TURP* transurethral resection of the prostate, *OPE* open prostatectomy, *HoLEP* holmium laser enucleation of the prostate, *PVP* photoselective vaporization of the prostate

Although resulting in an extensive bladder neck obliteration, the subset of postprostatectomy strictures due to distraction defect injuries after RP should be discriminated as a special subset, as these are often misclassified as BNC [1].

Besides these strictures with a posterior localization, anterior urethral strictures can occur, especially after endoscopic treatment for BPH, mainly located in the membraneous urethra, the penoscrotal angle, or the meatus. The incidence of anterior urethral strictures after transurethral prostatectomy is reported to be 1.1–3.2 % [2–5]. The treatment of these anterior strictures is based on the same principles as for urethral strictures of other causes and will be discussed elsewhere.

The incidence of sclerosis of the bladder neck after transurethral prostatectomy is reported to be 0–9.7 % [6, 7]. Time of occurrence usually is early (between 2 and 6 months), although late development after many years is described [7]. Presentation due to BNC within the first 6 months is reported by Park et al. in 72 % [8], by Surya et al. in 94 % [9], and by Besarani et al. in 66 % [10] of all cases. Lee et al. described a mean time of BNC diagnosis after initial surgery of 18.5 months (range 2–108) [7]. Elliot et al. described the rates of stricture formation in an analysis of the CaPSURE database of 6,597 cases tapering off after 1 year and totally flattened out after 2 years. Potential reasons for the discrepancies regarding the time of diagnosis might be the different degree in severity, the physician's index of suspicion, and the patients' tolerance.

No technique of transurethral prostatectomy seems to be protective in terms of lower rates of development of posterior or anterior strictures. The incidence for bladder neck sclerosis after photoselective vaporization ablation is described in contemporary publications as 1.1–7.4 % [11–14], after electroresection as 1–9.7 % [5, 7, 15], and for laser enucleation as 1.3–6 % [16, 17] (Table 22.1).

Table 22.2 Reported incidences of BNC after RP

Reference	Year of publication	No. of patients	Surgical approach	% stricture
[35]	1972	105	RRP	21
[36]	1979	136	RRP	4
[37]	1977	159	RRP	4
[38]	1980	36	RRP	6
[39]	1981	50	RRP	6
[40]	1983	75	RRP	3
[41]	1983	143	PRP	9
[42]	1984	215	PRP	18
[43]	1985	81	PRP	6
[44]	1987	692	RRP	5.4
[45]	1987	150	RRP	1.3
[46]	1989	100	RRP	9
[9]	1990	156	RRP	11.5
[47]	1992	620	RRP	0.5
[48]	1992	122	PRP	7
[49]	1994	36	PRP	0
[50]	1996	135	RRP	12.6
[51]	1996	81	RRP	4.9
[52]	1998	239	RRP	15
[53]	1998	340	RRP	7
[54]	1999	1,870	RRP	4
[30]	2000	863	RRP/PRP	20.5
[55]	2000	467	RRP/PRP	11.1
[8]	2001	753	RRP	4.8
[10]	2004	510	RRP	9.4
[56]	2005	246	LRP	1.2
[29]	2006	952	LRP	0.2
[57]	2007	3,310	Var.	8.4
[33]	2008	634	RLRP	1.1
[58]	2009	406	RRP	0.7
[59]	2009	4,132	RRP	2.5
[60]	2010	485/1,253	RRP/RLRP	4.5/0.2
[34]	2010	695/293	RRP/RLRP	2.6/1.4
[61]	2011	371	RLRP	3.8

RRP retropubic radical prostatectomy, *PRP* perineal radical prostatectomy, *LRP* laparoscopic radical prostatectomy, *RLRP* robotic-assisted laparoscopic radical prostatectomy

In contemporary studies, the likelihood of BNC after RP is reported to be 0.2–20.5 % [29–32].

However, a significant difference of incidence of BNC between open and (robotic-assisted) laparoscopic RP is described [33, 34]. In a review of BNC rates, the weighted mean incidence was 5.1 % for open RP, 1.1 % for laparoscopic RP (LRP), and 1.4 % for robot-assisted laparoscopic radical prostatectomy (RLRP) [33] (Table 22.2).

Mechanisms and Risk Factors

A number of general risk factors have been discussed for BNC after treatment of benign prostatic hyperplasia. In small prostates, BNC was found more often after resection than in larger prostates. Al-Singary et al. therefore proposed an initial bladder neck incision to reduce the risk for BNC [26]. However, other authors did not find any reduction in BNC incidence after bladder neck incision [62]. Wurnschimmel and Lipsky [63] reported the presence of an indwelling catheter for more than 3 days after surgery as the only 1 of 11 investigated risk factors for BNC. Furthermore, technical problems like faulty insulation of loops have been suggested as risk factors for stricture formation [64].

Sikafi et al. [65] suggested the extent of tissue damage at the bladder neck caused by electroresection to influence the degree of contracture. They described an elevation of the posterior lip of the bladder neck or slight circumferential narrowing and rigidity as the mildest form. The severest form consists of formation of a diaphragm occluding the whole bladder neck down to a pinhole opening.

For the development of BNC after radical prostatectomy, a number of risk factors have been proposed but no single, easy to eliminate risk factor has been found. Described risk factors for stricture formation are multiple previous interventions [52], excessive blood loss [66, 67], urinary leakage [67], obesity [57], and narrow bladder neck reconstruction [66]. On the other hand, extravasation at catheter removal was implicated as a risk factor in some series [52], while in others it had no adverse effect [68]. In an analysis of leak versus non-leak group after RRP, Rebuck et al. [61] showed no correlation between incidence of BNC and anastomotic leakage. Among a total of 213 patients, 27 men (12.7 %) experienced an anastomotic urine leak. In a univariate analysis, there was no difference in the risk of acquiring a BNC between the leak and non-leak groups (7.4 % vs. 3.2 %; $P=0.268$). In a multivariate analysis controlling for the additional covariates of age, blood transfusion, bladder neck reconstruction, and anastomosis type, the effect of leak group remained nonsignificant ($P=0.924$). Erickson et al. [59] suggested that all these risk factors have the potential to alter wound healing, possibly leading to scar formation. Furthermore, an adequate microvascular environment at the site of the healing anastomosis seems to play a vital role: in patients with comorbidities leading to impaired microvascularization – such as coronary artery disease, diabetes mellitus, and current smokers – the incidence of BNC was found to be higher than in patients without these comorbidities [69]. Poor microcirculation may also help explain the higher BNC rate after RP in patients with prior TURP: as electrocauterization may disrupt the peri-bladder neck vascular supply, healing after RP can be impaired by these surgeries [70]. Apart from that, Erickson et al. [59] found timing of the patient's RP to be the most important independent risk factor, as men undergoing RP early in their series ($n=4{,}132$) had a significantly higher risk of BNC formation. Suggested reasons for these findings were surgeons' experience and technical modifications. Moreover, with introduction of RLRP, running anastomotic sutures became common. Breyer et al. [34] reported an incidence for BNC after RLRP of 1.4 % as opposed to 2.6 % in the open RP group. It is likely that multiple factors contribute to the development of BNC after RP. The influence of changes in surgical technique is emphasized in a number of publications: Orvieto et al. showed a reduction of BNC incidence by surgical modifications in 977 patients from 31/548 (5.7 %) to 1/429 (0.2 %). Surgical modifications were (1) reconstruction of the bladder neck to a diameter of 28 French; (2) placement of the posterior (6 o'clock) vesicourethral suture on mild traction before placing this suture into the bladder, allowing inspection and, if necessary, replacement of any of the previously placed sutures; and (3) bladder displacement when tying the vesicourethral sutures which allows the sutures to be tied under direct vision [71].

Evaluation and Preoperative Management

Development of BNC after TURP can occur within weeks to years after initial treatment and is not always associated with severe subjective complaints. Recurrent, persisting, or de novo obstructive or irritative symptoms like a reduced force of stream or incomplete emptying of the bladder after TURP should raise the suspicion of a BNC.

After TURP or even more frequently after holmium laser enucleation or laser vaporization, obstructive or irritative symptoms can initially persist for up to 3 months, while appearance of these symptoms after RP is uncommon, and further evaluation for suggested BNC should be undertaken.

Evaluation prior to a secondary intervention in general is very important to distinguish between functional bladder problems in terms of persisting storage or emptying issues after desobstructive surgery and outlet obstruction due to BNC.

Evaluation for BNC should include:

1. Medical history:

   Review of the previous intervention, previous urodynamical findings, medication (i.e., narcotics, anticholinergics), preexisting conditions, and the actual symptoms and complaints provides the basis for diagnostic workup and planning of further interventions.

   Subsidiary validated questionnaires (i.e., International Prostate Symptom Score (IPSS), International Index of Erectile Function (IIEF), and International Consultation on Incontinence Questionnaire (ICIQ)) should be used to objectify symptoms and condition.
2. Urine analysis by urine dipstick, if indicated urinary sediment and urine culture:

   Obligatory prior to further instrumentation to detect infections, which can be the underlying cause of the voiding symptoms.

   Hematuria can be evidence for a bladder tumor or for complication of an obstruction, i.e., bladder calculus.
3. Uroflowmetry:

   Flow rate recording provides the best noninvasive test to detect and quantify an outlet obstruction. Although a peak flow rate of less than 15 ml/s alone does not differentiate between obstruction and bladder decompensation, the appearance of the curve can provide additional important information.

   For accurate interpretation micturition volume should be more than 150 ml.
4. Postvoid residual urine:

   As it can be measured with sufficient accuracy by transabdominal sonography, it gives cost-effective information about the state of bladder emptying.

Fig. 22.1 Combined RUG/VCUG showing the bladder neck contracture

5. Combined retrograde urethrogram (RUG) and voiding cystourethrogram (VCUG):

   To assess the exact localization and extent of a stricture. The simultaneous performance allows the evaluation of the whole lower urinary tract proximal and distal to the level of the stricture. Concomitant pathologies such as bladder calculus or diverticula can be diagnosed concurrently (Fig. 22.1).

   If performed sufficiently with simultaneous urethral sphincter contraction, useful information about the local relation to the stricture can be obtained.
6. Cystoscopy:

   Offers additional information about the lower urinary tract distal to the stricture, such as anterior urethral pathology and sphincteric integrity. The degree of stricture can be assessed by direct visualization, although the length of the stricture sometimes can be underestimated (Fig. 22.2).
7. Urodynamics:

   In the case of suspicion of concomitant functional bladder dysfunction, urodynamic evaluation can be indicated prior to further surgical intervention to document an obstructive voiding pattern and to rule out OAB as a cause for incontinence.

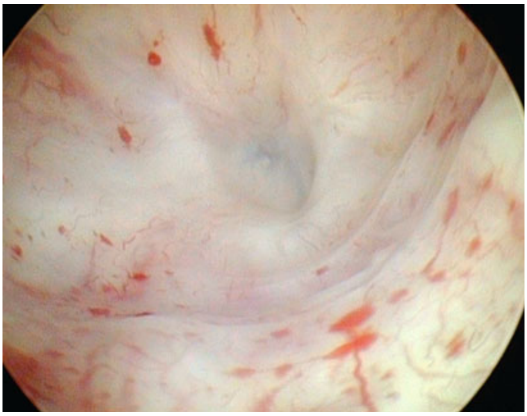

Fig. 22.2 Endoscopic view of the bladder neck contracture

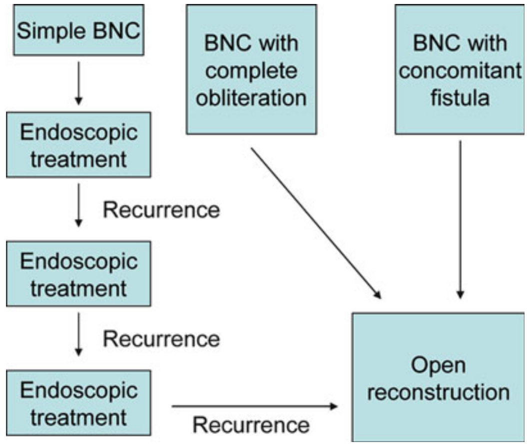

Fig. 22.3 Treatment algorithm for bladder neck contracture

8. Assessment of incontinence:

   In case of a preexisting urinary incontinence (UI), a pad-weighing test (Tage Hald method) can be performed as it offers a noninvasive opportunity to measure the amount of urinary loss and state of continence. The state of continence should be an important factor to plan an adequate surgical approach.
9. Transrectal ultrasound (TRUS):

   To measure regrowth of adenoma after TURP and for follow-up on prostate cancer.

A meticulous diagnostic workup prior to surgical intervention is indispensable to ensure adequate therapy with an optimal outcome and reduction of adverse effects. Evaluation of severity of posterior stricture predicts the aggressiveness of intervention, as higher-grade lesions require a more comprehensive course of action due to poorer prognosis.

Pansadoro et al. proposed a classification of posterior urethral strictures due to transurethral or open prostatectomy for BPH based on the extension and site of scar tissue in the prostatic fossa [72, 73], described as follows:

Type I: Fibrous tissue involves the bladder neck only, best known as bladder neck contracture.

Type II: The stricture is localized to the median part of the fossa. The bladder neck is usually wide, and the verumontanum is present.

Type III: The stricture involves the whole prostatic urethra.

Management of Stricture

The management of postprostatectomy stricture is variable, and no generally accepted treatment algorithm exists. However, it seems widely accepted that endoscopic treatment should be preferred over open reconstruction for the first attempts at treatment. We find the algorithm shown in (Fig. 22.3) helpful as a guideline. In general, endoscopic treatment should be preferred in simple cases, and open reconstruction be reserved for complex or highly recurrent BNC. However, comorbidities have to be considered, and variation of the algorithm may be required. Even urinary diversion may be an option in some patients with a complex history such as highly recurrent BNC after irradiation and with serious comorbidities (Fig. 22.3).

Surgical Management: Endourological Treatment

There is no consensus for the management of BNC. Several strategies of endourological therapy in some extent with inconsistent outcome are described. Possible techniques are dilatation alone or in combination with other procedures, incision by cold knife, laser or electrocoagulation, resection of the bladder neck, implantation of urethral stents, and additional injection of antiproliferative agents like triamcinolone or mitomycin C.

The review of described outcomes of the various procedures is often complicated as patient collectives are inhomogeneous, often BNC after radical and transurethral prostatectomy are not to be differentiated. Validated data considering the patients quality of life (QoL) in relation to the different procedures is rarely available. As QoL can be altered considerably by a resulting postoperative incontinence or the subsequent procedures, this should be a major item in the evaluation of the different procedures. Besides the severity of BNC, the number and type of prior interventions and a preexisting incontinence are influencing the QoL and therefore should be a major factor for the aggressiveness of the intervention, especially in recurrent BNCs.

Dilatation alone performed in cases of less-severe BNC after RP is reported to be successful in 100 % of 5 cases with a median follow-up of 10 months by Kochakarn et al. [74]. Ramchandani et al. reported a success rate of 59 % for balloon dilatation for BNC after RP [75]. Other authors describe stabilization of BNC by several dilatations and a following period of clean intermittent self-catheterization (CISC) [10]. Major factors for the outcome of dilatation may be time after initial therapy, length, thickness, and location of BNC.

To avoid burdensome and unpleasant palliative management by CISC or chronic dilation, urethral stenting has been proposed as a minimal invasive approach for the therapy of BNC. Although initial outcomes were encouraging, currently it is used sparingly because of challenges with tissue regrowth and recurrent contracture, urinary tract infections, perineal pain, stent encrustation, or intrusion and migration into the bladder [76, 77]. Magera et al. reported 48 % of a total of 25 cases treated by urethral wall stent insertion for BNC after RP required additional procedures, and 24 % were complete treatment failures at 2.9 years of follow-up [76].

Recently, Erickson et al. reported a final success rate of 89 % for the management of posterior urethral strictures with the Urolume® stent in 38 patients. In 82 % of cases, a postoperative incontinence was noted and treated by implantation of an artificial urinary sphincter (AUS) [78]. Due to tissue reaction, stent implantation can devastate the condition of the bladder neck in the long-time follow-up and may lead to urinary diversion as the last resort.

After Transurethral Resection of the Prostate

Unlike in post-RP, BNCs' simple dilatation alone is rarely successful after TURP [65].

For cold-knife incision of BNC after transurethral resection, success rates of 90 % are reported by Herrando et al. in 18 cases with a mean follow-up of 44.5 months [24]. Other authors indicate success rates for this procedure of up to 100 % [79].

Pansadoro et al. referred an overall success rate of 86 % after a single and 92 % after a second procedure in 122 patients with a mean follow-up of 63 months, following a stricture severity adapted strategy of cold-knife incision in type I strictures and additional resection in type II and III strictures [72].

In type I strictures, incision by Collings knife at the 3- and 9-o'clock position is deepened until a wide bladder neck is obtained and healthy tissue is reached.

In types II and III strictures, extension of the incision to the periprostatic fat is supposed. Subsequently the scar is resected leaving strips of healthy mucosa at the 6- and 12-o'clock positions. It is suggested that the preserved strip of mucosa hastens reepithelialization and prevents regrowth of scar tissue [72].

Moudouni et al. published a success rate of 100 % for combined incision and transurethral resection of BNC after prostatectomy for BPH with a mean follow-up of 12 months [80].

The use of bladder neck incision and simultaneous injection of mitomycin C as an antiproliferative agent for recurrent BNC in 18 patients after TURP or RP was recently published by Vanni et al. [81]. At a mean follow-up of 12 months (range 4–26), they reported an overall success rate of 94.4 %. A patent bladder neck was achieved in 72 % of the patients after one procedure, in 17 % after two procedures, and in 5.6 % after four procedures. For a reliable evaluation of this technique, a longer follow-up is needed, in particular with regard to a recurrence-free interval, as this is reported up to 21.4 months before recurrence after endoscopic treatment of BNC [53].

Based on the literature, our algorithm of treatment of BNC after TURP consists of inverse Y-shaped incision combined with resection of the bladder neck under consideration of the extent of the stricture. In recurrent BNC, up to three endoscopic interventions are performed in an ascending aggressiveness of the resection. After three failures of endoscopic treatment, an open surgical approach is preferred.

After Radical Prostatectomy

In the treatment of anastomotic strictures, there should be differentiation between early "immature" strictures that occur within days to weeks after catheter removal and "mature" scarring, which mostly occurs within the first 6 months [50]. For early postoperative BNC, urethral dilatation with sounds or filiforms and followers is indicated [53]. In both cases, cystoscopic placement of a guidewire or long filiform reduces risk of false passage or disruption of a recent anastomosis. Dilatation allows spontaneous voiding while the scarred region stabilizes. The success of dilatation in these circumstances is low [50], although some series report long-term favorable outcomes with this approach [10].

For strictures that fail initial dilatation or occur more than 6 weeks after RP, we recommend an attempt of cold-knife incision of the vesicourethral anastomotic stricture in an inverse Y-shaped manner as described by Giannari et al. previously [82]. For an initial attempt of direct vision internal urethrotomy, success rates of 87 % are reported by Yurkanin et al. in 61 cases with a mean follow-up of 31 months [83]. The incisions should be carried down to bleeding tissue, but we refrain from excessive coagulation as this facilitates regrowth of scar, because of thermal effects on deeper tissue. For the same reason, we resign laser incision of BNC, although other authors report success rates up to 86 % with this technique [84].

Due to the possibility of the resection of the scarred tissue of recurrent strictures, transurethral resection of the BNC seems to be superior to the cold-knife incision. For this technique success rates up to 100 % are published by Popken et al. in 15 patients with a follow-up of 12–72 months [53]. The technique of resection of the bladder neck for BNC is considered to be a high-risk procedure regarding incontinence. Suraya et al. observed incontinence in three of four patients after stricture resection [9]. Accordant with other publications, in our experience the external sphincter region is not endangered by a meticulous resection in the standard situation [9]. In recurrent BNC a transurethral resection of the bladder neck is carried out with increasing aggressiveness up to three times before performing open reconstruction in our department.

The risk of incontinence due to aggressive resection of the bladder neck must be weighed against the likelihood of long-term bladder neck patency. In most cases the patients are highly symptomatic and willing to accept the risk of incontinence after multiple previous interventions for recurrent BNC. If an incontinence occurs, treatment by male sling or implantation of an AUS is a safe procedure with a high rate of success and satisfaction. Implantation of an AUS after BNC should be performed with a distal double cuff position to offer the possibility to carry out transurethral surgery without endangering the cuffs if a recurrence of BNC occurs (Figs. 22.4 and 22.5).

Key Points

Transurethral Resection of the Bladder Neck

- Urethroscopy for identification of the stricture and placement of a guidewire to prevent a false passage.
- Incision with Collings knife in an inverse Y-shaped manner at 4, 8, and 12 o'clock
- Inspection of the bladder with visualization of the urethral orifices.
- Inspection of the external sphincter using the hydraulic sphincter test: after emptying of the bladder, the resectoscope is brought beyond the sphincter region; cutting the water flow by digital pressure of the pipe will contract the

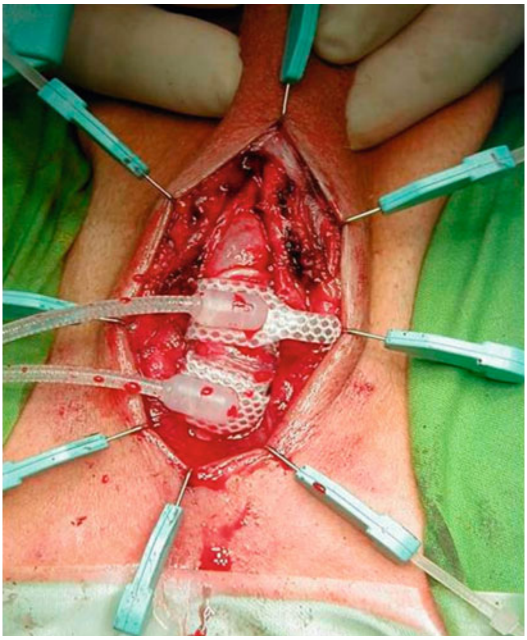

Fig. 22.4 Placement of distal double cuffs at AUS implantation

Fig. 22.5 Plain x-ray film showing AUS location (Note balloon, pump and cuff are filled with contrast)

sphincter concentric due to the change of hydrostatic pressure.

- Resection of the scarred tissue until periprostatic fat is reached under meticulous protection of the sphincter region.
- Avoid excessive coagulation; small bleedings will stop by itself.
- Placement of an 18–20 French catheter for up to 48 h.
- Figure 22.6a–d.

Potential Problems

Transurethral Resection of the Bladder Neck

- In a nearly completely obstructed bladder neck, it may be necessary to fill the bladder with methylene blue by suprapubic puncture. With hand-assisted suprapubic pressure, the lumen can usually be identified and sounded by a hydrophilic guidewire.

Surgical Management: Open Reconstruction

Surgical management of posterior postprostatectomy urethral stricture differs considerably, depending on the primary surgery (treatment for benign prostatic hyperplasia or radical prostatectomy) and concomitant risk factors such as prior radiation therapy and life expectancy. Also, a preexisting incontinence needs to be assessed and considered for planning of the surgery. In open reconstruction, a suprapubic catheter is placed if urinary diversion is required, and the reconstruction postponed until 3 months after the last transurethral manipulation to ensure final stabilization of scar tissue growth. Urinary diversion can be performed at any time after endoscopic treatment, and the principles remain standard in terms of selection of diversion type and timing.

After Treatment for Benign Prostatic Hyperplasia

For highly recurrent BNC after treatment for benign prostatic hyperplasia, usually a YV reconstruction as described by Young [85] can be performed. Only in rare cases it is necessary to perform a bulbo-bladder neck reanastomosis, if a long-segment stenosis is found. However, in these cases an abdominal approach yields the best access, allowing for YV reconstruction or a reanastomosis. In both techniques, urinary incontinence can occur postoperatively. For these patients, simultaneous AUS placement has been

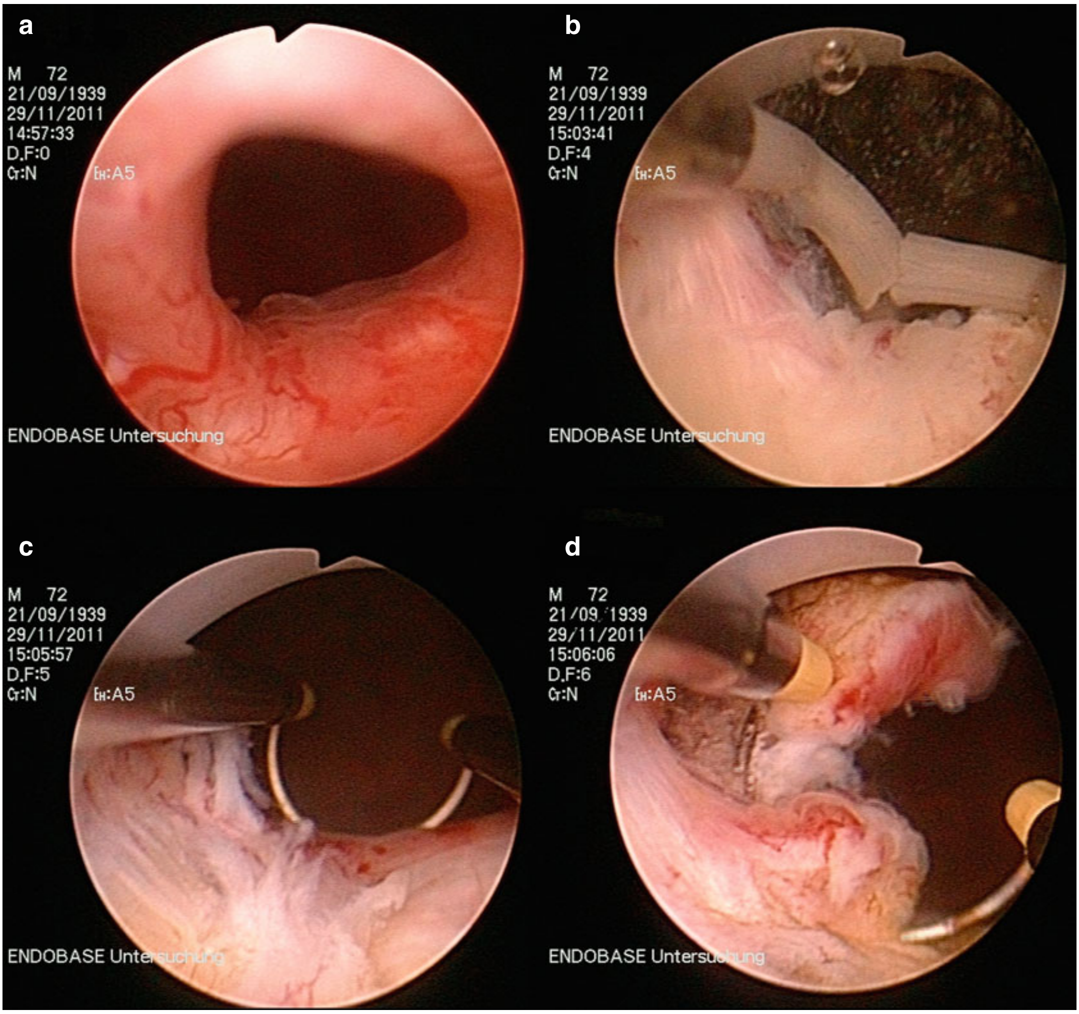

Fig. 22.6 Bladder neck contracture (**a**) Bladder neck incision (**b**) and resection (**c, d**)

advocated [86]. However, we prefer a two-staged approach, to ensure a stable patent bladder neck at time of AUS implantation and to reduce the risk for AUS infection. If required and if the patient remains free of a recurrence of the BNC, the AUS is implanted 3 months after surgery and activated 6 weeks after implantation.

After Radical Prostatectomy

Although endoscopic treatment is highly effective in the treatment of posterior postprostatectomy strictures, a small number of patients suffer from highly recurrent BNC despite numerous attempts of endoscopic treatment. In these patients urinary diversion is often considered as the last resort [87], leaving the patient with a catheterizable or incontinent urostomy. Unfortunately, this decision is often made without referral to a major urologic reconstructive center, as in these patients, an open reanastomosis can be successfully performed in experienced hands [1]. Possible surgical approaches are a perineal, an abdominal, or a combined access. As open reconstruction is a challenging procedure, a reconstructive surgeon with a wide armamentarium is required in these patients [1].

For retropubic reanastomosis, access is gained via an abdominal midline incision. The bladder neck is dissected, all scar tissue is excised, and the ureters are stented. Subsequently, the urethra is exposed with a 24 French Grunwald retractor, an instrument facilitating the placement of sutures. The anastomosis is performed using 5–8 3/0. Biosyn (Glycomer™ 631) sutures. Afterwards, the incision is closed in layers. The advantage of this approach is excellent bladder neck exposure and mobilization as well as allowing for preservation of continence if the external sphincter is intact.

In our own series of 20 patients [88], BNC recurred in 40 % of patients, while the remaining 60 % were recurrence-free. All but one recurrence were successfully treated endoscopically, resulting in an overall combined success rate of 95 % at a median follow-up of 59.2 months. We suggest treatment by cold-knife incision for BNC recurrence after open reanastomosis was more effective due to the previous meticulous scar tissue removal.

Urinary diversion consequently was performed in only 5 % of these patients for BNC recurrence after reanastomosis and consecutive endoscopic treatment. However, 31 % had de novo incontinence, which can easily be treated by implantation of an AUS.

Another option is a transperineal reanastomosis [89–91] with the advantage of surgery in virginal tissue after retropubic surgery. This approach allows mobilization and resection of scarred tissue in distal and proximal direction and suturing of the anastomosis under direct vision and for fistula closure in the same session, adjunctive tissue transfer can easily be performed if required. If transsphincteric mobilization of the urethra is required to achieve a tension-free anastomosis, de novo urinary incontinence is a known consequence.

In recent years, we have used the perineal approach rather than the retropubic and found excellent results. At a mean follow-up of 13.4 months (range 6–35 months), recurrence-free survival after reanastomosis was achieved in 15 patients (93.3 %). After one additional cold-knife incision, the final success rate was 100 %. Again, we suggest that incision after open reanastomosis was more effective due to the previous scar tissue removal. An improvement in quality of life by this approach was noted in 86.7 % of cases, 13.3 % reported no change. Patients' satisfaction with the outcome of the procedure was high or very high in 86.7, 13.3 % were undecided.

For successful perineal reanastomosis, adequate exposition is of utmost importance. The patient is placed in an exaggerated lithotomy position, and a perineal incision in a half-moon manner is performed. Next, dissection of the urethra is done under recto-digital palpation using an "O'Connor" rectal shield (Figs. 22.7 and 22.8).

The scar tissue is completely excised, starting from the urethral lumen until healthy tissue is reached. For better orientation and identification of the distal end of stricture, a 22 French catheter is inserted. Wide mobilization of urethra and bladder is mandatory for tension-free anastomosis of the bulbar urethral stump and the bladder neck. After dorsal spatulation of the anterior urethra, interrupted 3/0. Biosyn (Glycomer™ 631) sutures are placed from distal to proximal and tied under direct visual control. After control for leak tightness and placement of 18 French transurethral catheter, reconstruction of bulbourethral muscles and closure of perineal fascia are performed, followed by

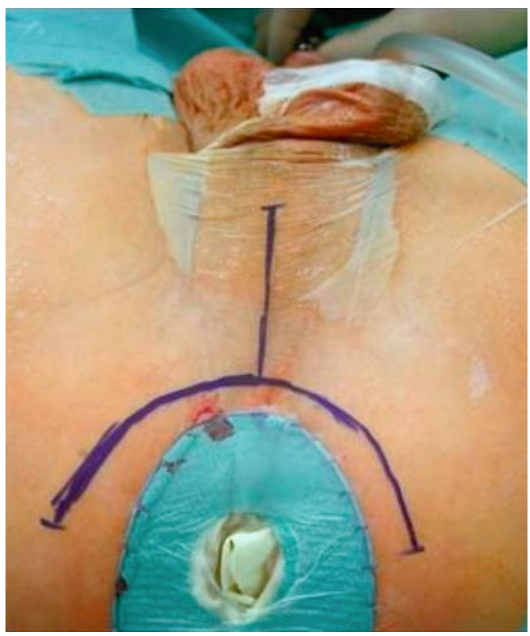

Fig. 22.7 For transperineal reanastomosis, access is gained via a half-moon incision

closure of the incision in layers. At last a suprapubic catheter is placed. Removal of the transurethral catheter is performed at day 21 postoperative, followed by a VCUG (Fig. 22.9a, b).

In general, all patients undergoing open reconstruction have to be aware that an implantation of an AUS may be required after surgery, as the urinary sphincter may not be present or functional after radical prostatectomy [1] and can be damaged at open bladder neck reconstruction.

We reserve urinary diversion for patients with complicating factors such as prior radiation treatment, severe neurogenic bladder with low functional volume, after failed open reconstruction. In these patients, principles remain standard in terms of selection of diversion type and timing. Even after irradiation of the prostatic fossa only, we prefer a continent vesicostomy using appendix or tapered ileum according to the Mitrofanoff principle. In patients with a small bladder capacity or after irradiation of the true pelvis, cystectomy and urinary diversion (pouch or conduit) using large bowel segments are performed.

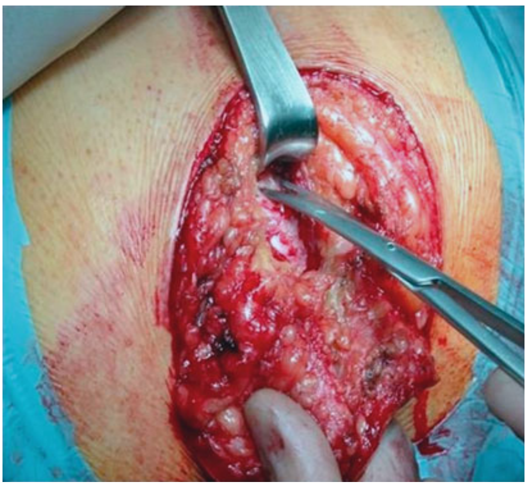

Fig. 22.8 Urethral dissection under recto-digital palpation

Surgical Pearls and Pitfalls

Key Points

Retropubic YV Plasty After BPH Treatment

- Access is gained through a midline incision, and the perivesical space and the bladder neck are defined.
- The bladder neck is incised in a Y-shape and sutured in a V-shape, thus widening the bladder outlet.

Retropubic Reanastomosis

- Access is gained through a midline incision, and the perivesical space and the bladder neck are defined.
- Scar tissue at the bladder neck and the proximal urethra is completely resected and the bladder neck is mobilized.
- A Grunwald retractor is inserted into the urethra and used to promote suture placement for the reanastomosis.

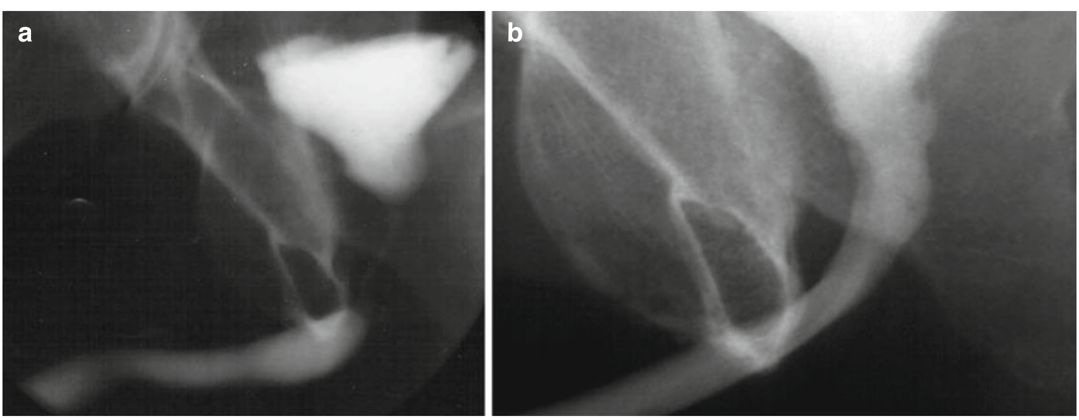

Fig. 22.9 (**a** and **b**) Pre- and postoperative view of the urethra at combined RUG/VCUG

- In case of a concomitant anastomotic fistula, an omentum or peritoneal flap can be placed to prevent fistula recurrence.

Perineal Reanastomosis

- Position in the exaggerated lithotomy position.
- Crescent-shaped perineal incision and urethral preparation under recto-digital palpation.
- Scar tissue at the bladder neck and the proximal urethra is completely resected and the bladder neck is mobilized.
- Reanastomosis of urethra and bladder neck under direct vision.
- In case of a concomitant anastomotic fistula, tissue interposition (gracilis, fat, or bulbospongiosus flap) is possible to prevent fistula recurrence.

Potential Problems

- Large gaping bladder neck: reconstruction by trigonizing the bladder neck
- Involvement of the ureteral orifice in the scar tissue: ureteral reimplantation
- Difficulty at establishing a tension-free anastomosis: combined abdominoperineal approach

Preferred Surgical Instruments and Suture Material of M. Fisch

Retropubic YV Plasty
Grunwald retractor
Perineal Reanastomosis
Scott retractor
Nasal speculum
Pair of very long fine-needle holders
Urethral Anastomosis
Suture material Glycomer™ 631 3/0 for perineal anastomosis: j-curved needle

Editorial Comment

Open reconstruction of bladder neck contractures and postprostatectomy anastomotic obliteration is a challenging endeavor. I like an abdominoperineal approach with partial pubectomy, which provides good visibility and excellent results. The lower abdominal incision with partial pubectomy allows wide resection of scar, while a concomitant perineal incision enables mobilization of the urethra, which is then passed up into the pelvis for tension-free anastomosis from above. Although the trend is toward managing postprostatectomy obliterations via a perineal approach alone, our experience with this approach has been hampered by limited visibility in a bloody field.

–Allen F. Morey

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Radiotherapy-Induced Urethral Strictures

23

Steven B. Brandes

Summary

The overall incidence of bulbomembranous urethral stricture or bladder neck contracture after radiation therapy is roughly 3–16 %. Time to stricture presentation is usually delayed (24 months) and insidious. Radiation urethral strictures typically have an unhealthy or pale appearance on cystoscopy, with varying degrees of local tissue induration or dense fibrotic scarring. Radiation-induced urethral strictures are often refractory to urethrotomy or dilation and merely palliative and require successive treatments. Management methods include intermittent self-catheterization, off-label use of an endourethral prosthesis, excision and primary urethral anastomosis urethroplasty, onlay flap and graft urethroplasty, salvage prostatectomy with anastomotic urethrovesical urethroplasty, combined abdominoperineal urethroplasty, onlay flap urethroplasty, and supravesical urinary diversion surgery. Urethroplasty seems to be feasible and reasonably successful for RT strictures in the short term, with the best results with anastomotic urethroplasty.

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Radiobiology

Radiation tissue damage occurs from either direct ionization or indirect ionization – where free radicals are formed as radiation interacts with intracellular water. The ultimate effect is free radical damage to DNA, causing impaired replication and protein synthesis. The effect of ionizing radiation on normal tissues is dependent on radiation total dose, dose fraction size, total volume treated, and elapsed time.

Radiation causes both acute and chronic effects on tissue. Acute effects usually occur within 2–3 weeks of therapy, while chronic effects can manifest months to years later. Tissues with a rapid cell turnover such as skin and mucous membranes are most susceptible to the acute effects of radiation. Chronic tissue damage is characterized by cell ischemia and fibrosis. Multiple theories have been postulated to explain chronic effects, these including microvascular damage and stem cell injury. The result is vascular damage characterized by endothelial proliferation and an obliterative endarteritis leading to ischemia and fibrosis of the effected and surrounding tissue.

Onset of subacute and chronic complications after radiotherapy is typically from 6 to 24 months [1]. However, some chronic complications, such as bleeding, fibrosis, and scarring, can occur even after decades. In general, some of the comorbid conditions that predispose to radiation complications and vascular damage are diabetes mellitus, hypertension, cardiovascular disease,

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prior surgery, and concomitant radiation sensitizing chemotherapy.

There have been tremendous advances in tumor localization with radiation therapy over the last 20 years. Originally, radiation oncologists used skeletal anatomy to guide the radiation beams. Prostate cancer was treated by aiming the beams at the area between the pubic symphysis and femoral heads. Computed tomography (CT) scanning, more widely utilized in the 1990s, allowed three-dimensional visualization of the target organ. This lead to more advanced techniques, termed three-dimensional conformal radiation (3DCRT), which employ sophisticated software to allow the radiation to "conform" to the shape of the target organ. Such advances maximize dose delivery to the target organ while limiting the amount of radiation delivered to surrounding organs [2].

Prostate brachytherapy (BT) achieves a high radiation dose to the prostate with a rapid falloff in the adjacent normal tissue [3]. Seeds are placed in a distribution to generally "spare" the prostatic urethra. The number and percent of men treated with BT has increased dramatically since the 1990s. Preimplant prostate volume and severe LUTS symptoms (as evidenced by a high AUA SS) are associated with higher post-BT urinary toxicity. Published rates of urethral morbidity are from the most experienced providers and centers, and thus the true incidence of complications is probably higher and underreported. Urethral strictures that result from BT typically involve the bulbomembranous urethra and result in obstructive voiding. In severe cases, the posterior urethra can be obliterated and require extensive reconstruction or supravesical diversion. Intensity-modulated radiotherapy (IMRT) is the next generation of 3DCRT that uses a combination of CT scanning and computer software to deliver high levels of radiation with better tumor targeting while minimizing exposure to surrounding organs.

Grading of Radiation Morbidity

The Radiation Therapy Oncology Group (RTOG) established a grading system for radiation complications. The system is based largely on the patients' performance status and what level of intervention is required. See Table 23.1 for the detailed morbidity scale to the urinary tract. Grades 1–2 describe minor treatment-related morbidities that require only outpatient care. Grades 3–4 result in more serious sequelae and require either hospitalization or surgical intervention (Fig. 23.1).

Table 23.1 Modified RTOG urinary toxicity scale

Grade	Description
1	Symptomatic nocturia and/or frequency requiring no therapy
2	Early obstructive symptoms requiring α-blockade and phenazopyridine
3	Requiring indwelling catheters or intermittent catheterization
4	Requiring postimplantation TURP, TUIP, urethral dilation, or suprapubic catheter placement

Adapted from [4]

TUIP transurethral incision of the prostate, *TURP* transurethral resection of the prostate

Incidence and Risk Factors

Incidence

The overall incidence of bulbomembranous urethral stricture or bladder neck contracture (BNC) following radiation therapy is roughly 3–16 % [1]. Time to presentation is typically 12–36 months (mean, roughly 24 months), and the typical presentation is obstructive and irritative voiding symptoms. Elliot et al. [1] in their analysis of the CaPSURE database (mostly community practices) noted that postradiation therapy strictures incidence was initially very low (near zero) but over time increased at a steady rate to 5–16 % by 4 years. Table 23.2 presents details of the rates of urethral stricture development by the type of prostate cancer therapy. The highest rates occur after radical prostatectomy and brachytherapy plus EBRT. As you can see from the actuarial life table analysis in Table 23.3, radical prostatectomy strictures typically occur in the first 6 months postoperatively, with the rates tapering off by 1 years and totally flatten out after 2 years. In con-

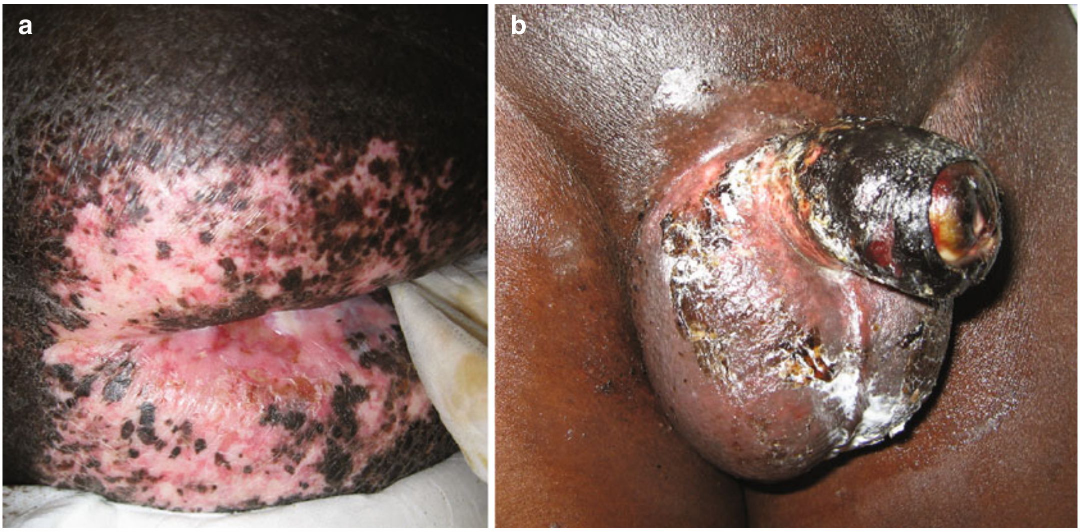

Fig. 23.1 Pendulous urethral stricture, urinary retention, and penile dry gangrene after pelvic RT for clinically localized prostate cancer in a diabetic with severe peripheral vascular disease. (**a**) RT skin changes of buttock (**b**) Penile dry gangrene

Table 23.2 Stricture incidence by type of prostate cancer treatment

Treatment	No. pts/no. stricture (%)
RP	3,310/277 (8.4)
RP+EBRT	73/2 (2.7)
Cryosurgery	199/5 (2.5)
BT	799/14 (1.8)
BT+EBRT	231/12 (5.2)
EBRT	645/11 (1.7)
ADT	961/19 (2.0)
WW	378/4 (1.1)
Total	6,597/344 (5.2)

From Elliot et al. [1]
Follow-up not considered

trast, the incidence of post-RT strictures initially was very low but over time increased at a gradual and steady rate. In other words, as in other areas of radiotherapy damage, the RT effects on the urethra and bladder neck are typically delayed and insidious.

Astrom and Pedersen [5] in 214 patients receiving high-dose brachytherapy for localized prostate cancer 13 (7 %) developed urethral strictures, one of whom, an obliterative stricture requiring urinary diversion. The median latency time was approximately 3 years [6]. Zelefsky et al. [7] in 248 patients who underwent I^{125} BT had a 10 % 5-years actuarial stricture rate. All their strictures occurred within the first 24 months (mean time till stricture 18 months). Galalae et al. [8] describe a 2.7 % incidence of urethral stricture after brachytherapy (4 of 148 patients), with a median 5-years follow-up. All four of those patients had TURP prior to radiation therapy. Demanes Rodriguez [9] also report a 6.7 % stricture rate after high-dose brachytherapy. In their series however, 8 % had preexisting strictures. Martinez and Pataki [10] reported a 5-year actuarial risk of 7 % as well. Of interest, Albert et al. [11] reported a urethral protective effect of MRI-guided brachytherapy such that the seeds are directed away from the prostatic urethral mucosa. In their multicenter trial, there were no urethral strictures over a median 2.8-year follow-up period [11].

Risk Factors

Multiple risk factors for the development of radiation strictures have been examined. History of TURP prior to radiation therapy has been implicated as a cause of urethral stricture and BNC. Sullivan et al. [12] noted that independent

Table 23.3 Actuarial table of stricture free rates after prostate cancer therapy

	% stricture treatment free (95 % CI)			
Primary treatment	6 months	1 year	2 years	4 years
RP	93 (92–94)	91 (90–93)	91 (89–92)	89 (86–91)
RP+EBRT	97 (88–99)	95 (85–98)	95 (85–98)	86 (46–97)
Cryotherapy	96 (92–98)	96 (92–98)	95 (89–98)	87 (66–95)
BT	96 (94–97)	94 (92–96)	93 (90–95)	89 (80–94)
BT+EBRT	96 (92–98)	92 (87–95)	88 (91–93)	84 (71–92)
EBRT	99 (97–99)	98 (96–99)	96 (93–97)	95 (90–98)
Hormones	96 (94–97)	94 (92–96)	93 (90–95)	92 (87–95)
WW	99 (97–100)	99 (97–100)	98 (95–99)	93 (68–99)

From Elliott et al. [1]
Log rank test $p < 0.01$

predictors for stricture development were HTN (HR 2.83), prior TURP (HR 2.81), and higher dose per fraction. Greskovich [13] reported a higher rate of stricture in patients who underwent prior TURP. Seymore et al. [14] noted that 72 % of the patients who developed bladder neck contractures after radiation therapy (RT) to 68Gy had a prior TURP[1] (mean 33 days before). The likely mechanism of stricture formation is ischemia and micro-fibrosis following cautery use (especially at the bladder neck, resulting in inability of the area to repair endothelial damage caused by radiation). To reduce the risk of such strictures, they recommended an interval between surgery and prostate RT of at least 6 weeks.

Merrick and Butler [3] examined a series of 1,186 patients who underwent brachytherapy and noted that the overall radiation dose to the bulbomembranous urethra and the use of concurrent external beam therapy correlated with urethral stricture formation (see Fig. 23.2, Merrick and Butler [3]). The higher the average urethral dose of radiation, the higher the rate of stricture (Fig. 23.2). All strictures involved the bulbomembranous urethra and <1 cm from the apex of the prostate. This stresses the need for very careful preplanning for brachytherapy and the use of supplemental XRT in a judicious manner. Careful seed placement and prostatic apical urethral sparing are essential. Merrick and Butler [3] reported 3.6 %, 9-years actuarial risk of urethral stricture disease, with a mean time to presentation of 2.6 ± 1.3 years. These patients presented with gross or microscopic hematuria, increased IPSS score, late onset dysuria, or

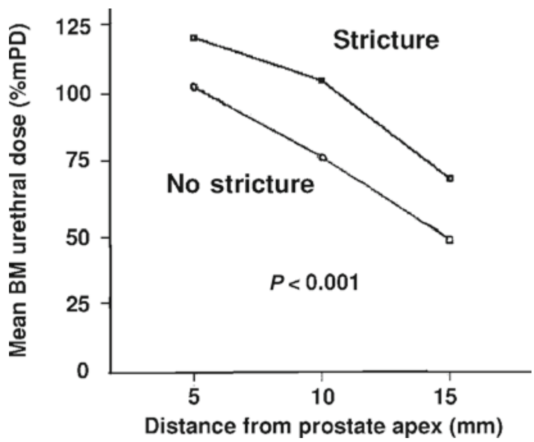

Fig. 23.2 Differences in urethral stricture rate after brachytherapy, as based on urethral RT dose at different distances from the prostate apex (*BM* bulbomembranous) (Redrawn from Merrick et al. [3])

increased post-void residual. Strictures were diagnosed by cystoscopy. Of those who developed strictures, roughly one-third had recurrent strictures after initial management. Wallner et al. [6] also reported an association of the late urethral toxicity and maximum urethral dose from I^{125} BT. For patients with grade 2 and 3 toxicities, average maximal urethral dose was 592 cGy compared to only 447 cGy for none to minimal late toxicities.

Therefore, overly aggressive implantation of BT seeds in the periapical region increases the risk for urethral stricture. With careful attention to planning and implant technique, including extensive use of the sagittal plane for intraoperative deposition of the seeds, it is possible to implant the apex within a 5 mm margin without excessive doses to the urethra. Clearly surgeon skill and dose planning are key.

Urethral Stricture Histology

There is little in the literature that describes the histopathology of the urethral strictures. Early changes in the formation of anterior urethral stricture are initial ulceration with subsequent proliferation of a stratified squamous epithelium with infiltration of elongated myofibroblasts and clumps of multinucleated giant cells. The proliferation of myofibroblasts has been proposed as causative factors for stricture formation, and giant cells are thought to promote collagen synthesis in the strictured area. Chamber also reported a change in the urethral epithelium which led to an increase in permeability of urine. Extravasating urine through this "leaky" urethra can cause a fibrotic reaction and narrowing of the urethral lumen. Lastly, Blandy described stricture formation as a result of microabscess formation in periurethral glands and extending into the corpus spongiosum.

Baskin and Constantinescu [15] describe an increase in the ratio of type I and type III collagen deposition within urethral strictures compared to the normal urethra. Cavalcanti and Yucel [16] also describe the functional role of nitric oxide in wound healing and collagen deposition within the bulbar urethra. They postulated a causal relationship between the loss of smooth muscle and increase in collagen deposition and lack of responsiveness to nitric oxide. Those patients were thought to have injury to the neuronal innervation of the bulbar urethra leading to a decreasing responsiveness to NO. In addition they found that there was a decrease in the vascularity of the surrounding corpora spongiosum.

Radiation therapy is known to cause fibrotic changes which, in the setting of stricture, mimics or even intensifies the process that worsens the clinical course of the stricture. So the radiation itself may not initiate the stricture, but it certainly exacerbates even the slightest insult (ischemic, traumatic, or inflammatory) to result in a more clinically relevant stricture process.

Stricture Evaluation

Typically evaluation begins with thorough history and physical exam. Often patients treated with XRT can have a component of radiation cystitis which may present with irritative symptoms, dysuria, and/or gross or microscopic hematuria. As with the evaluation of all strictures, regardless of etiology, urethrography is the gold standard for evaluation. It should always be performed under the direct supervision of the urologic surgeon who will be managing the stricture in order to obtain a full understanding of the length, location, and caliber of the stricture. In general, we find cystoscopy useful to visualize the color appearance of the epithelium (pink or gray) and lumen size, as to the stricture being obliterative or nonobliterative. Direct palpation of the urethra can also help assessment of the degree of spongiofibrosis – the more firm to palpation, the more severe the spongiofibrosis.

Management of Radiation-Induced Urethral Strictures

In general, radiation impairs the healing potential of tissues, particularly as a result of endarteritis hypovascularity, decreased intrinsic cellular vitality, and interstitial fibrosis. Radiation urethral stricture typically has an unhealthy or "washed leather" appearance on cystoscopy and has varying degrees of local tissue induration or dense fibrotic scarring.

Merrick and Butler [3] noted that 29 of 1,186 patients developed a membranous or proximal bulbar urethral stricture after prostate brachytherapy. All 29 strictures were initially managed by dilation or urethrotomy. Roughly one-third (9/29) had recurrent strictures requiring repeat urethrotomy and intermittent self-catheterization to prevent restenosis. Of these 9, 3 became obliterative and refractory strictures and thus were eventually managed with suprapubic urinary diversion (Fig. 23.3a, b). Thus, it appears that roughly one-third of BT related urethral strictures are recurrent, and of these, one-third are devastating, requiring a urinary diversion. Of all the BT-treated patients, the need for supravesical diversion

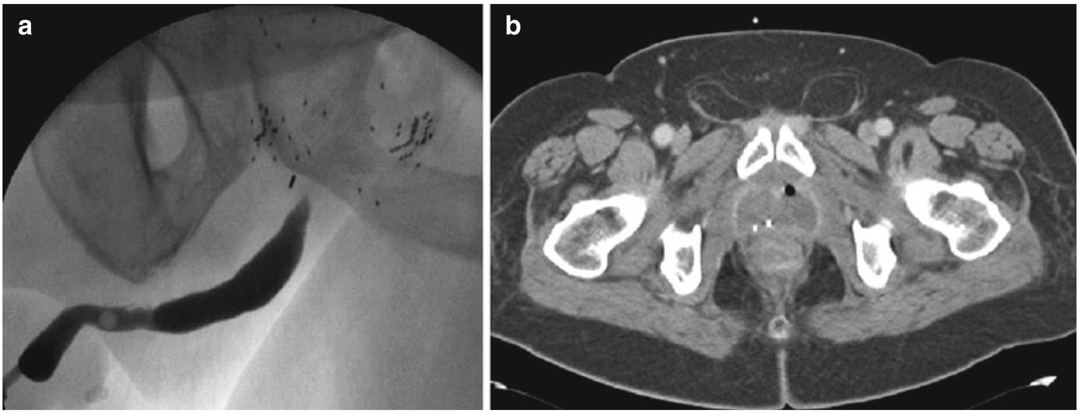

Fig. 23.3 (**a**, **b**) Prostate liquefaction and obliterative prostatic and membranous urethral strictures after prostate brachytherapy. Note poor distribution of seeds due to tissue liquefaction

translates to a 0.25 % incidence. Others have also noted that most post-BT urethral stricture are minor and can be managed by an endoscopic means. Ragde [17] noted 12 % bulbomembranous strictures at a median follow-up of 69 months. Of all their urethral strictures, most were short and managed by urethral dilation with and without self-catheterization.

Refractory Radiation Strictures

In contrast, Moreira et al. [18] reported their experience with severe BN contractures after I^{125} BT in seven patients. All seven had recurrent contractures, each of whom had failed at least three or more intraoperative transurethral incisions. Final management consisted of self-catheterization in 1, indwelling Foley catheter in 1, and open reconstruction and supravesical urinary diversions in the remaining 4/7. Of these diversions, 3 underwent enterocystoplasty and continent catheterizable stomas and 1 a salvage cystoprostatectomy and Florida pouch catheterizable urinary diversion. All the diversion patients reported successful urinary control and improved quality of life after reconstruction.

In our experience, radiation-induced urethral strictures are typically refractory to urethrotomy or dilation and thus more mimic the South Florida experience [18]. The large proportion of radiation urethral strictures we have treated are typically complex and management dilemmas; yet, this may have more to do with our referral practice, rather than to conclude that minor strictures do not occur after RT. The methods that we have employed over the years with our refractory radiation-induced strictures have been urethrotomy and intermittent self-catheterization (Fig. 23.4), off-label use of the Urolume ^{R} endourethral prosthesis (Fig. 23.5a, b), EPA urethroplasty, salvage prostatectomy with anastomotic urethrovesical urethroplasty, combined abdominal-perineal urethroplasty, onlay flap urethroplasty, or supravesical urinary diversion surgery.

Hyperbaric oxygen (HBO) therapy had been shown to help stimulate angiogenesis, which can help to physiologically repair the baseline obliterative endarteritis-induced ischemia. Treatment typically requires breathing 100 % oxygen at two atmospheres of pressure for 2–3 h per day for a total of 40–60 sessions. HBO has been utilized with varying results with bladder complications and fair results with grade 2 and 3 rectal complications. Theoretically, HBO could be used as an adjunctive method to promote angiogenesis of the urethra and thus improve the success of a subsequent urethroplasty or a staged reconstruction. However, this is all theoretical and there are no reports in the literature to support its practical value.

Fig. 23.4 Radiation-induced bulbar urethral stricture after EBRT for prostate cancer, managed successfully by urethrotomy and BID intermittent self-catheterization ×2 years. RUG demonstrates traumatic self-catheterization resulting in proximal bulbo-rectal fistula. Rocky septic course eventually managed by end colostomy, abdominal washout, and SP tube diversion

Urethral Dilation and Urethrotomy

We recently reviewed our institutional experience at Washington University with 76 men with urethral stricture out of 3,579 (2.1 %) men who were treated with pelvic RT for prostate cancer from 1983 to 2007. Treatment modalities included brachytherapy (BT), external beam radiotherapy (EBRT), and brachytherapy plus external beam radiotherapy (CRT). Population demographics, age at time of radiotherapy, and comorbidities were similar between groups. HTN (69 %) and smoking (53 %) were prevalent. Mean pre-procedure flow rate, AUA symptom scores, and post-void residuals were similar, 6.1 ml/s, 20.8, and 265.3 ml, respectively. Median time to stricture was 26 months, with CRT in 11 months. 72 % developed posterior strictures (mean 1.8 cm). CRT strictures were mostly >4 cm and obliterative. Initial management was dilation or optical urethrotomy in 82 %. Recurrence rates were high, >80 % requiring >2 procedures (mean, 3.4). CRT required the most treatments (4.4). Time till recurrence shortened with each treatment (BT 3.7–2; EBRT 26–9 months).

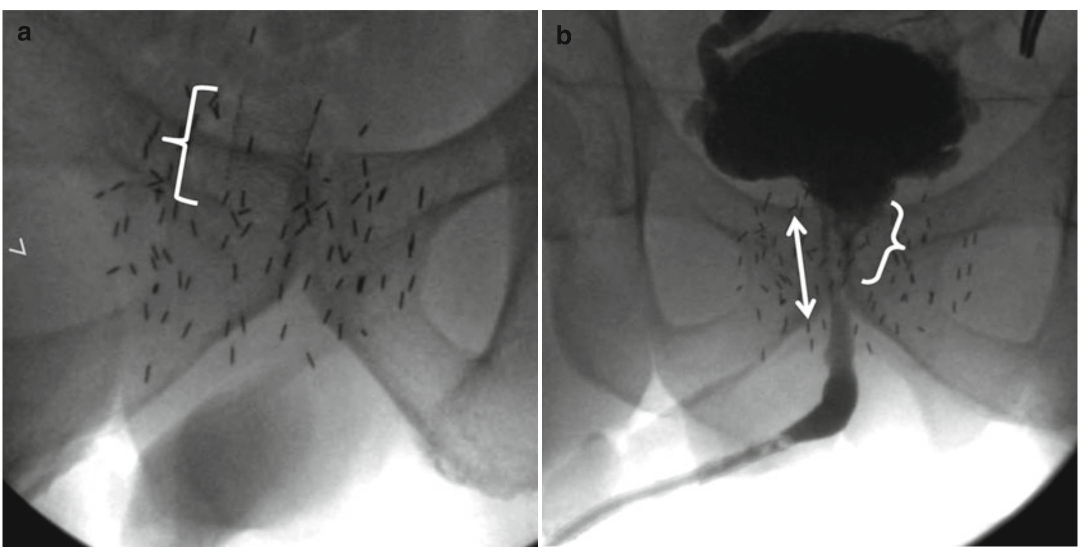

Fig. 23.5 (**a**) Urolume stent (see *white brackets*) at bladder neck in a brachytherapy patient. (**b**) Retrograde urethrogram noting a 3 cm stricture (see *double sided arrow*). *Brackets* denote Urolume stent

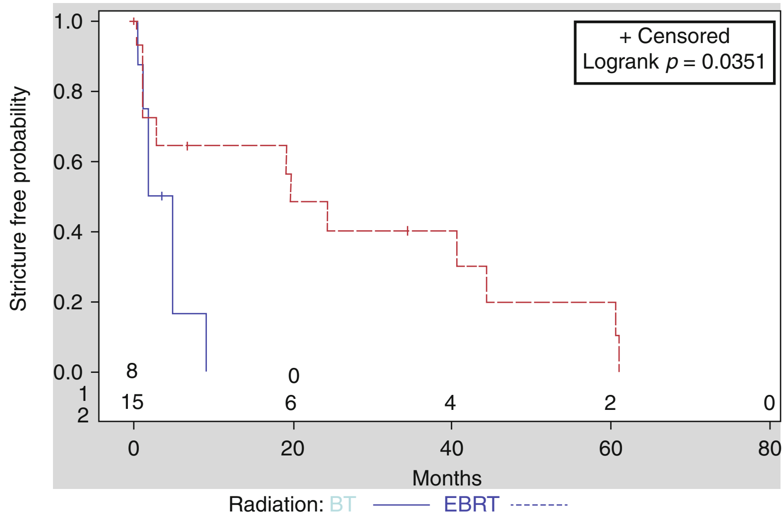

Fig. 23.6 Success after DVIU or urethrotomy for *EBRT* and *BT*

Overall, post-RT urethral strictures were usually short and often can be managed with dilation or urethrotomy. However, nearly all strictures recur in the short term and successive procedures are needed. Long strictures, usually after CRT, often require numerous futile re-treatments.

Stricture Length

Most studies on urethrotomy or dilation for urethral stricture in the literature do not report pretreatment stricture length. Moreover, of the reported series of RT urethral strictures managed endoscopically, none report stricture length. Steenkamp et al. [19], in non-RT etiology stricture patients, noted that recurrence rates after urethrotomy (OIU) for strictures <2 cm at 12 months was 40 % and >4 cm 80 %. For strictures 2–4 cm, recurrence rates were 50 % at 12 months and 75 % at 48 months. In our series, mean RT stricture length was 2.5 cm, so that chances for long-term success for treatment, we could have predicted to be poor. Mean success after dilation or OIU for our EBRT strictures was 26 and 3.7 months for BT (Fig. 23.6). BT mean stricture length was 2.4 cm and location BM (81 %) – both no different than EBRT strictures. Therefore, the cause for such high failure with BT urethral stricture after OIU and dilation is probably from high dose fraction of radiation (not stricture length or location). Moreover, EBRT does seem to adversely affect strictures response to urethrotomy and OIU as our success rates were similar to radiation-naïve series [19, 20]. Our stricture lengths, however, were significantly longer for CRT etiology at 3.5 cm and more typically obliterative at 40 %. CRT is a method of dose escalation RT, where 125–145 Gy is typically delivered (well beyond IMRT and 3DCRT levels of 78–84 Gy) [21]. CRT strictures occurred more quickly at 10.9 months. They also required on average more procedures (>3) to keep them open. Our high failure rate to minimally invasive methods for such CRT strictures are probably due to higher dose per fraction and radiation dose to the urethra [3, 12]. This further stresses the need for very careful seed placement and urethral sparing.

Successive Urethrotomy/Dilation

Successive urethrotomy/dilation is palliative, with poor durability and little efficacy. After 48 months of follow-up of our BT strictures, after the first, second, and third urethrotomy, recurrence rates were 100, 100, and 100 %, respectively (Fig. 23.7). After 48 months of our EBRT strictures, recurrence rates were 80 % after the first urethrotomy. Pansodoro and Emiliozzi [20] found similar, high 5-year recurrence rates after urethrotomy. In their series of

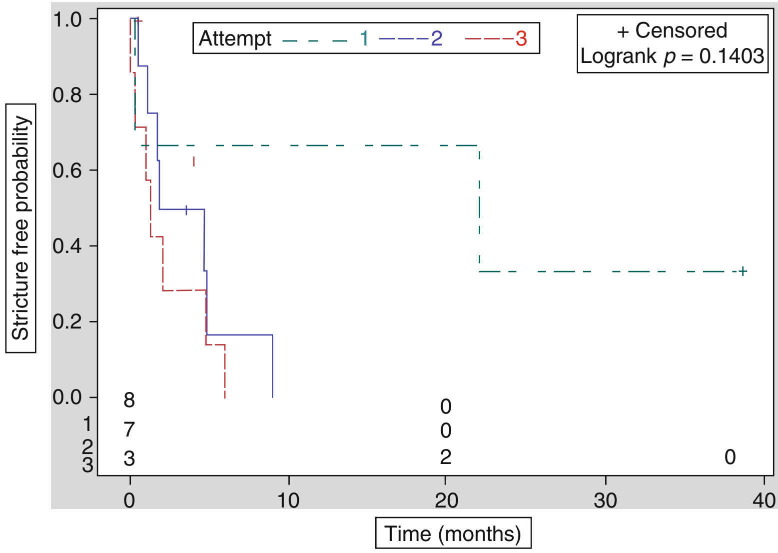

Fig. 23.7 Success after each attempted DVIU or urethrotomy for BT-induced urethral strictures

224 non-RT patients, stricture recurrence rate after 1 urethrotomy was 68 %, while after a second 96 % and after a third or fourth urethrotomy 100 %. Heyns et al. [22] in a prospective randomized trial had similar high recurrence rates and poor durability with urethrotomy. After 48 months of follow-up, after the first, second, and third urethrotomy recurrence rates were 61, 100 %, and 100. 89 % of our RT urethral strictures were initially managed by a minimally invasive method. However, as evidence of the futility of managing RT stricture by dilation/urethrotomy is that overall long-term management of the 72 patients was 28 % intermittent self-catheterization, and 40 % indwelling Foley or suprapubic catheter (60 % with CRT strictures used a Foley). Sullivan et al. [12] with 38 CRT urethral strictures (92 % bulbomembranous) also initially managed all strictures by minimally invasive methods (15/38 dilation and 20/38 OIU). After a median of 16 months, 49 % required repeat therapy. For Merrick and Butler [3], of 29 BT strictures, 31 % recurred. In both of these series, stricture length is not reported, follow-up methods not detailed, and follow-up time short – and this suggests eventual stricture recurrence may be much higher.

Time from urethrotomy or dilation till stricture recurrence for our BT strictures was very short – 3.7 months (after the first) and 2 months (after the second) treatment. In other words, minimally invasive methods for BT strictures are futile and palliative. Time till stricture recurrence also was shortened after the second treatment for our EBRT strictures, from 26 to 9 months. Other studies on urethral stricture (non-RT) report similar findings – where if stricture recurrence does occur after urethrotomy, it occurs soon after the procedure – and with each successive procedure, the time interval to recurrence shortens [19, 20]. Steenkamp et al. [9] noted stricture recurrence greatest at 6 months, while Pansodoro and Emiliozzi [20] noted greatest stricture recurrence with 12 months. Heyns et al. [22] noted similar findings with median time to recurrence after the second treatment at 21 and 4.5 months after the third. As successive urethrotomy or dilation is short-lived and palliative, 80 % of our patients required repeat treatment and most more than three.

Urethroplasty: Feasibility and Viability

Radiotherapy-induced urethral strictures are often difficult to manage due to proximal location, compromised vascular supply, and poor wound healing. Based on two recent reports, it appears technically possible and with reasonable success and durability to perform an open urethroplasty for a radiation-induced stricture. Since buccal and skin grafts rely on the host bed for vascularity (imbibition and inosculation), which is typically compromised in the pelvic irradiated patient, one would think that grafts to the radiated stricture would not be successful. Despite our bias that a graft would be compromised in a radiated field, its results appear to be reasonably successful. Theoretically, a pedicle island skin flap would also appear to be a better choice over a graft for reconstructing the radiated stricture, because it has its own blood supply. Another option for urethral reconstruction is the use of a graft that has been quilted onto a gracilis muscle flap and then used as an onlay flap. See Chap. 18 in this text by Zinman for details of this technique. The best results, however, appear to be for anastomotic urethroplasty, and we favor such an approach, particularly if the stricture is short and proximal (bulbar or membranous).

Glass et al. [23] reported retrospective UCSF data on 29 patients, mean age 69 years, who underwent urethroplasty for radiation-induced stricture. Radiation therapy included EBRT in 38 %, radical prostatectomy and EBRT in 24 %, EBRT and BT in 24 %, and BT alone in 14 %. Stricture length was on average 2.6 ± 1.6 cm and managed mainly by anastomotic urethroplasty in 76 % [23] patients, buccal mucosal graft in 17 % [6], and perineal flap repair in 7 % [2]. Stricture locations were bulbar urethra in 12 (41 %), membranous in 12 (41 %), vesicourethral in 3 (10 %), and panurethral in 2 (7 %). Success rates were highest for EPA at 95 % and BMG at 80 %. Overall success rate was 90 % at a median follow-up of 40 months (range 12–83), with a median time to recurrence of 12 months. Meeks et al. [24] reported a similar successful outcome with urethroplasty for radiation strictures. With 30 men (mean age 67 years), 24 underwent excision and primary anastomosis, 4 a fasciocutaneous skin flap, and 2 a buccal graft. All strictures were bulbomembranous. Mean stricture length was 2.9 cm (range 1.5–7). EBRT for prostate cancer was the etiology of stricture disease in 15 (50 %), with BT in 7 (24 %) and a combination in 8 (26 %). Successful urethral reconstruction was achieved in 22 men (73 %) at a mean of 21 months. Mean time to stricture recurrence was 5.1 months (range 2–8). Incontinence was transient in 10 % and persistent in 40 %, with 13 % requiring an artificial urinary sphincter. Such incontinence rates are probably because of need for resection of the external sphincter during the urethroplasty and a poorly functional internal sphincter. Such high rates of post urethroplasty incontinence are not insignificant, and a proper informed consent needs to be discussed with the patient. The rate of erectile dysfunction, however, does not appear to be effected by urethroplasty (47 % preoperative, 50 % postoperative).

Urethroplasty for radiation-induced strictures has an acceptable rate of success and can be performed without tissue transfer techniques in most cases. Less than half of these men will experience some degree of incontinence as a result of surgery, but erectile function appears to be preserved.

Illustrative Cases

To illustrate some of the surgical methods for dealing with radiation-induced urethral strictures, we present a few select cases.

Case Study 1

HL is a 64-year-old gentleman with stage T1C Gleason 7 (3+4) prostate cancer, initially treated with I^{125} BT, followed by a boost of 45 Gy of EBRT in 25 fractions. Two years later, he develops severe LUTS, AUA SS 27/35, and a Qmax flow rate of 6 ml/s. Endoscopy noted a near obliterative membranous stricture to 6 Fr. Patient refused formal urethroplasty so over the next 2 years was managed by urethral dilation twice and internal urethrotomy once. Subsequent recurrence managed by urethral dilation and Urolume endourethral stent. Hyperplastic tissue ingrowth quickly obstructed the stent after 6 months. Stricture managed by transurethral resection on a low cutting current twice (Fig. 23.8). See Chap. 26 by Buckley on Urolume

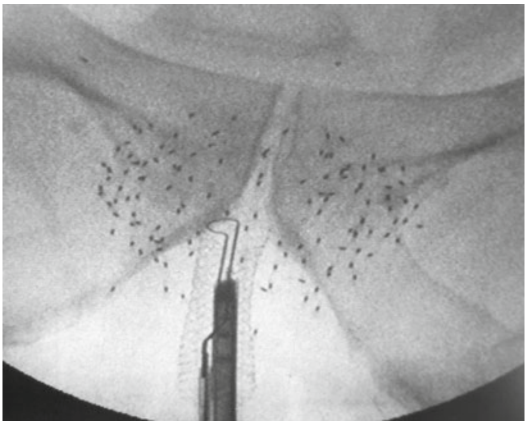

Fig. 23.8 Transurethral resection of hyperplastic ingrowth obstructing Urolume stent placed for prostate brachytherapy-induced membranous urethral stricture 6 months before

complications and management. The stricture recurred after 3 months and the patient subsequently agreed to undergo Urolume removal and a successful posterior anastomotic urethroplasty.

Case Study 2

MC is a 76-year-old with peripheral vascular disease, hypertension, and gout with T1C Gleason eight prostate cancer managed with I^{125} brachytherapy and a boost of EBRT, followed by hormone ablation therapy. Severe obstructive LUTS and retention 2 years later. Membranous and prostatic urethral stricture was managed over the next 2 years by urethral dilation ×2, OIU ×2, TURP ×2, and a failed "cut-to-the-light" procedure. Retention develops despite intermittent self-catheterization. Urethrography then notes a 4 cm obliterative membranous and prostatic urethral stricture, confirmed by cystoscopy from above and below (Fig. 23.9a, b). Suprapubic tube is placed. Bladder is very friable and develops hemorrhagic cystitis, eventually responding to oral AMICAR therapy. Unable to keep SP tube plugged due to small bladder capacity and bothersome bladder spasms, undergoes palliative supratrigonal cystectomy and transverse colo-conduit urinary diversion.

Case Study 3

NK is a 68-year-old healthy man with only glaucoma who had a history of a bulbar urethral stricture managed by a two-stage Johanson urethroplasty in 1985 and 1986. He was voiding well with minimal complaints until being treated for TIC Gleason 6 prostate cancer with three D conformal EBRT to a total dosage of 78 cGy, completed in May 2007. Subsequently, develops a mid-bulbar urethral stricture and severe obstructive voiding, managed initially by optical urethrotomy in January of 2009 and again in 2010. Obstructive voiding recurs and urethrography is performed noting a 6 cm mid-bulbar urethral stricture (Fig. 23.10). Because of the pelvic irradiation, a fasciocutaneous island flap of penile skin was selected as an onlay flap, through a scrotal window. At 2-year follow-up peak urinary flow rate is 17 ml/s. and AUA SS 7.

Case Study 4

WL is a 68-year-old who underwent I^{125} brachytherapy in for TIC Gleason 7 (3+4) prostate cancer. 18 months post-BT, he develops a dense proximal bulbomembranous urethral stricture initially managed by internal urethrotomy ×2. After the second urethrotomy he developed an obliterative stricture managed by a SP tube. Urethrography noted a proximal 3 cm postradiation stricture. At the time of his planned perineal approach urethroplasty, the stricture was too dense and long to feel through transmission of the antegrade placed sound. An abdominoperineal urethroplasty is then performed, requiring a total pubectomy to adequately expose the apex on the prostate (Fig. 23.11a–c). The urethra is routed through the pubic bone for a primary anastomosis. The urethra subsequently remains open, yet postoperative incontinence is severe and requires a bulbar urethral artificial urinary sphincter. The initial sphincter works well yet erodes after 6 months. One year later a transcorporal artificial urinary sphincter is successfully placed.

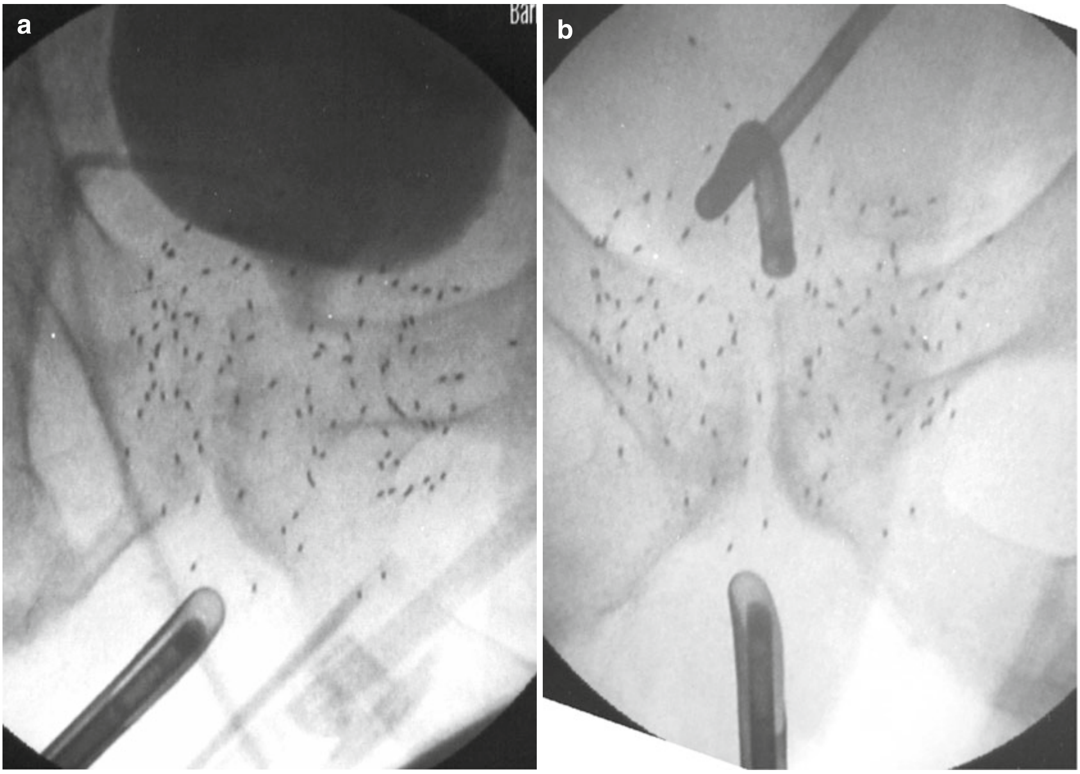

Fig. 23.9 (**a**, **b**) Obliterative prostatic and membranous urethral strictures after prostate brachytherapy. Managed by supravesical diversion, initially by SP tube and later by ileal-vesicostomy

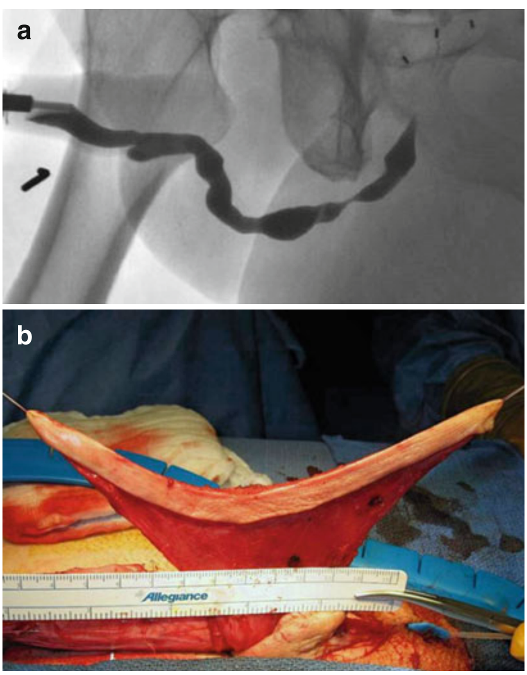

Fig. 23.10 (**a**) Radiation-induced mid-bulbar urethral stricture (6 cm) after radiotherapy for Gleason 6 prostate cancer. (**b**) Circular penile island skin flap

Editorial Comment

We have recently had extensive experience treating men with refractory radiation-induced bulbomembranous urethral strictures. This group is both a unique subset of stricture patients and a unique subset of prostate cancer patients. Many are elderly and/or deconditioned men who are poor candidates for major reconstructive surgical procedures. Many have a poor quality of life due to frequent obstructive episodes requiring repeated or indwelling urethral catheterization.

As a general rule, we have found it helpful to start with cystoscopy under anesthesia and suprapubic tube placement. This allows for safe urinary diversion and urethral tissue recovery and allows direct inspection of the prostatic urethra for cavitation or extensive radionecrosis, factors which will be influential in selecting candidates for diversion or prostatectomy over urethroplasty. Most will completely obstruct within weeks of SP tube placement. Many of those with concomitant incontinence will com-

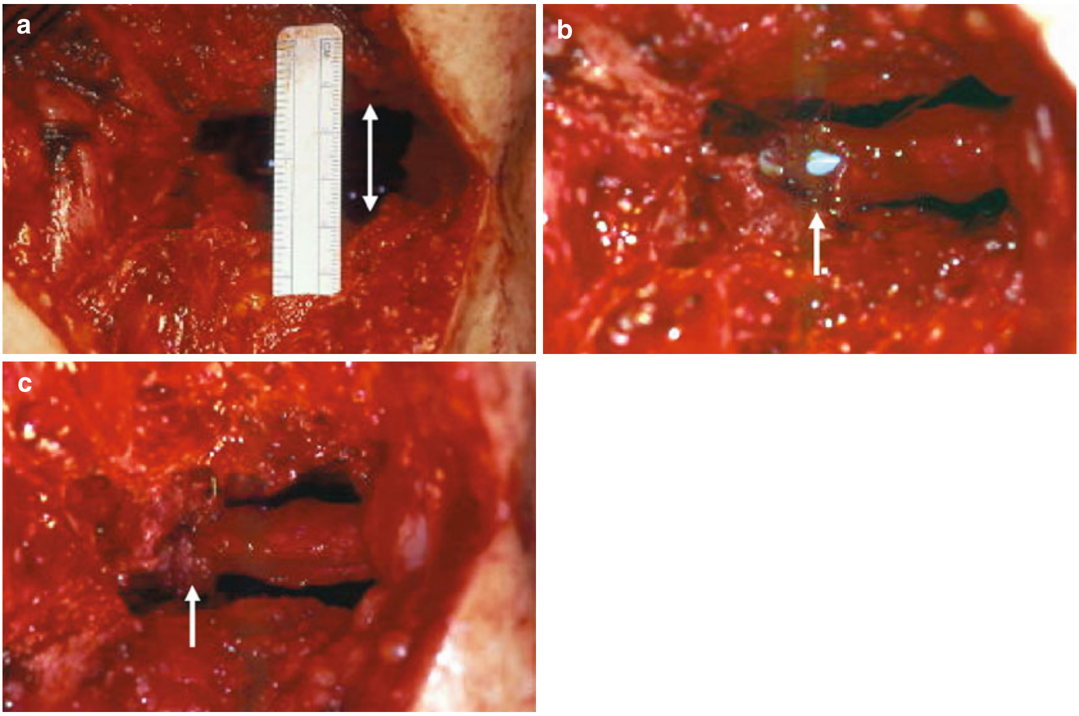

Fig. 23.11 (**a**–**c**) Abdominoperineal urethroplasty approach with pubectomy (2.5 cm excision) and primary anastomosis for an obliterative membranous urethral stricture after pelvic RT. *Arrows* notes anastomosis site

pletely resolve. Some will be quite pleased to undertake chronic SP tube diversion using a plug for intermittent drainage. Most of those requiring surgery will be amenable to an excision with bulbomembranous primary anastomosis. Although these procedures can be quite difficult due to the extensive radiation changes throughout the field, recurrent strictures seem easier to deal with because of the debulking effect of the primary excision.

—Allen F. Morey, MD

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Complex Urinary Fistulas of the Posterior Urethra and Bladder

24

Steven B. Brandes

Summary

The management and reconstruction of complex rectourinary and vesicoperineal fistulas are some of the most difficult problems to treat in urology. To decide on the proper management, a detailed knowledge of the fistula etiology, integrity of the anal and external urethral sphincters, functional status of the bladder, extent of rectal radiation damage, size and location of the urinary fistula, and the overall performance and nutritional status of the patient is needed. Few surgeons have had a large experience with such fistulas and this explains why there is no clear standard surgical approach. Treatment needs to be tailored to the specifics of the fistula, the etiology, and the patient. Fistulas that result from radiation therapy are more complex and difficult to reconstruct than those developing after other forms of treatment, with the frequent concomitant problems of urinary and fecal incontinence and/or urethral stricture. Small, nonradiated fistulas are successfully managed by the transanal or York-Mason approach. Complex fistulas that are large, or of radiation or cryotherapy etiology, are often best managed by primary repair, buttressed with a gracilis interposition flap, or by proctectomy and colo-anal pull through, or supravesical urinary diversion. Herein we have detailed the varying surgical methods for fistula repair as well as for salvage.

Introduction

To decide on the proper management of a rectourethral fistula (RUF), a detailed knowledge of the fistula etiology, integrity of the anal and external urethral sphincters, functional status of the bladder, extent of rectal radiation damage, size and location of the urinary fistula, and the overall performance and nutritional status of the patient is needed. Small, nonradiated fistulas often are successfully managed by the transanal or York-Mason approach. Complex fistulas that are large or of radiation or cryotherapy etiology are often best managed either by primary repair, buttressed with a gracilis interposition flap, proctectomy, and colo-anal pull through, or if the bladder and sphincter function is poor, by supravesical urinary diversion.

Fistula Etiology

By definition, a fistula is an extra-anatomic, epithelialized channel between two hollow organs or a hallow organ and the body surface. Acquired RUFs are uncommon and are usually the result of

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trauma, pelvic radiation therapy, iatrogenic injury during pelvic surgery (such as laparoscopic and open radical prostatectomy, prostate cryotherapy, or abdominal perineal resection), or an infectious or malignant tumor cause. Concomitant urethral and rectal injuries from blunt abdominal trauma and pelvic fracture or penetrating missile injury has been reported as a cause (yet, admittedly rare cause) for RUFs. Potential infectious causes of RUF include Crohn's disease, fistula in ano, perirectal infections, or tuberculosis. With the increased usage of brachytherapy and its combination with external beam radiotherapy boost, particularly devastating fistulas can occur. Most of the reported cases in the literature are from radical retropubic (laparoscopic or open) or perineal prostatectomy, with an incidence of 1–3.6 % for the former and up to 11 % for the later. Rectourethral fistulas after brachytherapy are reported in up to 0.4–0.8 % of cases and for brachytherapy plus external beam radiation therapy (EBRT) up to 2.9 % [1]. Such radiation fistulas are more common when being used as salvage therapy or if the anterior rectal wall has been biopsied after RT. Transanal rectal wall or rectal ulcer biopsies (via sigmoidoscope) in the pelvic RT patient are unwise and have a high chance of eliciting a RUF. Reported average time from last RT session until RUF diagnosis is roughly 2 years. Mean time from a rectal procedure till RUF is 4 months. Few surgeons have had a large experience with RUF, and thus, there is no clear standard surgical repair approach. Treatment needs to be tailored to the specifics of the fistula, the etiology, and the patient. Fistulas that result from radiation therapy are more complex and more difficult to reconstruct than those developing after other forms of treatment, with the frequent concomitant problems of urinary and fecal incontinence, and/or urethral strictures.

Rectourinary Fistulas

Signs and Symptoms

The presence of an RUF fistula is typically readily apparent. The most common symptoms are watery stools (in roughly 90 %), urinary incontinence, irritative voiding complaints, and pneumaturia and fecaluria (in roughly 60 %). To a lesser degree, patients present with dysuria, fever, discolored or feculent urine, recurrent urinary tract infections (usually poly-organism), or with an associated metabolic acidosis from systemic absorption (via the colon) of the urine. One of the initial signs of a developing RUF after RT or cryotherapy typically is severe rectal pain, which resolves when the necrotic/ischemic tissue eventually breaks down and the fistula occurs. Although uncommon, pelvic and abdominal sepsis can also be the presenting event (in roughly 10 % of cases).

Diagnosis

Methods used to diagnose a RUF include endoscopic and radiographic means (Fig. 24.1). Cystoscopy is used to determine the degree of radiation damage to the bladder as to capacity and compliance and the location of the fistula in relation to the ureteral orifices and the bladder neck. Proctoscopy is used to determine the level of rectal entry, to identify the fistula, fistula proximity to the anal sphincter, and to rule out other rectal-colon pathology (radiation proctitis, concomitant colon cancer). Other important evaluation methods are examination under anesthesia, digital rectal exam, and retrograde urethrography (RUG) and voiding cystourethrography (VCUG; Fig. 24.2). Computed tomography (CT) of the pelvis is typically fairly sensitive and specific qualitatively for diagnosing a fistula, with the note of air in the bladder (without any prior instrumentation), but not readily for location and size of the fistula. Rectovesical fistulas on CT imaging will typically show a thickened trigone and posterior bladder wall and nonspecific bladder air (without being instrumented). For cases of high index of suspicion but negative studies, an oral charcoal slurry test followed by urinalysis for charcoal can be performed. The Bourne test is also helpful in making a diagnosis. Here, oral contrast is consumed by the patient, or a hypaque enema performed, and the urine collected, centrifuged, and X-rayed. Radioopaque material in the radiograph confirms the presence of a fistula. When the fistula is small, flow through the fistula is typically in "one way,"

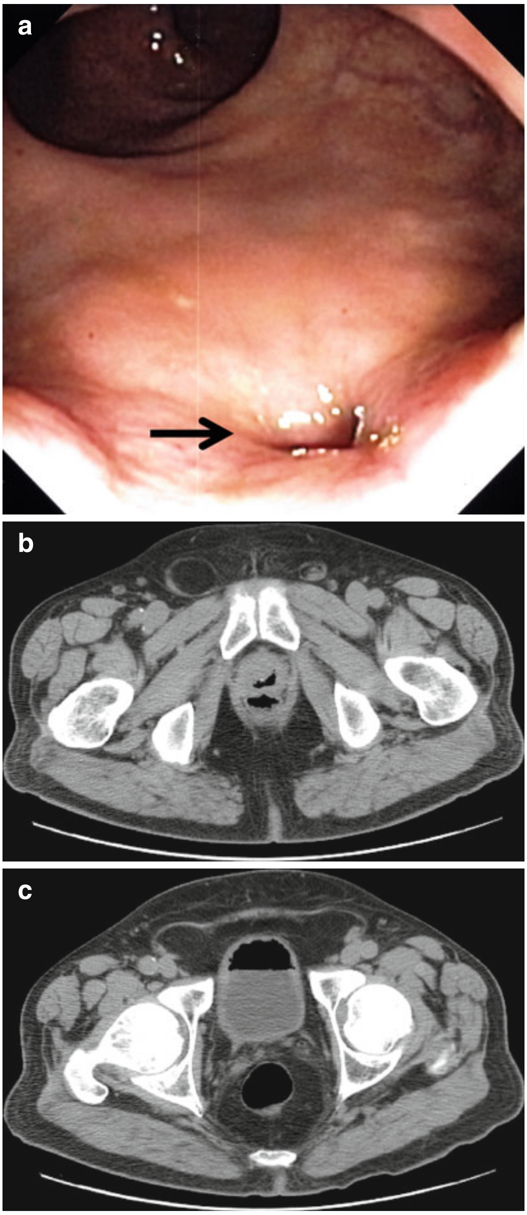

Fig. 24.1 Prostatorectal fistula after cryotherapy for low stage prostate cancer. (**a**) Colonoscope view of fistula (*arrow marks* fistula). (**b**) Pelvic CT of the fistula. Note air in prostate and rectum (noninstrumented system). (**c**) CT demonstrating air in bladder (noninstrumented system)

from the high-pressure to low-pressure system. The low transsphincteric RUF of Crohn's disease or an anterior rectal space infection is difficult to diagnose and often demands magnetic resonance imaging of the pelvis, combined with meticulous transanal examination.

Fig. 24.2 Cystogram demonstrating vesicorectal fistula

Preoperative Assessment and Decision-Making

To decide how to manage and repair RUF, it is essential to preoperatively determine the function of the anal and external urethral sphincters, the presence of a concomitant urethral stricture or bladder neck contracture, the visible and palpable health of the tissue adjacent and near the fistula, and the size and location of the fistula (particularly in its proximity to the ureteral orifices). Another important factor to determine preoperatively is patient nutritional status, performance status, and overall condition. Cigarette smoking will greatly impair the chances for a successful fistula repair and reconstruction. We routinely send such patients to a smoking-cessation program.

The function and capacity of the bladder is also important to determine. Unfortunately, urodynamics is usually difficult, if not impossible, to perform in patients with a large RUF. Although others claim that a Fogarty balloon can be passed to occlude the fistula and then perform a urodynamics study, we have not had success with this technique.

Instead, we typically rely on the visual appearance of the bladder urothelium as a surrogate measure of bladder radiation damage and postfistula repair poor bladder capacity. Urothelium that appears white/blanched or hemorrhagic (friable with multiple telangiectasias) often demonstrates bladder dysfunction and radiation damage. Such visual changes do not portend well for good postsurgical bladder capacity.

Urinary and Fecal Diversion

Indications for Diversion

Patients who present with RUF but without evidence of surrounding inflammation or sepsis, fecal, and urinary diversion are not essential prior to fistula repair and can be delayed till the time of fistula surgery. However, if the patient is particularly symptomatic and suffers from recurrent sepsis, severe rectal pain, or overwhelming urinary and/or fecal incontinence, then fecal and urinary proximal diversion should be performed and the patients nutritionally supplemented. Conversely, if a patient with a radiation RUF has not been diverted before presentation, such patients typically undergo fecal and urinary diversion to prevent sepsis and to reduce inflammation around the fistula track.

In rare and fairly select cases, some small surgical fistulas (up to 25 %) will close spontaneously with just urinary (suprapubic or Foley catheter) and/or rectal diversion and suppressive antibiotics. Such conservative therapies are usually reserved for poor surgical candidates [2].

Moreover, if the rectal sphincter is irreversibly injured or incompetent, an end colostomy is usually the better option for fecal diversion. If a reconstructive procedure is a potential option, a temporary loop ileostomy (upstream segment of bowel), which can easily be performed laparoscopically, is also performed. Laparoscopic loop ileostomy is a quick, less invasive, and readily reversible form of diversion without the need for a staged laparotomy for reversal. For cases of tenuous repair, previous failed attempts at fistula repair, complex (radiation or cryotherapy induced), or large fistulas that cannot be closed primarily and require adjunctive procedures such as a patch graft and/or muscle interposition flap, fecal diversion is generally mandatory for a successful outcome. A general rule of thumb is that if the tissues are friable and the repair tenuous, then temporary fecal diversion should be part of the reconstruction.

Anatomy of the Anal Sphincter and Rectum

An intimate knowledge of the rectal and anal anatomy allows for successful fistula repair, with limited morbidity. The levator ani muscles are divided in a lateral and medial division: the medial division is the puborectalis sling, which forms a muscular sling that arises from the pubic bone and encircles the anorectal flexure. This sling is crucial to maintaining fecal continence. The most caudal part of the sling forms the longitudinally oriented external anal sphincter (Fig. 24.3). The blood supply to the levator ani and the external and internal anal sphincters is the pudendal artery, while the nervous innervation comes from the pelvic plexus, from the S2–S4 nerve roots. The nerves and vasculature to the rectum are enclosed within a fascial capsule, known as Waldeyer's fascia. The ventral aspect of Waldeyer's fascia is more commonly known as Denonvilliers fascia.

Specific Reconstruction Methods

As to evidence that there is no one correct method and that there is uncertainty as to what the best approach for repair is, there are numerous surgi-

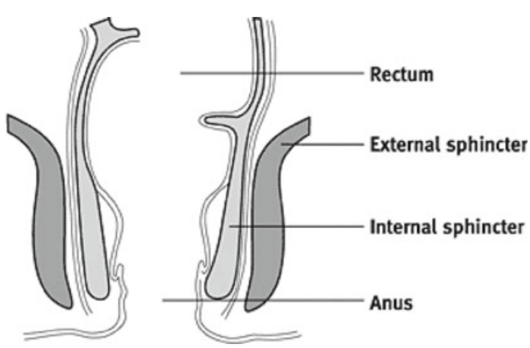

Fig. 24.3 Muscles of the anal sphincter

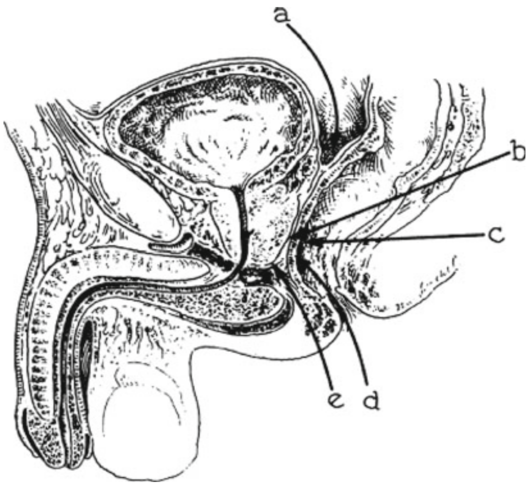

Fig. 24.4 Approaches for repair of rectourethral fistulas. (*a*) Transabdominal. (*b*) Kraske laterosacral. (*c*) Posterior transsphincteric (York-Mason). (*d*) Transanal. (*e*) Perineal (From Wood [3])

cal procedures detailed for fistula repair. The surgical technique selected is largely dictated by the surgeon's preference as well as the size, location, and etiology of the fistula (Fig. 24.4).

Transanal Rectal Advancement Flap

A sliding rectal advancement flap performed transanally is an effective method for small non-radiated, low-lying prostate-rectal fistulas [4]. The procedure is very well tolerated and relatively minimally invasive. Reported success rates range from 75 to 100 %. The patient is placed jackknife prone, the anus dilated, and a speculum and/or Lone Star retractor used to expose the fistula in the anterior wall of the rectum. The tissue surrounding the fistula (lateral and distal) is de-epithelialized. A "U"-shaped incision is made in the rectal wall to create a full-thickness rectal wall flap that is advanced distally to cover the fistula and sutured to the edges of the caudal denuded rectal mucosa (Fig. 24.5). The fistula is closed primarily with interrupted absorbable polyglactin (Vicryl) sutures. No suture lines are overlapping. We have had particularly good success with this technique for surgical fistulas after open or laparoscopic radical prostatectomy. As a relatively minimally invasive procedure, proximal fecal diversion is typically not performed. For failures, the advancement flap can be repeated along with a diverting loop ileostomy and urinary diversion. The other option for failures, which is preferred, is the anterior transperineal approach, buttressed with gracilis muscle flap.

Posterior-Sagittal Approach

For fistulas that are too low to approach from the abdominal incision and too high to access from below, the posterior-sagittal approach was described in the late 1800s. Kraske popularized this technique, where a posterior midline incision is made extending to the left paramedian aspect of the coccyx and sacrum, that often required coccygectomy and sacrectomy. Here, the rectum is swept laterally to avoid dividing the anal sphincter.

York-Mason Repair

The York-Mason technique is a posterior, midsagittal, trans-anosphincteric approach to RUF repair [5]. It is the most reported and widely used repair method. It is often not necessary to perform concomitant fecal and urinary diversion at the time of the fistula repair. In general, York-Mason repairs are useful and successful in small postsurgical fistulas (especially those that follow radical prostatectomy) that are too proximal and thus hard to reach with a sliding rectal flap. York-Mason is not suitable for large, complex (radiation, cryotherapy, etc.) fistulas that may require an interposition muscle flap, concurrent urethral reconstruction, or patch grafting. Other relative contraindications for the York-Mason are prior anorectal dysfunction or impaired wound healing (e.g., after RT or in patients with HIV). In the properly selected patient, York-Mason had good success without severe bowel dysfunction or fecal incontinence, except for a higher incidence of impaired flatulence control.

The key to preventing fecal incontinence is a midline transsphincteric incision and careful tagging of the sphincteric muscle, followed by an anatomical restoration of the rectal wall. The patient initially is cystoscoped and a wire and subsequent catheter placed across the fistula. The patient is then placed prone, jackknife, the buttocks taped laterally, and an incision made from the tip of the coccyx to the anal verge (Fig. 24.6, inset). The posterior anal sphincter is divided and each layer

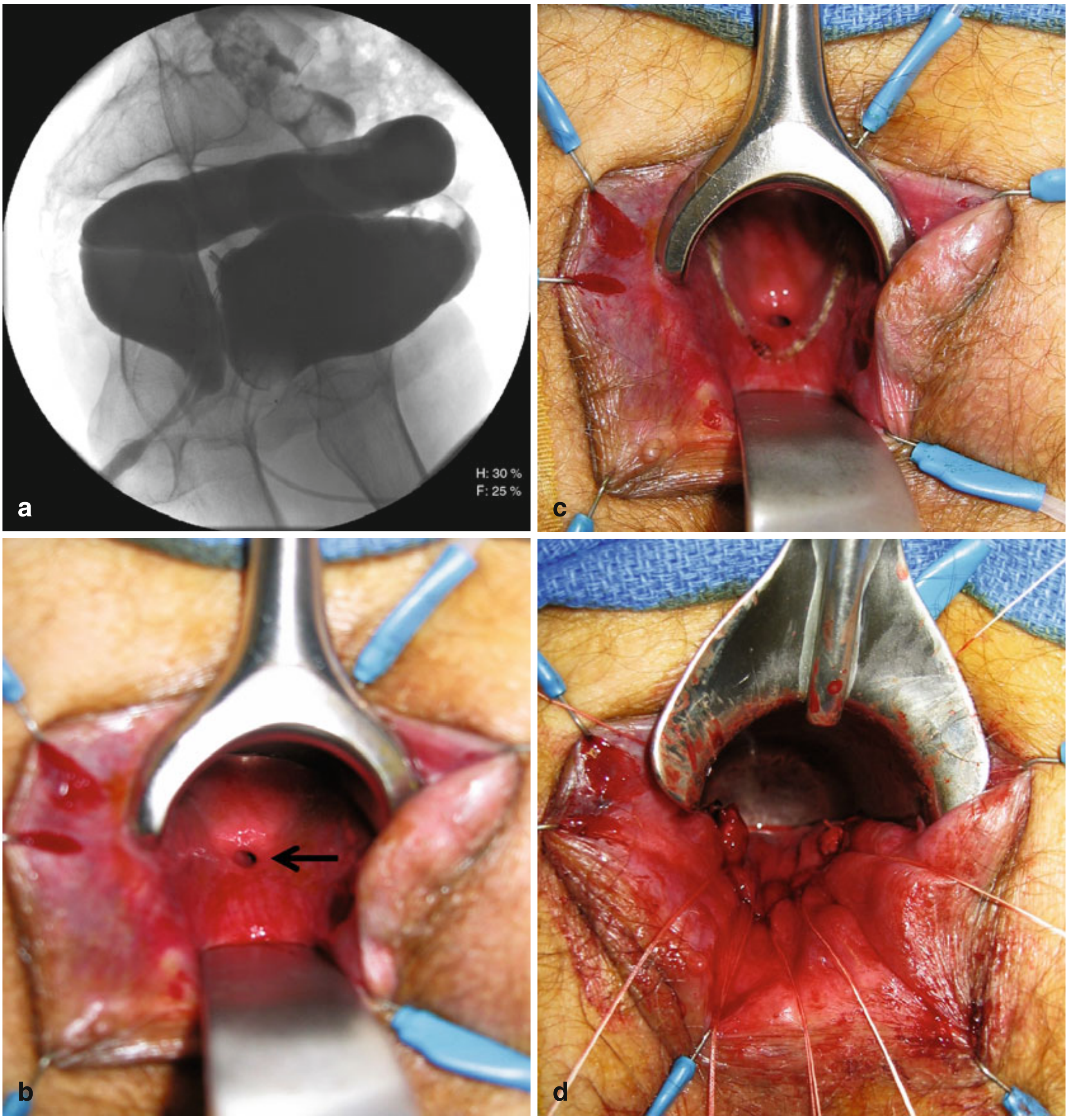

Fig. 24.5 Bladder neck-rectal fistula after salvage radical prostatectomy for post-HIFU local recurrence. (**a**) Hypaque enema demonstrating bladder filling. (**b**) Transanal view of fistula (*arrow*). (**c**) Sliding flap marked out. (**d**) Sliding rectal flap advanced distally and sewn into place with interrupted sutures

is carefully tagged for subsequent reconstruction. The anterior rectum and fistula are well exposed once the posterior rectal mucosa is divided (Fig. 24.6). The main advantage to the York-Mason approach is that it allows rapid access through unscarred tissue and provides a wide working space to operate in. The posterolateral rectal innervations, urinary continence, and potency are consistently preserved by staying in the midline and avoiding the lateral pelvic and pararectal space. The fistula is sharply excised, and the rectum and urinary tracts are separated and undermined. After closure of the fistula in the urethra, a full-thickness rectal wall flap is developed and sutured down in a "vest over pant" method. In so doing, the suture lines do not overlap. Alternatively, a fish-mouth-shaped excision of the fistula followed by primary closure can be made. The rectum is closed in two layers

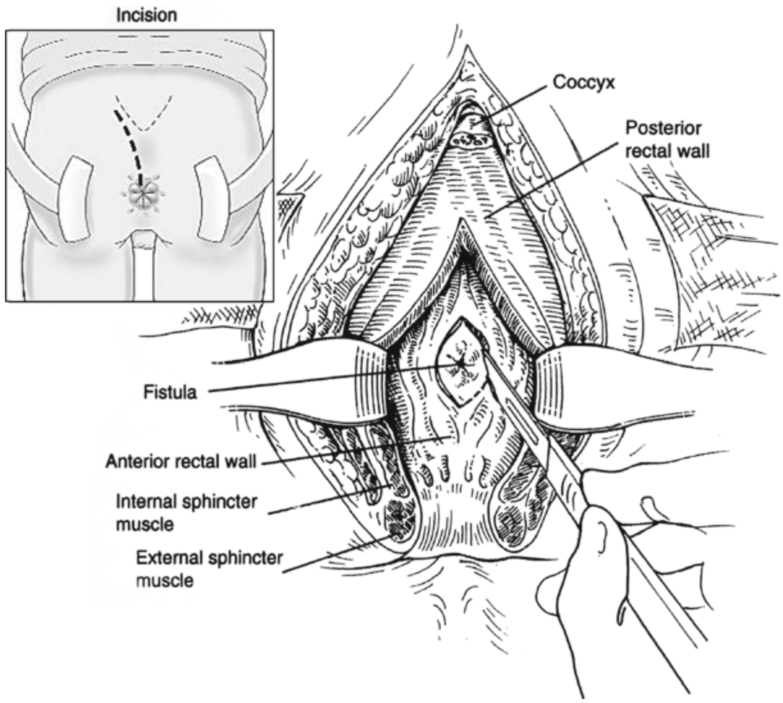

Fig. 24.6 York-Mason posterior transsphincteric approach (Modified from Jones et al. [4])

with absorbable interrupted sutures. Each of the paired anal sphincter sutures is then tied and the rectal wall and the sphincteric muscle components carefully restored. A presacral drain is left in place for 2 days. Urethral catheterization is maintained for 3 weeks or until cystourethrography demonstrates no leak. This approach, in the properly selected patient, has a low recurrence rate and demonstrates that anal sphincter can be divided and not result in fecal incontinence.

Large and Complex Fistulas

For large prostatorectal or perineal urinary fistulas in radiated field, salvage prostatectomy sounds at first like a good idea. However, in our hands, we have found that salvage prostatectomy typically results in vesicourethral anastomotic stricture and/or severe urinary incontinence. Therefore, we prefer either to repair such urinary fistulas by the methods detailed in this section or to perform an exenterative pelvic surgery with concomitant ileal or colo-conduit, or at times, a continent catheterizable stoma/neobladder [6].

Transperineal Approaches

For repair of RUF, we prefer to use an anterior perineal approach augmented with a gracilis muscle flap for bulk and vascular tissue interposition. Obviously, fistula size, etiology, location, failed prior attempts of repair, and concomitant urethral or bladder neck stricture determine the specific procedure.

Transsphincteric Anterior Approaches

We have found the transsphincteric method of Gecetler [7] to be successful for small fistulas of postsurgical (after open or laparoscopic prostatectomy) or trauma (pelvic fracture) etiology and/or when a simultaneous urethral stricture and reconstruction is planned. A normal anal sphincter and lack of any anorectal pathology is essential. The patient is placed in the lithotomy position with stirrups. The patient is cystoscoped and the fistula cannulated with a wire, which is subsequently pulled out the rectum and used as a guide for Fogarty or Foley placement through the fistula, via the rectum. An incision is made in the midline perineum from the scrotal base to the anal verge. The transverse perinei, the perineal body, and the anal sphincter (through both the external and internal anal sphincter and rectal wall) are divided in the posterior midline, in the same manner as a York-Mason. Each of the components of the internal and external anal sphincter is carefully tagged with sutures in pairs for subsequent anatomic reconstruction of the sphincters (Fig. 24.7). A bulbar or membranous urethral stricture can be repaired at this time either by excision with primary urethral anastomosis (for a short stricture) or by a substitution method of graft or flap (for longer, more complex, strictures). The fistula is repaired primarily of with a free graft, followed by a buttress of a gracilis muscle flap, transferred from the posterior medial thigh (Fig. 24.8). The sphincters are reconstructed and the rectum closed in two layers with absorbable polyglactin suture. Catheters are maintained for a minimum of 3 weeks, or until the cystogram shows no leak. Anal sphincteric control of solid stool takes roughly 3 weeks, whereas control of liquid and gas typically takes 6 or more weeks. If a fecal diversion has been performed, we usually delay reversal for at least 3 months after fistula repair, when cystoscopy and/or urethrography demonstrates a healed rectal and urethral lumen and the anal sphincter is intact and functional.

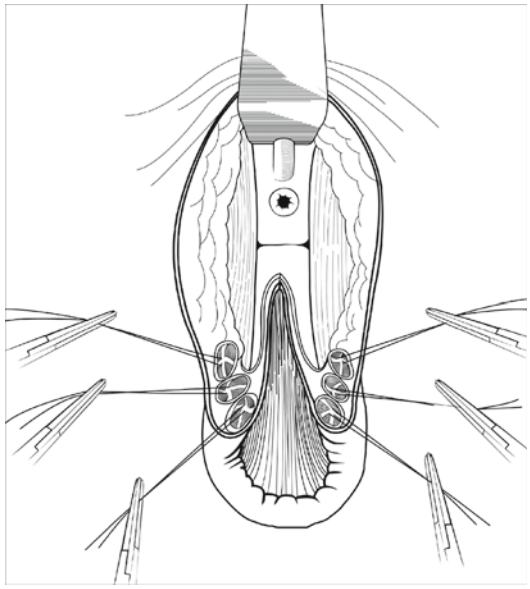

Fig. 24.7 Transsphincteric anterior approach to a RUF (after Gectler). Note tags on divided anal sphincter

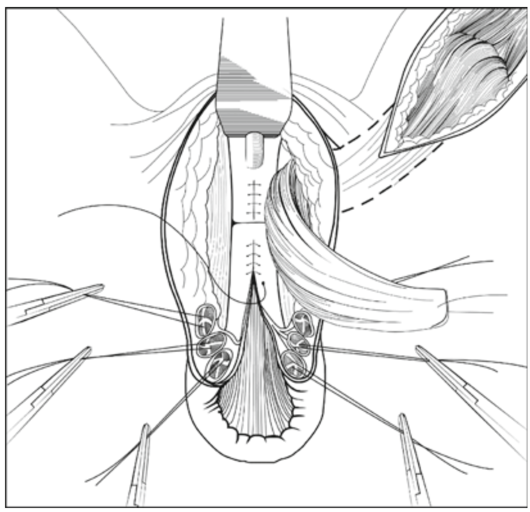

Fig. 24.8 Gracilis interposition flap to repair fistula

Anterior Perineal Approach

In general, the anterior perineal approach buttressed with gracilis muscle is our preferred method for repairing RUF (Fig. 24.9) [8]. The patient is placed in the lithotomy position, and a classic inverted "U" incision (perineal prostatectomy-like incision) is made in the perineum (Fig. 24.9a). A transverse incision is made 3 cm anterior to the anal verge and then carried medial to the ischial tuberosities and posteriorly to lie lateral to the sphincter at 3 and 9 o'clock. The ischiorectal fossa is then dissected out bilaterally bluntly and with electrocautery. The central tendon is isolated bluntly and then divided (Fig. 24.9b). Dissection is then performed between the longitudinal rectal fibers on the ventral aspect of the rectal wall and the external anal sphincter. A finger in the rectum helps control the depth of dissection. The longitudinal fibers of the rectum are followed to the rectourethralis muscle, which attaches to the rectum to the posterior GU diaphragm. The rectourethralis is then divided. A plane is dissected between the rectum and the prostate and bladder to the level of the peritoneal reflection. The dissection starts superior to the anal sphincter and is then carried down onto the rectum. By avoiding any lateral or posterior dissection, the innervation

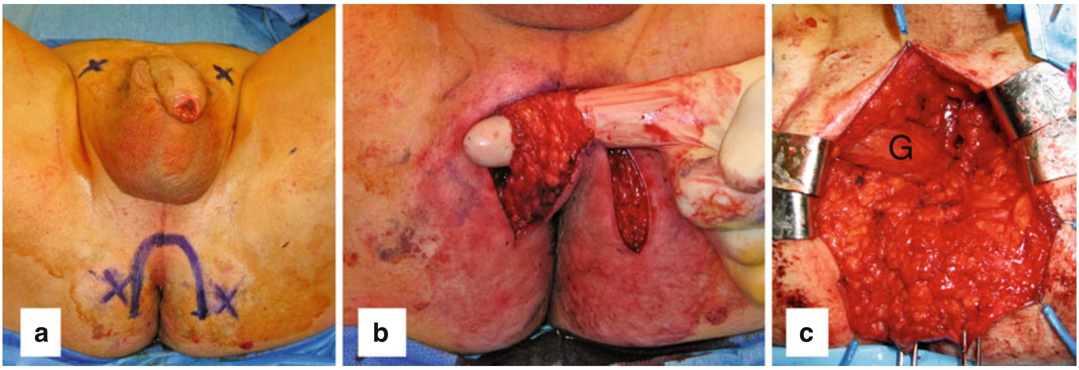

Fig. 24.9 Rectourethral fistula. (**a**) Exposure in lithotomy position by inverted "U" incision. "X" marks ischial tuberosities. (**b**) Transection of central tendon as is done with perineal prostatectomy. (**c**) Gracilis flap from right thigh shown mobilized and placed as an interposition flap and fistula coverage

of the anal sphincter is preserved. A Lowsley prostatectomy sound (retractor) can be placed in the urethra and into the bladder to help localize and palpate the prostate and the fistula. A blue colored Foley catheter (modified into a council with a distal hole) placed into the bladder over a guide wire greatly facilitates dissection. Often times, the Lowsley can be difficult to place because the pelvis/prostate are often fixed. Otherwise, under cystoscopic guidance, a wire and subsequent small council tipped catheter is placed across the fistula. If the fistula is small (<12 FR), it can be dilated with sounds until a size that a small catheter can be placed across. The rectum, urethra, and prostate are widely separated (Fig. 24.10). The rectum is widely mobilized and preferentially closed transversely in two-layered closure to prevent anal stenosis. The fistula margins are typically debrided till a supple margin. The hole on the urinary side is closed primarily with interrupted suture, if the fistula is small. When the defect is too large to be easily closed primarily, a tailored buccal graft is placed on the urethra or prostate fistula defect. It is important to quilt the graft to the gracilis muscle first and then sew the whole complex – both muscle and graft together to cover the fistula. In this way, you insure good apposition of the graft and muscle – and this promotes better graft take, rather than sewing the graft in first.

When there is a concomitant stricture of the membranous urethra, the urethrotomy can be extended ventrally from the level of the fistula and through the stricture. Into the defect (stricturotomy) a muscle flap augmented buccal graft or only flap is typically placed. The proximal graft is covered with a well-vascularized gracilis muscle flap, while the proximal bulbar areas can be covered by the corpus spongiosum (as in a spongioplasty; Fig. 24.11). The grafts are fenestrated and quilted/sutured to the gracilis muscle. In so doing, the muscle acts as the vascular bed for the graft. The muscle flap is the main reason that the fistula repair is successful, by separating the rectal and urethral suture lines, filling the

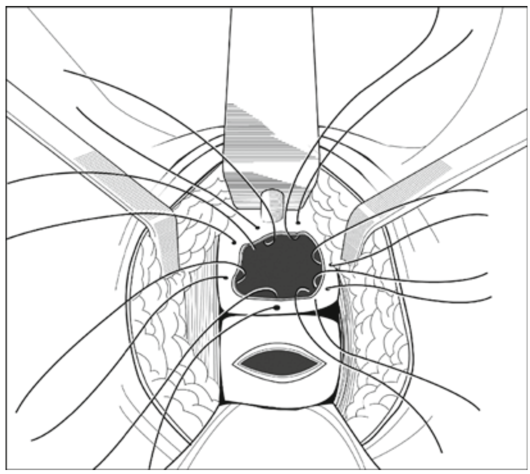

Fig. 24.10 Perineal approach and exposure of prostate-rectal fistula. Note wide separation of the prostate and rectum and stay sutures placed in the prostate to "parachute" a buccal graft

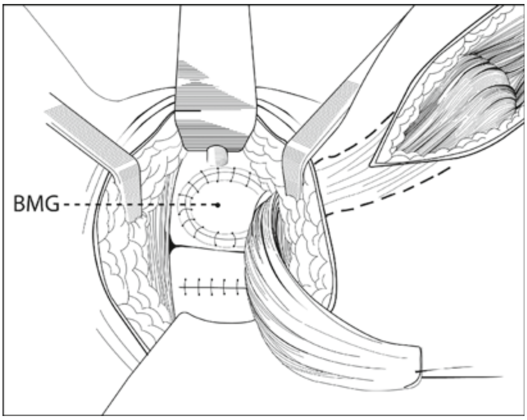

Fig. 24.11 Completed buccal graft to prostatic fistula. On the right is a gracilis muscle flap mobilized as an interposition flap and to provide buccal graft vascularity. *BMG* buccal mucosal graft

Table 24.1 Gracilis muscle flap characteristics

Function	Adducts the thigh and flex the knee
Origin	Ischium and inferior ramus of pubis
Insertion	Medial tibia
Nerve supply	A branch of the obturator nerve (L2, 3, 4)
Size	4–8 cm wide; length = patient's inner thigh length
Blood supply	Single artery of profunda femoral artery
Artery	Small; <1–2 mm
Vein(s)	2 venae, 1 often larger than the artery (1.5–3 mm)
Pedicle length	Usually no more than 4 cm

dead space, and interposing well-vascularized nonradiated tissue that can act as a host bed. The transperineal approach with muscle flap interposition has a reported success of roughly 84 % (for radiated/ablation fistulas) and close to 100 % for nonradiated fistulas [9]. The transperineal approach is best suited when the rectum and perirectal tissues are not overly damaged and will allow adequate healing and primary closure of the rectum.

Potential complications of this method can be significant and include minor fecal soiling (up to 25 %), anal stenosis (4 %, managed by periodic dilation), and urinary incontinence (29–75 %). In severe cases, the urinary and fecal outlets are devastated, resulting in permanent urinary diversion (up to 16 %) (FN 11) and fecal diversion (colostomy) in 16–31 %, with 31 % for radiated/ablation fistulas [2, 9–11]. For stress urinary incontinence, this can be successfully managed by a staged, transsphincteric artificial urinary sphincter. However, urge incontinence, because of a small contacted radiated bladder, is very refractory to conservative treatments, such as anticholinergics. Such patients will require adjunctive procedures such as augmentation cystoplasty or exenterative procedures and urinary diversion. In our recent review of our last 17 patients with RUF, we concluded that in patients that are pelvic radiation naïve, small RUF can successfully be managed by rectal sliding advancement flaps [12]. However, complex RUF in patients treated with pelvic radiation at times may be better served by exenterative surgeries due to severe underlying bladder and sphincter dysfunction. Therefore, proper patient selection is the key. Although it is often difficult to determine preoperative bladder capacity or sphincter function, this is essential to determine the optimal surgery so that social urinary continence can be achieved.

Gracilis Muscle Flap

The gracilis muscle is long and thin, tapering from its widest point superiorly to a tendinous insertion on the medial knee inferiorly. It acts as a thigh adductor and a flexor of the knee joint, but when mobilized causes no significant donor functional loss. It is an expendable muscle since the adductor longus and magnus totally replace the function of adduction of the thigh. The medial thigh scar is slightly posterior to the midline and relatively inconspicuous. The consistent vascular anatomy and relative ease of dissection make this muscle an excellent choice for perineal and urethral reconstruction. See Table 24.1 for a summary of gracilis muscle flap characteristics.

Anatomy

The origin of the gracilis muscle starts with a tendinous aponeurosis to the ischiopubic ramus and distally inserts into the adductor tubercle (medial

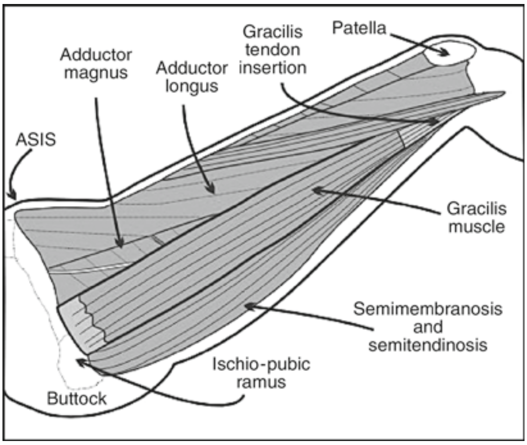

Fig. 24.12 Gracilis origin on ischiopubic ramus and insertion distally on medial tibia at adductor tubercle. Muscle lies on adductor magnus (Courtesy Rudolf Buntic)

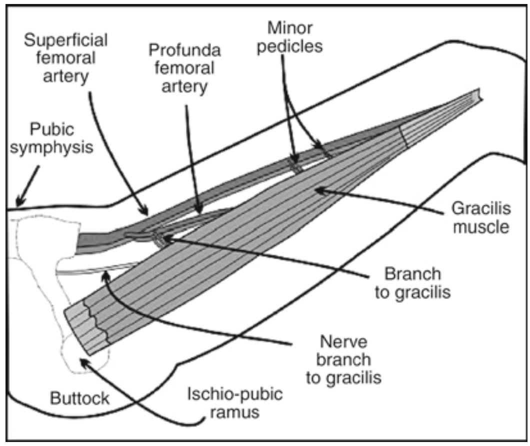

Fig. 24.13 Gracilis muscle blood supply. Note main pedicle from profunda femoral artery and secondary minor pedicles distally (Courtesy Rudolf Buntic)

condyle) of the tibia. Depending on patient leg length, the gracilis muscle is approximately 24–30 cm in length and roughly 6 cm wide, proximally, and 4 cm, distally. The width of the muscle can be extended by splitting the investing epimysium, which will increase the width an additional 30–50 %. The muscle lies on the adductor magnus along most of its course, with the adductor longus superiorly and the sartorius inferiorly (Fig. 24.12). The muscle is innervated by the anterior branch of the obturator nerve (motor function) and the medial cutaneous nerve of the thigh (for sensory function). The nerve enters the muscle slightly more cephalad and superior to the upper aspects of the vascular pedicle. A long leash of nerve can usually be dissected free (up to 6–7 cm). Under loupe magnification, the nerve can even be dissected intraneurally, so that the muscle can be split into smaller anterior and posterior segments, if so needed.

Vascular Anatomy

The gracilis is a type 2 muscle (after Mathes and Nahai), with a single dominant and several secondary minor vascular pedicle(s). The primary pedicle is very consistently located about 8–12 cm (mean, 10 cm) distal to the bony origin. The main arterial supply is the medial circumflex femoral, which is a proximal branch of the profunda femoral vessels in most cases, running between the adductor longus and magnus muscles and then enters the undersurface of the gracilis. The artery is surprisingly small in comparison to most muscle flaps, with an external diameter of less than 1 mm in pediatric patients and ranging from 1 to 2 mm in the adult. It has two veins, often smaller than the artery, although occasionally one is larger. On rare occasions, the gracilis is supplied by two arteries and with an origin from the adductor pedicle. The medial circumflex femoral pedicle usually measures 6–7 cm (occasionally up to 10 cm) in length and emerges between the adductor brevis and the adductor longus, with small branches to both muscles. The artery enters the gracilis and branches into multiple branches, which pass proximally and distally along the muscle. The distal secondary pedicles to the muscle are relatively insignificant arterial branches, which can be routinely sacrificed without worry of compromising the viability of the muscle (Fig. 24.13).

Surgical Dissection

The patient is typically placed in the lithotomy position, and the entire lower extremity is prepped and draped and positioned with the leg abducted and the knee flexed (Fig. 24.14). It is wise to prep out both legs since one gracilis muscle may have insufficient bulk to cover the fistula repair. However, we prefer to use the left gracilis to pre-

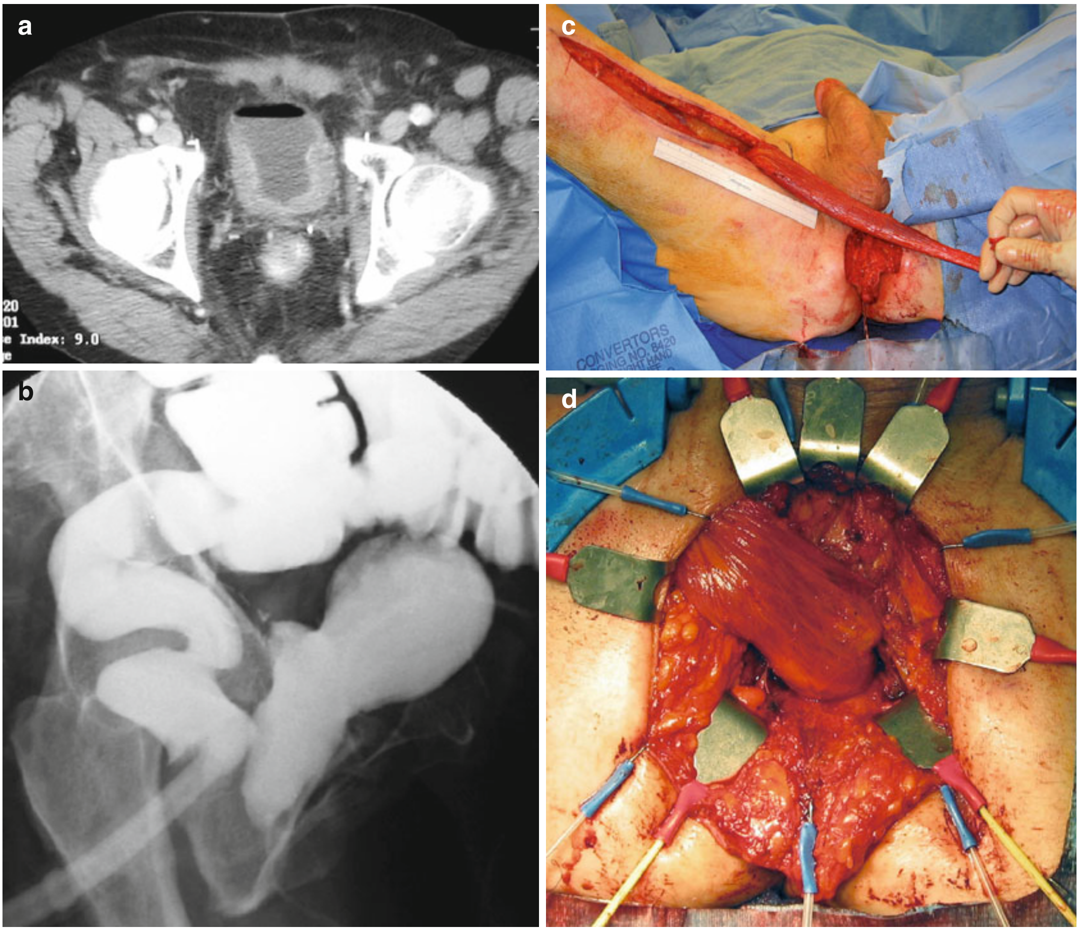

Fig. 24.14 Prostatorectal fistula. (**a**) CT of pelvis. Note typical air in bladder and thick wall bladder base from chronic infections. (**b**) Hypaque enema noting bladder filling. (**c**) Gracilis mobilized from right inner thigh. Note muscle length and mobility. (**d**) Completed gracilis flap to fistula site

vent the patient from experiencing problems with pushing the brake/accelerator pedals while driving, should the patient have residual deficits from harvest of the muscle. The gracilis can also be harvested in the prone position (Fig. 24.15). The muscle location is marked by first drawing a line from the pubic tubercle to the medial tibial condoyle of the knee. We then measure from the inguinal crease distally and place a mark on the skin at 8–10 cm. This marks the likely insertion site of the vascular pedicle. The incision (roughly 8 cm in length) is then made three fingerbreadths posterior and parallel to this line and distal to the pedicle insertion. The incision site often appears to be overly posterior to the untrained eye. Unless the patient is obese, the muscle can be palpated through the skin by pinching the skin between the thumb and index finger at the 10-cm mark. The muscle is easily identified at the base of the wound after the subcutaneous fat and muscular fascia are divided. On the anterior border of the muscle, the vascular pedicle and nerve can be identified 8–10 cm distal to the ischiopubic ramus entering the deep surface of the gracilis (Fig. 24.16). Early identification of the pedicle enables the dissection to proceed more rapidly. Since the vessels to the gracilis are so small, we prefer to use a handheld Doppler to help confirm their location. The proximal dominant pedicle is preserved, but not skeletonized, so as to avoid

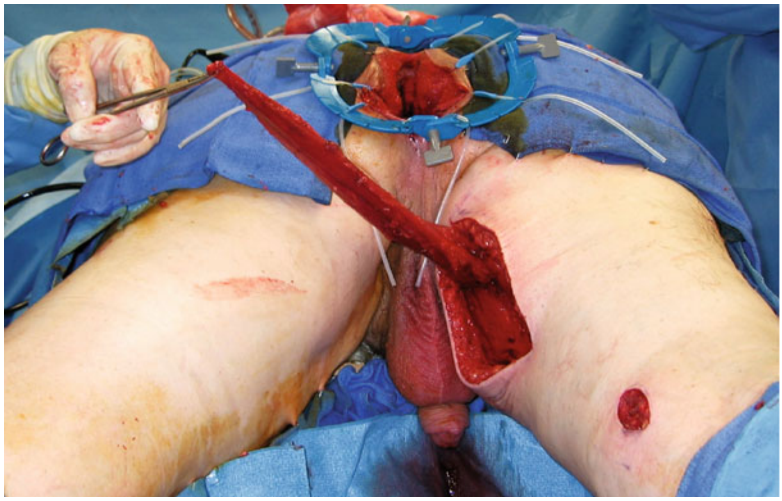

Fig. 24.15 Gracilis muscle mobilized in the prone position. Note main incision and small distal counter incision

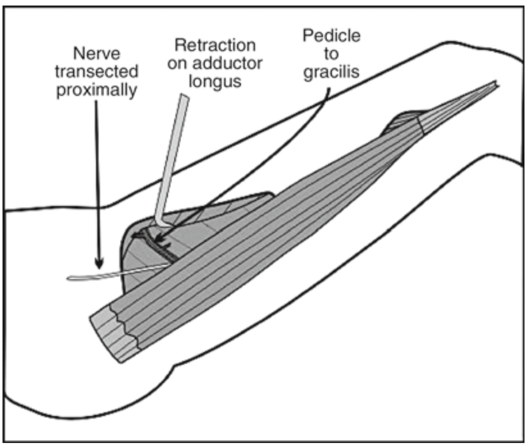

Fig. 24.16 Adductor longus freed and retracted away from underlying magnus to expose pedicle. Note vascular pedicle and nerve (Courtesy Rudolf Buntic)

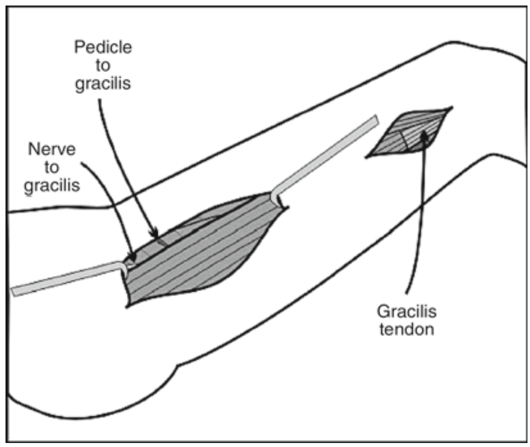

Fig. 24.17 Distal counterincision to identify and dissect free the gracilis tendinous insertion (Courtesy Rudolf Buntic)

vascular spasm and injury. A Penrose drain is placed around the muscle and used as a handle to facilitate dissection. A small counterincision is then performed over the distal leg to identify and dissect free the tendinous insertion (Fig. 24.17). With a combination of electrocautery and blunt finger dissection, the gracilis muscle can be freed up from its attachments to the adductor magnus, while the adductor longus is retracted away from the magnus. A small sponge on a stick is used to further dissect out the distal aspects of attachments to the muscle. It is much easier to do the blunt dissection first with the muscle held at two points (origin and insertion) and then, secondarily, transect the gracilis tendon. A 0 Vicryl stay suture is placed around the tendon, and traction and countertraction are applied between the muscle belly and the tendon to verify that the correct structures were dissected out prior to transection of the tendon with electrocautery. The gracilis tendon can be easily distinguished by being distinctively long and its insertion on the medial tibial tubercle, as part of the coalescence of the tendons of the gracilis, sartorius, and semitendinosus muscles (pes anserinus) (Fig. 24.18). It is not to be confused with the semimembranosus tendon which is thicker, more posterior, and shorter than the gracilis tendon.

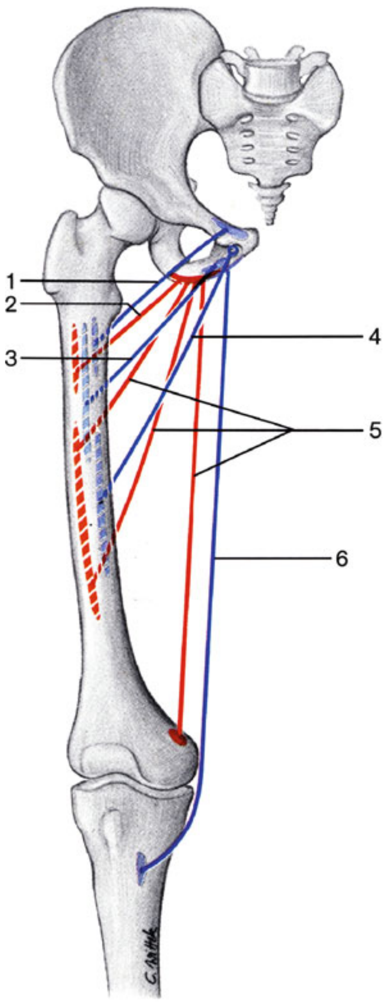

Fig. 24.18 Course of adductor muscles demonstrating origin and insertions. *1* pectineus, *2* adductor minimus, *3* adductor brevis, *4* adductor longus, *5* adductor magnus, *6* gracilis, note long and distal tendon insertion onto tibial condyle (From Rohen et al. [13])

The distal gracilis is then pulled through the medial incision. In doing so the secondary pedicles underneath the intact skin are avulsed – however, the vessels are very small and typically vasospasm off and do not bleed much.

Alternatively, both incisions can be joined to form a single large exposure. The distal accessory pedicles are difficult to discern and vascular control is easily achieved with electrocautery. Electrocautery is used to create a hiatus between the perineum and the thigh to transfer the muscle into the perineum. The muscle is then rotated 180° and tunneled into the perineum, taking care not to twist the muscle to prevent avulsion or occlusion of the primary vascular pedicle. The flap is then sutured to the perineal defect.

The thigh incisions are closed in three layers, with the skin by running a subcuticular stitch and then Dermabond. At the end of the case, we typically place a closed suction drain for a couple of days to help drain any blood or lymphatic fluid. Once the skin is closed we also place a loosely wrapped ACE bandage around the thigh and knee. Patient ambulation usually begins postoperative day 1 or 2. Some patients may ambulate with a limp, but this typically resolves after a few days.

Limitations

The use of the gracilis muscle can have limitations. The gracilis length is directly proportional to the length of the leg. Therefore, in patients with shorter legs, the use of the gracilis flap for the repair of rectourethral fistulae in higher locations may be limited, because the distance from the primary pedicle (constant location) to the distal end of the muscle (variable length) limits the segment of the muscle that can be rotated into the wound. The gracilis muscle is typically long enough to reach the prostatic urethra, but not the bladder. For vesicorectal fistulas, a gluteal maximus flap works well and easily reaches. Occasionally, one gracilis muscle provides insufficient bulk to cover the defect; in such cases, the contralateral gracilis muscle can be harvested and brought into the wound.

Transabdominal Approaches

The transabdominal approach uses an omental or rectus muscle flap for repair or a colo-anal sleeve pull through procedure (after Park's or Turnbull-Cutait). The other advantage of the transabdominal approach is that a simultaneous fecal diversion can be performed. Limitations of transabdominal are that the pelvis can be deep and narrow and make exposure poor, particularly because most rectourethral fistulas are below the level of the levator ani.

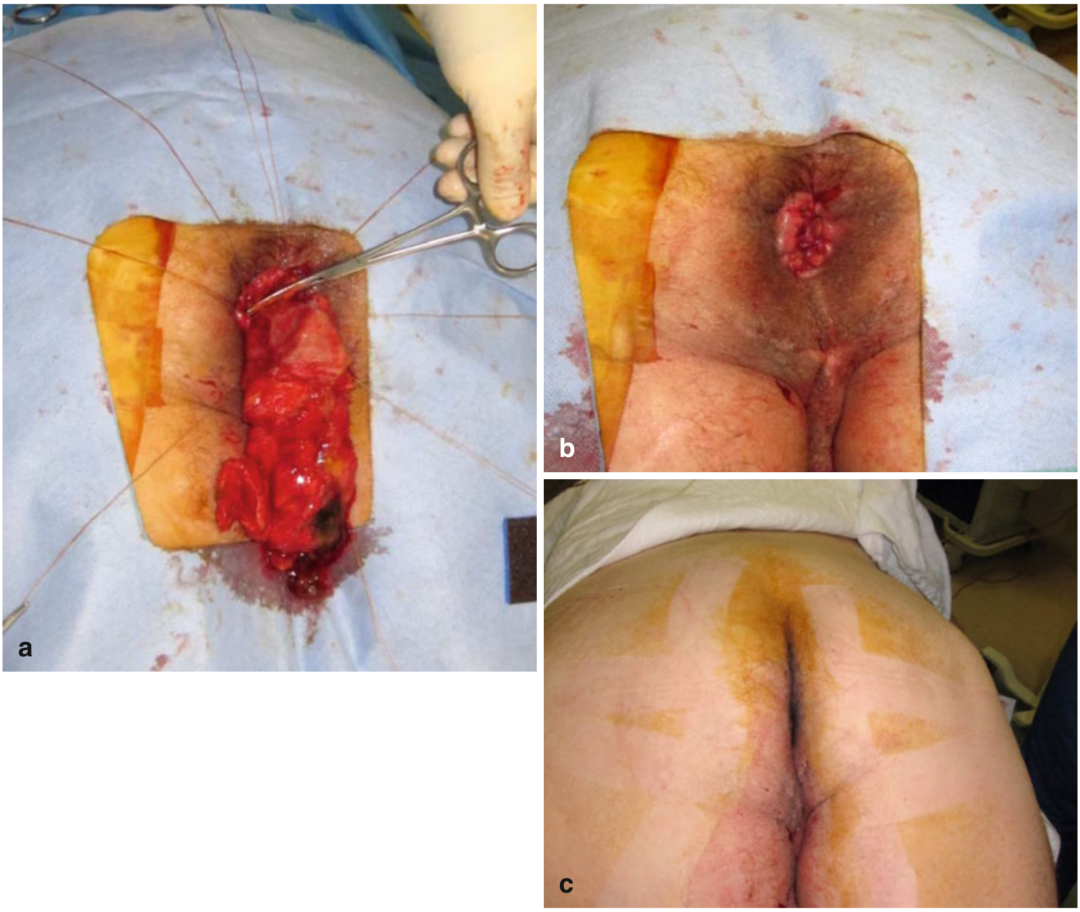

Fig. 24.19 (**a**) Colo-anal pull through at post-op day 5. Hemostat notes the level that the colon will be transected. Note the circumferential preplaced sutures at the dentate line (**b**) Exteriorized colon transected and the colon sutured in place. (**c**) Gluteal cleft postsurgery

Furthermore, abdominal surgery is more morbid and more of a cardiovascular stressor than perineal surgery. Fistulas that are rectovesical or vesicoperineal can be more easily exposed abdominally than rectourethral fistulas.

Abdominoperineal Approach (Turnbull-Cutait Colo-Anal Pull Through)

When the rectum is extensively damaged by radiation that will not allow primary rectal closure due to severe radiation proctitis or extensive tissue loss, these fistulas are often better managed by proctectomy and pull through of healthy rectum. The patient is initially placed in the prone jackknife position and a proctectomy and buccal graft closure of the urinary fistula performed. The patient is then positioned supine and a midline abdominal incision made. The rectosigmoid colon is divided intra-abdominally as is the distal rectum at the dentate line (preserving the anal sphincter). The proximal sigmoid colon is then pulled through to cover the patched or repaired fistula and in so doing provides an excellent vascular bed to insure healing and take of the graft and suture lines are not overlapping. The sigmoid is left emanating from the anus is moist gauze (Fig. 24.19a). In a delayed fashion (days later), the segment of exteriorized colon is transected and the colon is sutured to the dentate line (by preplaced sutures from the first stage), with the mesentery facing the urethral side (Fig. 24.19b, c). By doing such a delayed pull through operation, there are no overlapping suture lines. After a few days, the distal colon has adhered in place, and then the anastomosis is performed.

Rectovesical and Urinary-Perineal Fistulas

Rectovesical fistulas are typically cephalad and difficult to reach perineally. Furthermore, the gracilis flap oftentimes will not be long enough to reach or is tethered by a high or distal vascular pedicle. We place such patients jackknife prone (Fig. 24.20). Open the perineum and the intragluteal fold. Such fistulas typically occur after abdominoperineal rectal resection (APR). Such patients have often received neoadjuvant pelvic radiation and chemotherapy. Often, a coccygectomy will need to be performed for exposure. Under cystoscopy, the fistula is cannulated and a Fogarty or small Foley is placed across and secured. Oftentimes, the fistulas are cephalad and involve the bladder – and thus under the sacrum. Here, a sacrectomy may be needed for exposure. Removal of S4 and S5 is often sufficient for exposure and avoids the morbidity of removal of S3 (Fig. 24.21a–c). To fill the dead space, a paddle of de-epithelialized skin and subcutaneous fat based on a pedicle of the gracilis muscle can be used. However, the gracilis is often too short to reach, so an inferior gluteus maximus muscle flap can be mobilized to fill the space instead, once detached from ileal-sacral ridge (Fig. 24.21d, e). *See* Chap. 18 by Zinman in this volume for more details on the gluteal muscle flap. The rectovesical fistula typically drains into a radionecrotic cavity, which then fistulizes to the perineum. Once the radionecrotic cavity is exposed, it should be curetted of its poorly vascularized tissue.

When the dead space to fill is large, tissue transfer methods to fill the gap are a rectus abdominal muscle flap, bilateral gracilis (gracilis with a de-epithelialized myocutaneous paddle), or by omentum (when it is robust), which is extensively mobilized off the transverse colon and greater curvature of the stomach to lengthen it. Another management option is a proctectomy and closure of the defect or supravesical urinary diversion.

Complex Urinary Fistulas in Patients with Poor Performance Status or Limited Life Expectancy

Patients with complex urinary fistulas and urinary incontinence need to have a decent performance status to undergo a major surgical reconstruction and repair of the fistula. Patients who have multiple comorbidities and, thus, poor surgical candidates with limited life expectancy have limited options for managing their urinary fistulas. Typically a suprapubic tube is initially placed to divert the urine away from the urethral-rectal or urethral-perineal fistula, as long as the internal urinary sphincter is intact. However, if the bladder neck is open or the urinary fistula is in the bladder, then the only noninvasive method to proximally divert the urine is bilateral percutaneous nephrostomy tube placement. Although in most cases the nephrostomies can divert the urine, in some instances the majority of the urine still travels down the ureters. An effective and durable method for managing such urinary fistulas and incontinence is bilateral percutaneous nephrostomy tube placement, followed by trans-ureteric embolization of the distal ureters with a combination of Gianturco coils (steel coils) and Gelfoam (gelatin sponge; Fig. 24.22).

We recently reported our 12-years experience with 29 patients (23 women and 6 men; mean age 59 years, SD 16) with complex urinary fistulas from the bladder or urethra that were refractory to nephrostomy drainage alone [14]. One patient had a history of severe perineal trauma, and the remaining 28 had a history of cancer. None of the patients were surgical candidates because of severe comorbidities or had a limited life expectancy. Seventeen fistulas occurred in the setting of previous surgery. Twenty patients had received adjunctive pelvic

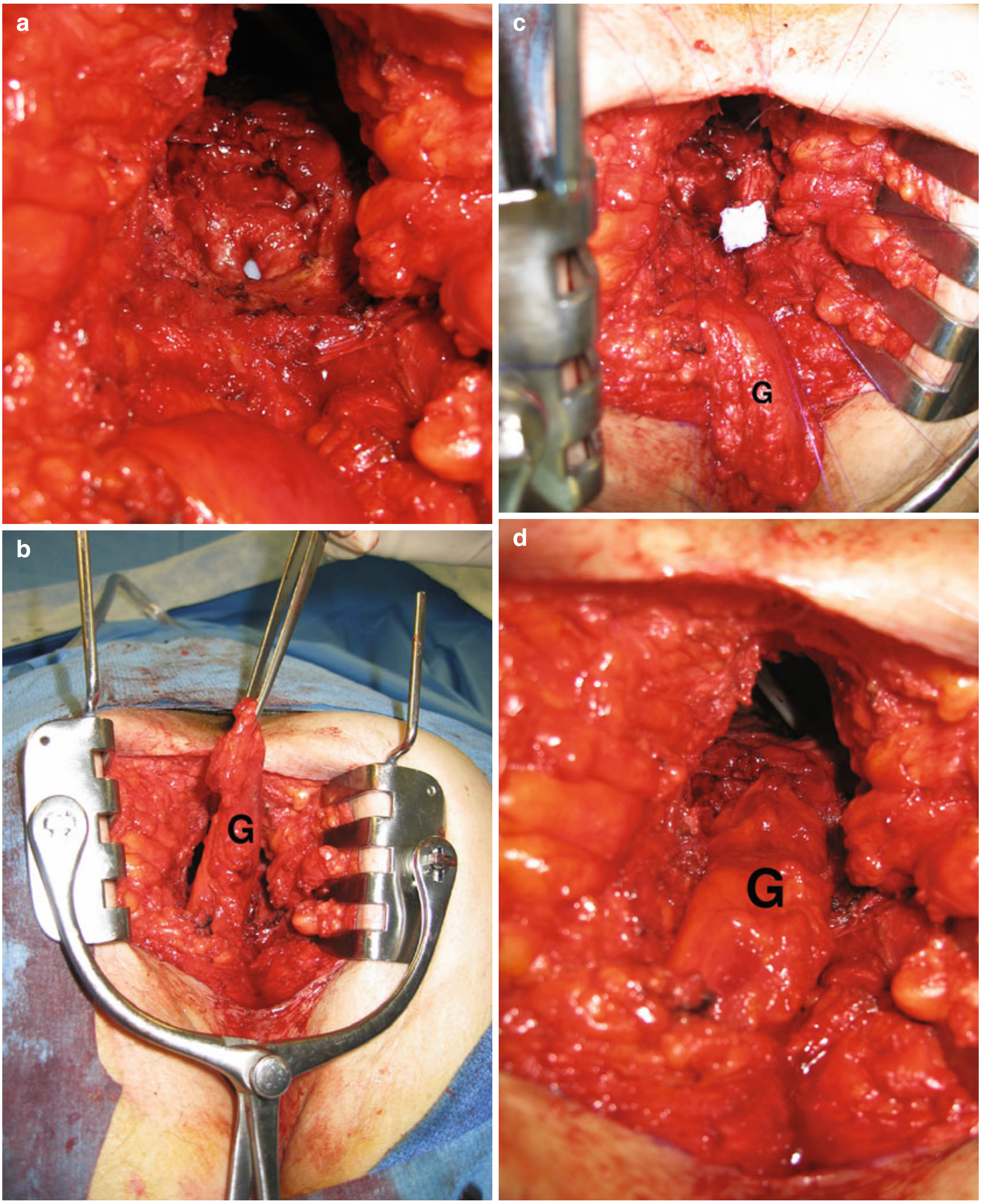

Fig. 24.20 Prostatoperineal urinary fistula after abdominoperineal resection and pelvic radiotherapy. (**a**) Prostatic fistula exposed via paracoccygeal incision in prone position. (**b**) Gracilis muscle mobilized into perineal wound. Note "bear claw" retractor for excellent exposure. (**c**) "Parachuting" in the buccal graft to the prostatic fistula. "G" denotes gracilis muscle flap. (**d**) Gracilis flap in place over buccal graft

irradiation, and 11 had had chemotherapy. In all, refractory urinary incontinence was managed by embolization of 52 ureters. Patients were then managed by long-term nephrostomy drainage until death or definitive reconstructive surgery.

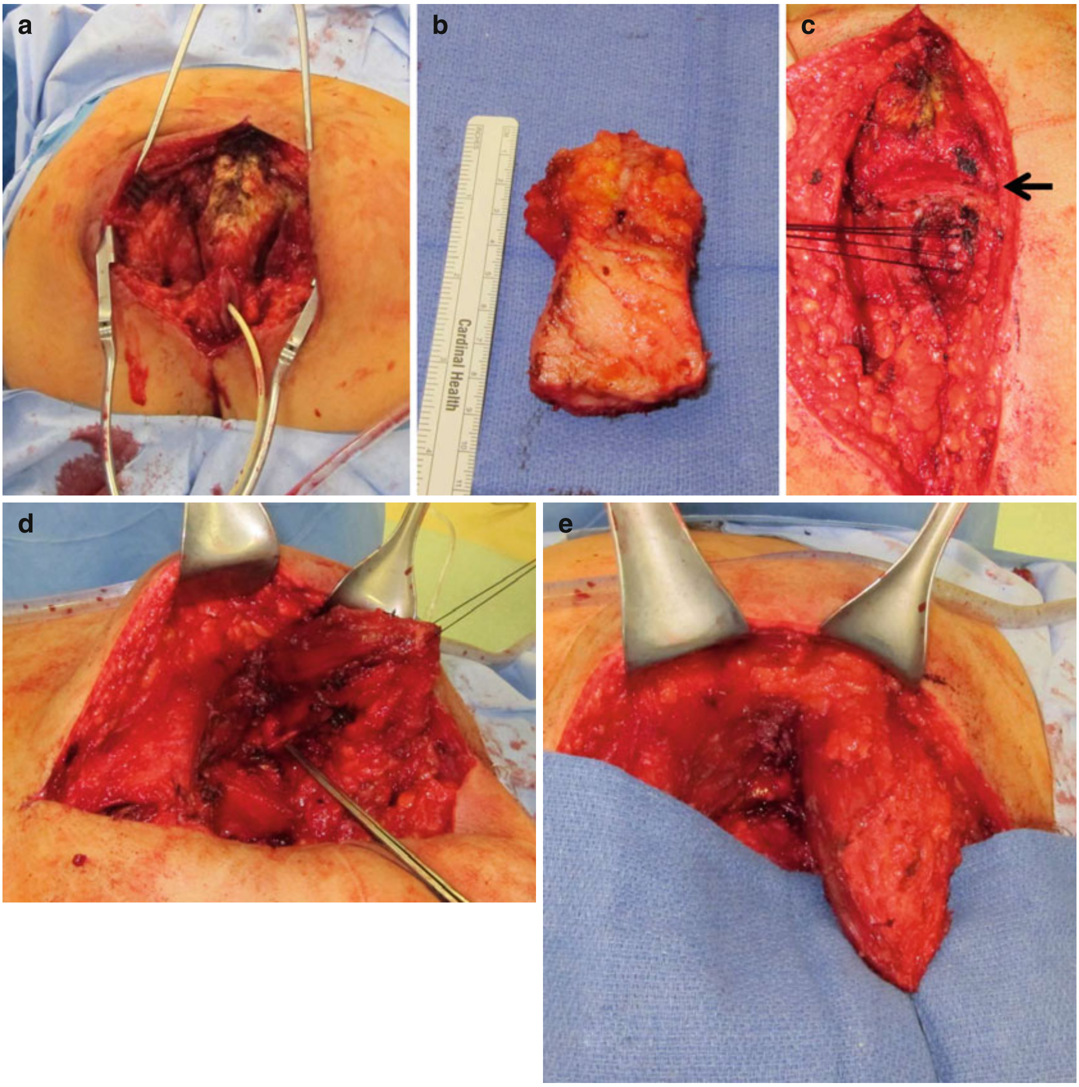

Fig 24.21 (**a**) Sacrum exposed in jackknife position. Note Foley catheter in fistula. (**b**) S4,5 sacrectomy. (**c**) Fistula closure. Note cut edge of sacrum (*arrow*) and excellent exposure. (**d**) Inferior gluteal maximus mobilized. Debakey points to inferior gluteal artery. (**e**) Note mobility of split gluteal muscle

Embolization Technique

In brief, the procedure is done with the patient under local anesthesia and conscious sedation. A nephrostomy tube is placed into both kidneys before embolization. Each nephrostomy tube is replaced at the time of embolization with an access sheath of comparable outer diameter (Fig. 24.22a). A nephrostogram is performed and a 4- or 5-French end-hole catheter advanced coaxially into the distal ureter. A nest of 0.9 mm stainless-steel coils (Gianturco coils, Cook, Bloomington, IN) is created with various sizes of 5–12 mm in diameter (Fig. 24.22b). Between 4 and 12 coils are typically needed to occlude the ureter. In some cases, gelatin sponge pledgets (Gelfoam) were also sandwiched among the coil nests to hasten lumen occlusion. An antegrade nephrostogram is then taken to confirm occlusion of flow at the level of the coils (Fig. 24.22c). The access sheath is then

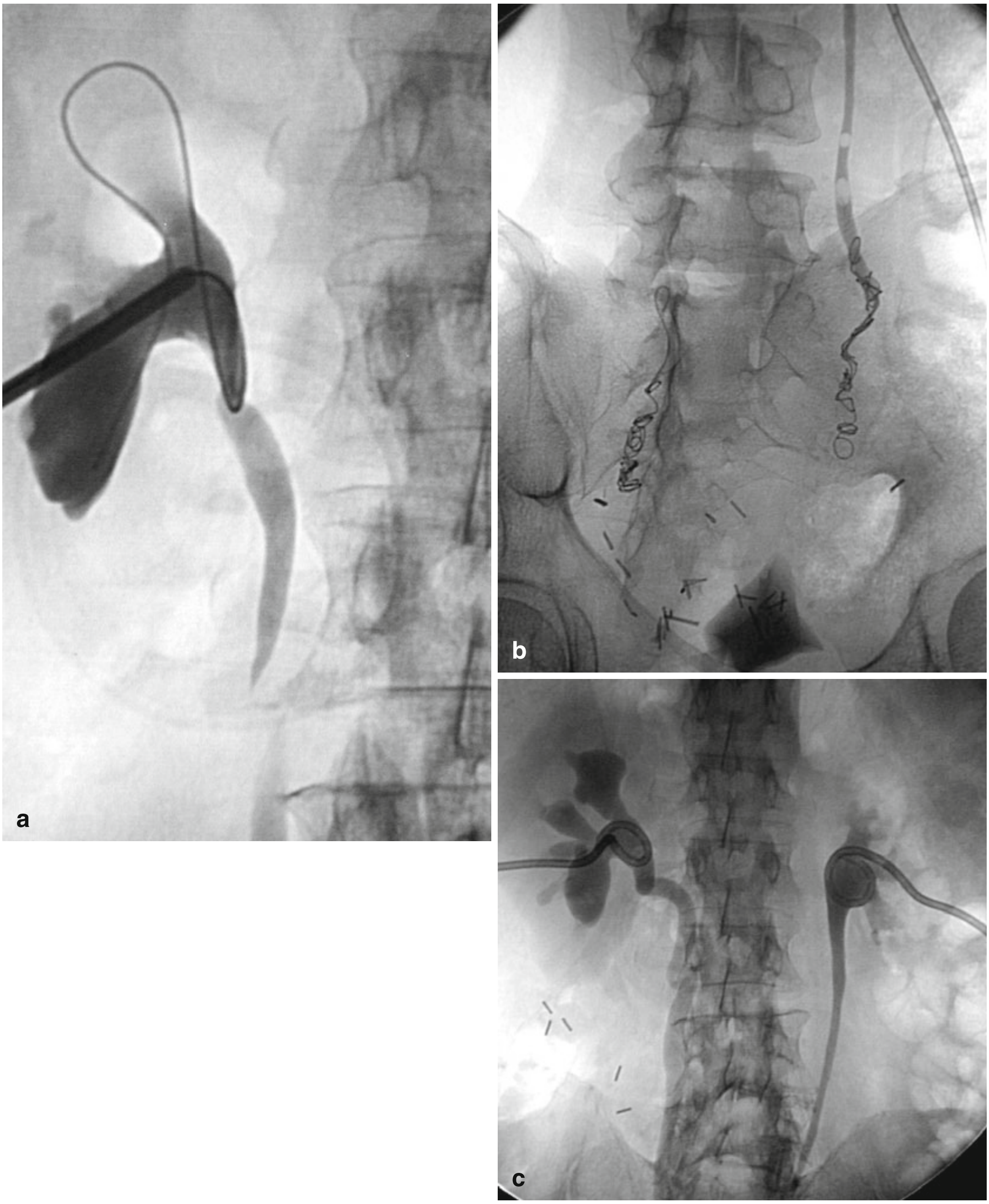

Fig. 24.22 Ureteral embolization for refractory urethrorectal fistula, urinary incontinence, and poor performance status. (**a**) Access sheath placed percutaneously into renal pelvis. (**b**) Deployed Gianturco coils into distal ureters. Left nephrostogram notes obstruction. (**c**) Nephrostomy tube placement after ureter embolization

replaced with a 10- or 12-French (depending on surgeon preference) nephrostomy tube and placed to gravity drainage. Subsequently, nephrostomy catheters are exchanged, typically every 8 weeks. The advantages of this procedure are the ease of using an existing nephrostomy tract and the ready availability and familiarity with the necessary equipment.

Embolization Costs and Outcomes

The results with stainless-steel coils are superior to those obtained with cyanoacrylate glues or detachable ureteric balloons. The procedure is also relatively inexpensive. At our institution, steel coils cost roughly $25 (USA) each and nephrostomy tubes cost roughly $50 (USA). The total material cost is thus $150–350 (USA) per embolized renal unit. The other equipment used for the procedure is commonly available in most interventional radiology suites. With a mean follow-up of 43.8 (38) months, occlusion was successful in all cases, with complete or near-complete (<1 pad/day) dryness within 3 days. No repeat embolizations were required and there were no significant complications. Twenty-three patients died from cancer at a mean of 8.1 ± 11.5 months after embolization. Four patients were alive, three having had staged surgical urinary diversions (colonic or ileal conduit) at a mean of 6 months after ureteric embolization. Ureteric embolization is a viable option for managing complex lower urinary tract fistula in patients with a poor performance status. Moreover, it can be used as definitive management in patients with a limited life expectancy (<1 year).

Editorial Comment

The primary distinction of radiation versus postsurgical fistulas cannot be overemphasized. We have routinely employed the York-Mason approach for postsurgical fistulas with excellent outcomes. We begin with cystoscopy, stent placement (if the fistula occurs in proximity to one or both ureters), cannulization of the fistula with a ureteral catheter over wire, and then urethral catheterization. We then reposition from lithotomy to jackknife position. When performing trans-anorectal fistulectomy, one must not excise too widely since this may create a large trigonal defect which will prove difficult to close. We use fibrin sealant and a free graft of buttock fat over the urinary closure, which is then covered by a rectal advancement flap.

One of the important considerations in the surgical treatment of radiation-induced rectourethral fistulas is the status of the prostatic remnant. Cavitation is often noted such that only a thin shell of residual prostatic tissue exists. Many can be repaired via a perineal approach with a buccal mucosa graft and gracilis flap. In some cases, subtotal prostatectomy with urethroprostatic anastomosis may be performed.

Those patients who have received combined modalities of treatment, such as radiotherapy followed by cryotherapy, often have extensive necrosis and/or calcification of the remaining prostate. These patients tend to experience the sequelae of chronic inflammation and recurrent infection when the residual prostate is unhealthy in appearance. In such severe cases, concomitant salvage prostatectomy or cystoprostatectomy with ileal conduit should be performed at the time of fistula closure.

We have shifted from a perineal approach to a retropubic approach over the years due to enhanced surgical exposure and the facilitation of concomitant prostatectomy or cystoprostatectomy. Most patients prefer to have orthotopic reconstruction via a fistula repair or salvage prostatectomy. Estimation of bladder capacity can be difficult in fistula patients but is important in determining the reconstructability of the lower urinary tract.

—Allen F. Morey, MD

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25 Reconstruction of Failed Urethroplasty

Steven J. Hudak and Allen F. Morey

Summary

While primary urethroplasty has a success rate of approximately 90 %, salvage repairs do not fare as well, having a success rate of roughly 80 %. Failed anastomotic repairs are usually the result of an inadequate excision of fibrotic tissue and/or inadequate distal urethral mobilization, resulting in an anastomosis performed under tension. The mainstay of treatment for recurrent penile urethral strictures remains a flap procedure with penile shaft skin. It is crucial to excise redundant sacculation, residual scar, and/or hair-bearing tissue remaining from prior procedures at the time of reconstruction. If distal stenosis should occur after a flap procedure, extended meatotomy is highly effective. Strictures most amenable to excision with reanastomosis are those in the proximal bulb—these allow for maximal use of the elastic properties of the distal bulbar urethra to bridge the gap created once the scarred segment is excised. For mid- or distal bulbar strictures longer than 3 cm, onlay grafting (with buccal mucosa or penile skin) is the most effective and efficient approach. The primary reason for failure of a primary open urethroplasty of the posterior urethra is inadequate exposure of the prostatic apex, resulting in incomplete excision of scar tissue. Urethral stenosis may recur after any of the above types of open urethral reconstruction—fortunately, the recurrent stricture is most often short and web-like and usually responds well to a single urethral balloon dilation or direct visual internal urethrotomy.

Introduction

During the past three decades, open urethroplasty has been increasingly used for the treatment of urethral strictures. Novel urethral reconstruction techniques have resulted in success rates for initial repair ranging from 80 to 90 % in most contemporary series [1–4]. Substitution urethroplasty procedures have fared worse than anastomotic procedures, with long-term success rates as low as 50 % [5]. Although recurrent stenosis may develop after open urethroplasty with the best of surgeons, many failures can be salvaged with a second (third, fourth, etc.) open reconstructive procedure. This chapter will focus on the causes of primary urethroplasty failure, along with the evaluation and subsequent treatment of these challenging patients in need of salvage surgery.

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Causes of Failure

Most patients present for urethral reconstruction after having failed multiple attempts at endoscopic stricture treatment (urethral dilation and/or internal urethrotomy) [6]. Repeated endoscopic procedures and dilations are costly, unhelpful, unpleasant, and counterproductive, compromising subsequent urethroplasty success rates [7–9]. Diabetes, hypertension, malnutrition, spinal cord injuries, tobacco abuse, and other comorbidities may also adversely affect tissue healing and contribute to failure [7]. De novo urethral cancer is a rare but catastrophic cause of urethroplasty failure, and thus, consideration of a urethral biopsy is warranted to rule out malignancy in refractory and advanced stricture cases.

Previous open repair has been shown to be an independent risk factor for subsequent salvage urethroplasty failure [7–9]. Failed anastomotic repairs usually are the result of an inadequate excision of fibrotic tissue and/or inadequate distal urethral mobilization, resulting in an anastomosis performed under tension. Inappropriate choice of repair may also contribute to urethroplasty failure. An excisional repair would be preferred over a flap or graft, for example, for a short, focally severe bulbar stricture.

Anterior repairs can fail due to inadequate extension of the urethrotomies into normal healthy urethra on both ends of the stricture during graft or flap procedures. A common area for failure of buccal mucosa graft urethroplasties is at the distal aspect of the repair; the recurrent stricture is often thin and weblike and tends to respond well to a simple dilation or visual urethrotomy. More complex stricture recurrences following substitution urethroplasty are often due to poor vascular and structural support of grafted tissues (leading to poor graft “take”) or flap ischemia due to tension on the pedicle, infection, or coexistent microvascular disease.

Failure of posterior urethroplasty is nearly always the result of inadequate resection of scar tissue on the proximal aspect of the urethral distraction defect [10]. Difficult exposure of the proximal urethral segment often occurs in conjunction with traumatic pubic bone displacement within the retropubic space.

Evaluation

Long-term postoperative follow-up from urethroplasty is important because of the occasional occurrence of late failure, particularly following substitution urethroplasty [6]. Typically, patients with stricture recurrence experience decrease in the force of stream or new onset of split stream. The American Urological Association Symptom Score Index has proven effective as screening tool, along with urinary flow rate testing, for men with a history of urethral reconstruction surgery [11–14]. Urinary tract infection with prostatitis or epididymitis may also occur, although most men with recurrent stricture do not have elevated post-void residual. Urethral palpation may demonstrate significant induration associated with spongiofibrosis in the area of the failed prior repair.

Periodic urethroscopy and/or retrograde urethrogram (RUG) is nearly 100 % sensitive in the detection of stricture recurrence. Because most failures tend to occur soon after surgery, most authors perform periodic RUG or urethroscopy within the first 6 months after the repair, then annually thereafter. Given the high sensitivity and specificity of obstructive symptoms to indicate stricture recurrence [11], we typically reserve these costly, unpleasant, and potentially morbid procedures for those with recurrent obstructive symptoms and/or decreased maximal urinary flow rate. The yield of invasive testing is especially low following anastomotic urethroplasty, given its long-term success rate exceeding 90 %.

High-quality, updated imaging prior to salvage repair is essential, as the length and location of the stricture may have changed significantly following previous procedures. A simultaneous RUG and cystogram per suprapubic catheter should be performed in patients with obliterative strictures of the urethra that have necessitated the placement of a suprapubic tube [10]. Oblique views are crucial to precisely determine the length of the stricture or defect. Radiographic irregularities (distorted course, redundancy, sacculation, etc.) are common after urethroplasty, even in asymptomatic patients.

When recurrent stricture is suggested on the basis of clinical findings and urethrography, flexible cystoscopy should be performed to further

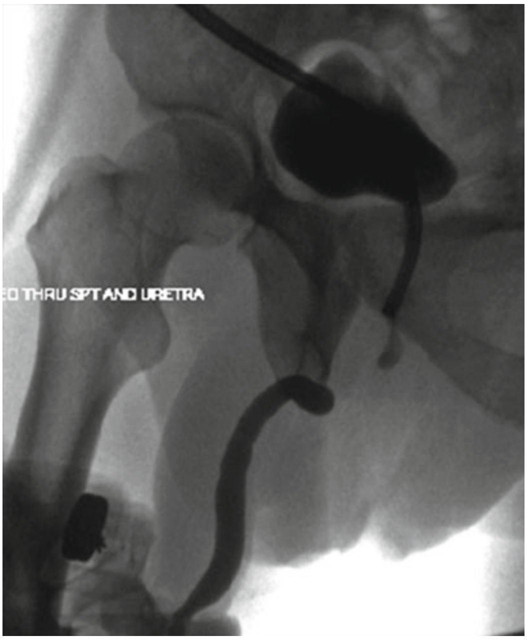

Fig. 25.1 A flexible cystoscope passed suprapubically delineates the fibrotic segment in conjunction with a retrograde urethrogram in this patient who had failed multiple attempts at proximal bulbar reconstruction

delineate the length and severity of the recurrence. If a 15-French scope passes into the bladder without difficulty, the patient may be safely observed without surgery. For posterior urethral or proximal bulbar strictures, imaging of the prostatic urethral segment may be difficult when the bladder neck does not open during cystography. In this scenario, a flexible scope may be used in combination with radiographic imaging to provide an "up-and-down-o-gram" to demonstrate the length of the fibrotic segment (Fig. 25.1).

Preparation and General Considerations

Patient counseling is crucial to ensure realistic expectations regarding salvage urethroplasty outcome and morbidity. Although initial open urethroplasty has a success rate of approximately 90 % (depending on the stricture characteristics and method of repair), salvage repairs do not fare as well, having a success rate of approximately 80 % [15–18]. While options for salvage repair are similar to those of primary repair [17], more extensive fibrosis to and lack of available genital tissue may limit the available options for reconstruction. We will focus this chapter on the differences and modifications of salvage repair as compared to primary urethroplasty.

Many men are reluctant to undergo urethral surgery of any kind because of concerns about potential pain or sexual dysfunction. Additionally, many surgeons are reluctant to embark on reoperative urethral reconstruction due to concerns about the severity of fibrosis in the operative field. As a result, patients are often referred to tertiary centers only after failing repeated attempts at endoscopic treatment and long-standing regimens of intermittent self-dilation of the strictured area. Unfortunately, while self-catheterization of a normal urethra for neurogenic bladder appears to be well tolerated [19], we have noted that chronic self-*dilation* of a diseased urethra following endoscopic treatment is different, having a clinical course involving pain, bleeding, progressive difficulty, false passage, and eventual failure often requiring urgent intervention for urinary retention. For these reasons, intermittent self-dilation is not a viable strategy for long-term stricture management.

If the stricture is short and weblike after previous repair, it may respond to a single attempt at balloon dilation or internal urethrotomy provided it is associated with minimal underlying spongiofibrosis. Long and/or dense recurrent strictures do not respond to dilation or internal urethrotomy. Rather, we have noted that repeated attempts at endoscopic treatment lead to increased stricture complexity and prolongation of the patient's symptoms. Once surgery is selected as the course of action, the reconstructive surgeon must tailor repair to the length, location, and character of the recurrent stricture.

Procedure selection is of paramount importance, and patient positioning, exposure, instrumentation, tissue handling, and choice of repair can all affect the success or failure of a salvage repair. A watertight, tension-free anastomosis is crucial to increasing the chance for surgical success. Tissue at the anastomotic site must be well vascularized, hairless, and supple to ensure a successful outcome.

Optical magnification with loupes is strongly advised to ensure that mucosal apposition at the anastomosis is achieved. A headlamp promotes maximal visualization during deep perineal dissection. Sharp dissection is preferred, limiting the use of electrocautery to fulgurate bleeding vessels only. For perineal cases, the Lone Star™ (Cooper Surgical, Trumbull, CT) self-retaining retractor has provided ample perineal exposure in nearly 1,000 cases in our experience. Sharp hooks provide excellent retraction of fibrotic, reoperative tissues, and blunt rakes are an excellent adjunct to retract bulky, redundant scrotal tissue. A plastic surgery set including calipers, fine-toothed forceps, and curved iris scissors is helpful during flap and graft harvest and anastomosis. We prefer 5–0 and 6–0 polydioxanone for our anastomotic sutures. Drains are rarely needed and may impede convalescence as most men are discharged home on the morning of the first postoperative day. We prefer to control friable oozing tissues with hemostatic agents in the perineum (i.e., Floseal™, Baxter, Deerfield, IL) or a compressive Coban™ (3M™, St. Paul, MN) wrap for penile urethral reconstruction. A 16-French silastic catheter is placed for 2–3 weeks postoperatively with a voiding cystourethrogram being done at the time of catheter removal. Indwelling suprapubic tubes are generally removed at the time of surgery and not replaced postoperatively unless the repair is tenuous.

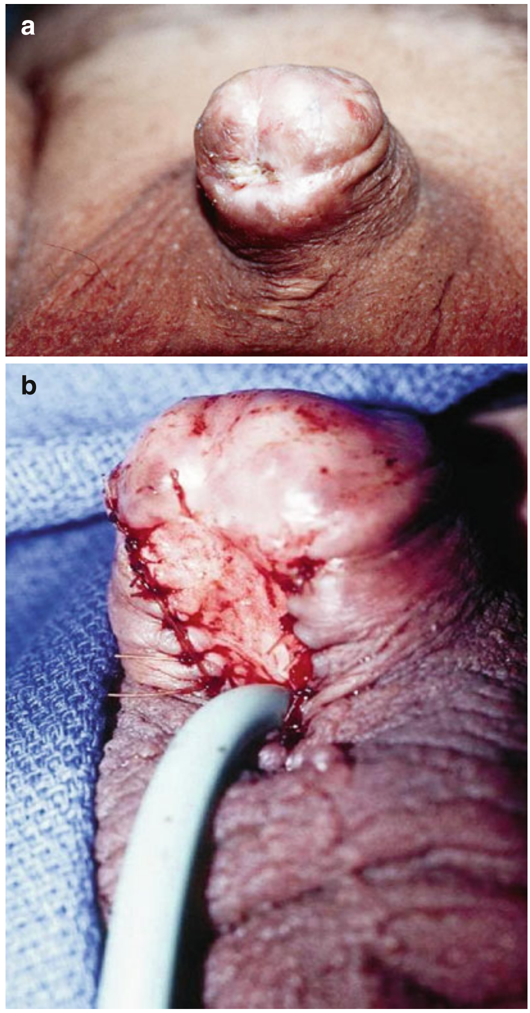

Fig. 25.2 (**a**, **b**) Extensive perimeatal LS is noted in conjunction with an extensive stricture of the pendulous urethra and fossa navicularis

Urethral Meatus

We have found that penile skin flap repairs work extremely well for healthy patients having discreet fossa navicularis strictures 2.5 cm or less. A penile fasciocutaneous skin flap tunneled under the ventral aspect of the glans provides excellent cosmesis [20]. For men with unfavorable tissue quality in the perimeatal area, however, penile skin flaps are discouraged.

Lichen sclerosus (LS) produces a pathognomonic whitish perimeatal thickening and is an adverse prognosticator which may limit treatment strategies. When LS is suspected, it is reasonable to document its presence with biopsy. Extended meatotomy (first-stage Johanson procedure) may be selected as a rapid, simple, and highly effective approach for perimeatal stenosis that extends through the fossa navicularis (Fig. 25.2) [21]. Such patients must be warned about the potential for sprayed or split stream. We have found that many reoperative and/or elderly patients will gladly accept a hypospadiac cosmetic appearance in conjunction with resolution of their voiding difficulties in lieu of a more complex repair or perineal urethrostomy. For patients desiring a normal cosmetic appearance, many experts now advocate a staged approach to all LS-related strictures of the fossa navicularis and pendulous urethra [22, 23].

Pendulous Urethra

The mainstay of treatment for recurrent penile urethral strictures remains a flap procedure with penile shaft skin. Excision with end-to-end anastomosis should be avoided on the penile shaft to avoid the risk of penile shortening and ventral penile curvature. Various flap configurations may be used as originally described by Orandi, Quartey, and McAninch [24–26]. All of these techniques involve a full thickness section of penile skin supplied by a pedicle consisting of the anterior lamella of Buck's fascia and the vascular tunica dartos layer.

One key to salvage repair is extension of the urethrotomy well into normal caliber urethra proximal and distal to the stricture—we open the stricture until a 24-French bougie passes without resistance. Even with previous open urethroplasty in the pendulous urethra or circumcision, there is usually enough extra penile skin distally or circumferentially to allow one of the above flap techniques. We prefer the circular penile fasciocutaneous flap as described by McAninch because it is extremely versatile and effective. It is crucial to resect redundant sacculations, residual scar, or hair-bearing tissue remaining from prior procedures at the time of reconstruction (Fig. 25.3) [17].

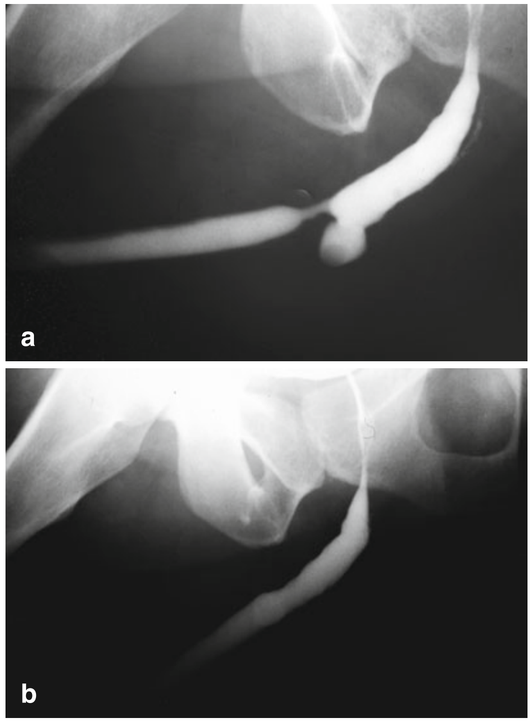

Fig. 25.3 (**a**) Sacculation of previous scrotal skin flap near recurrent stricture. (**b**) Postoperative appearance after excision of redundant hair-bearing tissue in conjunction with a 4-cm circular penile skin flap onlay during revision urethroplasty

When genital skin is lacking, buccal mucosa provides the optimal graft tissue because of its robust nature, reliability, availability, and ease of harvest [27–31]. Lingual grafts are thinner yet adequate if bilateral buccal mucosal harvests have been performed previously, since repeat cheek harvesting is exceedingly difficult and yields less satisfactory grafts [32–34]. Grafts may be placed ventrally, dorsally, or laterally depending on surgeon preference with equally good results, although our preference remains ventral onlay due to its simplicity [35, 36]. Although grafts have traditionally been discouraged in the pendulous urethra because of the limited vascularity of the distal corpus spongiosum, we have found buccal mucosa grafts to perform very well for pendulous reconstruction, particularly in the salvage setting. When spongioplasty is not possible, we utilize tunica dartos, Buck's fascia, and/or tunica vaginalis flaps (obtained via a scrotal counter-incision) for ventral graft support. A compressive penile wrap further stabilizes the grafts to their host tissues and prevents graft shear.

Care must be taken to ensure an adequate urethral plate width during any onlay repair for advanced stricture disease. When found to be inadequate (<1 cm in width), urethral plate "salvage" via a dorsal buccal mucosa graft may be accomplished in conjunction with ventral skin flap or overlapping ventral buccal mucosal graft onlay as an alternative to flap tubularization (Fig. 25.4) [37, 38]. Hairless scrotal flaps and/or staged procedures utilizing either buccal mucosal grafts or meshed split thickness skin grafts may be considered for severe, refractory strictures, although these options are rarely used in our experience [39].

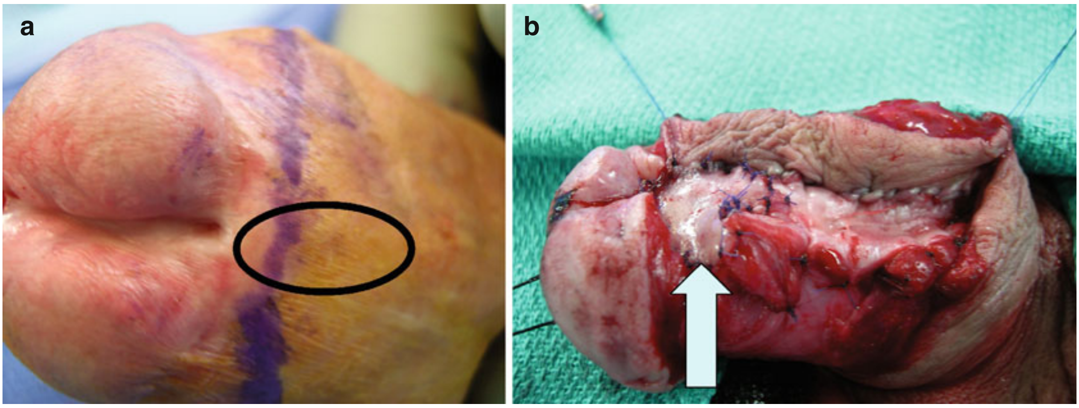

Fig. 25.4 (**a**) Focally severe (5 Fr) distal stricture (*oval*) located at distal end of pendulous stricture. (**b**) Dorsal buccal mucosa graft (*arrow*) used for urethral plate salvage at terminal end of ventral penile skin flap onlay repair. The subcoronal meatus location is prudent to avoid subsequent meatal stenosis in reoperative cases

Bulbar Urethra

Excision of fibrotic urethra with end-to-end anastomosis is the most efficacious method of bulbar urethral reconstruction. This remains true for salvage repairs regardless of the technique used prior to failure (graft, flap, staged, etc.), provided the excised segment is a length that will not preclude a tension-free anastomosis (Fig. 25.5) [16, 40]. In our experience, approximately 50 % of failed graft or flap repairs have short (<3 cm), obliterative recurrences which are ideal for excision and primary anastomosis with outcomes approximating that of primary anastomotic repairs (Fig. 25.6).

Strictures most amenable to primary excision with reanastomosis are those which are located in the proximal bulb (Fig. 25.7). This enables maximal use of the elastic properties of the mobilized distal bulbar urethra to bridge the gap created once the scarred segment is excised. We have repeatedly noted that failed graft procedures may be successfully salvaged by EPA, even when defects approach 5 cm in length. Conditions favorable for an extended anastomotic urethroplasty include stricture location in the proximal half of the perineum and adequate stretched penile length (14 cm or greater) [41, 42]. For non-obliterative strictures greater than 2 cm long in the distal bulb, onlay graft (penile skin or buccal mucosa) is usually the most effective and efficient approach since anastomotic repairs performed within the scrotum tend to be under more tension [17]. Although flaps have the advantage of carrying their own blood supply, transfer into the perineum is a formidable undertaking due to the extensive genital dissection required and is thus discouraged. Further, sexually active young men are prone to complaints of penile shortening or ventral tethering when penile flaps are used for bulbar reconstruction [43].

Grafts may be performed in the bulb for both primary and salvage urethroplasty; the thick ventral spongiosum is an ideal recipient site, and these procedures are extremely well tolerated. Although we prefer ventral graft placement because it is more straightforward, a dorsally placed graft may be preferred if the spongiosum is deficient [35]. Grafts may also be used to augment a partial anastomosis in the bulbar urethra if the stricture is focally obliterative but too long for end-to-end anastomosis [44].

Posterior Urethra

Posterior urethral injuries are usually the result of pelvic trauma, resulting in pelvic fracture with urethral disruption at the bulbomembranous junction. If treated acutely via early primary realignment over a catheter, most men will eventually develop a short stricture 1–3 cm in length amenable to a straightforward anastomotic repair. Longer strictures and those associated with fistula, abscess, or other complicating factors may require extensive dissection via a simultaneous perineal and transpubic approach [45].

The primary cause of failure after posterior urethral reconstruction is inadequate exposure of the prostatic apex, resulting in incomplete excision of scar tissue. When performing salvage posterior urethroplasty, the amount of fibrosis and length of defect will ultimately determine the dissection necessary to achieve a tension-free anastomosis. If the recurrent stricture is relatively short, a perineal anastomotic repair with excision of fibrotic tissue and end-to-end anastomosis is performed. Complete excision of the "plug" of fibrotic tissue separating the prostatic apex and healthy bulbar urethra is essential before performing the anastomosis. In all but the most severe injuries, the bulbar urethra remains well vascularized via retrograde blood flow, allowing repair of defects up to 5 cm in length.

Intraoperative cystoscopy is essential during revision posterior urethroplasty to detect eggshell calculi which may form on long-standing suprapubic catheter balloons (Fig. 25.8) and to visualize

Fig. 25.5 (**a**) Attempted staged urethroplasty with perineal urethrostomy in 27-year-old healthy male. (**b**) During reoperation, the entirety of the 4-cm diseased segment was excised, along with the prior stenotic first-stage urethrostomy. (**c**) A tension-free primary anastomosis was performed. (**d**) Postoperative VCUG reveals normal appearance

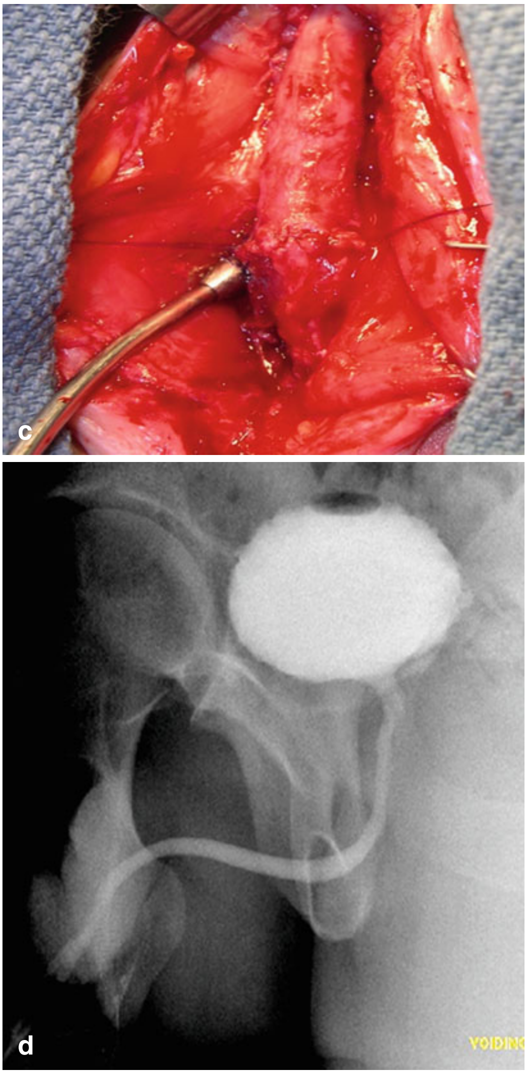

Fig. 25.5 (continued)

the prostatic apex to ensure the correct proximal anastomotic site (Fig. 25.9). The progressive repair popularized by Webster involves separation of the corporal bodies, inferior pubectomy, and/or supracrural rerouting of the urethra [46]. We have found that sharp scalpel excision of all fibrotic tissues between the proximal corporal bodies and directly under the inferior pubic symphysis is essential in reoperative cases, a maneuver facilitated by separation of the proximal corpora.

An abdominal-perineal approach with or without pubic bone resection has proven helpful in multi-reoperative and/or pediatric posterior urethroplasty cases [47]. Utilizing two separate operative teams is essential to limit time in the lithotomy position during these complex cases. Several factors predicting the need for this combined approach include a long or high urethral defect (>3 cm), a chronic periurethral cavity or fistula, or a prior failed perineal approach [18, 48, 49]. Complete mobilization of the bulbar urethra to the level of the suspensory ligament of the penis promotes tension-free repair of nearly all posterior defects following scar excision. An omental flap may be brought down to protect the anastomosis and fill retropubic dead space [50]. Finally, the timing of a salvage repair is important as one should optimally wait at least 6 weeks after any urethral instrumentation to allow for maximal healing and thus increased tissue pliability and accurate identification of healthy versus diseased tissues.

Surgical Pearls and Pitfalls

Key Intraoperative Surgical Points

- Recurrent strictures must be accurately delineated with retrograde urethrography, voiding cystourethrography, and cystoscopy prior to any salvage treatment.
- Short, weblike recurrences are appropriate for a *single attempt* at internal urethrotomy or balloon dilation.
- Recalcitrant meatal/fossa navicularis strictures are easily managed with extended meatotomy provided the patient accepts the risks of spraying and cosmetic changes.
- Recurrent pendulous strictures are ideal for onlay flap or graft reconstruction, depending on the amount and quality of penile skin available.
- Most recurrent proximal bulbar strictures are amenable to excision and primary anastomosis. Buccal mucosal graft onlay is appropriate for long and/or distal bulbar recurrences.
- Recurrences after posterior urethroplasty are typically due to poor exposure of the deep perineum resulting in inadequate scar excision proximally. A two-team, abdominal-perineal approach may be helpful in selected complex reoperative cases.

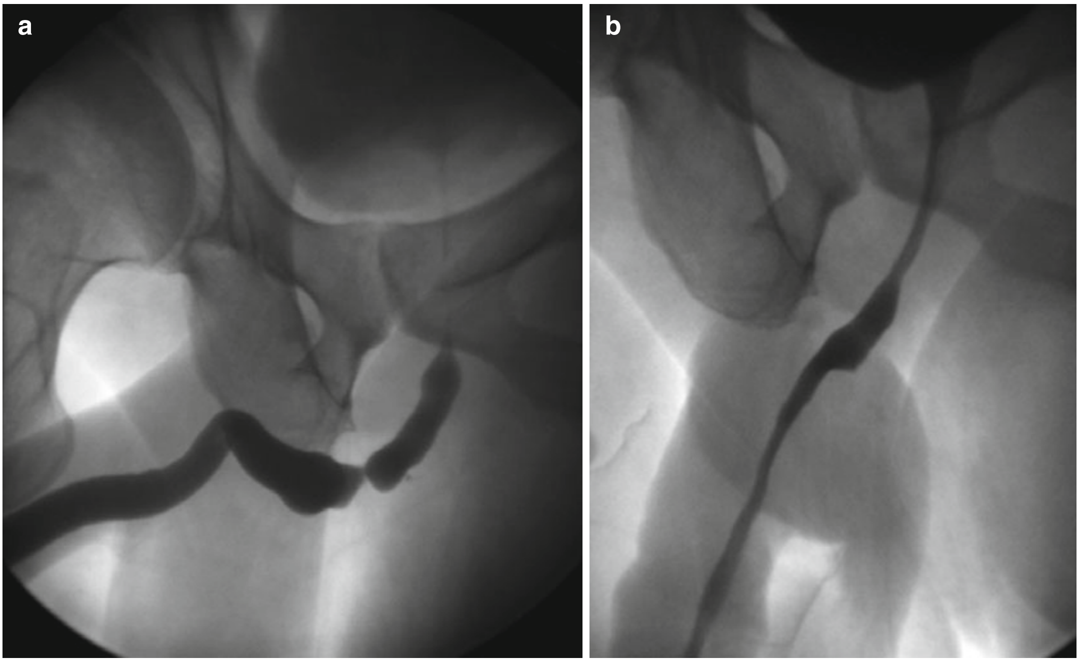

Fig. 25.6 (**a**) Preoperative retrograde urethrogram showing a short, severe mid-bulbar stricture many years after a failed 2-stage scrotal inlay procedure. (**b**) Postoperative voiding cystourethrogram after excision and primary anastomotic repair

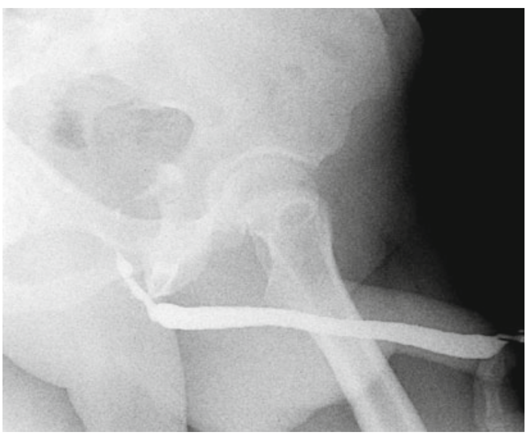

Fig. 25.7 Proximal bulbar stricture 3.5 cm in length after prior penile skin graft urethroplasty successfully reconstructed via complete excision with primary anastomosis

Potential Intraoperative Surgical Problems

- Repeated endoscopic treatment of recurrent urethral strictures is futile and often leads to increased spongiofibrosis resulting in increased stricture length and severity.
- Profuse glans bleeding during extended meatotomy can be managed with temporary penile tourniquet placement until the epithelial edges can be matured to the glans skin.
- If an attempted anastomotic urethroplasty appears to be under excessive tension, the dorsal wall should be anastomosed and secured to the corporal bodies. The resulting ventral defect (typically <3 cm) may easily be augmented with a small patch of penile skin or buccal mucosa.
- Obliterated urethral segments must be excised. If the resulting defect is long or located in the pendulous urethra, the urethral plate can be reconstituted with a dorsally placed buccal mucosal graft. Single-stage repair is completed with an overlapping penile skin flap or buccal mucosal graft onlay.

Preferred Surgical Instruments of AF. Morey

- Lone Star™ (Cooper Surgical, Trumbull, CT) self-retaining retractor, #3304G
  - 5-mm sharp hook, #3311-1G
  - 12-mm blunt hook, #3350-1G
  - 4 prong blunt rake, #3334

Fig. 25.8 Numerous eggshell calculi removed cystoscopically in conjunction with repeat posterior urethroplasty

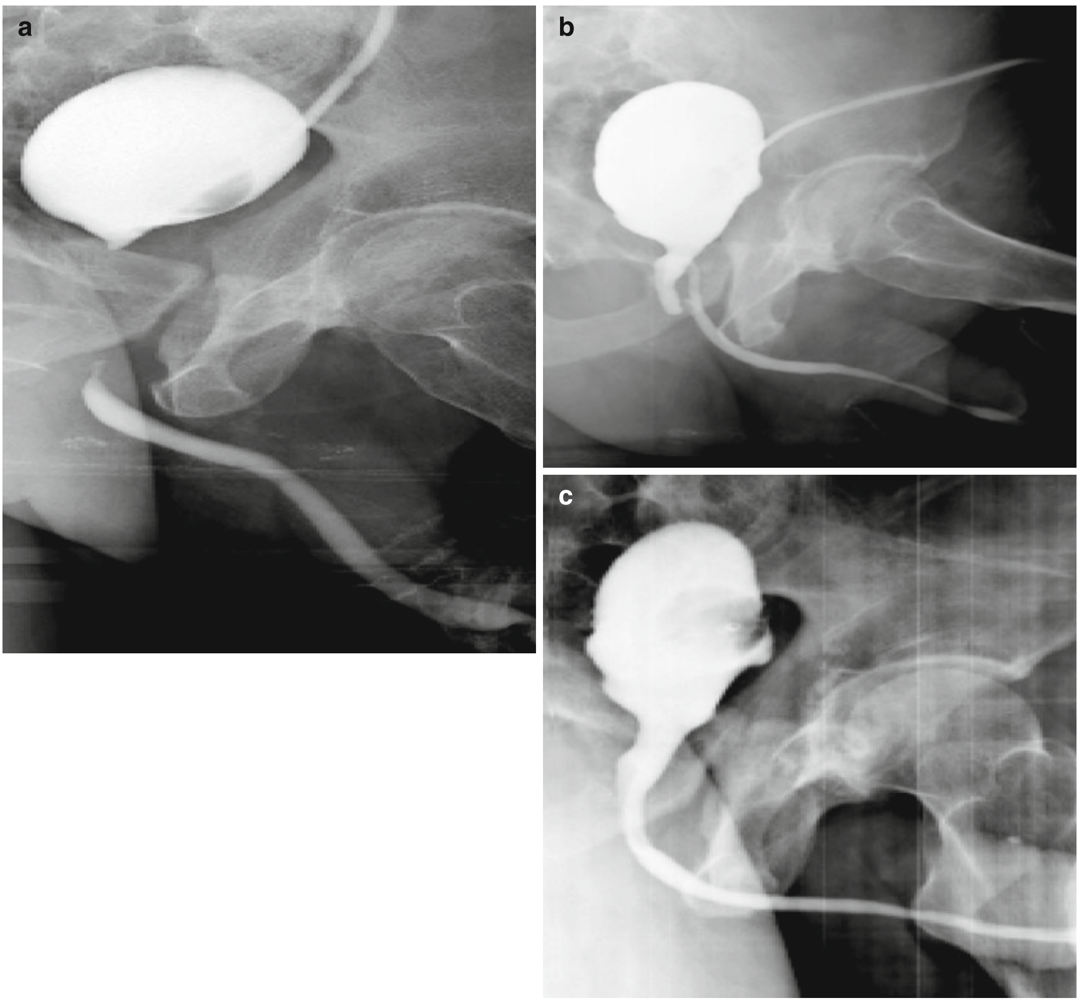

Fig. 25.9 (**a**) Preoperative combined cystogram/retrograde urethrogram shows long posterior urethral defect after pelvic fracture. (**b**) Appearance after initial repair (during which intraoperative cystoscopy was not performed) shows bulbar urethra anastomosed to anterior prostate. (**c**) Repeat perineal urethroplasty in same patient demonstrates bulbar urethra anastomosed correctly to prostatic apex

- DeBakey vascular forceps: generic dissection and atraumatic grasping of the corpus spongiosum
- Toothed Gerald forceps: grasping the urethral epithelium during anastomosis
- Super-sharp Metzenbaum scissors
- Curved iris scissors
- Olive-tipped bougie a boulé sounds: urethral calibration
- Van Buren sounds: placed via suprapubic tube tract during prostatic apex identification

Urethroplasty Suture

- Double armed, 5-0 polydioxanone, RB-1 needle: anastomosis and flap/graft onlay
- Double armed, 5–0 polydioxanone, RB-2 needle: posterior reconstruction proximal sutures
- 6-0 polydioxanone, TF needle: posterior reconstruction with tighter working space
- 4-0 polyglactin, RB-1 needle: urethral stay sutures and ligation of bulbar arteries
- 4-0 chromic, RB-1 needle: extended meatotomy epithelial maturation sutures

Editorial Comment

Urethroplasty typically fails because of one or more of the following reasons:

1. The host bed was inadequate to keep the buccal graft alive.
2. The vascularity of the pedicle to the skin flap was compromised or inadequate.
3. Insufficient scar was excised or the urethrotomy was not made long enough into normal tissue.
4. The anastomosis was on tension or the blood supply of the cut ends of the urethral had inadequate collateral blood flow.

In general, when a urethroplasty fails, it is important to note the time interval till the failure and the length and location of the restenosis. An extensive work up of urethrography and cystoscopy is essential. Typically, the restenoses are short and annular (<1 cm) and can be salvaged by optical urethrotomy. I have found the strictures after a graft or flap are almost always at the very ends, where the blood supply is most tenuous. It is very rare to see a stricture in the middle of a graft or flap. Strictures that recur within the first 6 months are usually due to a technical error and often refractory to urethrotomy. The strictures that occur in a delayed fashion are the ones most amenable to salvage by urethrotomy, as in these cases the spongiofibrosis and ischemia is not as severe.

If the salvage urethrotomy fails, or the stricture is located in the penile urethra, I typically try to do a different kind or type of urethroplasty then the first time around. For a bulbar urethroplasty that fails, if the first surgery was a ventral buccal graft, for the salvage surgery, I place the graft dorsal. This places the graft in a fresh and potentially less compromised vascular bed and makes dissection potentially easier as the planes are virginal and thus should be less scarred. If a repeat graft surgery fails and the stricture is long, I will salvage with an onlay flap of penile skin, brought into the perineum via a scrotal window. If this fails, I will resort to a staged urethroplasty with buccal grafts. If the stricture is short yet refractory, an EPA is reasonable. For young and potent patients however, I tend to shy away from EPA, unless the stricture etiology is traumatic or the lumen is obliterative.

For recurrent penile strictures, where the first time around they were repaired by a dorsal buccal graft, I will salvage with an onlay flap of penile skin, depending on the amount and quality of penile skin available. If the initial urethroplasty was a ventral onlay flap of penile skin and if the urethral plate is ≥1 cm, I will try to salvage with an Asopa inlay with oral mucosa or a dorsal buccal graft. If the plate is <1 cm, I will usually salvage with a staged reconstruction.

Posterior urethroplasty failure is a bit of a different animal than failures of anterior urethroplasty. Here, the reasons of stricture recurrence are tension on the anastomosis, inadequate bipedal blood flow, or insufficient and inadequate scar excision. If the patient is referred to me after a failed posterior urethroplasty, the main cause for restenosis is inadequate and not aggressive enough scar excision. It makes sense for me then to do a repeat posterior anastomotic urethroplasty. A graded, progressive approach may be needed the second time around, such as corporal splitting.

A two-team, abdominal-perineal approach may be helpful in select complex reoperative cases.

As posterior urethroplasty is essentially a urethral advancement flap, proximal urethral ischemia is a real possibility in impotent patients, hypospadias patients, and concomitant penile urethral stricture patients, where perforators and collaterals are compromised. For such patients that restenose, evaluating the ED with penile duplex sonography, followed by arteriography and possibly penile revascularization, prior to more surgery, may help improve collateral blood supply and thus EPA success. For the hypospadias or penile stricture patient with a failed posterior urethroplasty, we prefer a staged urethroplasty for salvage.

—Steven B. Brandes

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Urethral Stent Complications and Methods for Explantation

26

Jill C. Buckley

Summary

The Urolume endourethral (American Medical Systems) prosthesis is a self-expanding braided, pliable, cylindrical mesh of steel wire first introduced in 1988 for short mid-bulbar urethral strictures. Original indications for permanent urethral stents were very limited and narrowed to recurrent and short bulbar strictures. Current indications for urethral stents are only in patients with severe comorbidities that prohibit safe anesthesia risk. Contraindications to urethral stent placement include meatal and penile urethral strictures, traumatic membranous strictures, strictures that cannot be cut or dilated sufficiently, active urinary tract infection, long stricture length, urethral fistula, and/or urethral cancer. Stent-related complications are high and include recurrent stricture, stent encrustation, chronic pain, chordee, post-void dribbling, and incontinence. Detailed herein are surgical methods for managing the complex problem of failed Urolume stent, in particular explantation and subsequent urethral reconstruction.

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Introduction

The Urolume, self-expanding endoprosthesis (American Medical Systems, Minnetonka, Minnesota) is a braided superalloy cylindrical mesh wire that is placed endoscopically to exert outward radial force to maintain urethral patency. Originally designed as an endovascular stent, it depends on complete epithelialization (typically between 6 weeks and 6 months) to prevent stent encrustation, stone formation, urethritis, and dysuria. The overly promising early reports of success in short bulbar urethral strictures lead to off-label placement of the device throughout the entire urethra, in multiplicity and for strictures of significant length. This initial enthusiasm has been replaced by the reality of high revision and complication rates (24–55 %) often creating a more difficult situation to manage than the original problem [1–3].

The 2011 Urethral Disease Consensus Statement performed a systematic and evidence-based review of the literature on the topic of urethral stenting and concluded permanent urethral stenting is not recommended as routine therapeutic management of any anterior urethral stricture for any patient considered a surgical candidate. It should be reserved for patients that are medically unfit for surgery with a short, recurrent bulbar stricture that cannot undergo or tolerate dilation or catheter drainage.

The original indication was for short (<2 cm) primary bulbar strictures and demonstrated marginal outcomes. Similar strictures

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currently undergo excision and primary anastomotic urethroplasty with well-documented (>95 %) and durable success [4–6]. In the subset of patients medically unfit for the risk of anesthesia, alternative management options could be utilized such as urethral or suprapubic tube drainage avoiding the high complication and re-intervention rates encountered with the Urolume stent. Contraindications (and thus an off-label use) to urethral stent placement include meatal strictures, pendulous urethral strictures, traumatic membranous strictures, strictures that cannot be cut or dilated to 26 French, active urinary tract infection, strictures >3 cm length, urethral fistula or cancer, and perineal urethrostomy.

When the Urolume is used for its limited indications, there is a well-reported and recognized complication and failure rate. Urolume failures often are surgical reconstructive challenges. The North American Multicenter Urolume Trial (NAUT) is the largest and longest follow-up study of the Urolume and bulbar urethral strictures. Shah et al. reported on 179 patients in a prospective, open-label study. Follow-up was poor at 11 years, with only 24 patients (13 %) [7]. A total of 87 % ($n = 155$) dropped out after the 5-year approval study. Of the limited number available for long-term follow-up, 33.3 % (8/24) failed and required transurethral resection (TUR) or restenting. The majority (78 %) of the recurrences occurred within 1 year of stenting. Moreover, Shah et al. reported in 2003 on the NAUT experience with Urolume explantation, noting that of 465 patients, 69 (14.9 %) required removal after 7 years, with stents removed according to etiology: 5 % for bulbar stricture, 22 % for DSD, and 23 % for benign prostatic hyperplasia. All stricture restenoses occurred within the first year of implantation. Restenosis was primarily hyperplasia ingrowth and focal inflammation. Risks for stent explantation for bulbar strictures were highest for prior urethroplasty and prior pelvic irradiation.

In 1996, Milroy et al. presented their intermediate results with 50 patients treated with stent placement for bulbomembranous strictures. Restenosis requiring retreatment developed in 8 patients (16 %), insignificant intraluminal narrowing developed in 1 patient (2 %), and extraluminal stricture developed in 9 patients (18 %) who also required additional treatment. Most restenoses occurred in strictures with a traumatic etiology or history of prior urethroplasty [8].

Patient satisfaction and urethral patency rates continued to decline with time. De Vocht et al. reported 10-year patient satisfaction rates after placement of the Urolume stent and found that only 2/15 patients were satisfied with their stent [2]. Patients reported discomfort with erection and/or ejaculation, and 50 % had stent-related incontinence. Four patients had their stents removed, two for intractable pain and two for stent obstruction. A recent long-term study from London reported that only 45 % of the patients were free of recurrence and complications and 45 % suffered multiple complications after Urolume placement such as obstruction from hyperplasia or stricture, stent encrustation or calcification post-micturition dribbling, and recurrent urinary tract infections [9].

Complication Specifics

Overlapping Stent Separation

If overlapping stents do not sufficiently cover each other, a gap will develop between them, as the implanted stents shorten as they expand. One of the stents can also become displaced. Regardless, hypertrophic scar typically forms between the separated stents, leading to lumen obstruction [10].

Recurrent Stricture

The location and length of the recurrent stricture after stent placement dictates the treatment. If the stricture and stent are at the proximal bulbar urethra and total urethral stricture disease is <2.5 cm, then urethral mobilization and a progressive

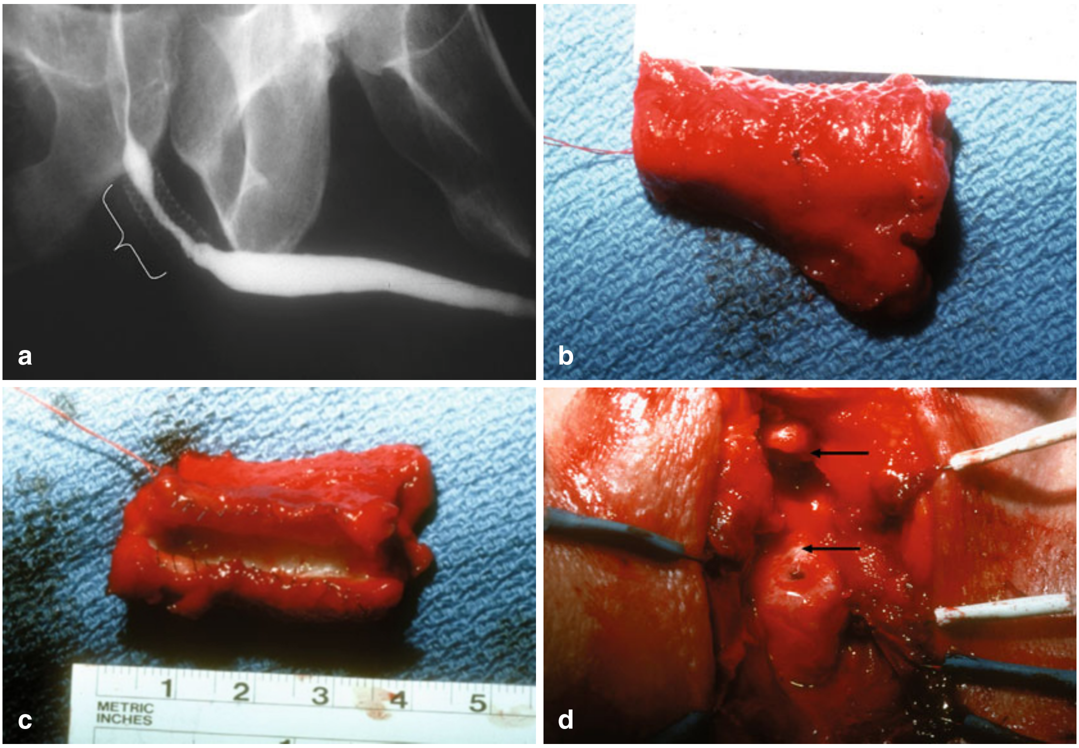

Fig. 26.1 (**a**) Intrastent bulbar stricture through Urolume. Bracket outlines stent limits. (**b**) Urolume and spongiosum excised. (**c**) Excised Urolume and spongiosum opened. Note wires. (**d**) Transected edges of urethra. *Arrows* at distal and proximal ends. Repair by BMG augmented anastomosis (Images courtesy of SB Brandes)

approach can bridge the gap with a primary anastomosis (Fig. 26.1). For a more distal, longer >2.5 cm, fibrotic, or tandem stent excision causing more extensive urethral stricture disease, an onlay or combination urethroplasty can be performed after careful removal of the Urolume is achieved (Fig. 26.2).

Hyperplasia

After Urolume placement, a narrowed lumen in follow-up can be from either hyperplastic tissue growing through the stent mesh or recurrence of the stricture due to fibrotic ingrowth. Most restenoses occur within the first year of implantation and within the stent from hyperplastic ingrowth and inflammation [10]. Some have reported that judicious TUR of the hyperplasia can be effective. Some claim that with each TUR the hyperplastic reaction and the need for repeat TUR will decrease. We have not had that experience. We have had short-lived success with TUR of hyperplastic ingrowth, and in our anecdotal experience we have noted that with each recurrence of hyperplastic growth, the time period till recurrence often gets shorter, not longer.

Chronic Pain and/or Chordee

After implantation, there are reports of chronic perineal pain, despite proper placement in the bulbar urethra. Upon sitting (particularly when on a hard surface), most patients report a discomfort or "poking" feeling in the perineum. Off-label placement of the Urolume in the pendulous urethra will result in painful erections and either tethering of the penis and urethra or painful erections. Distally placed stents are furthermore palpable and create an abnormal cosmetic and dysfunctional result.

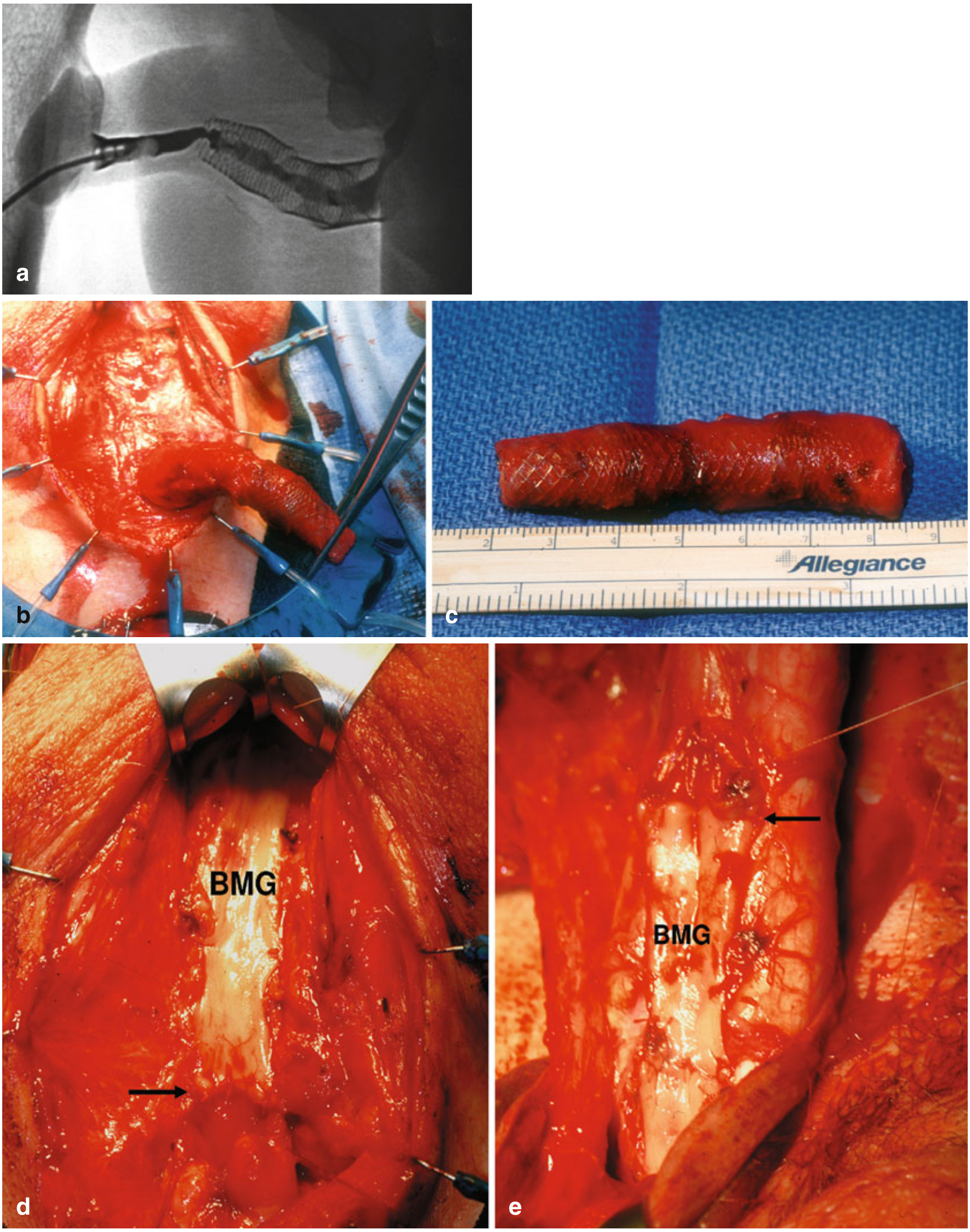

Fig. 26.2 Graft and flap urethral reconstruction for failed, sequential Urolumes ×3, for a bulbar and proximal pendulous stricture. (**a**) Long intrastent stricture on urethrography. (**b**) Urethra and Urolume mobilized. Note forceps on Urolume. (**c**) Urolumes excised. (**d**) Buccal graft to perineum (*arrow* at proximal anastomosis). (**e**) Second buccal graft to penile shaft (*arrow* at distal anastomosis). (**f**) Onlay flap to buccal plate in perineum. (**g**) Onlay flap to buccal graft on penis *BMG* buccal mucosal graft; *CFF* circular fasciocutaneous flap. (Images courtesy of SB Brandes)

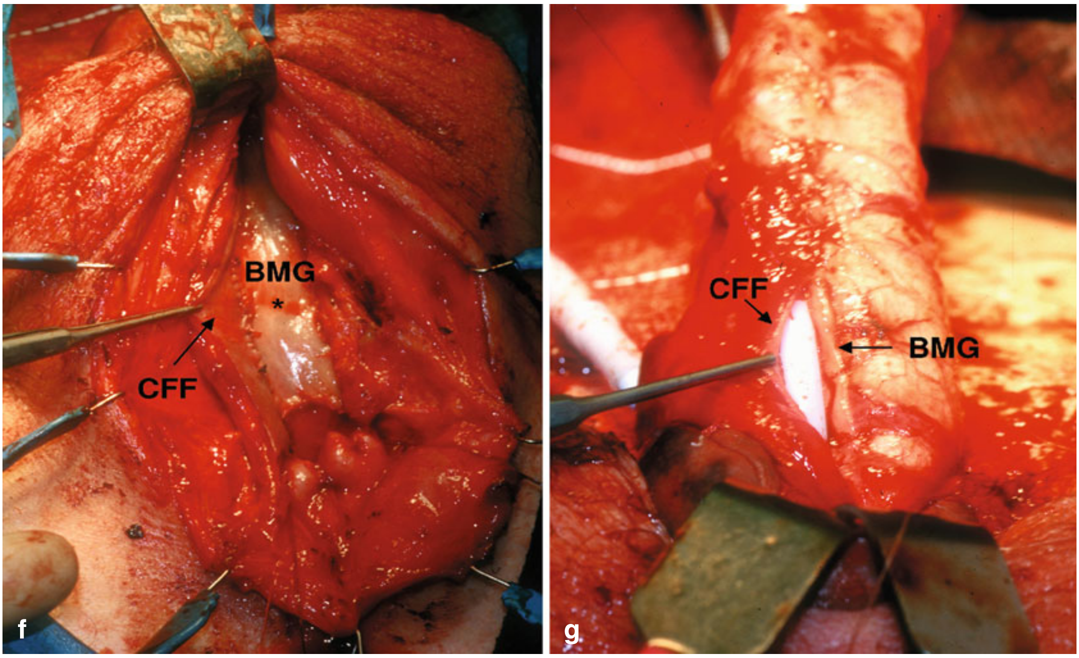

Fig. 26.2 (continued)

Post-void Dribbling

Most patients notice some post-void dribbling incontinence for the first 6–8 weeks after Urolume stent placement. The dribbling resolves spontaneously in most but persists in roughly 20 %. Persistent dribbling may require the use of an incontinence pad and is more significant in those stented with multiple Urolumes (e.g., >3 cm overall stricture). It is theorized that the problem relates to a combination of serous exudate from the hyperplastic epithelium covering the stent, together with the pooling of urine in the bulbar urethra, due to the rigid and inelastic tissue (preventing tissue coaptation), and to the mid-bulb's dependent nature.

Stent Encrustation

When the Urolume stent is placed in a patient with prior pelvic radiation, the stent is much less likely to endothelialize. Without epithelial coverage, the wires can act as a nidus for stone formation. The encrustations are typically soft and can be successfully cleared with the use of TUR cautery or laser lithotripsy.

Urolume Explantation

It is the overuse and off-label use of Urolume stents that lead to the most severe complications and the most difficult challenges to reconstruct (Fig. 26.3). From a national practice patterns study of the US board-certified urologists, the Urolume stent was a commonly used method (23.4 % per year) for recurrent bulbar strictures. Furthermore, it appeared that the off-label use of the Urolume is common. Herein we detail the endoscopic and open surgical methods for managing severe complications [11].

Endoscopic Methods

In the initial postoperative period, before stent epithelialization, stent explantation can be attempted

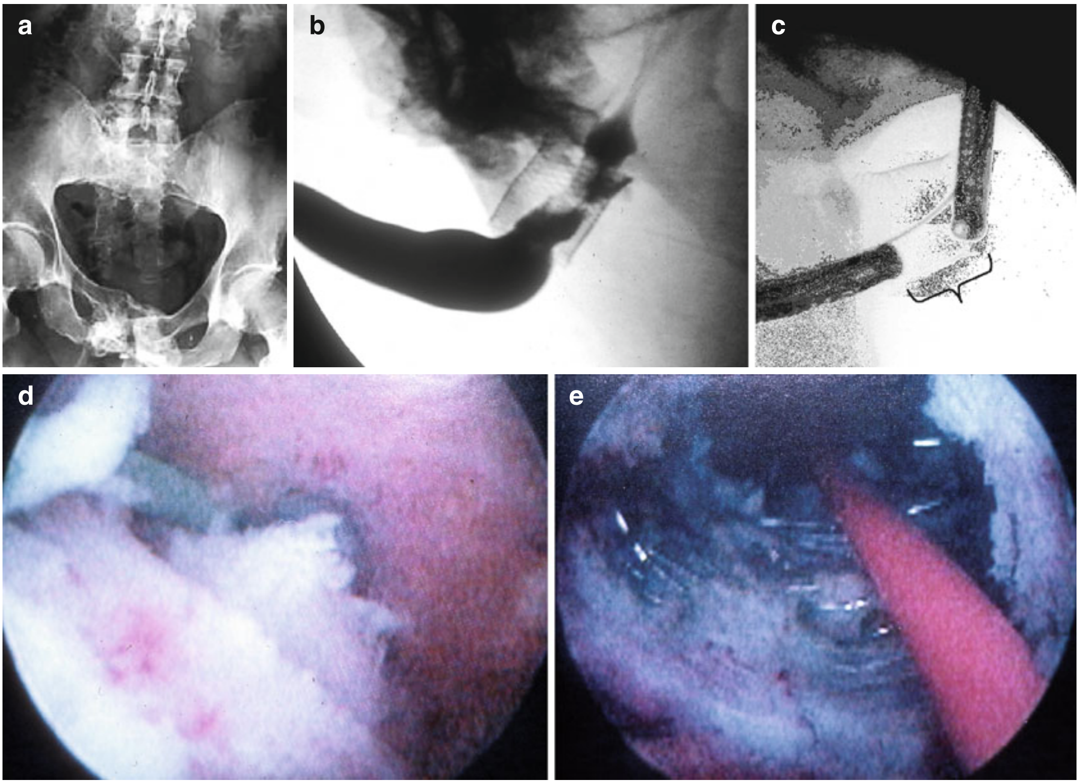

Fig. 26.3 A 52-year-old with posterior urethral injury after pelvic fracture from a motorcycle accident. (**a**) AP films of pelvic fracture (after reduction). (**b**) Failed multiple urethrotomies and now Urolume. (**c**) Antegrade and retrograde endoscopy confirming stricture and length. (**d**) Hyperplastic obstructing ingrowth. (**e**) TUR down to the wires. Eventually undergoes definitive EPA and open stent removal (Images courtesy of SB Brandes)

cystoscopically by dislodging and elongating the stent. Once the stent is epithelialized and fixed in position, endoscopic Urolume stent removal is difficult and trying. TUR of the epithelium or hyperplastic tissue is performed until the wires of the stent are completely exposed. To do so, we first place a "Superstiff" guidewire across the stenotic urethra cystoscopically into the bladder and dilate the stenosis to 24 or 26 French. A resectoscope is then placed, and using a low-current setting (e.g., 75 W pure cut), the resectoscope loop is used to remove ("resect") the scar and overlying epithelium (Fig. 26.4). The hot loop is used to resect the tissue within the Urolume until the metal tines of the stent can be seen circumferentially. This can also be achieved with a laser. The cutting current is reduced to prevent the tines from melting. If the stent is somewhat mobile and not embedded within the urethral wall, it may be possible to grasp the stent for removal. With the use of alligator forceps and a cystoscope, the distal three to five diamonds of the stent mesh are grasped. As it is pulled, the stent should elongate and narrow, yet still keep its orientation due to the preplaced guidewire. We prefer to do such procedures under combined fluoroscopy and cystoscopy to ensure that the remaining urethra is not injured. Extreme force should be avoided as transmural wall injury can occur.

An alternative method is to dislodge the stent into the bladder. Similarly, a guidewire is placed and TUR is carried out down to the wires. Then, with a grasper, the distal end of the stent is pulled cephalad to dislodge the stent into the bladder. At this point the Urolume can be attempted to be regrasped to facilitate transurethral removal or removed via a simple cystotomy, which avoids additional damage to the

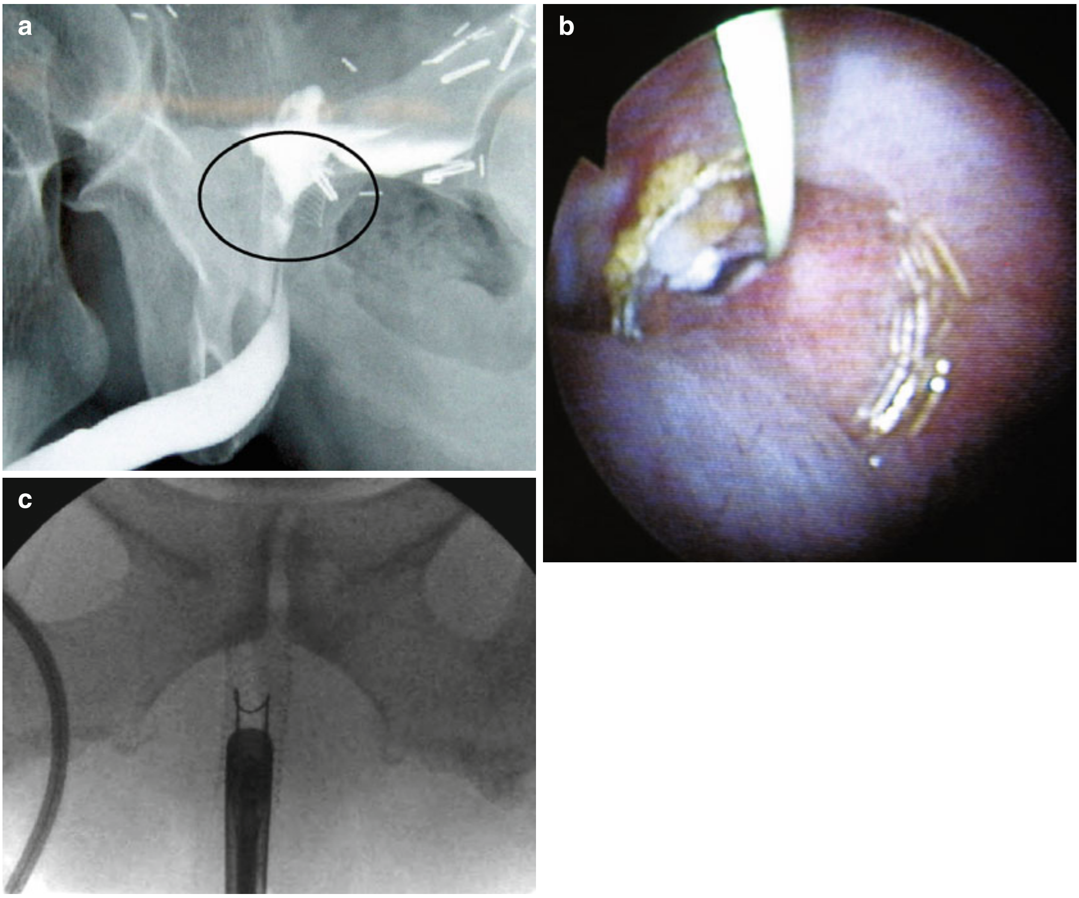

Fig. 26.4 (**a**) Recurrent BN contracture and hyperplastic ingrowth into Urolume stent after off-label use for recurrent BN contracture after RRP. Note circle. (**b**) Wire placed across stricture. Note non-endothelialized Urolume. (**c**) TUR of hyperplastic tissue ingrowth (Images courtesy of SB Brandes)

urethra. We emphasize that either of these approaches should only be attempted in very early Urolume stent removal.

A third approach is to use a laser fiber (i.e., holmium) to cut the stent allowing individual tine removal, which can be tedious and difficult to complete. We have tried using endoscopic scissors with little success.

Open Surgical Methods

Buckley and Zinman have described a method to explant a Urolume by open surgery [3]. A standard urethroplasty approach is used to dissect down directly onto the Urolume. The urethra is mobilized in a 360° fashion, and a dorsal incision is made at least 1 cm distal and proximal to the Urolume. The dorsal urethrotomy is extended into healthy urethra as the stricture often extends beyond on the Urolume. Using heavy scissors, the Urolume is transected vertically down its entire length (Fig. 26.5a). The wires are removed individually and with little difficulty (Fig. 26.5b). The preservation of the urethra allows a single-staged procedure to be performed using an onlay dorsal buccal graft. When complete obliteration is encountered, a segment of the ventral urethra is resected and a combined primary ventral augmentation and onlay urethroplasty is performed (Fig. 26.5c). They achieved long-term patency rates (>4 years' follow-up) of 83 %, which is

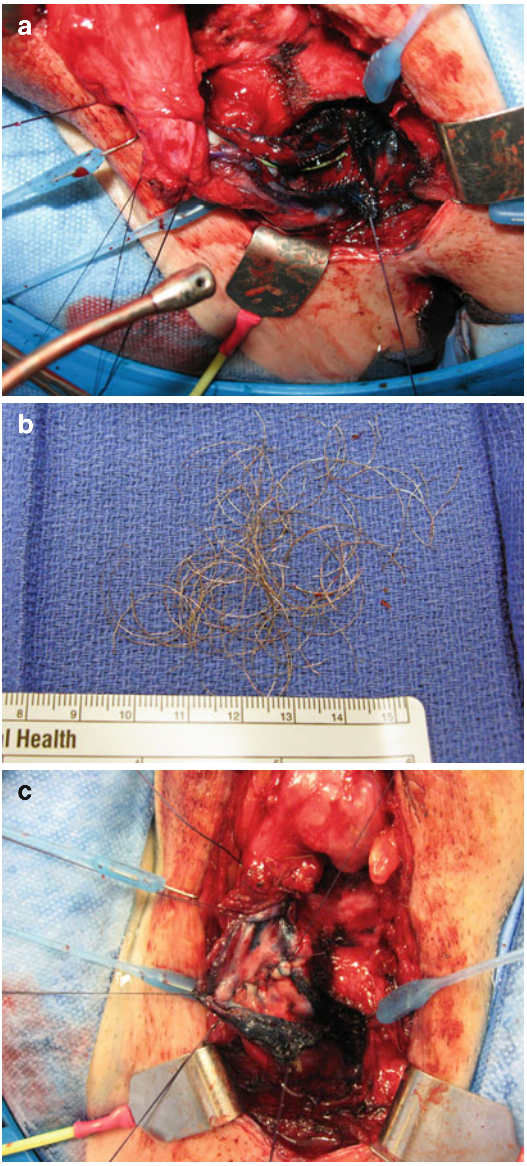

Fig. 26.5 (**a**) Urethra rotated 180° to expose the dorsal urethrotomy made through Urolume. (**b**) Urolume wires pulled out individually. (**c**) Reconstruction by an augmented anastomotic urethroplasty; note the remaining intact urethral plate after the wires have been removed and the ventral anastomosis (Images courtesy of SB Brandes)

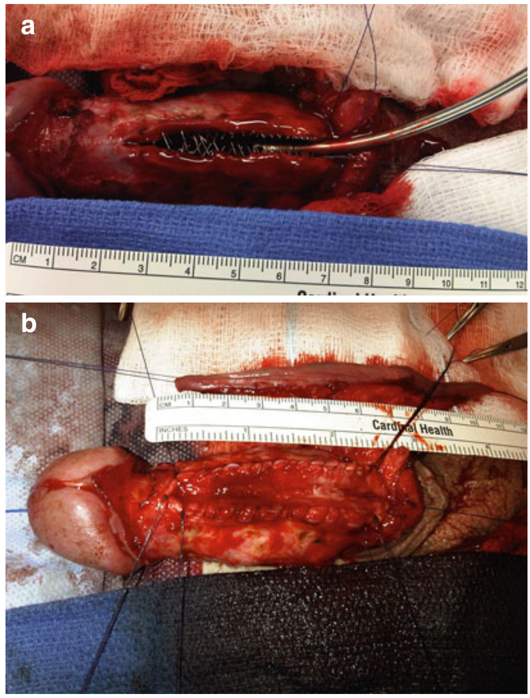

Fig. 26.6 (**a**) Urolume placed in the penile urethra opened by ventral urethrotomy to expose the wires. Note the suction demonstrating the urethral lumen. (**b**) After the wires were removed one at a time, note that there is sufficient intact plate for which to place an onlay skin flap for urethral reconstruction (Images courtesy of SB Brandes)

comparable to primary onlay urethroplasty outcomes. On occasion, the urethra may be found to be unusable, and a staged procedure is carried out performing a standard first-stage urethroplasty.

A ventral onlay graft is a theoretical option; however, the spongiosum blood supply has been compromised, making graft take unreliable and suboptimal. The vascular bed for a dorsal graft has not been altered and likely explains the similar success rate Buckley and Zinman and others experience compared to a primary onlay urethroplasty. A fasciocutaneous flap can also be utilized placing it either dorsally or ventrally as it reliably provides its own blood supply (Fig. 26.6a, b).

Gelman et al. reported a similar successful experience with one-stage reconstruction of the urethra after explantation [12]. In their experience with ten patients and 51 months' follow-up, the urethra was reconstructed with three dorsal buccal grafts and one skin island flap to a residual plate, one combined dorsal and ventral buccal graft, and five primary anastomoses (for three membranous and two proximal bulbar strictures). Therefore, Urolume stent excision and open explantation followed by a one-stage reconstruction is technically feasible and with durable results.

There may be occasion when the urethra is found to be unusable and a staged procedure is carried out performing a standard first-stage urethroplasty.

An alternative method would be to perform a two-stage Schreiter-type urethroplasty. Mundy described such a two-stage method of stent excision, with the epithelium and some of the spongiosum. Here, most of the spongiosum is retained along with the tunica of the spongiosum. To the remaining vascular bed, a graft is sutured and quilted to the tunical edges in a one-stage Schreiter-type first stage, followed by tubularization after graft maturation in 6–12 months.

Editorial Comment

While Mundy has called the placement of a Urolume an "assault" upon the patient, I do not feel that the Urolume is totally evil. A definitive urethroplasty is clearly preferred in almost all cases. However, for the properly and highly select patient, an endourethral stent (Urolume) can be a very useful tool.

Situations where I have found the Urolume (urethral stenting) to be useful are:

1. *Refractory bladder neck contractures after radical prostatectomy and salvage pelvic radiation*. In patients who have failed recurrent transurethral incision of bladder neck, despite adequate "Mercedes Benz" cuts deep into fat, I have found reasonable success in placing a 3 cm Urolume at the bladder neck. The advantages of a Urolume are that open bladder neck reconstruction in an irradiated field is often difficult and complex and often leaves the patient incontinent. After urethroplasty, incontinence can be treated with artificial sphincter yet only after a delay of a year suffering with incontinence. Attempts to place an artificial urinary sphincter any earlier than 1 year usually result in cuff erosion. Most of my patients do not want to be totally incontinent for a year. As stricture surgery is quality of life surgery, by placing a Urolume, the artificial urinary sphincter can be placed a month later – thus minimizing morbidity. If the Urolume is too long and juts into the bladder, stone formation can be common. I have had good success with a side firing holmium laser to cut off the protruding tines and to break up the stones.
2. *Elderly patients or sickly patients with limited life expectancy*. While urethroplasty is successful and safe in the elderly, many patients refuse such open surgery. For bulbar strictures <2 cm in length, *non*traumatic origin, and no prior urethroplasty, a Urolume can be reasonable. Short refractory radiation strictures of the membranous urethra after brachytherapy or pelvic radiation treatment for prostate cancer are further reasonable candidates for endourethral stent. Anastomotic urethroplasty for such strictures is feasible, but success rates are 80 % at best (much lower than 95 % for nonradiated EPA). After informed discussion with the patient as to success rates and morbidity, many still choose the Urolume stent.

Open Urolume removal. Over the years I have modified my method for removing the Urolume and concomitant urethral reconstruction. Earlier in my career, I used to mobilize the urethra and excise the Urolume and entire corpus spongiosum segment en bloc. To reconstruct a whole circumferential segment of urethra, I would typically place a dorsal buccal graft and ventral penile skin onlay flap. While this technique is successful, it is overly aggressive and complex and typically unnecessary. A much easier technique is the one described within by Buckley/Zinman. They mobilized the urethra and placed their buccal grafts dorsally. However, I would suggest you place the graft ventral or dorsal, based on your standard of practice for buccal grafts. In other words, I prefer a dorsal buccal graft for distal and mid-bulbar strictures, while I prefer a ventral graft for proximal bulbar strictures. I think the Lahey Clinic's concern that the spongiosum is unreliable or suboptimal to support a ventral buccal graft is unfounded and unsubstantiated. I have had good long-term success with ventral grafts after the removal of a mid- or proximal bulbar Urolume. If the urethra is obliterated for a segment, I prefer a dorsal anastomosis and a ventral graft – as it is technically much easier.

Endoscopic method to remove the Urolume. (1) Dilate the stricture over a Superstiff guidewire to 24FR. (2) Transurethrally resect the hypertrophic scar down to the wire mesh. I perform this under combined direct vision and fluoroscopy. Fluoroscopy is very helpful to delineate the proximal and distal ends before starting resection. (3) Use the noncontinuous flow, 24 Fr resectoscope sheath, and use low power (<75 W). If you use cut at too high a power (>75 W), the Urolume will melt and the tines will separate into the lumen. The tines will then need to be pulled out, one at a time with alligator forceps. This is a very tedious method and takes time – yet successful method. (4) Once the wire mesh is all exposed, I prefer to dislodge the Urolume with alligator forceps into the bladder over a Benson guidewire – then grasp the distal end of the wire and pull both ends out the sheath. In so doing, the Urolume is pulled into the sheath and crushed.

Overall, I predict that we will see dramatically fewer Urolume complications in the near future. This will be the direct result of AMS no longer manufacturing the Urolume stent for the US market as of January 2013. Moreover, with continued reeducation, the practicing Urologist will be more sensitive to the potential problems and dangers of the off-label use of the Urolume.

—Steven B. Brandes

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Reoperative Hypospadias Surgery and Management of Complications

27

Douglas E. Coplen

Summary

Reoperative hypospadias surgery is often complicated by the general lack of healthy tissue for urethroplasty and skin coverage. The penile skin that is present is typically scarred and has a variable and poorly defined blood supply. Each case is different and demands individualized evaluation and care. Reoperation is delayed at least 6 months after the last repair, in order to maximize tissue healing and vascularity. Earlier attempts at definitive repair are often fraught with more complications. Common post hypospadias repair complications are urethrocutaneous fistula, urethral diverticulum, persistent chordee, and urethral stricture. A procedure using "wide" exposure may be required to correct what appears to be a small problem. Successful reconstruction of such refractory, postsurgical strictures, requires the whole surgical armamentarium, namely, vascularized onlay flaps, buccal mucosal grafts, and planned-staged procedures.

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Introduction

Current hypospadias techniques set a high standard for functional and cosmetic outcomes. A slit-like meatus in an orthotopic position on a conical glans is the goal. This should be achieved with a single operation in patients with a glandular hypospadias. Success is greater than 95 % in boys with a distal hypospadias. In large series, complication rates after proximal hypospadias repair can be as high as 30–40 %. The complications are lower if the urethral plate is preserved and may be lowest if the repair solely utilizes the urethral plate and not vascular or grafted preputial skin [1–4]. Regardless of meatal position the complication rate is highest and approaches 100 % in some series of primary hypospadias repair in postpubertal males [5, 6].

The most important factor that impacts reoperative hypospadias is the presence of healthy tissue that is needed for urethroplasty and skin coverage. There is usually a paucity of penile skin that is scarred and has a variable and poorly defined blood supply. Natural tissue planes often are disrupted, and dissection may damage the blood supply to the penile skin. Each case requires individual evaluation and managemvent based upon sound plastic surgical principles. Every attempt should be made to review the previous operative notes.

There are no randomized trials assessing the efficacy of testosterone administration prior to primary or reoperative hypospadias surgery.

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There are reports showing both increased and decreased complication rates after preoperative administration of testosterone [7, 8]. There is evidence that the microvasculature of preputial skin in hypospadias patients is lower than in normal controls [9]. It is unknown if testosterone improves vascularity, but there is some evidence in the plastic surgery literature that androgens may inhibit wound healing while estrogens may decrease inflammation and promote healing [10].

In general, reoperative surgery should be delayed at least 6 months after the last repair to eliminate any residual inflammation and allow complete healing. Time allows in growth of new blood supply to relocated penile skin. Earlier attempts at definitive repair may actually create a more significant complication. The glansplasty is the key to a normal postoperative appearance, so urethrocutaneous fistulae, diverticula, or urethral strictures in the presence of a normal glandular urethra may be technically easier and more successfully repaired than cases where postoperative disruption of the glansplasty has occurred.

Surgical Complications

Urethrocutaneous Fistula

When a fistula is identified, the urethra and meatus are examined under anesthesia prior to making any incisions. I like to observe the urinary stream prior to manipulating the urethra. Crede recapitulates urination and helps assess for meatal stenosis (Fig. 27.1). The urethra is calibrated with bougie-a-boule. I perform this after crede because the bougies can easily dilate a very soft stricture. This also assesses for any urethral irregularity. Depending upon the age of the patient and the previous surgical technique used, urethroscopy may be indicated to exclude urethral hair or encrustations that would complicate the fistula closure. The urethra is pressurized with saline or water through a catheter to confirm the location and number of fistulae.

We pass a small lacrimal duct probe through the fistula tract and out the urethral meatus. This step helps to define the tract and identifies the exact point of communication with the urethra. Lidocaine with epinephrine is infiltrated around the fistula site. Electrocautery is rarely if ever required during these cases and should be discouraged.

Fig. 27.1 Expressed urinary stream shows a very narrow stream. This observation is important in young boys who are not yet toilet trained. If a boy is toilet trained, every effort should be made to observe his stream during outpatient office evaluation

The principles of fistula closure include dissection of the tract flush with the urethra, excision of unhealthy tissues, an inverting watertight closure, and placement of one or more barrier layers between the urethra and the skin [11]. A dartos-based subcutaneous pedicle flap can usually be advanced to cover the fistula closure, although tunica vaginalis may be used in more complex cases [12, 13].

Small fistulae on the penile shaft can be circumscribed and excised flush with the urethra. However, subcoronal or glandular fistulae may require a more extensive dissection because of a paucity of healthy adjacent tissues. In these cases, a takedown of the glansplasty may be required to facilitate fistula excision. A distal urethroplasty can then be performed, followed by interposition of a dartos pedicle and reapproximation of the glans wings. Simple fistula closures without meatal reconstruction rarely require a postoperative catheter, but when distal edema may increase urethral voiding pressure, a catheter or urethral stent is preferable.

Urethral Diverticulum

Diverticular formation after hypospadias surgery may be indicative of urethral meatal stenosis but, in most cases, calibration reveals no evidence of narrowing. Children may present with dysuria (urethritis), a urinary tract infection, or post-void dribbling. Occasionally ballooning of the ventral aspect of the phallus is presenting observation (Fig. 27.2a). If the child presents with a febrile UTI, a cystogram can be attempted but often the catheter cannot be easily manipulated across the proximal aspect of the urethroplasty (Fig. 27.2b). Repair is most accurately performed after degloving the ventral phallus. A feeding tube is passed transurethrally and the diverticulum is distended with saline (Fig. 27.2c). This distension facilitates dissection by defining the appropriate plane between the diverticulum and skin while sparing the blood supply to the urethra. The diverticulum is opened in the ventral midline along its entire length (Fig. 27.2d). Calipers are used to mark the appropriate urethral width (10–12 mm in a prepubertal male (Fig. 27.2e) and 20–24 French postpubertal) on the dorsal urethral wall. Redundant epithelium is sharply excised while sparing the subcutaneous blood supply. The urethra is closed with a running and interrupted inverting suture line. The redundant subcutaneous tissue is an excellent covering layer and can be approximated over the urethroplasty in a pant-over-vest fashion. Because of the length of the closure, catheter drainage is advisable (Fig. 27.2f).

Repair of a urethral diverticulum using plication has been reported [14]. This approach, however, does not remove the redundant mucosa, and since absorbable sutures are used, the diverticulum might recur. Definitive excision and urethroplasty are recommended to eliminate potential long-term concerns.

Urethral Stricture

Stenosis of the urethral meatus is the most common site of narrowing after hypospadias repair. This can occasionally be corrected with either a dorsal or ventral urethral meatoplasty. A midline incision is made across the narrowing and carried deep into the glans tissues. The edges are reapproximated in Heineke-Mikulicz fashion using 7-0 absorbable sutures. A dorsal meatoplasty sometimes causes dimpling of the dorsal glans and can affect the direction of the urinary stream. A ventral meatoplasty may effectively improve the urinary stream, but this may result in a coronal opening (megameatus).

At times it is difficult to ascertain if the narrowing is at the meatal level or extends more proximally. Because of patient age (anxiety for invasive testing) and the history of penile surgery, we often do not obtain a urethrogram prior to reoperation, but as part of informed consent, parents need to understand that a more extensive procedure may be required. In boys with a history of urinary tract infections after hypospadias repair, a urethrogram or cystogram is advisable (Fig. 27.3). If a longer distal stricture is identified, then this needs to be marsupialized and corrected with either a vascularized flap or grafting. With a distal stricture there is high likelihood that biopsy will show balanitis xerotica obliterans. In these cases the use of local tissues should be avoided as they are similarly affected by this pathology.

Strictures in the midportion of a urethroplasty are actually very uncommon. Narrowing of the proximal junction between the reconstructed and native urethra is more common. These are often diaphanous narrowings that are amenable to an attempt at optical urethrotomy, although the long-term success is less than 50 % [15].

Persistent Chordee

Persistent penile curvature may be a result of ventral skin tethering, corporal disproportion, and urethral foreshortening [16–18]. Historically, the urethral plate was divided to correct penile curvature. However, in the 1990s, Duckett and others popularized the concept of corporal disproportion as the primary etiology of penile curvature [8]. Histological evaluation of the urethral plate usually reveals healthy spongy tissue that clinically is very elastic.

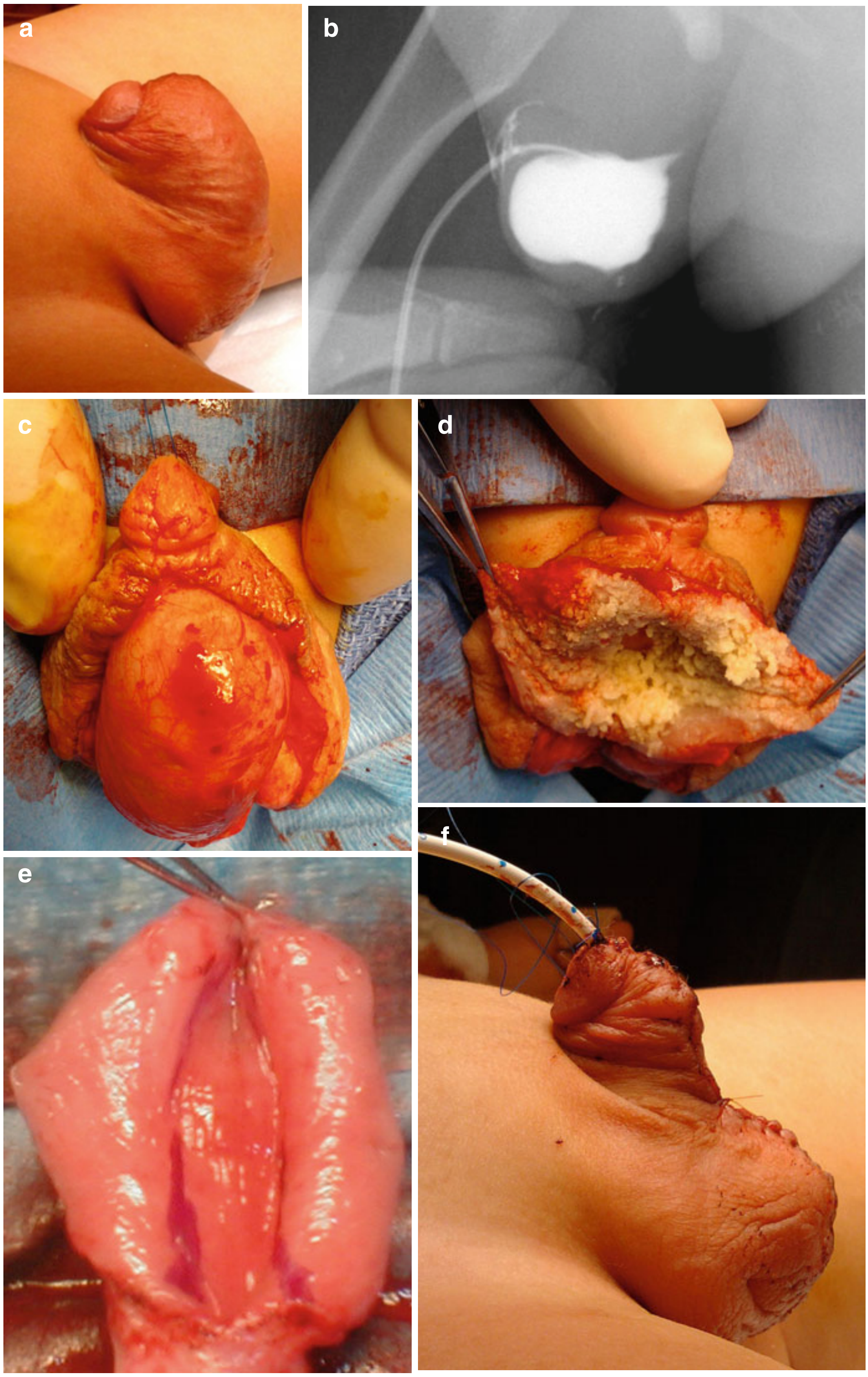

Fig. 27.2 Large urethral diverticulum after onlay island flap hypospadias repair. (**a**) Marked ventral ballooning noted during urination, (**b**) he presented with a febrile UTI and a retrograde urethrogram confirms a large diverticulum. The catheter could not be advanced into the bladder, (**c**) the diverticulum is distended and a midline incision is made over the diverticulum, (**d**) squamous epithelial debris is noted inside the diverticulum once it is opened, (**e**) in a prepubertal male, a 12-mm strip of mucosa is marked for the urethroplasty. The redundant epithelium can be sharply excised with preservation of the underlying vascular tissue that provides an excellent barrier layer to prevent subsequent fistula formation, (**f**) appearance of the phallus immediately after urethroplasty and skin closure

Fig. 27.3 Voiding views on a VCUG show a distal urethral stricture 5 years after a tubularized incised plate hypospadias repair. This boy presented with strangury and recurrent cystitis

Fig. 27.4 Recurrent penile curvature in a 12-year-old boy. He is 11 years s/p dorsal plication and tubularized incised plate hypospadias repair. In this case there is marked corporal disproportion and a staged correction is likely required with first stage-ventral lengthening (dermal grafts or parallel relaxing incisions) and buccal graft Second stage-urethroplasty

Curvature may recur years after the initial hypospadias repair even when corporoplasty (plication and/or ventral grafting) was used to successfully correct chordee at the first surgery (Fig. 27.4). There are no good data showing whether or not free graft urethroplasties are at greater risk for recurrence of curvature when compared with vascularized flaps or primary plate tubularizations. However, a urethral graft with some fibrosis is less likely to grow in concert with the rest of the phallus at puberty. Even if the urethral plate was not previously divided because of a normal appearance, it is possible that the primary surgeon did not appreciate its contribution to curvature.

At reoperation, an artificial erection is induced intraoperatively. The urethra is inspected to determine whether it is supple or a "bowstring" (indicative of fibrosis). When urethral tethering is suspected, then the urethra should be transected and fibrous tissue resected. A repeat erection after transection may show persistent curvature in up to 50 % of cases, indicating coexisting corporal disproportion. Either ventral dermal grafting or dorsal plications can be used to correct the curvature in these cases. In cases where the urethra is normal, then a primarily dorsal approach to correction is indicated. In some cases, prior dorsal plications may have disrupted, but it is also possible that the intrinsically disproportionate corporal growth pattern persisted at puberty.

Complex Reoperative Hypospadias Techniques

Urethral Plate Retubularization

Tubularized incised plate (TIP) hypospadias repair was introduced in 1994 and is the operation of choice for distal hypospadias repair in many centers. There is good evidence that the preserved urethral plate can be used in reoperative hypospadias [2, 20–23]. Extensive experience with the primary procedure is helpful when assessing the quality of the urethral plate. If the plate appears supple without scarring or evidence of a prior incision, then tubularization is reasonable. The complication rate with tubularization of the plate in secondary operations is similar to the rate when used in primary repairs (Table 27.1).

Table 27.1 Outcomes after TIP repair in reoperative hypospadias

	No plate incision		Prior plate incision	
	Number	Complication (%)	Number	Complication (%)
Borer et al. [19]	24	25	1	0
Shanberg et al. [20]	12	17	1	0
Yang et al. [21]	18	17	7	57
El-Sherbiny et al. [2]	30	17	4	25
Snodgrass et al. [22]	63	19	35	20
Cakan et al. [23]	28	25	9	11

Previous surgery that involved incision of the urethral plate might alter the blood supply and decrease the success of a second tubularization. In addition, a failed TIP may be indicative of an intrinsic abnormality with the plate and spongiosum that precludes a second attempt at urethroplasty using the same technique. Because of these factors, there has been reluctance to perform a repeat TIP, although literature reports show that a repeat TIP does not appear to be associated with a higher complication rate in experienced hands (Table 27.1).

The plate can always be incised at the time of reoperation. If it is apparent after the incision that fibrosis is present that precludes a healthy tension-free urethral closure, adjacent genital tissues or a free graft can be utilized. Incision of the plate does not burn a bridge and exclude other operative approaches [24].

The most common complication with retubularization is fistula formation, so the use of a barrier flap is very important in these reoperative cases. If a circumcision was not performed at the time of the prior hypospadias repair, a dartos subcutaneous is available for neourethral coverage. Otherwise, adjacent ventral dartos or tunica vaginalis flaps are useful barriers.

Adjacent Genital Tissues

If the urethral plate is not suitable for retubularization, then the use of vascularized adjacent genital tissues may be possible (Fig. 27.5 [3, 17, 25–30]). Local flaps may be preferable to grafts because the former do not rely upon the reestablishment of vascularity. Care must be taken when harvesting the flap in the presence of scarring from multiple prior procedures. Both meatal-based and dartos pedicle flaps can be used for the urethroplasty, but ventral blood supply is often more highly compromised than tissues that are laterally or dorsally positioned. Scrotal skin is often well vascularized, but it is usually hair bearing and is associated with a high incidence of future urethral complications.

As noted in Table 27.2, an additional procedure will likely be required in at least 25 % of patients when a vascularized flap is used for the urethroplasty. This complication rate is clearly higher than the outcomes when flaps are used in a primary repair. The penile skin adjacent to the meatus is often not well vascularized at the hinge of the flip-flap. If this technique is utilized, the dartos pedicle from the prior Byars' flap is preserved as the blood supply for the ventral flap.

Although skin is usually available, there is a significant incidence of postoperative fistulae, strictures, and glansplasty breakdown when adjacent skin is used for repeat hypospadias repairs. Some authors express concern that the glansplasty and meatal appearance are abnormal after flap urethroplasty, but with appropriate glans wing dissection, an orthotopic vertical meatal opening can be achieved. The limiting factor for a normal-appearing glans is the degree of glans scarring and contraction after the prior repairs.

Extragenital Tissues

Frequently, a paucity of genital tissue is available in reoperative hypospadias. A skin graft urethroplasty using either squamous [4, 17, 31–33], transitional (bladder mucosa [34–36]), or pseudostratified (buccal mucosa [22, 33, 37–41]) is then required. Most hypospadias surgeons are somewhat uncomfortable with this approach because they are now trained in primary repairs that consist of either primary plate tubularization or vascularized flaps.

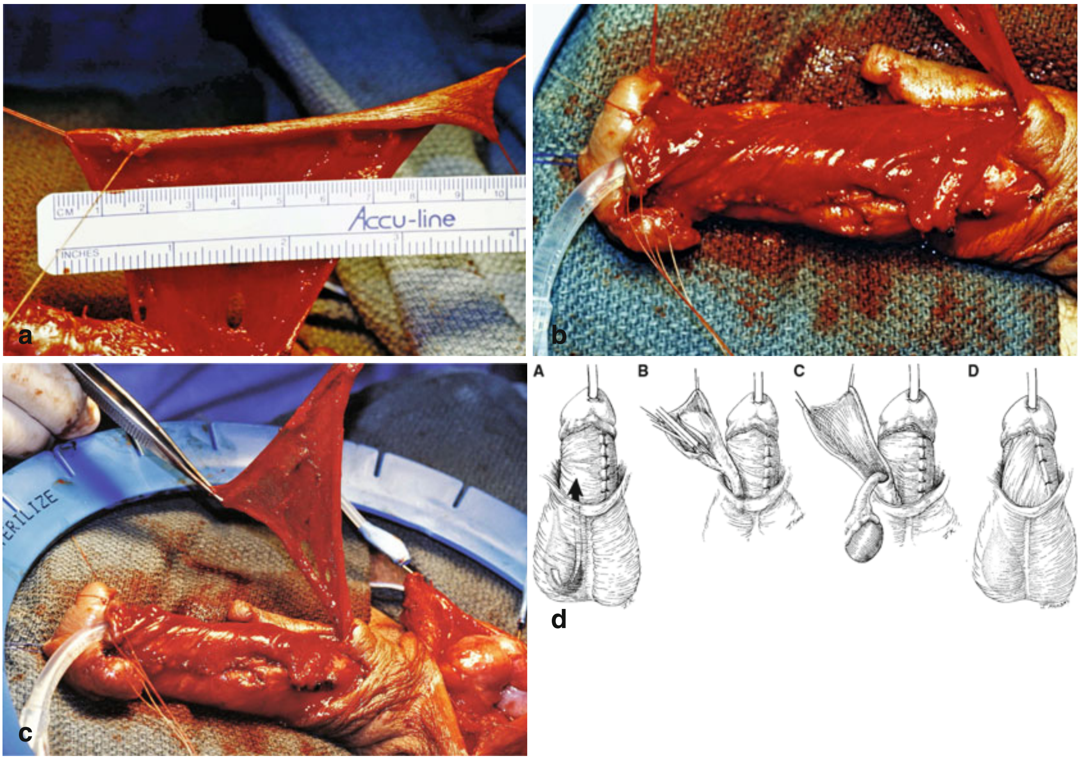

Fig. 27.5 (**a**, **b**) A 10-cm vascularized flap urethroplasty is performed. (**c**) A tunica vaginalis flap is harvested from the left hemiscrotal compartment and transposed with its vascular supply to cover the urethroplasty. (**d**) Illustration of tunica vaginalis flap dissection (Images courtesy of S.B. Brandes)

Table 27.2 Surgical outcomes after the use of adjacent genital tissue in reoperative hypospadias

	Technique	No. patients	Success rate (%)
Jayanthi et al. [25]	Flip-flap	28	71
	Vascularized flap	16	43
Teague et al. [26]	Flip-flap	9	89
Emir et al. [27, 28]	Flip-flap	55	75
	Vascularized flap	33	58
Secrest et al. [17]	Flip-flap	34	53
	Vascularized flap	35	71
Simmons et al. [29]	Flip-flap	17	76
	Vascularized flap	36	86
Soutis et al. [30]	Vascularized flap	21	76
Zargooshi [3]	Vascularized flap	20	85

Grafts can be approached with a one- or two-stage operation. A graft must establish vascularity to survive. In reoperations, this neovascularity comes from the scarred recipient bed. Graft take is theoretically more reliable in a staged approach because the corporal bodies are likely healthier than the shaft skin that would be important in supplying blood to the ventral aspect of an onlay or tube graft. If a tube graft is used, a tunneled placement may cause less disruption to the ventral blood supply.

Bracka uses a staged grafting technique for most primary hypospadias, and this same technique is very useful in reoperative repairs [4]. During the first operation, the scarred urethral plate and unhealthy ventral tissue are excised. The graft is secured to the corporal bodies from the proximal urethral opening to the tip of the glans. The graft can be quilted onto the corporal bodies and a gentle compression dressing that immobilizes the graft. This prevents hematoma formation and the shear forces that inhibit the development of blood supply. Graft take can be assessed before a second tubularization at least 6 months later.

A staged approach may give a better cosmetic result to the patient [4, 22, 41]. When a hypospadias repair fails, the glans wings often contract, and there is not sufficient width or mobility to achieve an orthotopic meatus after the second procedure. Glandular scarring can be excised, and the graft can be interposed between the corporal bodies to give a deep groove for subsequent glansplasty and distal urethroplasty.

A barrier layer is required and this can be challenging when there is a paucity of local skin. A tunica vaginalis or subcutaneous scrotal flap has an excellent blood supply and can usually be mobilized to give a barrier layer (Fig. 27.5). The use of small intestinal submucosa has been described but in some series did not inhibit fistula formation, and there was the subjective assessment of increased fibrosis ventrally.

Squamous Epithelium

Nonhair-bearing squamous epithelium has historically been the graft material of choice. Bracka uses the inner preputial skin for staged repairs, but the prepuce is frequently unavailable in reoperative cases [4]. Single-stage skin graft urethroplasty in these cases has a 30–50 % failure rate with complete graft loss in up to 25 % of cases. A split thickness technique has been described but the grafted area is usually very small, so meshing may not be required to achieve coverage [31, 32].

Bladder Mucosal Graft

Bladder mucosal urethral replacement was popularized in the middle of the 1980s. Penile dissection and correction of chordee is completed before harvesting of the bladder mucosa. A Pfannenstiel incision is used to harvest the bladder. Distending the bladder and sharply excising the muscle giving the typical "blue-domed cyst" appearance of the bulging mucosa best performs this. The bladder mucosa is very thin and difficult to handle.

Urethral meatal prolapse is a unique complication with bladder mucosa urethroplasty. The exposed transitional epithelium becomes sticky and hypertrophic [35]. Construction of a 20-French urethral meatus, prolonged catheter drainage, anchoring of graft to the corporal bodies, and a distal skin graft may reduce this complication. A greater than 75–85 % success rate has been described when bladder mucosa is utilized for urethral replacement. Certainly transitional epithelium is a natural choice for urethral replacement since it is normally exposed to urine. The need for the lower abdominal incision has led to the use of other graft materials.

Buccal Mucosal Graft

Buccal mucosa is a thick epithelium with good tensile strength and a very vascular submucosal plexus that favors graft take [37]. The thickness aids in dissection and subsequent manipulation of the graft material. The buccal mucosa can be harvested from either the inner cheek or lip. The harvest minimizes fat and avoids dissection into muscle. There may be a little bit less morbidity if the donor site is closed, but many surgeons allow the site to heal by secondary intention. In the early 1990s, there were several reports of short-term success with single-stage buccal mucosal grafts in complex urethroplasty. Surprisingly, tube grafts seemed to do better than onlays, but the overall complication rate was as much as 60 % with long-term follow-up [40].

Buccal graft urethroplasty using the staged technique described by Bracka has improved outcomes when compared with single-stage buccal repairs [22, 41]. In this technique, the initial graft take is probably better because it is dependent only upon the corporal bodies and not upon the previously operated ventral skin. The ability to inspect the graft prior to retubularization allows regrafting when clinically indicated. This likely decreases the development of urethral strictures (Fig. 27.6). In a recent series [22] first-stage graft revision was required for graft contraction or loss in 10 % of patients. A urethroplasty complication occurred in 17 of 45 (38 %) patients after the second stage. The complication rate did not seem to be related to patient age, number of prior surgeries, or location of the meatus. Glans dehiscence occurred in one-third of patients when a cheek graft was used and 0 of 17 when a lip graft was utilized. The authors hypothesize that the inner lip buccal mucosa is thinner and facilitates a tension-free glansplasty.

Critics of staged procedures correctly note that some patients did not require two additional

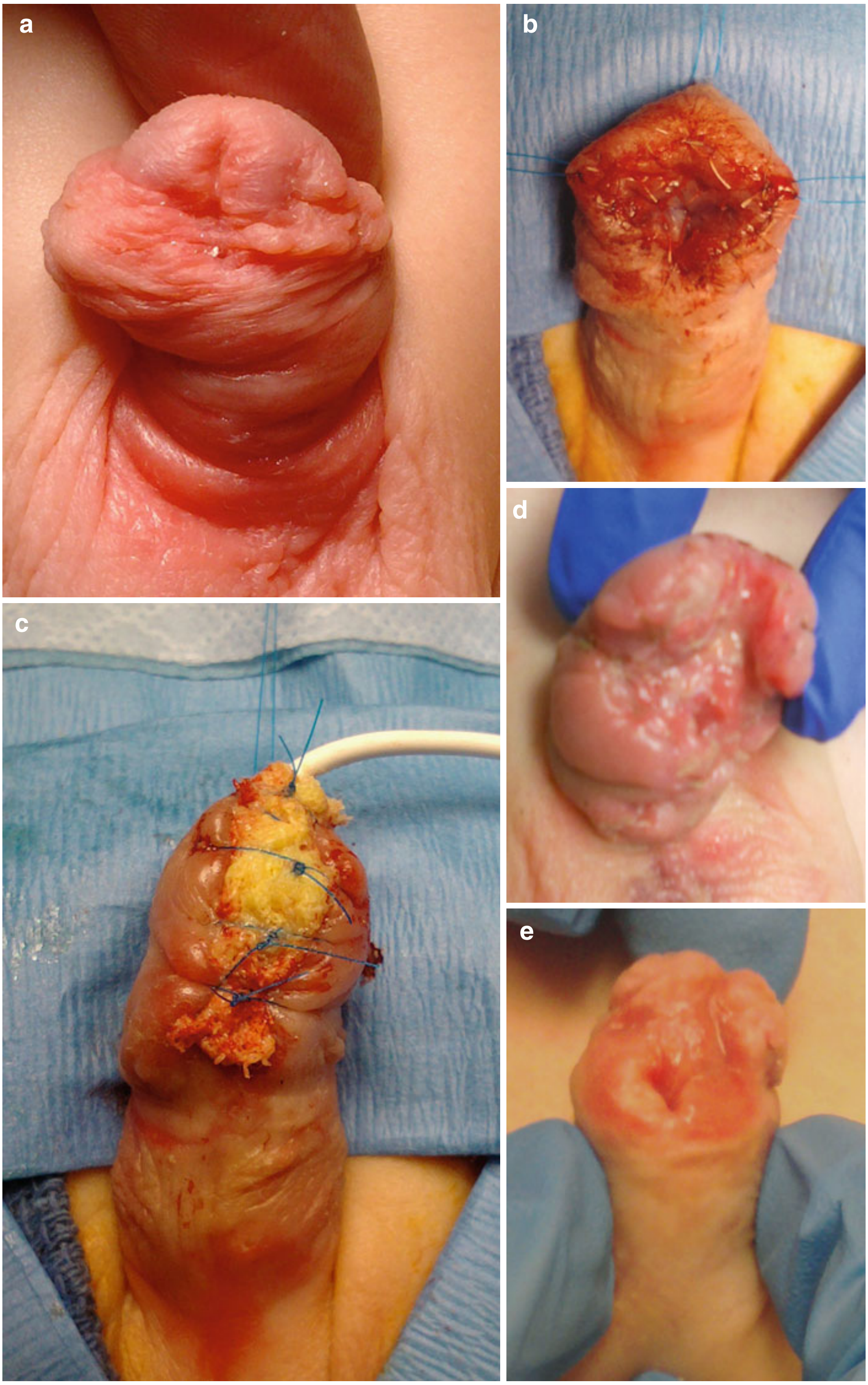

Fig. 27.6 Buccal mucosal graft. (**a**) Coronal meatus (glans dehiscence) after tubularized incised plate hypospadias repair, (**b**) a deep, clefted incision is made in the glans midline and buccal mucosa is sutured/quilted directly onto the corporal bodies, (**c**) a compression dressing consisting of xeroform gauze and horizontal mattress nylon sutures is left in place for 1 week. Depending upon patient age the urine is diverted with either a urethral catheter or a suprapubic tube, (**d**) normal appearance with fibrinous exudate at the time of dressing removal, (**e**) appearance of buccal graft 6 months after primary graft

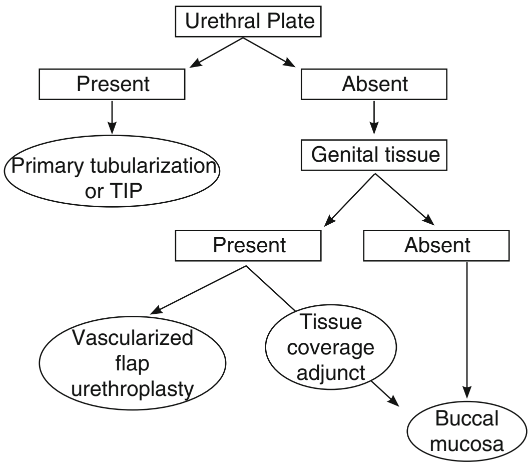

Fig. 27.7 Treatment algorithm for reoperative hypospadias surgery

surgeries. Dorsal grafting (inlay) of an attenuated yet supple plate and "primary" urethroplasty has been described as part of a single-stage repair. In a small series this approach was successful in 11/13 (85 %) patients [22]. The decision to proceed with this approach requires an appropriate assessment of the recipient bed.

A summary of our treatment algorithm for complex reoperative hypospadias repair (glans dehiscence, diverticulum, urethral stricture) is detailed in Fig. 27.7. This algorithm is different than that proposed by Snodgrass et al. [22] who does not see a role for vascularized flaps in reoperative hypospadias.

Postpubertal and Adult Complications

Adult hypospadias surgery is associated with a much greater complication rate even in de novo cases [5, 6]. Even though the techniques are similar, there are clear differences in wound healing, infections, and overall success rate. A number of steps may be taken to reduce the risk of complications in adults. All adults presenting for hypospadias repair should have a urine culture with directed treatment for positive cultures. Chronically infected or hair-bearing tissue should be removed at the time of surgery.

A postoperative suprapubic diversion may be beneficial from both a comfort and healing standpoint. A urethral catheter has a tendency to pull on the phallus, and this can be very uncomfortable in the postoperative period. This distal tension may also disrupt the glansplasty.

The adult "cripple" has an abnormal meatus, a scarred glans, curvature that is either intrinsic or related to ventral urethral contraction, an absent foreskin, and very thin or scarred ventral shaft skin that is usually adherent to the underlying urethra [42]. Any future surgery is complicated because well-vascularized skin is not available for flaps and the lack of a good vascular bed hinders the success of free grafts. If redundant tissue is present, it can be rearranged during a first stage and subsequently tubularized. Care should be taken to avoid the use of hair-bearing skin (Fig. 27.8).

Strictures often develop long after an apparently successful hypospadias repair. This may be secondary to failed growth at puberty, but Bracka suggests that balanitis xerotica obliterans is causative in at least 30 % of late hypospadias failures and strictures [43]. In these cases, a skin graft is doomed to failure, and buccal mucosa should be used as the graft material.

Surgical experience is a key to success, and ideally the extent of the problem can be determined preoperatively. Abnormalities of only the distal shaft and glans are more readily corrected than cases where the entire urethra needs to be replaced. In theory, even in reoperative cases, the glans (spongiosum) has excellent blood supply. If there is minimal glans injury, a deep cut into the ventrum gives an excellent vascular bed for a free graft.

If the urethral abnormality extends proximal to the glans, then the region between the glans and the more proximal normal spongiosum is at risk for recurrent fistula, stricture, or complete breakdown. A planned-staged procedure is preferable in these cases. The advantages of a staged repair are more reliable and secure graft revascularization. In addition, one can observe graft take or contraction prior to completing the secondary tubularization.

The phallus should be degloved and all ventral fibrotic tissues should be sharply excised. If curva-

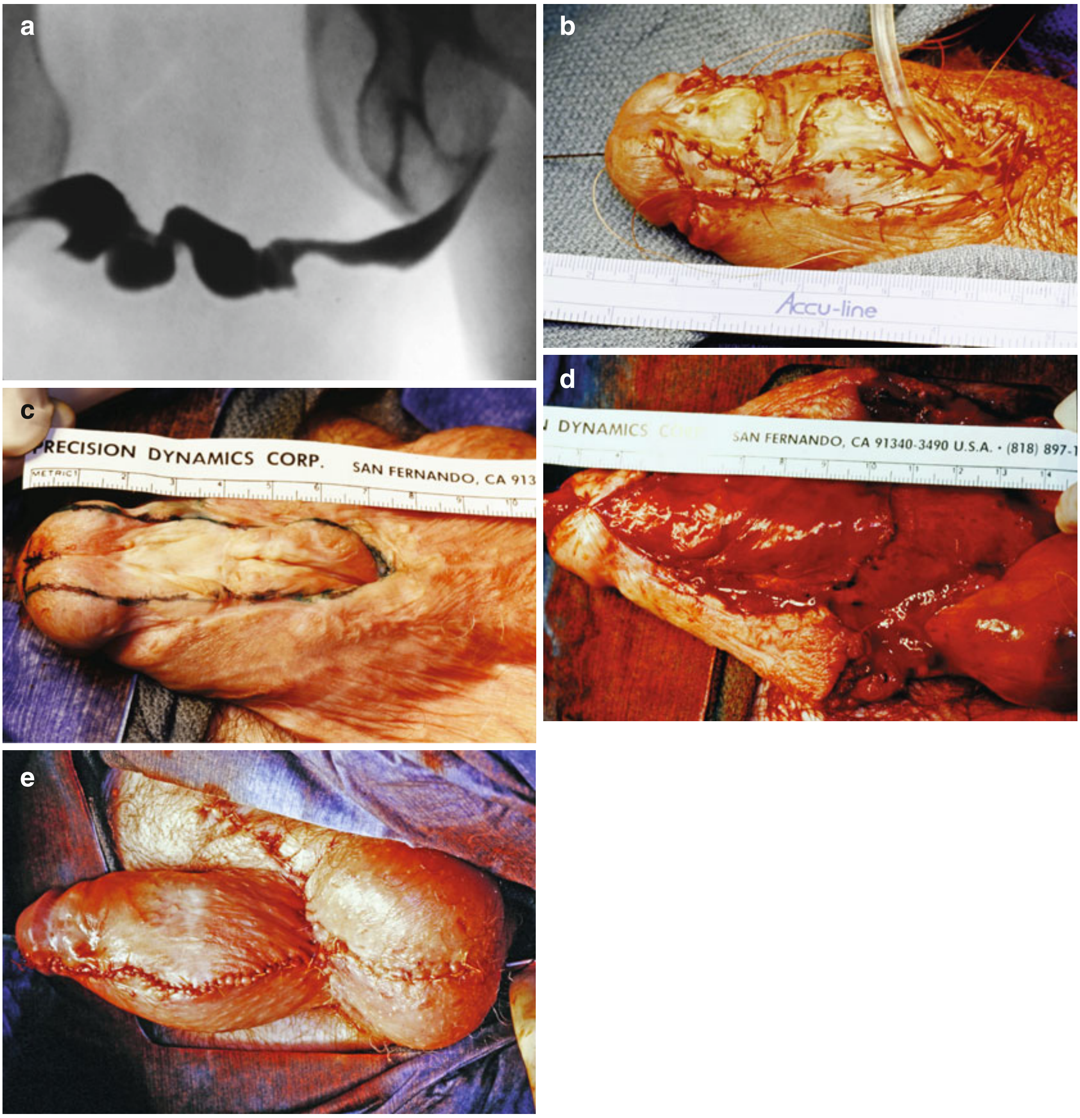

Fig. 27.8 A retrograde reveals distal tortuosity, stricture, and mild diverticular formation after prior hypospadias surgery (**a**). The phallus is degloved and the ventral urethra is opened. The tissue is rearranged distally, advanced into a deep glans cleft, and allowed to heal in preparation for a second stage (**b**). Six months later, there is a nice supple template available for tubularization and glansplasty (**c–e**). Although this was the result of inlay of vascular tissue, this is also the appearance after a free graft when adjacent genital skin is not available (Courtesy of S.B. Brandes)

ture persists, then dorsal plications are usually performed. If the phallus is foreshortened and ventral grafting is performed, then a third operation will be required because a graft will not survive when placed on another graft. Snodgrass has described multiple transverse "feathered cuts" in the ventral corporal bodies at the time of a first-stage buccal mucosal graft. This is successful only if the graft is aggressively quilted to eliminate hematomas under the graft and improve the take.

After the curvature is corrected, the entirety of the denuded tunica albuginea is grafted (Fig. 27.6). The results of this procedure are assessed 6 months later for adequacy of graft take, depth of the glans cleft, and suppleness of the surrounding tissues. Tubularization of the urethra is completed only if these are satisfactory. A tunica vaginalis flap is usually available to cover this urethroplasty.

Urethral Hair

Urethral hair is an annoying complication that occurs when hair-bearing skin is inadvertently incorporated into a urethroplasty. Infections, calculi, and trichobezoar (hair ball) may result (Fig. 27.9). Obviously, the use of nonhair-bearing skin flaps or free grafts is preferable. Preemptive depilation of hair-bearing skin has been described, but electrocoagulation of the dermal papillae is usually ineffective because of poor depth of penetration. The Nd:YAG laser has 4- to 5-mm penetration and destroys hair follicles more effectively.

However, if hair-bearing skin has been previously used, eradication and prevention of recurrence is very important. When isolated hair is identified, endoscopic removal with laser coagulation of the base may be effective. When hair growth is more abundant, a urethrotomy should be performed. One has to decide whether the urethral segment needs to be replaced with a nonhair-bearing graft (in a staged fashion) or if the hair can be removed and the segment effectively depilated. If the segment then it should be closely followed for regrowth and chemical depilation can be attempted using reducing agents that break the cross-linkage disulfide bonds in keratin [44].

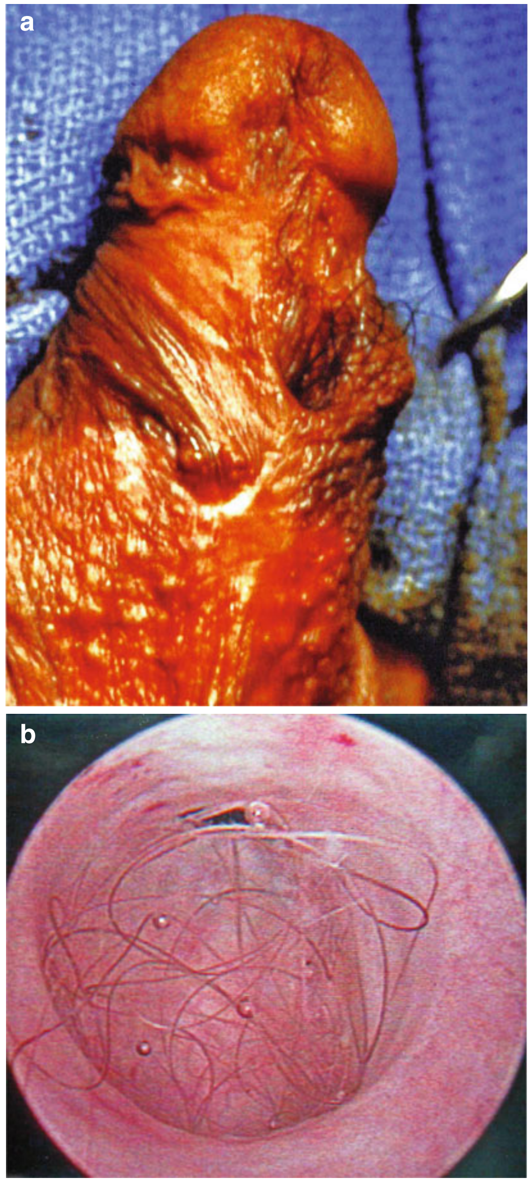

Fig. 27.9 (**a**) Hair extrudes from a distal shaft meatus. (**b**) The endoscopic appearance of urethral hair and urethrocutaneous fistula is shown (Courtesy of S.B. Brandes)

Editorial Comment

I often joke that when I see an adult patient with urethral stricture who comes to the office with his parents, I can always accurately guess that he is a "hypospadias cripple." Strictures in the hypospadias cripple are difficult to treat, in particular because of the psychological baggage and number of years that the patient and his family have suffered. Early in my surgical career, I was often overly aggressive and tried to manage adult hypospadias cripple patients with one-stage repairs. While surgically complex and elegant looking and often requiring the use of a combination of grafts and flaps, the failure was exceedingly high. After prior failed hypospadias repair, one-stage penile skin flaps typically fail, because the blood supply is often compromised (especially flap vascularity) and disrupted from prior surgical mobilization and the penile skin is scarred.

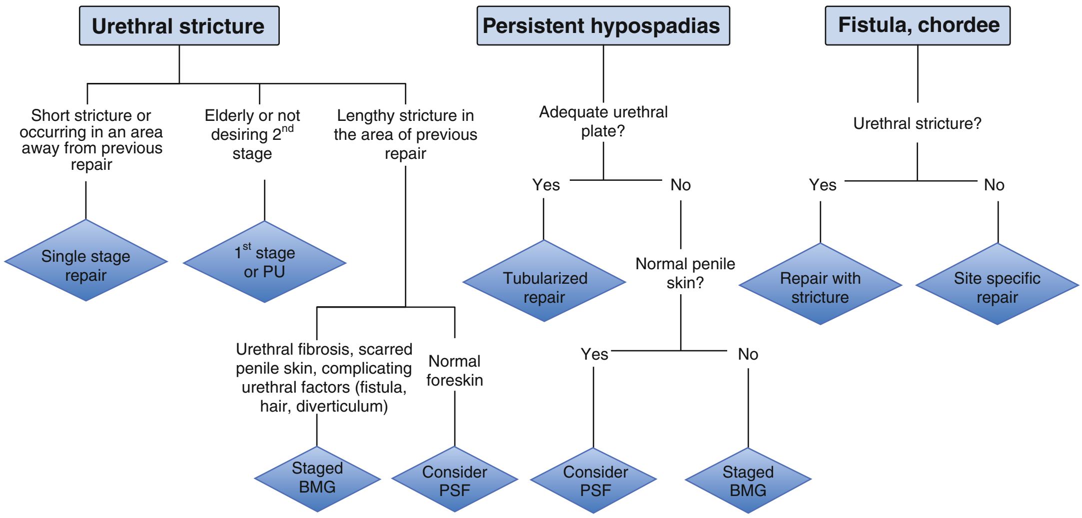

Fig. 27.10 Algorithm for the surgical management of the adult with failed hypospadias reconstruction (From Myers et al. [45])

I have evolved my surgeries for hypospadias cripples to a staged approach of buccal grafts followed by a 2nd or 3rd stage to tabularize 6–12 months later. To prevent urethrocutaneous fistula formation, I typically interpose a tunica vaginalis flap at the final stage. The key is to keep the penis on stretch when tabularizing the plate and while mobilizing the tunica vaginalis to the external ring (if not mobilized enough, with erection, the testes will be pulled up into the high scrotum or groin). Barbagli recently reported his experience with 1,176 hypospadias cripples. Highlighting the complexity and difficulty of reconstruction such adult patients, they required a median of 3 operations for repair, with 10 % requiring more than 5 operations. Success rates for the staged approach in adults range from 67 to 86 %. My general personal surgical experience with hypospadias cripples has been at the lower end of the range – with roughly a 30 % complication rate – whether it be restricture, diverticulum, post-void dribbling, chordee, or urethrocutaneous fistula.

At the second (or third) stage, where we tubularize the urethra, if the plate is a little narrow (<3 cm), I will place an inlay buccal graft in the Asopa technique. As per the Dennis Browne principle, the primary purpose of the urethral Foley, if to act as a scaffold to promote epithelization, and not really for urinary drainage. I place a 12 F Foley for the urethra, in order to prevent ischemic compression of the mucosa and to promote periurethral gland drainage (glands of Littré). I plug the urethral Foley and keep the SP to gravity, as I have had many patients with just a urethral Foley who accidently pulled or slept on the catheter, resulting in disruption of the suture line, resulting in an iatrogenic subcoronal hypospadias.

Occasionally, the hypospadias adult patient presents with a urethral stricture well away from the prior surgical site – such as in the bulbar urethra. For such strictures, I typically have shied away from stricture and primary anastomosis repairs, as the collateral and bipedal blood flow to the penile urethra is often poor. As the hypospadias-constructed penile urethra is often nothing more than a skin tube, rather than a vascular corpus spongiosum, there is deficient vascularity supplied from perforators and circumflex arteries. I am concerned that transecting the urethra as in an EPA will lead to ischemia of the distal urethra/spongiosum. For such bulbar strictures, I prefer to perform an onlay buccal graft. For distal bulb strictures, I place the graft dorsal and for the mid- and proximal bulb strictures, I place the graft ventral. See the algorithm in Fig. 27.10 – it is a nice summary of the general surgical strategy for the hypospadias cripple and a little more detailed than the one supplied in the above chapter.

—Steven B. Brandes

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Follow-Up Strategies After Urethral Stricture Treatment

28

Chris F. Heyns

Summary

Follow-up strategies after urethral stricture treatment include noninvasive (symptom assessment, uroflowmetry) and invasive methods (urethrography, urethral calibration/bouginage, and urethrocystoscopy). Uroflowmetry is often used as an objective test. The presence of a urethral stricture is suggested by a peak (maximum) urinary flow rate (Qmax) less than 10 mL/s and a uroflow tracing which is flat and box shaped, whereas the absence of a stricture is indicated by a Qmax greater than 15 mL/s.

Using a combination of the International Prostate Symptom Score (IPSS) and Qmax may avoid invasive testing. There is a significant inverse correlation between the AUA SS and urethral diameter as well as Qmax, and a positive correlation between urethral diameter and Qmax. Using cutoff values of an IPSS greater than 10 and Qmax less than 15 mL/s provides about 93 % sensitivity and 68 % specificity for predicting the presence of a stricture and avoids further invasive testing in 34 % of patients.

Urethral calibration is more accurate than urethrography, since the urethra may look narrow radiologically but still easily admit a 16–18 F catheter. Some define a significant urethral stricture as one that will not easily accept a 16–18 F flexible cystoscope. Others feel that endoscopy could underestimate stricture recurrence and that urethrography should be the gold standard.

A reasonable recommendation is to perform initial evaluation using noninvasive tests (symptom score and uroflowmetry) to select men who require further invasive testing.

There is no consensus about the optimal intervals and duration of follow-up. Since most stricture recurrence occurs in the first 12 months after treatment, 3–4 monthly follow-up for 24 months and then yearly seems reasonable. After anastomotic urethroplasty patients should be followed for at least 5 years and after substitution urethroplasty for 15 years or more.

Follow-Up Strategies

There is no (clear consensus about the best protocol for follow-up or the definition of stricture recurrence after treatment. Meeks and associates performed a meta-analysis of 86 articles on urethroplasty published between 2000 and 2008 and found that 46 % of the articles described a multiple-tier approach to evaluate for stricture recurrence, using a mean of 3 modalities (range 1–8) [1]. A common strategy was to perform screening with a noninvasive test, followed by more invasive and expensive evaluations when

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Table 28.1 Modalities used to detect stricture recurrence after urethroplasty (meta-analysis of articles on urethroplasty)

Procedure	Overall use (%)	Primary (%)	Secondary (%)
Uroflowmetry	56	98	2
RUG	51	73	27
AUA SS/patient symptoms	47	98	2
Cystoscopy	46	53	47
Urine culture	24	100	0
Urethral calibration	24	52	48
VCUG	15	77	23
PVR	8	85	15
SUG	8	0	100

Adapted from Meeks et al. [1]
AUA SS American Urological Association Symptom Score, *PVR* post-void residual urine volume, *RUG* retrograde urethrography, *SUG* sonourethrography, *VCUG* voiding cystourethrography

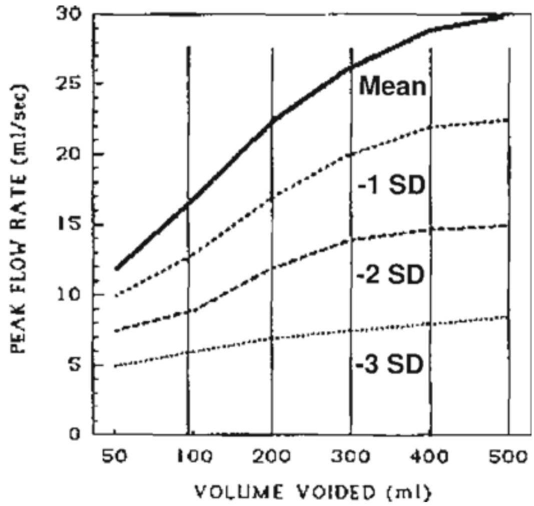


Fig. 28.1 Nomogram of urinary peak flow rates (mL/s) by voided volumes (Adapted from Siroky et al. [5])

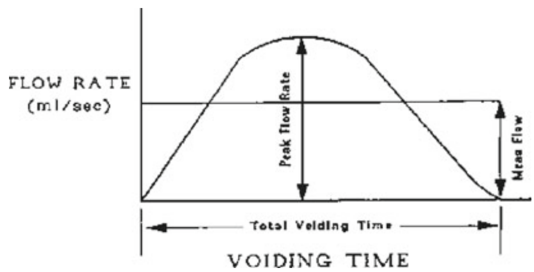


Fig. 28.2 Typical hyperbolic, bell-shaped urinary flow rate curve of a normal, unobstructed urethra (Adapted from Siroky et al. [5])

indicated. The percentage of overall, primary, and secondary use is shown in Table 28.1. Of the studies that used a multitier screen, 74 % used at least two screening methods, while 26 % used three separate methods [1].

A nationwide survey of urologists in the USA found that the modalities most often used for detecting stricture recurrence after treatment were uroflowmetry (63 %), cystoscopy (33 %), urethral calibration (28 %), symptom score (28 %), RUG/VCUG (13 %), and SUG (3 %) [2, 3].

A survey among urologists in the Netherlands found that their routine follow-up after stricture treatment included uroflowmetry and PVR (93 %), cystoscopy (17 %), International Prostate Symptom Score (IPSS) (11 %), voiding diary (11 %), RUG (10 %), VCUG (2 %), and urethral calibration (2 %), while 6 % performed no routine follow-up [4].

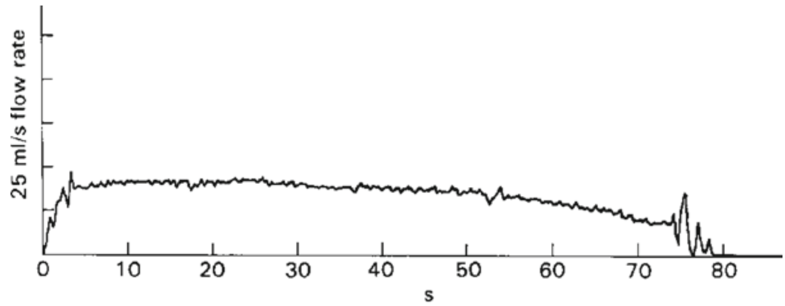
Noninvasive Evaluations

Uroflowmetry

Uroflowmetry is typically recorded using an electronic flow meter which plots the flow rate (mL/s) versus voiding time. The peak (maximum) flow rate (Qmax) is directly dependent on the volume voided (Fig. 28.1) [5]. Peak flow rates with voided volumes less than 150 mL are typically inaccurate.

A normal urinary flow tracing is a smooth, hyperbolic, bell-shaped curve (Fig. 28.2). A uroflow tracing which is flat and box shaped (plateau-like) is characteristic of a urethral stricture (Fig. 28.3) [6].

Uroflowmetry is simple, cost-effective, and noninvasive. However, flow rates may be affected by operator error, prostatic enlargement, detrusor dysfunction, and variations in voided volume. Uroflowmetry has an established role in the follow-up of pediatric hypospadias surgery, where the absence of other urinary tract pathology makes it more reliable in assessing for stricture recurrence [7].



Voiding time	$t100$	79	s
Flow time	tQ	78	s
Time to max flow	$tQ_{max.}$	3	s
Max flow rate	$Q_{max.}$	9.3	ml/s
Average flow rate	$Q_{ave.}$	6.6	ml/s
Voiding volume	$V_{comp.}$	518	ml

Fig. 28.3 Typical flat, box-shaped (plateau-like) flow rate tracing in the presence of a urethral stricture (Adapted from Blandy and Fowler [6])

There is evidence that, in relatively young men (mean age less than 50 years) with known stricture disease, a Qmax less than 10 mL/s has a positive predictive value of about 95 % for the presence of a recurrent stricture [8, 9]. Heyns and Marais [9] showed that a urethral diameter of 18 F or larger correlates well with a Qmax greater than 15 mL/s and an AUA SS less than 10, confirming the view that a Qmax greater than 15 mL/s indicates the absence of a significant stricture [9].

The shape of the uroflowmetry curve is important, since urethral stricture is associated with a plateau curve [10]. Interpretation of curves is subjective, but assessors demonstrate higher agreement rates for plateau than other pathological curve patterns [11].

A study of men evaluated after urethroplasty showed that using a Qmax less than 10 mL/s resulted in only 54 % test sensitivity to predict recurrence. The highest sensitivity and negative predictive value (each 99 %) were achieved when all men with symptoms and/or obstructed flow curves were evaluated. The authors concluded that uroflowmetry is an adequate test to screen for postoperative stricture recurrence, but only when the voiding curve and urinary symptoms are also evaluated [12].

The real value of uroflowmetry may be in the follow-up of individual stricture patients, where changes from baseline may indicate success or failure of treatment. A study comparing pre- and postoperative uroflowmetry in men who had undergone urethroplasty showed that the mean increase in Qmax in men without stricture recurrence was 19.2 ± 11.7 mL/s versus 0.2 ± 6.4 mL/s in those with recurrence [13]. Setting a change in Qmax less than 10 mL/s as evidence of stricture recurrence had a sensitivity and specificity of 92 and 78 %, respectively.

Symptoms

Some authors contend that the most practical and meaningful indicator of therapeutic efficacy is the absence of symptoms [14], although it is well known that symptoms alone will detect fewer recurrences than when uroflowmetry is used [15].

Controversy exists as to whether strictures with a caliber larger than 18 F are symptomatic [8, 16]. Especially in elderly men it is impossible to determine whether symptoms are due to urethral stricture, prostatic enlargement, bladder neck stenosis, or detrusor dysfunction, unless the symptoms improve significantly after stricture treatment.

The AUA Symptom Index (AUA-SI) was created in 1992 and originally consisted of seven questions (hence its original name AUA-7). Subsequently a quality of life (QoL) question was added, and the 8-item questionnaire was adopted by the World Health Organization as the International Prostate Symptom Score (IPSS) [17]. Although symptom scores of individual

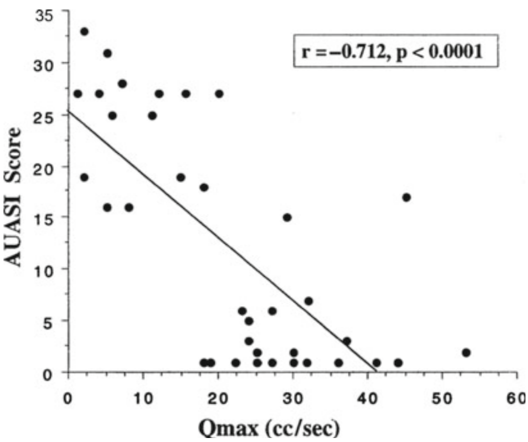


Fig. 28.4 Correlation between AUA SS and Qmax before and after successful urethroplasty (Adapted from Morey et al. [19])

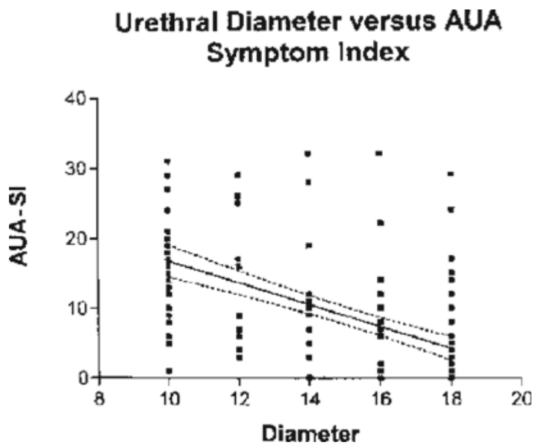


Fig. 28.5 Correlation between urethral diameter and AUA SS ($r = -0.57$, $p < 0.001$); *dotted lines* indicate 90 % CI (Adapted from Heyns and Marais [9])

patients are not directly comparable, due to inter-individual differences in terms of perception of symptoms and understanding of the questions, their true value is in longitudinal follow-up to assess changes in symptom severity and to evaluate treatment efficacy [18].

Morey and associates were the first to examine the role of the AUA SS in the assessment of urethroplasty outcomes [19]. A significant inverse correlation was found between the AUA SS and Qmax (Fig. 28.4). Successful urethroplasty outcomes were noted in follow-up when the AUA SS was less than 7. Stricture recurrence, as confirmed by urethrography, correlated well when the symptom score was greater than 20. The authors concluded the AUA SS is a useful tool in the outcome assessment of urethral stricture treatment [19].

Some of the earliest studies on direct vision internal urethrotomy (DVIU) noted the close correlation between symptomatology and urine flow rates [20]. In a more recent study of urethral stricture patients (average age 48 years), Heyns and Marais [9] found statistically significant negative correlations between the AUA SS and urethral diameter (Fig. 28.5) and between the AUA SS and Qmax (Fig. 28.6).

Pre- and postoperative symptom assessment is a reliable, noninvasive method to assess treatment outcome, particularly from the patients' perspective [21]. A recent study used only mailed IPSS

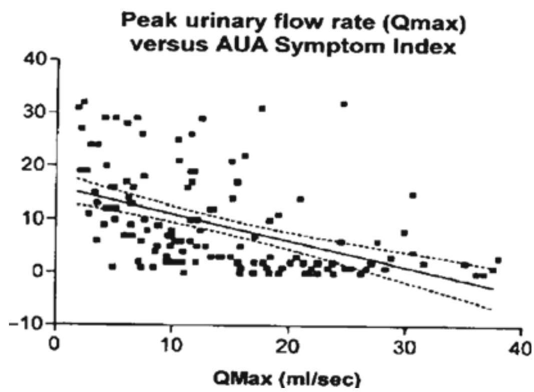


Fig. 28.6 Correlation between AUA SS and Qmax ($r = -0.47$, $p < 0.001$); *dotted lines* indicate 90 % CI (Adapted from Heyns and Marais [9])

and quality of life (QoL) questionnaires to evaluate men after laser DVIU [22]. In the pediatric population follow-up by means of patient- or parent-reported symptoms is definitely preferable to invasive tests [23]. A recent study recommended the use of mobile phone contact to follow up men after urethroplasty in a developing country, because financial and logistic considerations impede clinic follow-up, whereas mobile phone networks are widely available [24]. It is clear that symptom score assessment can be used as an inexpensive screening tool to assess the need for more invasive testing to confirm stricture recurrence [1].

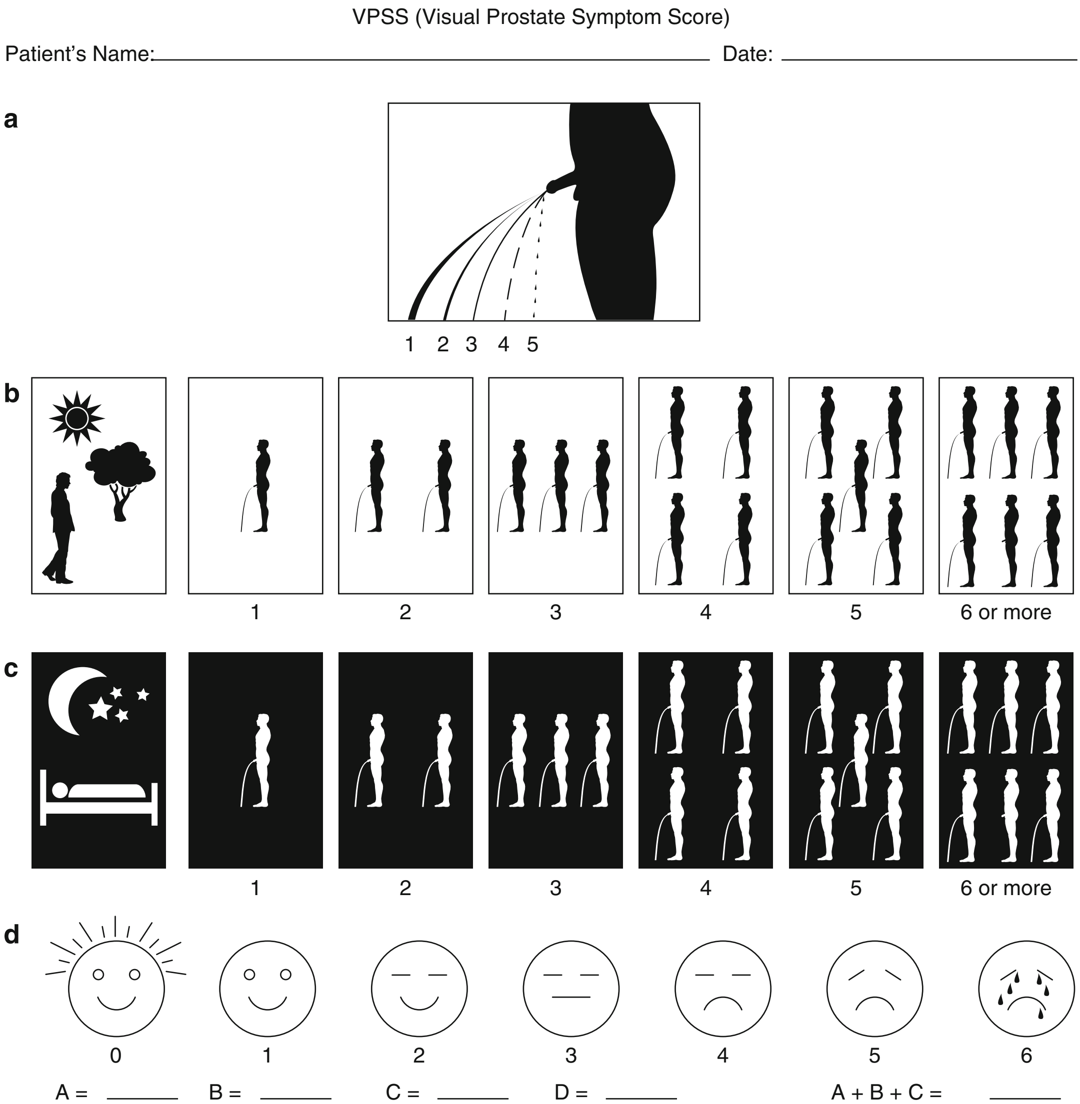


Fig. 28.7 Visual prostate symptom score (Adapted from Walt et al. [32] and Heyns et al. [33])

One problem with using symptom scores such as the AUA SS or IPSS in non-English-speaking countries is that they have to be translated and validated in the regional language [25]. Another problem is that many patients (30–70 %) find it difficult to comprehend the questions, especially patients with a lower level of education [26–29]. Using medical staff to assist the patient in completing the form introduces potential bias and imposes an additional burden on the medical staff [30, 31]. The time required to complete the IPSS varies according to patient education and intelligence but is approximately 8 min [26, 28].

Recently a visual prostate symptom score (VPSS) was described, using pictograms to assess the force of the urinary stream, frequency, nocturia, and QoL [32, 33]. In a study of men (mean age 64 years) referred to a urology clinic with LUTS, the VPSS correlated significantly with the IPSS and Qmax and could be completed without physician assistance by a greater proportion of men with limited education [32, 33]. A revised version of the VPSS (Fig. 28.7) is

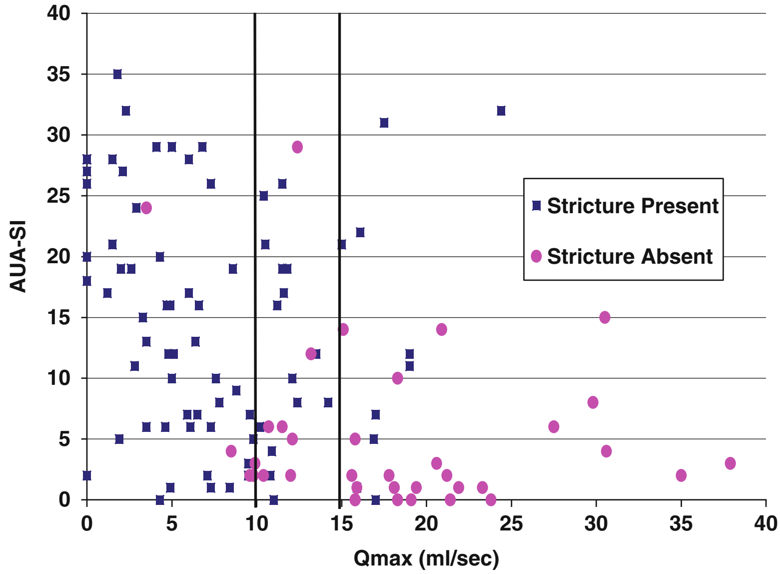


Fig. 28.8 AUA SS and Qmax in men with and without a urethral stricture (Adapted from Heyns and Marais [9])

currently being evaluated in the assessment of men with urethral stricture disease.

Combination of Symptom Score and Uroflowmetry

Heyns and Marais [9] suggested using a combination of the AUA SS and urinary Qmax to predict the presence or absence of a stricture. In their study cohort of men with a mean age of 48 years, the best combination to maximize both sensitivity and specificity was an AUA SS of greater than 10 plus Qmax of less than 15 mL/s. This provided 93 % sensitivity and 68 % specificity, avoided further invasive studies in 34 % of patients, and missed only 4.3 % of recurrent strictures (Fig. 28.8) [9].

Aydos and associates [34] combined the AUA SS and uroflowmetry in the assessment of men after urethroplasty. Those with recurrent stricture on RUG had a mean AUA SS of 30 and Qmax of 6 mL/s, whereas men without recurrence had a mean AUA SS of 6 and Qmax of 25.7 mL/s [34].

Erickson and associates [12] reported that using a Qmax of less than 10 mL/s resulted in only 54 % sensitivity to predict stricture recurrence after urethroplasty. Symptoms alone had a high specificity (87 %), sensitivity (88 %), and negative predictive value (95 %). A combination of symptoms and uroflowmetry gave the greatest sensitivity and negative predictive value (each 99 %) for stricture recurrence, with curve characteristics proving more useful than maximum flow rates. They concluded that symptoms in combination with uroflow curve characteristics are adequate to screen for stricture recurrence, whereas the flow rate alone is not a reliable tool [12].

Post-void Residual Urine Volume (PVR)

Ultrasound PVR is a noninvasive technique that provides objective measurement of bladder emptying. When ultrasound equipment is unavailable, PVR can be determined by passing a catheter after micturition and measuring the urine volume drained. However, PVR has been shown to be highly variable, with poor inter-test reliability and poor predictive value with regard to the need for invasive therapy in men with lower urinary tract symptoms (LUTS) due to benign prostatic enlargement [35, 36]. PVR has not been tested in a stricture population, despite being used by many urologists in screening for stricture recurrence [1, 4].

Urine Culture

Urinary tract infection (UTI) is a common complication of DVIU as well as urethroplasty, but there are no studies directly correlating postoperative UTI with stricture recurrence. Nonetheless, 24 % of articles on urethroplasty described the use of urine culture as a screening method to identify stricture recurrence (Table 28.1) [1]. It seems reasonable that urine dipstick analysis should be part of the assessment after stricture treatment, with urine culture being performed in symptomatic patients with dipstick findings indicative of UTI.

Sexual Function

Erectile dysfunction (ED) and changes in ejaculatory function have been described after DVIU as well as urethroplasty [37, 38]. In most cases recovery of ED occurred within 6–12 months. Improvement of ejaculatory function after urethroplasty is probably due to the relief of urethral obstruction, whereas in some men ejaculatory dysfunction may be ascribed to denervation or surgical disruption of the bulbocavernosus muscle [39, 40].

Questionnaires that have been used to evaluate sexual function after urethroplasty include the Brief Male Sexual Function Inventory (BMSFI) [39], International Index of Erectile Function (IIEF) [40], and Male Sexual Health Questionnaire (MSHQ) [41].

It appears increasingly important to assess changes in sexual function after stricture treatment. Patient satisfaction after urethroplasty is significantly determined by factors influencing sexual function. Men with marked or severe penile curvature or shortening, deterioration of erection, or impairment in sexual function reported considerably more dissatisfaction [21].

Patient-Reported Outcome Measure (PROM)

A recent paper reported on the development of a patient-reported outcome measure (PROM) for urethral stricture surgery. The PROM comprised a LUTS construct consisting of six summative questions, a LUTS-specific QoL question, a visual voiding scale to grade the force of the urinary stream, and a visual analogue scale to assess overall health-related QoL. The study found a statistically significant correlation between LUTS and Qmax before as well as after urethroplasty [42].

Invasive Evaluations

Urethral Calibration or Bouginage

The term bouginage comes from the French word *bougie* (candle) and refers to the technique of passing soft wax candles of varying diameter to calibrate and dilate the lumen of the urethra. Urethral calibration may be more accurate than urethrography, since the urethra may look narrow radiologically but still easily admit a 16–18 F catheter or bougie without difficulty [14].

Based on the assumption that the mean caliber of the normal adult male bulbar urethra is 33–36 F, Stormont and associates [14] considered "large-caliber" bulbar strictures to be greater than 20 F. In 65 % of their patients, the bulbar urethral stricture diameter was more than 20 F, which would certainly not qualify as a stricture by the definition of most reports in the literature [43, 44].

Some define a significant urethral stricture as a lumen that will not easily accept a flexible cystoscope, i.e., less than 16 F. In men known to have stricture disease, there is a statistically significant negative correlation of urethral diameter with AUA SS (Fig. 28.5) and a significant positive correlation of urethral diameter with Qmax (Fig. 28.9) [9]. However, there is clearly not a single cutoff point for urethral caliber that separates normal from abnormal; therefore, the definition of urethral stricture in terms of urethral lumen diameter remains somewhat arbitrary.

Urethrography

Retrograde urethrography (RUG) may fail to demonstrate strictures which are very distal or very proximal [44]. In case of a severe stricture or

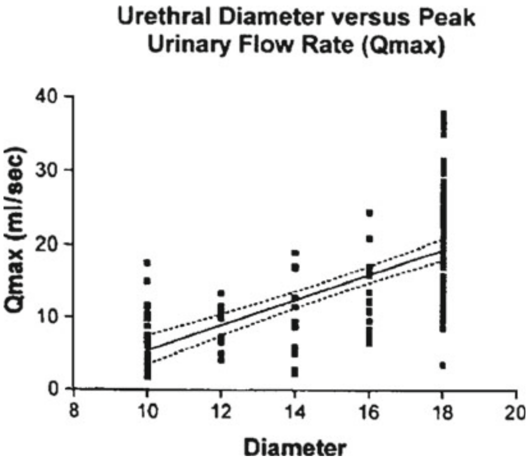


Fig. 28.9 Correlation between urethral diameter and Qmax ($r = -0.66$, $p < 0.001$); dotted lines indicate 90 % CI (Adapted from Blandy and Fowler [6])

complete obliteration of the urethra, RUG can be combined with voiding cystourethrography (VCUG) or antegrade urethrography through a suprapubic cystostomy to define the proximal extent of the stricture [45]. Disadvantages of RUG and VCUG are the requirement for X-ray fluoroscopic equipment, radiation exposure, patient discomfort, and the risks of UTI and radiological contrast reaction.

Some authors recommend performing urethrography 2–3 weeks after urethroplasty to evaluate the urethra prior to catheter removal. A pericatheter urethrogram (PUG) to assess adequate healing after endoscopic urethral realignment or urethroplasty may also be performed [46]. A study of patients who underwent VCUG at a mean of 24 days after urethroplasty showed that only 3 % had extravasation. The authors suggested that imaging can be omitted after uncomplicated excision and primary anastomosis urethroplasty [47]. A survey of Dutch urologists reported that 54 % did not routinely perform RUG or VCUG after urethroplasty, whereas 25 % performed urethrography 2–3 weeks after the procedure and the remaining 21 % performed it at intervals varying from 1 to 12 weeks [4].

Sonourethrography (SUG) provides information about stricture location and length as well as the extent of spongiofibrosis and may be more sensitive in diagnosing strictures of the penile compared with the bulbar urethra [48, 49]. SUG may cause less pain and bleeding than RUG [49, 50]. Its drawbacks include operator dependency and semi-invasiveness, because full urethral distension may require local or general anesthesia.

Urethroscopy

Urethroscopy using a flexible cystoscope is regarded by some as the "gold standard" for confirming or excluding the presence of urethral strictures [49, 51, 52]. Others feel endoscopy could underestimate the presence of stricture recurrence and feel that any narrowing on urethrography denotes recurrence. Urethroscopy does not allow measurement of stricture length if the stricture is smaller in caliber than the cystoscope. In some cases, the use of a pediatric cystoscope or ureteroscope can allow assessment of small-caliber strictures.

Flexible cystoscopy as an office procedure without local analgesia causes mild discomfort in about 56 % of men, with 14 % reporting severe pain [53]. It has a low risk of causing urinary tract infection (around 2 %) [54]. The cystoscope need not be passed beyond the bulbomembranous junction to assess the surgical repair in many cases, thus decreasing patient discomfort and risk of infection. Because of the relatively low recurrence rate after urethroplasty, routine urethroscopy would be unnecessary in more than 80 % of cases [1].

Definition of Treatment Success or Failure

Postoperative success following DVIU or urethroplasty differs from stricture recurrence and may not be the major determinant of patient satisfaction. There is considerable variation in the definitions of successful stricture treatment, for example, Qmax greater than 15 mL/s with a normal urethrogram [20]; Qmax greater than 15 mL/s, VCUG normal, and urine sterile [55]; patient satisfied and Qmax greater than 10 mL/s [56]; no clinical symptoms and Qmax greater than 15 mL/s [57]; and satisfactory voiding, normal retrograde RUG and VCUG, and Qmax greater than 15 mL/s [58]. It is clear that with these definitions postoperative success rates will tend to be higher than the stricture-free rates.

There is also considerable variation in the definitions of stricture recurrence in different studies, for example, patient symptomatic and Qmax less than 6 mL/s [59]; Qmax less than 15 mL/s and urethra not permitting the passage of a 21 F cystoscope [56]; Qmax less than 10 mL/s (with a micturition volume greater than 100 mL) and a characteristic flow curve [15]; inability to pass an 18 F catheter [9, 43]; and obstructive symptoms, Qmax less than 10 mL/s (with a voided volume greater than 150 mL), obstructive urine flow pattern, and/or impossible dilation [60]. A meta-analysis of papers on urethroplasty showed that stricture recurrence was defined as the need for an additional surgical procedure or DVIU in 75 % or articles and the need for dilation in 53 % of studies [1]. It seems likely that these definitions may also underestimate the true rate of stricture recurrence.

Patient satisfaction with stricture treatment does not necessarily depend on objective evidence of stricture absence. A study assessing patient satisfaction after urethroplasty relative to objective criteria found that patient satisfaction was not directly related to the urologist's definition of success (in this study: no evidence of restricturing, Qmax greater than 15 mL/s, PRV less than 50 ml, and no UTI) [21]. Patient satisfaction in men with successful versus failed urethroplasty was 78 % versus 80 %.

Follow-Up Frequency and Duration

There is no consensus about the optimal intervals or duration of objective testing, which has varied from 3 to 4 monthly for 12–24 months in different reports [61, 62]. There is a clear correlation between the duration of follow-up and the risk of recurrence after DVIU, with most recurrences occurring within 6–12 months [20, 57]. However, late stricture recurrence may sometimes occur more than 5 years after DVIU or dilation [61, 62].

A long-term follow-up study of men who had undergone urethroplasty showed that the stricture recurrence rates at 5, 10, and 15 years after anastomotic urethroplasty were 12, 13, and 14 %, respectively, and after substitution urethroplasty 21, 31, and 58 %, respectively [63]. This suggests that anastomotic urethroplasty patients may be followed for only 5 years, whereas substitution urethroplasty patients should essentially be followed up for life. However, in many health-care systems, it is difficult to continue monitoring patients for many years. Therefore, a final assessment at 18 months following urethroplasty would seem reasonable, with ongoing scheduled evaluation limited to those with a possible impending stricture.

Meeks and associates [1] recommended a 2-tier system to evaluate patients for stricture recurrence. The first tier involves obtaining an AUA SS as a cost-effective, noninvasive screening method. If voiding symptoms are present, flexible cystoscopy in the clinic setting is recommended as the second tier procedure [1]. It seems advisable to add uroflowmetry to symptom assessment, if the necessary equipment is available, because this may improve the selection of patients for invasive evaluation. If flexible cystoscopy in the clinic setting is unavailable, an option may be to pass a transurethral catheter, which is not more invasive than flexible urethroscopy or urethrography. The size of catheter selected for urethral calibration will largely depend on the urologist's threshold for further intervention (dilation, DVIU, or urethroplasty) to enlarge the urethral lumen.

Editorial Comment

Unfortunately there is no current consensus or standard when it comes to the definition of a urethral stricture, what constitutes a success or failure after urethroplasty, or how often and how long to follow patients after urethroplasty. This is a sad comment on our profession as urethral surgeons. What is more disturbing is that this important topic has not been taken up on any serious level by our Genitourinary Reconstructive Surgical Societies. An effort at this endeavor, cosponsored by the International Consultation of Urologic Diseases and the Society of International Urologists, assembled an international consultation of urethral experts in Marrakech Morocco in 2011. The proceedings of that meeting have recently been published in book form. Without a true consensus or standard, we cannot objectively assess or compare results from published surgical series. It leaves the "science" of urethral surgery relegated to retrospective series and to anecdotal and personal experience. We can do better, and I urge the reconstructive societies to champion the cause and create a panel of experts to publish a true guideline as to standards when it comes to urethral stricture and surgery.

To further investigate the practice patterns of urethral surgeons from around the world, we conducted an international survey of the members of the Society of Genitourinary Reconstructive Surgeons in 2010 via e-mail [64]. Participants were surveyed regarding nomenclature used to define strictures, urethroplasty practice patterns, follow-up practice patterns, and methods used to screen for stricture recurrence. Respondents defined urethroplasty failure as the need for a secondary urethral procedure (60.0 %), significant narrowing on imaging (14.4 %), urethral narrowing preventing passage of 16 F cystoscope (12.2 %), or poor uroflow or American Urological Association Symptom Score (AUA SS) (7.8 %). Only a third of responders followed their patients longer than 3 years after surgery. To screen for stricture recurrence, 85 % used uroflowmetry, 56 % used post-void residual, 19 % used flexible cystoscopy, and 17 % used retrograde urethrography. 48 % of the surgeons did not use validated instruments to evaluate quality of life after urethroplasty. For those who used validated questionnaires, the ones most often used were the AUA SS (41 %) and Sexual Health Inventory for Men (19 %).

The conclusion of our survey reconfirmed that there is no consensus regarding follow-up practices after urethroplasty, even among urethral surgeon experts. Another surprising result was that most experts define urethroplasty failure as a "need for a secondary procedure," do not follow patients long term, and do not use validated questionnaires. A standardized definition for stricture recurrence and a standardized follow-up protocol are desperately needed.

It is evident from the literature that anastomotic urethroplasty is highly successful and has sustained durable results. EPA stricture recurrence slightly rises from 1 to 5 years of follow-up and is stable at 10 and 15 years. It seems reasonable then that EPA patients should be followed for just 5 years. In contrast, substitution urethroplasty has progressive and ever-increasing rates of failure with time (even up to 15 years after surgery). Thus, our standard of practice for EPA patients is annual follow-up visits for a maximum of 5 years and for substitution urethroplasty patients, essentially for life. However, while such long-term follow-up is preferred and ideal – in reality many of our patients travel great distances to our center for reconstruction. It is a big burden and large expense and just pain unfair to force patients to be evaluated far away from home if they are asymptomatic and pleased as to their voiding. For such patients, we have them follow up with their local urologist with an annual flow rate, AUA SS, and PVR.

As urethral stricture surgery is quality of life surgery, it is essential that we follow our patients not just for voiding function but with validated questionnaires to assess quality of life. Moreover, follow-up after urethroplasty is a balance of assessing urethral bother, voiding function, and overall QOL by noninvasive versus invasive testing. It is our bias that if a patient has little bother, is satisfied with his voiding, and has good quality of life, we are hard pressed to justify invasive testing. While early in my career, I insisted that all patients be evaluated by cystoscopy and urethrography; I have gradually dropped invasive testing in favor of noninvasive surrogates for urethral stricture evaluation. Our current follow-up standard post-urethroplasty is a baseline urinary flow rate, post-void residual urine by ultrasound, AUA SS, QOL questionnaires (i.e., SHIM, ICIQ, PGI, SF-12), and flexible cystoscopy at 3 months follow-up. If all the parameters are normal at 3 months, follow-up is then yearly by noninvasive tests. Subsequent triggers for invasive testing are a flow rate <15 or AUA SS >10 or patient complaint of voiding bother and/or symptoms or complications.

—Steven B. Brandes

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29 Urethral Rest as Precursor for Urethroplasty

Steven J. Hudak and Allen F. Morey

Summary

Patients and community urologists should recognize that transurethral instrumentation of severe strictures mandates a significant recovery phase of several months duration prior to embarking upon definitive repair; dilation procedures should therefore be avoided when success is unlikely. For patients presenting to tertiary referral centers soon after urethral manipulation, urethral rest is a sound strategy based upon the fundamental principles of wound healing which appears to be a valuable first step toward promoting successful urethroplasty. Radiographic delineation of unstable urethral pathology occurs as a result of tissue remodeling, a process which allows accurate determination of stricture severity. Strictures that have been recently manipulated will frequently become obliterative, thus requiring focal or complete excision rather than a straightforward onlay procedure. Early SPT followed by repeat imaging in 2 months and open reconstruction 1 month subsequently is preferred for men with severe strictures in lieu of the unnecessary costs, delays, and collateral damage associated with unhelpful endoscopic treatments.

Introduction

Men referred to tertiary care centers for definitive management of urethral strictures often present immediately following endoscopic interventions, either with an indwelling Foley catheter in place or while actively engaged in a regimen of self-catheterization. Because urethral dilations profoundly alter stricture characteristics, the rational determination of appropriate care by the accepting physician at the time of initial presentation is often rendered impossible.

Little guidance is currently available in the urologic literature regarding the timing of urethroplasty in patients who present soon after transurethral instrumentation. We have routinely implemented a period of "urethral rest" in recently instrumented cases, with or without suprapubic urinary diversion, to encourage tissue recovery and promote accurate radiographic depiction of the extent of urethral pathology as a guide for surgical decision making. The benefits of a several month period of urethral rest following pelvic fracture-related urethral distraction injuries are well documented as a prelude to successful posterior urethral reconstruction [1]. The objective of this chapter is to discuss the rationale and potential benefits for urethral rest prior to anterior urethral reconstruction.

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Wound Healing Principles as Rationale for Urethral Rest

Urethral rest initiates a process of tissue stabilization that mimics normal wound healing processes occurring elsewhere in the body after injury. Wound healing is known to occur via three overlapping phases – inflammation, proliferation, and remodeling (Fig. 29.1) [2]. The initial inflammatory phase, beginning at injury and lasting through days 4–6, is precipitated by the exposure of collagen which activates the clotting cascade [3]. The proliferative phase, occurring between days 4 and 14, ends with formation of granulation tissue and development of wound contraction. The remodeling phase primarily consists of collagen deposition, cross-linking, and degradation. It is a dynamic process lasting more than 1 year following the injury and ultimately results in formation of a contracted scar lacking the elasticity of uninjured tissue.

For recently instrumented urethral strictures, catheter removal initiates the process of tissue remodeling and wound contraction – this produces a natural collapse of the strictured lumen, thus allowing identification of the location and severity of the pathologic process. As the key steps of wound healing are orchestrated by the subepithelial extracellular matrix (ECM), the endoscopic appearance of the urothelium alone may not reflect the degree of underlying spongiofibrosis, which often extends beyond the presumed boundaries of stricture involvement at the time of surgery [4–7]. Our rationale for implementing a 3-month period of urethral rest is that it appears to allow for wound contraction (stricture) in accordance with completion of the inflammatory and proliferative phases of wound healing, although the degree of remodeling that may occur during additional rest is unknown.

Each transurethral stricture manipulation represents a newly induced iatrogenic injury which reinitiates another wound healing cycle. Multiple treatments prior to urethroplasty is an established risk factor for recurrence and for stricture extension [8–10]. Programs of self-catheterization and dilation not only inconvenience patients, but put them at risk for traumatizing both involved and uninvolved segments of the urethra [11]. Repeated endoscopic stricture manipulation, although costly and futile, unfortunately remains a common treatment regimen for many urologists not skilled in urethral reconstruction [12–16]. Urethral rest can facilitate reconstruction of strictures complicated by recent repeated transurethral manipulation via a standardized surgical approach with excellent outcomes similar to men presenting with stable, previously unmanipulated anterior urethral strictures [17].

3 phases of wound healing

- Inflammatory phase (0–3 days)
  - Hemostatic plug, fibrin formation
  - Chemoattractant for macrophages, neutrophils
- Proliferative phase (4–14 days)
  - Fibrin plug degraded, extracellular matrix replaced
  - Collagen synthesis
- Remodeling phase (8 days–1 year)
  - Collagen thickening and cross-linking
  - Wound contraction, tensile strength increase

Fig. 29.1 Three phases of wound healing

Urethral Rest as Initial Phase of Reconstruction

Men presenting for urethral reconstruction with indwelling catheters or following recent urethral manipulation will have unstable stricture anatomy due to the repeated "injury" and ongoing wound healing which cannot progress into the remodeling phase. In these patients, urethral rest should be instituted to allow tissue recovery and stricture maturation as a guide for reconstructive decision making. Indwelling urethral catheters are removed at the time of initial consultation, and patients on active regimens of self-catheterization are instructed to discontinue this practice immediately in preparation for delayed urethroplasty.

For those with a high level of concern for urinary retention (rapid symptom recurrence after prior urethral dilation and/or increased difficulty with self-dilation), suprapubic tube (SPT) placement is recommended as soon as possible in an outpatient surgical setting. We prefer the Suprafoley® (Rüsch, Duluth, GA) suprapubic introducer trocar with a peel-away sheath, placed in the midline two fingerbreadths above the pubic symphysis. The 16 Fr suprapubic Foley catheter is a highly reliable form of drainage which can be easily and painlessly changed in the office after 2 months of tract maturation. For men presenting with an indwelling Foley catheter or following recent endoscopic stricture treatment, endoscopic guidance of SPT placement is facilitated by concomitant flexible cystoscopy. If the stricture has already progressed in severity, the bladder should be filled retrogradely (via a catheter tip syringe applied to the meatus or via trans-stricture passage of a 6 Fr ureteral catheter) or suprapubically (via an 18 gauge spinal needle). Ultrasound guidance may be helpful for patients with multiple abdominal surgeries. However, resist the temptation to refer the patient to interventional radiology, as patients will often return with small (10–14 F) pigtail catheters placed off the midline.

Although we have found SPT urinary diversion to be safe and reliable in the overwhelming majority of patients, the risks of infection, pain, calcification, and abdominal visceral injury are present; many men are reluctant to accept SPT when initially offered due to fear or the anticipated detrimental impact on their daily activities. However, these risks must be balanced against the potential pitfalls of continuation of impaired, high-pressure voiding, UTI, urinary retention, and the delay caused by urethral manipulations prior to referral. Supraphysiologic voiding pressures proximal to a stricture may play a role in extending the disease through both inflammatory and mechanical forces via a "water hammer" effect [6, 18]. Some authors have noted proximal urethral hydrodilation to be associated with development of unfavorable histological changes and proximal extension of pathology within the ECM [4]. Not surprisingly, such alterations are less common among patients with SPT for at least 30 days prior to urethral reconstruction [6].

Diverting urine from a urethral defect to avoid mechanical irritation is a time-honored yet underappreciated concept [19–21]. While in developing countries SPT diversion has long been performed as part of initial management of advanced inflammatory sequelae of untreated strictures, we continue to observe a growing problem of persistent, unhelpful urologic instrumentation of significant strictures that have not yet resulted in abscess or fistula. Among men with anterior urethral trauma, Park et al. found that SPT placement increased the chance of receiving an EPA repair as opposed to complex urethroplasty with tissue transfer, which was required more often after transurethral manipulations [22]. In management of pelvic fracture urethral distraction defects, concern of extending inflammation and fibrosis via realignment has led most experts to recommend 3 months of SPT diversion prior to EPA [1]. Recently, beneficial effects of SPT diversion have even been noted following radical prostatectomy. Krane et al. reported that utilizing SPT diversion after robotic radical prostatectomy instead of the traditional urethral catheter appeared to prevent anastomotic strictures [23].

Our favorable experience with early SPT placement suggests that this strategy is underutilized in treatment of urethral strictures. For severe strictures, the security and dramatic symptomatic relief provided by SPT seem to be far preferable to obligatory self-catheterization regimens and far outweigh the negligible risk of SPT placement. Moreover, SPT initiates a rapid and salubrious process of tissue recovery within the strictured segment, thus optimizing urethroplasty outcomes.

The practice of removing urethral catheters as soon as possible after tertiary referral for complex strictures appears to be well substantiated. Prolonged urethral catheterization complicates healing via multiple mechanisms, thus possibly explaining why the overwhelming majority of strictures in our practice become obliterative following catheter removal (Fig. 29.2). Bacteria found in catheter biofilm prolong the inflammatory phase and interfere with wound contraction [2]. Bacterial endotoxins lead to release of collagenase which may destroy the surrounding, previously normal tissue. Although most urine flows through the catheter lumen, stenting of the bladder neck allows urine to also travel along the outside of the catheter, with potential urinary extravasation adding inflammatory insult to the periurethral tissues. Urine damages the underlying interstitium largely via the toxic concentration

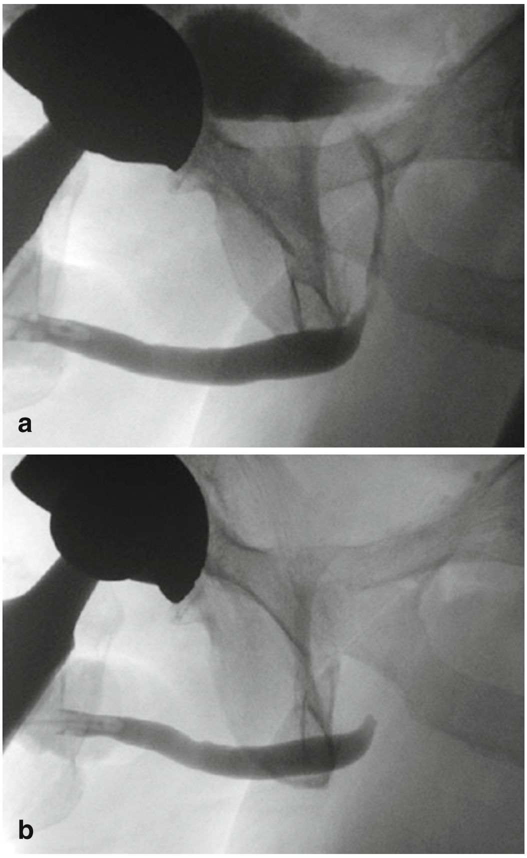

Fig. 29.2 (**a**) Retrograde urethrogram immediately following catheter removal in a patient who had failed multiple endoscopic procedures for a bulbomembranous stricture following proton beam therapy for prostate cancer. (**b**) Retrograde urethrogram 3 months after suprapubic tube placement demonstrating progression of the stricture to complete obliteration

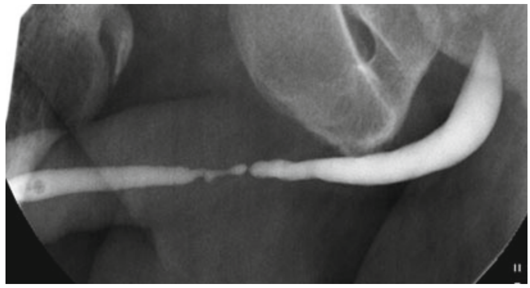

Fig. 29.3 Retrograde urethrogram 6 weeks after removal of a 16 Fr catheter that had been repeatedly exchanged over a 2-year period following blunt urethral trauma. Suprapubic tube urinary diversion was performed in conjunction with Foley catheter removal. The patient was ultimately successfully treated with an augmented anastomotic urethroplasty involving focal excision, dorsal reanastomosis, and ventral buccal mucosa graft onlay

of potassium [24]. Apart from mechanical irritation and inflammation, increased mural pressure from indwelling urethral catheters may produce relative tissue ischemia and development of a wound milieu that upregulates contraction and may lead to increased stricture complexity [6, 25].

Repeat Imaging and Operative Planning

After a minimum of 6 weeks of urethral rest, patients return for repeat urethrography and SPT exchange (if present). Urethral rest allows the remodeling phase of wound healing to progress, resulting in scar contraction visualized as a dramatic decrease in the caliber of the diseased urethra seen on urethral imaging, thus facilitating selection of the appropriate urethroplasty technique. Urethral reconstruction is subsequently performed approximately 1 month later, thus completing the 3-month total urethral rest period.

We are often surprised by the frequency and rapidity with which recently instrumented strictures become obliterative during a brief period of rest and the high number requiring subsequent reconstruction with excisional techniques [17]. Even patients presenting with a long-standing indwelling catheter frequently manifest significant collapse of the urethral lumen soon after catheter removal (Fig. 29.3), suggesting that tissue remodeling (luminal contracture) occurs early after initiation of urethral rest and that imaging findings obtained after 6–8 weeks of urethral rest correlate closely to the location and severity of strictures identified intraoperatively thereafter [17].

Positive Impact of Urethral Rest

We recently reported the beneficial effects of urethral rest prior to anterior urethral reconstruction [17]. Among 128 men who underwent anterior urethral reconstruction (excluding meatoplasty) at our center during a 3-year period, a surprisingly high number (28/128, 21.9 %) received urologic instrumentation elsewhere just prior to referral, thus warranting a period of urethral rest prior to reconstructive surgery. Fifteen urethral rest patients (54 %) received SPT placement, and the other 13 voided adequately without requiring urgent instrumentation while waiting for urethral reconstruction.

Urethral rest reliably promoted distinct radiographic identification of stricture extent and location by the second month (Fig. 29.4). Severely fibrotic stricture segments were identified in most cases, prompting focal or complete stricture excision in 21/28 patients (75 %), with graft or flap onlay used in the remainder (7/28, 25 %). This experience was nearly identical to the 100 urethroplasties performed during the same period on patients without recent instrumentation (82 % focal or complete excision, 18 % substitution without excision). Stricture recurrence was seen in 14 % of urethral rest patients, a value similar to the 10 % recurrence rate found among urethroplasty patients who did not require urethral rest. Thus, a 3-month period of urethral rest effectively allowed tissue recovery which promoted appropriate procedure selection and successful reconstruction via a standardized surgical approach [17].

Success of EPA urethroplasty, widely considered to be the gold standard, is based primarily on identification and complete removal of fibrosis, thus allowing preservation and reapproximation of surrounding healthy tissue [26–28]. Obliterative strictures too long for EPA are better served by an augmented anastomotic approach incorporating focal excision with graft application extending well into normal tissue at each end of the repair [29]. These data illustrate the value of an initial period of tissue recovery of several months duration to allow the natural history of the stricture to manifest itself prior to undertaking surgery.

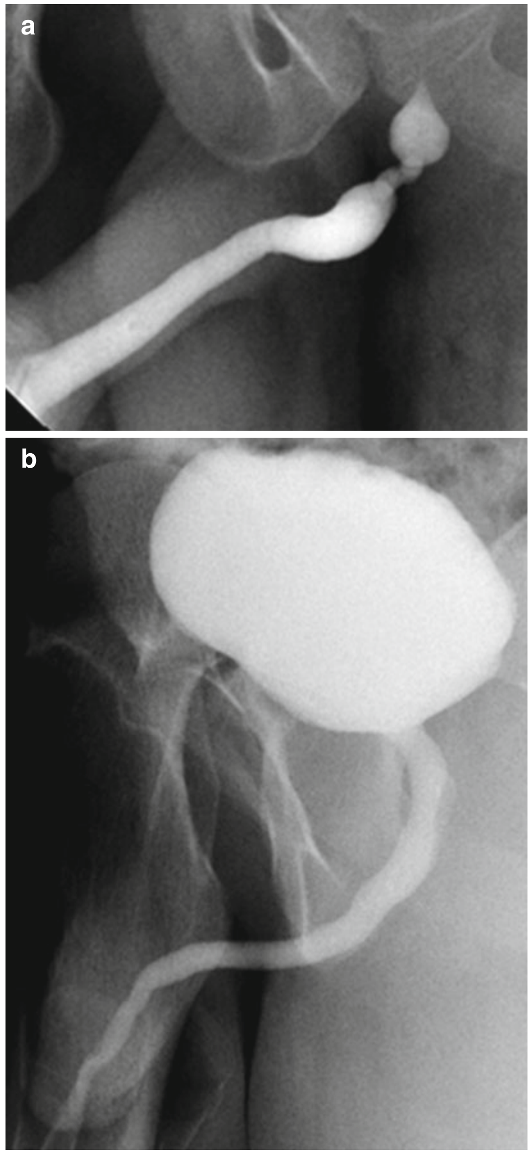

Fig. 29.4 (**a**) Retrograde urethrogram following 6 weeks of urethral rest demonstrating a 2 cm stricture nearing obliteration. The patient presented 6 weeks previously with an indwelling catheter immediately following urethral dilation for acute urinary retention. (**b**) Voiding cystourethrogram from the same patient 3 weeks after anastomotic urethroplasty reveals a widely patent urethral lumen

Future Considerations

Although the rationale for a 3-month rest period does appear to be sound, the optimal duration of preoperative urethral rest remains unknown. Prospective histopathologic correlation with radiographic changes would likely provide further insight into the biological foundations of these observations. Although our experience suggests that SPT diversion elicits a rapid collapse of strictures which expedites their identification and repair, the degree and time with which tissue changes occur is unknown compared with simple catheter removal and cessation of self-catheterization alone.

Surgical Pearls and Pitfalls

Key Intraoperative Surgical Points

- Suprapubic tubes are best placed via an endoscopically guided, percutaneous approach.
- If a nearly obliterative stricture prohibits passage of a flexible cystoscope, the bladder can be filled retrogradely via a catheter tip syringe applied to the meatus or via a 6 Fr ureteral catheter passed across the stricture or via suprapubic placement of an 18 gauge spinal needle.

Preferred Surgical Instruments for Urethral Rest

- 18 gauge spinal needle
- Suprafoley® (Rüsch, Duluth, GA) suprapubic introducer trocar
- 16 F peel-away sheath, #AC851
- 16 F Foley catheter

Editorial Comment

The concept of avoiding manipulation of the urethra for 3 months and allowing the urethral scar to mature prior to definitive urethroplasty has been a common practice of most urethral surgeons and makes good intuitive sense. I like the coined phrase of "urethral rest" – as it well describes the concept and is sexy in its simplicity. My practice differs somewhat from Morey and Hudak, in that it is very difficult for me to convince patients to have a suprapubic tube placed who are able to void with a reasonable post-void residual, not in urinary retention or near retention. Surprisingly, it appears that 54 % of all their patients had obliterative strictures, necessitating urinary diversion. I am not sure if they just see more strictures that are of a greater severity mechanism and more traumatic etiology, but I would estimate that only 10 % of my stricture patients are in retention. Morey's high percentage of obliterative strictures helps explain for me why this group performs such a large percentage of EPA urethroplasty and why they have pushed the envelope of extended limits for EPA to the extreme of 4 cm or more.

I also have a similar referral pattern to the Dallas group, in that many of my patients are sent to me by community urologists, directly after they have dilated or cut their urethral strictures. However, instead of urethral rest and routine placement of a SP tube, my standard practice is to allow the patients to continue to void and to follow up at 3-month intervals until they are symptomatic. My trigger for performing invasive testing (urethrography and cystoscopy) is a flow rate <15 ml/s and a AUA SS >10. If they end up in retention or near retention, I have them call me and we emergently place a SP in the office or emergency room. I do not feel that a 16 Fr Foley is really necessary and more often than not overly morbid – especially for a young man. I prefer instead a 12 Fr Cope loop placed percutaneously – it is much less painful for the patient to place and is less annoying and better tolerated than a large Foley catheter. For patients who refuse a SP tube but are willing to do intermittent catheterization, while not ideal, I am okay with the patient doing self-intermittent catheterization with a 10 or 12 Fr catheter until the time of surgery. Overall, the concept of urethral rest is intuitive and makes good common sense and is useful in facilitating strictured urethral segments to better declare themselves – and thus be more adequately and completely reconstructed.

—Steven B. Brandes

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30 The Use of Patient-Reported Outcome Measures in Men with Urethral Stricture Disease

Lee C. Zhao and Christopher M. Gonzalez

Summary

The use of patient-reported outcome measures represents a noninvasive, cost-effective method to assess voiding symptoms, sexual function, quality of life, and treatment outcomes in men with urethral stricture disease. The American Urological Association Symptom Index (AUASI) was originally designed to assess lower urinary tract symptoms (LUTS) in men with BPH. The use of this patient-reported questionnaire has also proven useful as a noninvasive method to assess men with LUTS related to urethral stricture. However, the inability of this instrument to capture the full range of voiding symptoms in men with urethral stricture limits its usefulness.

Erectile dysfunction (ED) may occur after anterior urethral reconstruction in up to one-third of patients and may be even more common in men with pelvic fracture-related urethral injury. Likewise ejaculatory dysfunction (EjD) has been reported in up to one-fourth of men presenting for the treatment of a urethral stricture. The International Index of Erectile Function (IIEF) is a validated, patient-reported questionnaire that has proven useful as a noninvasive method to assess perioperative sexual function in men with urethral stricture. Similar to the IIEF, the ejaculatory domain of the Male Sexual Health Questionnaire (MSHQ) has also proven useful in the assessment of perioperative ejaculatory function in men undergoing treatment for urethral stricture.

The reported utility of existing patient-reported questionnaires represents a noninvasive method to assess men with urethral stricture; however, an instrument specifically designed and validated to assess perioperative LUTS, sexual function, and quality of life outcomes in men with urethral stricture has yet to be constructed.

Introduction

While urethral reconstruction provides benefit in bladder function and relieves outlet obstruction, the successful treatment of urethral stricture disease should also lead to improvements in voiding symptoms, quality of life, and preservation of sexual function. Consequently, an accurate measurement of treatment outcomes is important to assess the success of interventions, particularly from the patient's perspective [1]. Several validated questionnaires have been utilized to evaluate the lower urinary tract symptoms (LUTS), sexual function, and quality of life in men with urethral stricture. In this chapter we describe the evolution of patient-reported outcome measures

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in men undergoing urethral reconstruction over the past 20 years and discuss the advantages and disadvantages of currently used noninvasive instruments.

Voiding Dysfunction

The American Urological Association Symptom Index (AUASI), also known as the International Prostate Symptom Score, is an instrument designed to assess LUTS related to benign prostatic hyperplasia [2]. Although it has not been validated for use in patients with urethral stricture, its wide availability, ease of use, and focus on voiding symptoms have led to its use to access outcomes of interventions for urethral stricture. From 2000 to 2008, 47 % of publications on urethroplasty used the AUASI to report outcomes [3]. Morey et al. were the first to examine the role of the AUASI in the assessment of urethroplasty outcomes [4]. Some 50 men between the ages of 16 and 73 with urethral stricture requiring operative intervention were evaluated. Excluding 12 men with posterior urethral disruption who had preoperative suprapubic cystostomy drainage, the mean preoperative AUASI score was 26.9. After urethral reconstruction, all men had postoperative evaluation that included the AUASI administered between 3 and 111 months postoperatively (average 38 months). Patients were also evaluated for narrowing by urethrography and/or cystoscopy. The 41 patients with no narrowing on retrograde urethrogram had a mean postoperative symptom score of 5.1. The nine patients who had narrowing on urethrography and/or cystoscopy had a mean score of 22.5. After these patients underwent repeat urethroplasty, the mean score decreased to 3.4. A significant correlation was found between increasing AUASI and low urinary flow rates. The authors concluded the AUASI was a useful tool for the assessment of voiding outcomes following urethroplasty.

Other studies have confirmed that high AUASI correlates with poor urinary flow in men with urethral stenosis or stricture. Adyos et al. combined AUASI, uroflowmetry, and RUG in the assessment of 33 men approximately 6 months after reconstruction for posterior urethral disruption [5]. Recurrent stenosis was found in six men on RUG. These men had a mean AUA score of 30 and maximal flow rate of 6 ml/s. Patients with no evidence of recurrence radiographically had a mean AUA score of 6 and maximal flow of 25.7 ml/s. While the sample size was small, these findings support the ability of the AUASI to identify recurrence of urethral stenosis in younger men (mean age 31), regardless of anatomical location.

Heyns and Marais attempted to define thresholds for AUASI and urinary flow rate that are indicative of the presence of urethral stricture from a sample of 49 patients, who were considered to have a stricture if an 18 Fr catheter could not be passed through the urethra [6]. Mean pretreatment AUASI was 12 and maximum flow 9.45 ml/s, with significant negative correlation between urethral diameter and symptom index and between symptom index and maximum flow. A significant positive correlation between urethral diameter and maximum flow was noted. The sensitivity and specificity of various cutoffs for AUASI and urine flow rate were calculated. The authors summarized that an AUASI greater than 10 or maximum flow less than 15 ml/s was the optimal cutoff point. This criteria provided 93 % sensitivity, 68 % specificity, and 82 % overall accuracy. The findings of this study support the potential role of patient-reported outcome measures in lieu of, or as an adjunctive test with, cystoscopy to initially diagnose or detect recurrence of disease following urethroplasty.

While the AUASI is widely used in men with BPH related LUTS, it is not designed for men with urethral stricture and may be inadequate to completely capture the array of specific voiding complaints relating to urethral stricture. In a study of 214 patients who underwent urethroplasty, Nuss et al. found that 21 % of patients presented with voiding symptoms not included in the AUASI [7]. These voiding symptoms included most commonly spraying of the urinary stream (13 %) and dysuria (10 %). Also of interest in this same cohort was the correlation of voiding symptoms with stricture etiology. Patients with lichen sclerosis were more likely to have obstructive symptoms (76 % vs. 55 %, $p<0.05$) but were less likely to have urinary retention (0 % vs. 16 %, $p<0.05$), whereas patients with urethral stricture due to trauma were more likely to present with symptoms not included in the AUASI (48 % vs. 33 %, $p<0.05$). This study, despite its retrospective design and potential recall bias, highlights the need for a validated questionnaire designed specifically for men with urethral stricture, as the AUASI would have missed over one-fifth of the presenting voiding symptoms in this cohort.

Erectile Dysfunction

The topic of erectile function following anterior urethroplasty was first evaluated by Coursey et al. in 2001 [8]. In this multicenter study, 200 men who underwent anterior urethroplasty were sent questionnaires that evaluated erectile angle, length, and satisfaction with erection. For comparison, the same questionnaire was sent to 48 men who underwent circumcision. Of the total 248 men who were sent questionnaires, 190 responded and 16 were excluded from analysis because they were not sexually active preoperatively. Among the 152 men that underwent urethroplasty, 31 % reported worsened satisfaction with erection as compared to preoperative function. A similar rate of sexual dysfunction was noted in the control group of patients, leading to the conclusion that urethral reconstructive surgery offered no more risk of erectile dysfunction than circumcision. Erickson et al. subsequently reported retrospective data utilizing the Brief Male Sexual Function Inventory [9] on 52 men following anterior urethroplasty. The preoperative data was collected on a recall basis, and ED was identified in 25 % of these men. Men who reported their outcome more than 1 year after surgery were less likely to have ED, perhaps indicating that recovery of erectile function occurs within 12 months [10]. The rate of 25 % for ED in this study was similar to the 30 % rate identified by Coursey et al.; however, recall bias and retrospective data collection were significant limitations of both studies despite the use of a validated instrument in the later report.

Prospective analysis of erectile function in men with urethral stricture undergoing urethral reconstruction has been studied mostly with the use of the International Index of Erectile Function (IIEF). The IIEF is a 15-question patient response survey first developed by Rosen et al. in 1997 [11]. The questionnaire covers the five domains of male sexual function including erectile function, orgasmic function, sexual desire, intercourse satisfaction, and overall satisfaction. The instrument can be used to evaluate individual domains or as an overall score. The erectile function (EF) domain has proven most useful in men with urethral stricture. The IIEF has been validated in multiple languages and has proven to have a high degree of test reliability, construct validity, and treatment responsiveness. Since treatment of urethral stricture is most likely to affect the domain of EF, an abridged, 5-question form of the IIEF, the Sexual Health Inventory for Men (SHIM), can also be used to assess EF in these men.

Anger et al. were the first to publish a prospective multi-institutional study using the IIEF in men with anterior urethral stricture [12]. At a mean follow-up time of 6.2 months, postoperative EF scores were not significantly different than preoperative values in 25 men undergoing urethroplasty ranging from primary anastomosis, augmented anastomotic repair, and dorsal onlay. There were no significant changes in any of the five IIEF domains after surgery; however, the follow-up was relatively limited in this cohort of men. The authors concluded that anterior urethroplasty in experienced hands should not impact upon erectile function postoperatively. Subsequent to this study Erickson et al. prospectively evaluated 52 men undergoing anterior urethroplasty for urethral stricture. The EF domain of the IIEF survey was used. Patients answered the survey preoperatively and at each postoperative visit, which were scheduled every 3–6 months within the first year, and annually thereafter. Preoperative ED, as defined by an IIEF less than a score of 25, was found in 44 % of men. The average IIEF score decreased significantly from 18.7 to 12.6 after surgery, but the overall rate of men with postoperative ED was only 38 % of the cohort. Of the 38 % of men that reported ED postoperatively, recovery occurred in 90 % of this subgroup over a mean time of 190 days [13]. The rate of ED was not different between men undergoing bulbar urethroplasty (40 %) as compared to men undergoing penile repairs (35 %). Of the men who underwent bulbar urethroplasty, there was a higher rate of ED for excision and primary anastomosis as compared to augmented anastomotic repairs (AAR) (50 % vs. 26 %). The relevance of these findings is not clear since both the EPA and AAR subgroups underwent complete division of the urethra. Although the patient-reported outcomes utilizing the IIEF have provided an instrument to assess key outcome parameters in this cohort of men with urethral stricture, the mechanism for concurrent ED and anterior urethral stricture both before and after urethroplasty is not clear. Nonetheless a significant proportion of men report some form of perioperative ED prior to or following treatment for anterior urethral stricture. These data suggest that patient counseling and education regarding sexual function outcomes is highly recommended.

The IIEF has also been used to evaluate EF in patients with urethral stenosis secondary to posterior urethral injury. Erectile dysfunction has been reported in 30–60 % of patients with pelvic fracture-related urethral injury [14, 15]. Anger et al. used the IIEF to assess ED in men with pelvic fracture-related urethral injury. A postoperative IIEF was completed in 26 men who had pelvic fracture-related urethral injury and underwent posterior urethroplasty. ED was identified in 14 of 26 men (54 %) at a mean follow-up of 4.4 years after surgery [16]. Unfortunately, there was no data on the erectile function preoperatively, and thus, no conclusions could be made regarding whether the ED was due to pelvic fracture or to the subsequent posterior urethroplasty. More prospective data are needed to assess the role of the IIEF in men with pelvic fracture-related urethral injury.

Ejaculatory Dysfunction

Besides LUTS and ED, men with urethral stricture may have concomitant ejaculatory dysfunction (EjD) [10, 17]. Normal ejaculation requires three coordinated steps: emission of the ejaculate into the urethra, bladder neck contraction to prevent retrograde ejaculation, and expulsion of the semen from the urethra by the somatically coordinated contractions of the bulbocavernosus and ischiocavernosus muscles [18]. Although the specific etiology is unknown, urethral stricture most likely affects ejaculatory function (EjF) by narrowing urethral lumen capacity for semen transit or potential scarring and dysfunction of the bulbocavernosus muscle. Furthermore, dissection of the bulbocavernosus muscle during urethroplasty may also contribute to EjD, especially in men with no prior difficulty of ejaculation. The first study that reported on postoperative EjD following urethroplasty involved 17 men undergoing pedicled island scrotal flaps. In three men, the authors were unable to re-approximate the bulbocavernosus muscle over the urethral repair, which led to pooling of the semen within an outpouching of the reconstructed urethra. The affected men noted post-orgasm “dribbling” of semen from the urethra, and it was presumed that this was from the loss of the bulbocavernosus contraction. Despite its novelty this study was limited by the small number of patients and the lack of a validated instrument to reliably quantify the level of EjD [19].

The first use of validated patient-reported outcome measures to assess EjF in men undergoing urethroplasty for urethral stricture was a retrospective study by Erickson et al. in 2007. This assessment was conducted on patients following anterior urethroplasty and utilized three EjF questions from the Brief Male Sexual Function

Inventory [10]. Postoperative data was obtained at least 4 months after surgery and compared with preoperative data that had been obtained based on recall. The authors found an overall increase in postoperative ejaculatory scores (5.3–6.2, $p=0.04$) following urethroplasty, indicating improvement in EjF. These findings should be interpreted with caution, however, due to known problems with sexual function recall [20]. Similar to this study a retrospective study evaluating the effects of posterior urethral reconstruction on EjF found that all 32 men involved in this study were reported to have antegrade ejaculation postoperatively [21] at a mean follow-up of 4.9 years. A non-validated questionnaire was used to evaluate the presence of antegrade ejaculation, change in ejaculatory volume, and fertility. Of these men, five (16 %) had decreased volume and one (3 %) experienced delayed ejaculation. However, similar to the Erickson study from 2007, patient-reported outcomes were obtained based on recall and thus susceptible to bias.

To avoid the recall bias inherent in the prior two studies, prospective evaluation of EjF was first reported using the validated Male Sexual Health Questionnaire (MSHQ) in men presenting for anterior urethroplasty [17]. The MSHQ is a self-administered questionnaire related to overall sexual function and patient satisfaction developed by Rosen and colleagues in 2004 [22]. The questionnaire contains a seven-item ejaculatory domain that asks questions related to ejaculatory frequency, latency of ejaculation, volume of the ejaculate, force of ejaculation, ejaculatory pain, ejaculatory pleasure, and the presence of dry ejaculation. This questionnaire has been proven to have a high degree of test reliability, construct validity, and treatment responsiveness. Similar in some respects to the AUASI for voiding symptoms, not all ejaculatory dysfunction is captured with this questionnaire. In the study by Erickson et al., 11/43 (25 %) men with an anterior urethral stricture reported poor preoperative EjF, six (20 %) of whom had a bulbar urethral stricture, and five (38 %) a penile stricture. Overall the most commonly reported problems in this cohort were poor ejaculatory volume (100 %), vigor (91 %), and pain with ejaculation (100 %). Of the 43 men in the study, there was no change in the overall ejaculatory score postoperatively (25.54 vs. 26.94, $p=0.17$) at a mean follow-up time of 8.1 ± 6.0 months. Few men complained of postoperative dysfunction at a median follow-up of 6.8 months, and a significant percentage (19 %) of men reported improvement in their EjF following urethroplasty. The results were most striking for men that had decreased preoperative EjF, with nearly 36 % of these men reporting improved ejaculation after urethroplasty, which was especially evident in the bulbar urethral stricture group. Of note, there were no individuals in this cohort that started with normal preoperative EjF who were later found to have a significant decrease in function. The authors in this manuscript reported that the bulbocavernosus muscle was routinely split during bulbar dissection and that this practice did not appear to impact upon postoperative EjF. Previous reports have shown the importance of the bulbocavernosus muscle in the normal ejaculatory process and that inhibition or damage of the bulbocavernosus muscle has resulted in decreased ejaculatory function [23, 24]. However, it is important to note that these data were not in men undergoing urethroplasty. Nonetheless, the MSHQ is a noninvasive, low-cost method to evaluate the benefits of minimally invasive urethroplasty techniques that aim to decrease postoperative complications and sexual dysfunction [25, 26]. Further study focused on the physiologic relationship of ejaculatory function and urethral stricture is necessary to corroborate the findings of these patient-reported outcome measures.

Quality of Life

Only a few studies have investigated the effect of urethral stricture and its treatment on quality of life. Measurement of quality of life is made difficult by two factors. First, humans are very adaptable and habituate to chronic problems. Second, quality of life is dependent upon the instrument used to measure it. Patient-reported outcome measures may be generic or disease specific. Generic instruments such as the SF-12 may contain items that are irrelevant of the disease at hand and show no change after effective interventions [27]. Thus, disease-specific quality of life measures may be more appropriate, but disease-specific quality of life measures should be well designed to address the specific aspects of outcome that are important for the patient population. These questionnaires are generated through interviews with patients and tested for validity in new populations of patients. Thus far, no instrument specific to urethral stricture has been used to evaluate quality of life.

The AUASI quality of life (QOL) score, although not designed for urethral stricture, has been used to evaluate the treatment of urethral stricture following laser urethrotomy [28, 29]. Kamp et al. found a change in QOL score from 3.5 to 2.2 in 32 patients undergoing holmium laser urethrotomy. In a study by Wang et al., the authors showed a decrease in average AUASI QOL score from 4.8 points to 2.5 points after thulium laser urethrotomy in 21 patients. Another study by Barbagli et al. found that QOL, when measured by a non-validated questionnaire, was preserved in 173 patients who underwent perineal urethrostomy for extensive anterior urethral stricture disease [30]. Since the psychometric properties of the questionnaire were not tested, this instrument may be inadequate to show the differences in QOL from this population. More study is required to determine how quality of life is affected by interventions for urethral stricture.

Further Developments

The spectrum of voiding symptoms, sexual function, and QOL associated with urethral stricture and its repair appear to be inadequately measured by a single available questionnaire. Most of the available instruments (AUASI, IIEF, MSHQ) utilized thus far were not validated specifically for men with urethral stricture. Investigators from the UK [31] have attempted to remedy this need with a patient-reported outcome measure instrument designed specifically for urethral stricture surgery (PROM-USS). The PROM-USS is composed of 15 questions on LUTS and quality of life. The PROM-USS was developed via focus groups with clinicians and patients alike. Of note, questions relating to sexual function were not included in the PROM-USS due to low, patient-reported baseline incidence. A total of 85 men were initially enrolled in this prospective analysis, and all were asked to complete a preoperative questionnaire. After anterior urethroplasty, 49 men completed a postoperative questionnaire. The content validity of the PROM-USS was supported by expert opinion, patient interviews, and literature review. The PROM-USS demonstrated good responsiveness to treatment, with improvement in the LUTS and quality of life domains after urethroplasty. Furthermore in comparison to the AUASI, the PROM-USS incorporates additional voiding symptoms that were identified as important to patients and confirmed by expert input such as urinary hesitancy and post-void dribbling. Although these data are preliminary, the PROM-USS represents an important initiative towards standardized evaluation of urethral stricture surgery. To increase its applicability, investigators have also validated the PROM-USS in different languages (Italian) [32]. One potential deficiency of the PROM-USS is the absence of evaluation of erectile and ejaculatory function. While evaluation of sexual function was not included in the PROM-USS due to low baseline incidence, these domains may be important for investigation of complications. Further patient focus group assessment from different regions of the world is required to determine the importance of including sexual function items within stricture-specific instruments like the PROM-USS.

Conclusions

The diagnosis and treatment of urethral stricture impacts voiding symptoms, sexual function, and quality of life. Standardized, validated patient-reported outcome measures are noninvasive, low-cost methods, which can prospectively quantify these effects. Although several patient-reported instruments have been used, an instrument designed specifically for outcomes related to urethral stricture treatment is needed.

Editorial Comment

As urethral surgery is a quality of life surgery, it makes intuitive sense to use validated questionnaires to evaluate the quality of life of patients before and after urethroplasty. Without asking the questions, the true scope of the potential side effects or problems of urethral reconstruction is not known. The antiquated stance that "no news is good news" should be dropped from the urethral surgeon lexicon. Using validated questionnaires on a broad scale and covering multiple aspects of quality of life is a major advance for the urethroplasty literature – and will help lift the "science" of our literature away from the low Oxford level of evidence of mostly retrospective case series, typically based on single surgeon and, at times, anecdotal experience.

It is a "no-brainer" to use patient-reported outcome measure questionnaires as they are readily available, noninvasive, and inexpensive methods for evaluating voiding function, sexual function, overall quality of life, and treatment outcomes in men with urethral stricture. While very useful, the current instruments are lacking, as they are not specifically designed nor validated in men with urethral stricture. We anxiously await such a validated and condition-specific questionnaire.

—Steven B. Brandes

Appendix A: International Index of Erectile Function (IIEF)

Question	Response options
Q1. How often were you able to get an erection during sexual activity?	0 = No sexual activity
Q2. When you had erections with sexual stimulation, how often were your erections hard enough for penetration?	1 = Almost never/never 2 = A few times (much less than half the time) 3 = Sometimes (about half the time) 4 = Most times (much more than half the time) 5 = Almost always/always
Q3. When you attempted sexual intercourse, how often were you able to penetrate (enter) your partner?	0 = Did not attempt intercourse
Q4. During sexual intercourse, how often were you able to maintain your erection after you had penetrated (entered) your partner?	I = Almost never/never 2 = A few times (much less than half the time) 3 = Sometimes (about half the time) 4 = Most times (much more than half the time) 5 = Almost always/always
Q5. During sexual intercourse, how difficult was it to maintain your erection to completion of intercourse?	0 = Did not attempt intercourse 1 = Extremely difficult 2 = Very difficult 3 = Difficult 4 = Slightly difficult 5 = Not difficult
Q6. How many times have you attempted sexual intercourse?	0 = No attempts 1 = One to two attempts 2 = Three to four attempts 3 = Five to six attempts 4 = Seven to ten attempts 5 = Eleven + attempts
Q7. When you attempted sexual intercourse, how often was it satisfactory for you?	0 = Did not attempt intercourse 1 = Almost never/never 2 = A few times (much less than half the time) 3 = Sometimes (about half the time) 4 = Most times (much more than half the time) 5 = Almost always/always
Q8. How much have you enjoyed sexual intercourse?	0 = No intercourse 1 = No enjoyment 2 = Not very enjoyable 3 = Fairly enjoyable 4 = Highly enjoyable 5 = Very highly enjoyable
Q9. When you had sexual stimulation or intercourse, how often did you ejaculate?	0 = No sexual stimulation/intercourse
Q10. When you had sexual stimulation or intercourse, how often did you have tile feeling of orgasm or climax?	1 = Almost never/never 2 = A few times (much less than half the time) 3 = Sometimes (about half the time) 4 = Most times (much more than half the time) 5 = Almost always/always

Appendix A (continued)

Question	Response options
Q11. How often have you felt sexual desire?	1 = Almost never/never 2 = A few times (much less than half the time) 3 = Sometimes (about half the time) 4 = Most times (much more than half the time) 5 = Almost always/always
Q12. How would you rate your level of sexual desire?	1 = Very low/none at all 2 = Low 3 = Moderate 4 = High 5 = Very high
Q13. How satisfied have you been with your overall sex life?	1 = Very dissatisfied
Q14. How satisfied have you been with your sexual relationship with your partner?	2 = Moderately dissatisfied 3 = About equally satisfied and dissatisfied 4 = Moderately satisfied 5 = Very satisfied
Q15. How do you rate your confidence that you could get and keep an erection?	1 = Very low 2 = Low 3 = Moderate 4 = High 5 = Very high

Note: All questions are preceded by the phrase “Over the past 4 weeks”

Appendix B: Male Sexual Health Questionnaire (MSHQ)

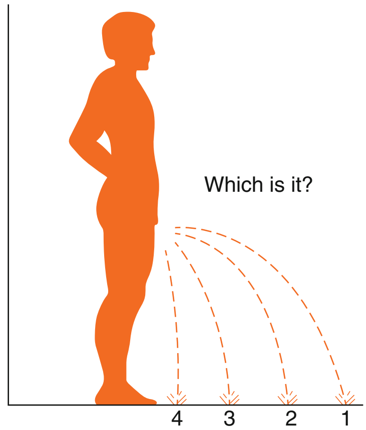
Ejaculation Scale

Question	Response options
1. In the last month, how often have you been able to ejaculate when having sexual activity?	5. All of the time 4. Most of the time 3. About half of the time 2. Less than half of the time 1. None of the time/could not ejaculate
2. In the last month, when having sexual activity, how often did you feel that you took too long to ejaculate or "cum"? (Check only one)	5. None of the time 4. Less than half of the time 3. About half of the time 2. Most of the time 1. All of the time 0. Could not ejaculate
3. In the last month, when having sexual activity, how often have you felt like you were ejaculating ("cumming"), but no fluid came out?	5. None of the time 4. Less than half of the time 3. About half of the time 2. Most of the time 1. All of the time 0. Could not ejaculate
4. In the last month, how would you rate the strength or force of your ejaculation?	5. As strong as it always was 4. A little less strong than it used to be 3. Somewhat less strong than it used to be 2. Much less strong than it used to be 1. Very much less strong than it used to be 0. Could not ejaculate
5. In the last month, how would you rate the amount or volume of semen when you ejaculate?	5. As much as it always was 4. A little less than it used to be 3. Somewhat less than it used to be 2. Much less than it used to be 1. Very much less than it used to be 0. Could not ejaculate
6. Compared to 1 month ago, would you say the physical pleasure you feel when you ejaculate has	5. Increased a lot 4. Increased moderately 3. Neither increased nor decreased 2. Decreased moderately 1. Decreased a lot 0. Could not ejaculate
7. In the last month, have you experienced any physical pain or discomfort when you ejaculated? Would you say you have	5. No pain at all 4. Slight amount of pain or discomfort 3. Moderate amount of pain or discomfort 2. Strong amount of pain or discomfort 1. Extreme amount of pain or discomfort 0. Could not ejaculate
EjD bother item	5. Not at all bothered
8. In the last month, if you have had any ejaculation difficulties or have been unable to ejaculate, have you been bothered by this?	4. A little bit bothered 3. Moderately bothered 2. Very bothered 1. Extremely bothered

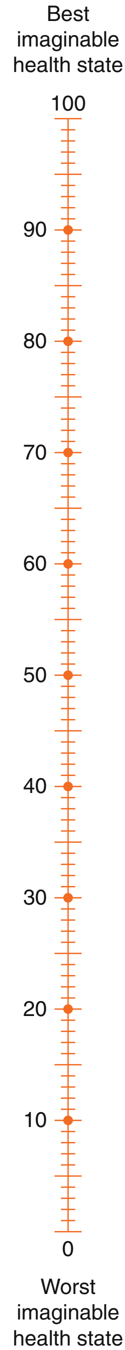
Appendix C: Patient-Reported Outcome Measure for Urethral Stricture Surgery (PROM-USS)

Question	Response
1. Is there a delay before you start to urinate?	○ Never ○ Occasionally ○ Sometimes ○ Most of the time ○ All of the time
2. Would you say that the strength of your urinary stream is…	○ Normal ○ Occasionally reduced ○ Sometimes reduced ○ Reduced most of the time ○ Reduced all of the time
3. Do you have to strain to continue urinating?	○ Never ○ Occasionally ○ Sometimes ○ Most of the time ○ All of the time
4. Do you stop and start more than once while you urinate?	○ Never ○ Occasionally ○ Sometimes ○ Most of the time ○ All of the time
5. How often do you feel your bladder has not emptied properly after you have urinated?	○ Never ○ Occasionally ○ Sometimes ○ Most of the time ○ All of the time
6. How often have you had a slight wetting of your pants a few minutes after you had finished urinating and had dressed yourself?	○ Never ○ Occasionally ○ Sometimes ○ Most of the time ○ All of the time
7. Overall, how much do your urinary symptoms interfere with your life?	○ Not at all ○ A little ○ Somewhat ○ A lot

(continued)

Question	Response
8. Please ring the number that corresponds with the strength of your urinary stream over the past month	
9. Are you satisfied with the outcome of your operation?	○ Yes, very satisfied ○ Yes, satisfied ○ No, unsatisfied ○ No, very unsatisfied
10. If you were unsatisfied or very unsatisfied is that because:	○ The urinary condition did not improve ○ The urinary condition improved but there was some other problem ○ The urinary condition did not improve and there was some other problem as well
By placing a tick in one box in each group below, please indicate which statements best describe your own health state today	
Mobility	○ I have no problems in walking about ○ I have some problems in walking about ○ I am confined to bed
Self-care	○ I have no problems with self-care ○ I have some problems washing or dressing myself ○ I am unable to wash or dress myself
Usual activities (e.g., work, study, housework, family, or leisure activities)	○ I have no problems with performing my usual activities ○ I have some problems with performing my usual activities ○ I am unable to perform my usual activities
Pain/discomfort	○ I have no pain or discomfort ○ I have moderate pain or discomfort ○ I have extreme pain or discomfort
Anxiety/depression	○ I am not anxious or depressed ○ I am moderately anxious or depressed ○ I am extremely anxious or depressed

Appendix C (continued)

Question	Response
To help people say how good or bad a health state is, we have drawn a scale (rather like a thermometer) on which the best state you can imagine is marked 100 and the worst state you can imagine is marked 0	
We would like you to indicate on this scale how good or bad your own health is today, in your opinion. Please do this by drawing a line from the box below to whichever point on the scale indicates how good or bad your health state is today	

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31 Reconstruction of Synchronous Urethral Strictures

Steven J. Hudak and Allen F. Morey

Summary

Aggressive reconstruction of synchronous urethral strictures may be safely and effectively performed with a single operative procedure using a systematic ascending reconstructive approach with individualized combinations of tissue transfer techniques. A 2-phase, distal-to-proximal ascending approach decreases patient time in the high lithotomy position and eliminates positioning-related complications. Outcomes appear to be comparable to those achieved via the repair of similarly complex solitary strictures and superior to those achieved by multistage techniques.

Introduction

The prevalence of multiple synchronous strictures among all men with strictures presenting to a tertiary reconstructive urology practice is estimated in the range of 6–11 % [1, 2]. Unfortunately, published operative series involving synchronous urethral stricture reconstruction are limited [2–6]. Management of these complex patients will uniformly require a combination of multiple urethral reconstruction techniques (excision and primary anastomosis [EPA], flap, graft, staged, etc.) Thus, the attempt to reconstruct a urethra with synchronous strictures should not begin unless the surgeon has a full repertoire of reconstructive techniques at his disposal. In this chapter, we summarize technical points which we feel are essential when reconstructing synchronous urethral strictures in a single stage.

Safety Concerns During Complex Urethroplasty

During the preoperative planning stage of complex urethroplasty, consideration should be paid to the expected duration of each phase of the repair with a specific focus on how long the patient will be in the high lithotomy position. When high lithotomy time is prolonged, debilitating lower extremity complications can result. In 2000, Anema et al. reported that high lithotomy-related ischemic injuries were related to the length of the urethral stricture and duration of reconstructive surgery [7]. Of 180 patients with urethroplasty, 10 % had mild lower extremity complications, while four required prolonged hospitalization and/or additional treatment for rhabdomyolysis, compartment syndrome, and/or neuropraxia. When duration in the high lithot-

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Fig. 31.1 Adjustable stirrups provide for easy repositioning between the high and low lithotomy positions as needed during oral graft harvest and synchronous urethroplasty

omy position was greater than 5 h, the risk of a severe complication was 5 %, and for a duration of longer than 6 h, that risk increased to 8 % with an overall injury rate of 27 % [7].

Since reporting this finding in 2000, we have adopted a repositioning protocol during the repair of synchronous strictures, as the risk factors of operative time and stricture length are unavoidable in these complex cases. In our protocol, the patient is placed into the high lithotomy position only when absolutely necessary. Thus, the case begins with the patient either supine or in a low lithotomy position using adjustable stirrups (Fig. 31.1). Oral mucosal graft harvest, penile skin flap mobilization, and meatal/pendulous/distal bulbar urethral reconstruction are performed as necessary with the patient in this low-risk position. The stirrups are then adjusted upward only when proximal bulbar/membranous urethral exposure is required. This "ascending" or "retrograde" approach is most practical using this repositioning protocol since it allows the patient to remain in the supine or low lithotomy position as long as possible, leaving only bulbar and/or posterior urethral repair to be performed while in the high lithotomy position.

Ischemic injury is thought to result from prolonged hypotension in the lateral compartment of the lower extremity [8]. Decreasing patient time in the high lithotomy position appears to eliminate the risk of ischemic leg complications at the expense of a negligible increase in total operative time. The absence of such complications with this approach reinforces the merit of repositioning to limit high lithotomy time during complex cases [2]. Additionally, we have noted no increase in wound infections or other adverse events as a result of stirrup repositioning [2].

Rationale for Retrograde Surgical Approach

In 2009, we reported our results with a large series of patients undergoing combined repair of synchronous urethral strictures in a single operation using an ascending/retrograde approach [2]. Among 30 patients who underwent synchronous urethroplasty, only three (10 %) encountered stricture recurrence requiring further procedures. Notably, despite an average procedure length of 4.5 h (range 2.5–6.4), no intraoperative or position-related lower extremity complications occurred, likely because none of the patients remained in the high lithotomy position for more than 5 h [2, 7]. We believe that our ascending/retrograde approach is responsible for the lack of lower extremity complications in our series compared to the 11 % lower

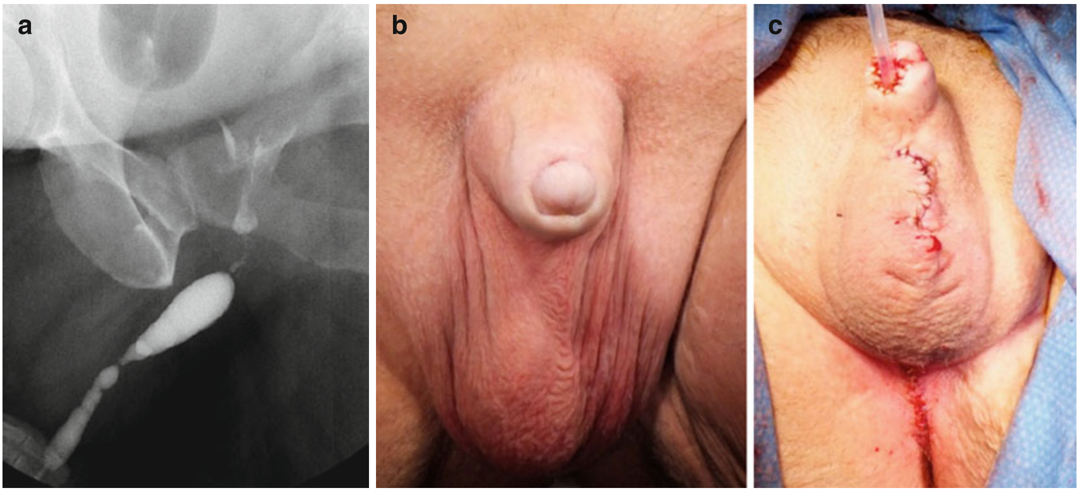

Fig. 31.2 (**a**) Multifocal urethral strictures in patient with lichen sclerosis of the foreskin and urethral meatus. (**b**) Using the ascending approach, synchronous extended meatotomy, ventral onlay buccal graft reconstruction of penoscrotal stricture, and anastomotic bulbomembranous urethroplasty were performed via three separate incisions (**c**)

extremity complication rate (2 of 18) reported by other authors utilizing a descending/antegrade approach [9].

We have found an ascending/retrograde surgical approach to be a more efficient strategy to systematically engage and repair each stenotic area as it is identified during passage of a flexible cystoscope, catheter, or bougie through the urethral meatus during reconstruction. Distal stricturotomy allows unimpeded access to the proximal urethra, where normal intervening segments and secondary, occasionally unanticipated, proximal strictures can be easily identified. Furthermore, retrograde passage of a bougie, catheter, or cystoscope during perineal dissection promotes identification of the urethra in the deep perineum, which is especially helpful in obese or reoperative patients in whom tissue planes are difficult to distinguish. We have not observed anastomotic disruption or other complications related to gentle instrumentation across freshly repaired distal strictures, regardless of which technique was used (flap, graft, or EPA). By using ventral onlay techniques preferentially for most bulbar strictures requiring grafting, we have subsequently been able to mobilize the entire bulbar dorsal urethral plate when necessary to bridge proximal or membranous anastomotic repairs in a tension-free manner.

Phase 1: Distal Urethroplasty

We frequently utilize an extended meatotomy (stage 1 Johanson procedure) technique for those patients with advanced fibrotic strictures involving the glans and fossa navicularis. These patients frequently present with findings consistent with lichen sclerosis and thus are not candidates for penile flap procedures, and/or they were elderly with more comorbidities and less concern for cosmesis (Fig. 31.2). Extended meatotomy is a rapid, straightforward, and effective maneuver that has been associated with excellent long-term efficacy and has been preferred for its simplicity by many patients [10]. For longer pendulous strictures not due to lichen sclerosis, fasciocutaneous penile skin flaps as described by McAninch [11] are the preferred modality distally. If necessary, the flap can be divided into two segments with each segment used for separate synchronous pendulous and/or fossa strictures. This is a testament to the versatility of this flap and its usefulness for stricture repair throughout the length of the urethra.

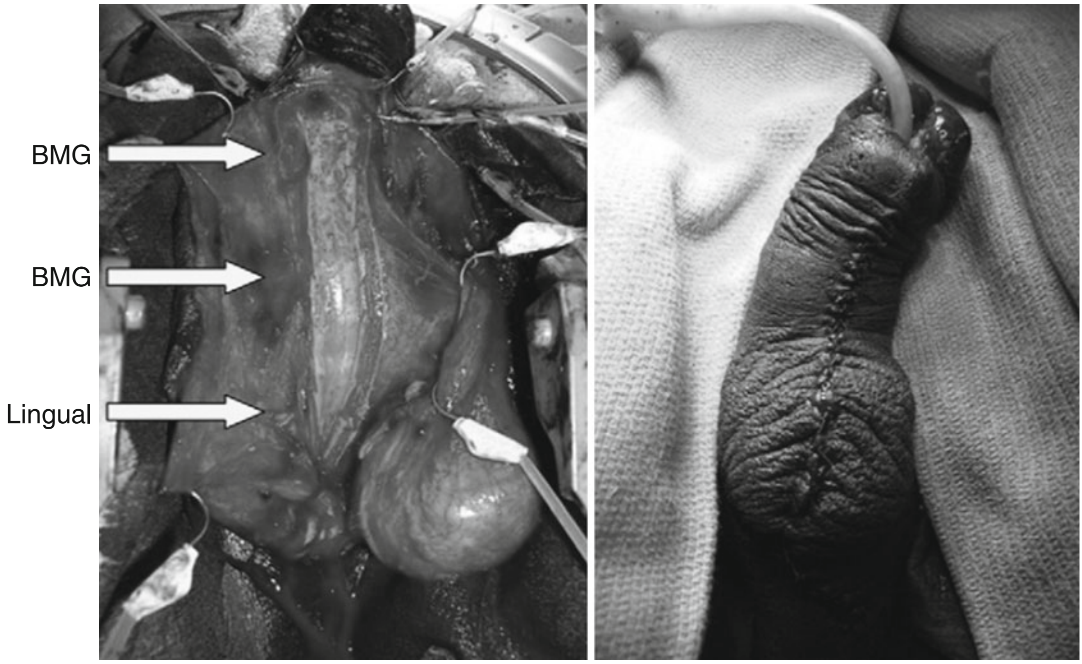

Fig. 31.3 Scrotal disassembly maneuver. (**a**) Scrotum is completely bisected in midline down to deep perineum, providing complete exposure of bulbar urethra for multiple ventral graft placement. (**b**) Closure after spongioplasty and extended meatotomy

Phase 2: Bulbar Urethroplasty

We prefer EPA whenever possible for bulbar strictures given its excellent long-term outcomes for bulbar and bulbomembranous strictures less than 3 cm [12, 13]. We have even occasionally employed dual EPA for men with short synchronous bulbar strictures [14], thus demonstrating that the dual blood supply of the urethra may be sufficient to supply a detached spongiosal segment between the anastomotic sites without significant ischemia despite dual urethral transection. Non-transecting anastomotic or augmented anastomotic techniques have emerged as a potentially less invasive alternative, albeit with short overall follow-up [15, 16]. For longer bulbar strictures we prefer ventral graft onlay with spongioplasty. A short penile skin graft "minipatch" is an excellent choice if only a short (<3 cm) graft is needed or for patients in whom oral graft harvest has already been performed [17]. For longer grafts (3 cm or greater), buccal mucosa is preferred, and simultaneous oral mucosa harvest utilizing a second surgical team is preferred due to its efficiency and safety. Patients with more extensive strictures will require two buccal mucosa grafts, one harvested from either side of the oral cavity. Lingual mucosal harvest is a useful addition to buccal tissue when faced with a large defect or reharvest [18].

An additional technique that has proved useful for complex bulbar strictures is complete scrotal disassembly (Fig. 31.3). Bisecting the scrotum along its entire midline length provides rapid, complete exposure of the entire bulbar urethra when necessary. This is especially useful in complex cases when time is of the essence and long strictures are being repaired with multiple grafts. Closure of the highly vascular scrotal septum is performed in multiple layers and can be expedited with a high degree of hemostasis using fibrin sealant. Our experience has been that patients tolerate this maneuver well and have no additional morbidity due to the scrotal disassembly while valuable high lithotomy time is saved.

Technical Considerations

Although alternative methods such as multi-stage graft or flap procedures have been advocated for complex strictures [3, 19, 20], it is our preference when possible to preserve normal intervening urethral segments longer than 2 cm and not include them in repair to avoid complications such as sacculations, urinary stasis, and dribbling. For normal intervening segments 2 cm or less, we incise and/or excise the entire segment and perform graft onlay as if it was a single long stricture (Fig. 31.4). To determine the urethral segments that may be preserved, we rely on the intraoperative passage of urethral bougies, accepting 24 Fr in the pendulous/fossa/meatal urethra and 28 Fr in the bulbar urethra as normal values. We have observed that most patients prefer 1-stage repair to 2-stage reconstruction when given the choice, and we believe that the decreased total catheter time of 1-stage repair is advantageous. Furthermore, we firmly believe that 1-stage repair yields less pain, recovery time, and loss of wages than 2-stage urethroplasty while maintaining excellent outcomes.

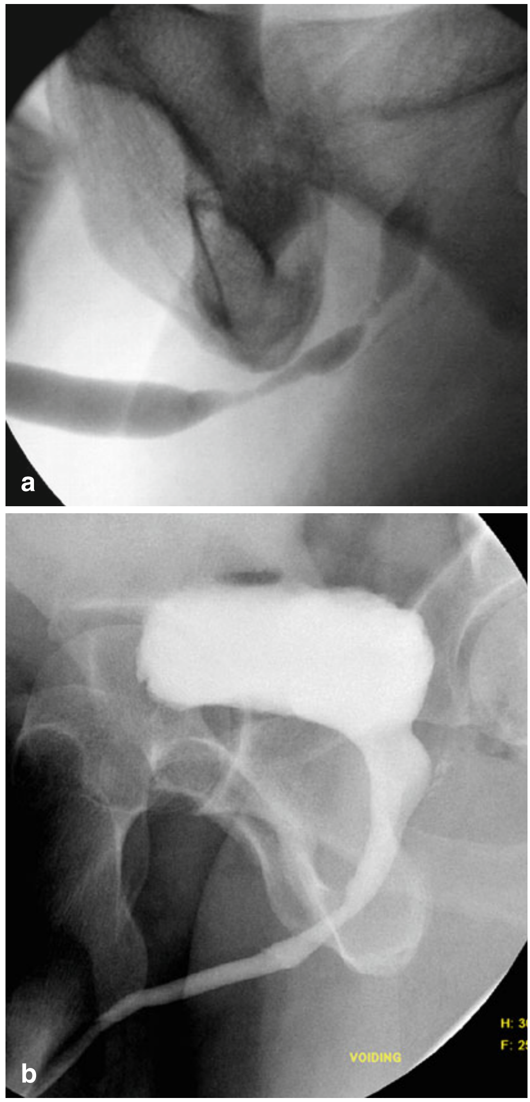

Fig. 31.4 (**a**) Two synchronous bulbar strictures separated by a short segment of normal caliber urethra. The distal obliteration was excised and the normal segment and proximal stricture were incised dorsally. A dorsally augmented anastomotic urethroplasty was completed using buccal mucosal graft. (**b**) Voiding cystourethrogram 4 weeks postoperatively

Surgical Pearls and Pitfalls

Key Intraoperative Surgical Points

- If the need for an oral mucosal graft is readily apparent from preoperative imaging, a synchronous two-team approach is used (team 1, oral graft harvest; team 2, urethral exposure and stricturotomy) to limit operative time.
- Full-thickness paired stay sutures placed 2 cm apart along the length of the stricturotomy minimize spongiosal bleeding and prevent mucosal injury when probing more proximally for synchronous strictures.
- Synchronous strictures less than 2 cm apart are incised together and treated as a single stricture. Strictures greater than 2 cm apart are treated separately, thus preserving the normal, intervening segment and reducing the graft requirement.
- Penile skin grafts are a reliable alternative to oral mucosal graft harvests when a short, unexpected synchronous stricture is encountered intraoperatively. It is easily harvested from the distal lateral penile shaft transversely, just proximal to the circumcision line.

Potential Intraoperative Surgical Problems

- Glans bleeding during distal urethroplasty can be managed with temporary penile tourniquet placement until the glans is closed.
- Obliterated urethral segments must be excised. If the resulting defect is long or located in the pendulous urethra, the urethral plate can be reconstituted with a dorsally placed buccal mucosal graft. Single-stage repair is completed with an overlapping penile skin flap or buccal mucosal graft onlay.

Preferred Surgical Instruments

- Lone Star™ (CooperSurgical, Trumbull, CT) self-retaining retractor, #3304G
  - 5 mm sharp hook, #3311-1G
  - 12 mm blunt hook, #3350-1G
  - 4 prong blunt rake, #3334
- DeBakey vascular forceps: generic dissection and atraumatic grasping of the corpus spongiosum
  - Toothed Gerald forceps: grasping the urethral epithelium during anastomosis
  - Supersharp Metzenbaum scissors
  - Curved iris scissors
  - Olive-tipped bougie à boule sounds: urethral calibration
  - Van buren sounds: placed via suprapubic tube tract during prostatic apex identification

Urethroplasty Suture

- Double-armed, 5-0 polydioxanone, RB-1 needle: anastomosis and flap/graft onlay
- Double-armed, 5-0 polydioxanone, RB-2 needle: posterior reconstruction proximal sutures
- 6-0 polydioxanone, TF needle: posterior reconstruction with tighter working space
- 4-0 polyglactin, RB-1 needle: urethral stay sutures and ligation of bulbar arteries
- 4-0 chromic, RB-1 needle: extended meatotomy epithelial maturation sutures

Editorial Comment

When it comes to synchronous stricture reconstruction, our standard of practice is very similar to that of Morey and Hudak. When possible, when there are synchronous urethral strictures, if the intervening urethral segment is of normal caliber and >2 cm in length, we typically do not include the intervening segment in the repair. Instead we repair each stricture separately.

In general, we prefer to perform the bulbar urethroplasty first and then put the legs down and perform the penile urethral reconstruction. We prefer adjustable Allen or Yellowfin stirrups here, to ease putting the legs down from lithotomy. We limit at all cost the time in lithotomy to <5 h, as the positioning morbidity incidence greatly increases at this time threshold.

As a general principle, we repair proximal bulbar strictures by EPA (if <3 cm in length, traumatic etiology, or near obliterative) or by ventral buccal graft urethroplasty. For mid- and distal bulbar strictures, we prefer a dorsal buccal graft reconstruction. For the concomitant distal (penile) stricture we typically use a circular (McAninch) or vertical (Orandi) fasciocutaneous flap. If the stricture involves the mid- or proximal penile urethra, we prefer to place the Orandi flap dorsally – thus avoiding the potential for sacculations or fistula formation. If the penile skin is not reliable or deficient (scarred), and/or the urethral plate is narrow, or the stricture etiology is LS, a staged approach is often the preferred method. If the urethral plate is of reasonable width (>5 mm), a ventral buccal graft reconstruction can also be a good choice.

—Steven B. Brandes

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Perineal Urethrostomy

32

Andrew C. Peterson

Summary

The perineal urethrostomy (PU) has often been indicated in patients as a temporizing procedure to bypass distal urethral obstruction and as the first step in different types of complex, staged urethroplasty procedures. In addition to these two indications, the PU was also used as a last resort surgical procedure in patients who had refractory distal obstruction. However, recently the PU has gained popularity as a definitive primary solution in multiple situations with complex obstructive urethral pathology offering a good solution to a bad situation with a straightforward surgical procedure resulting in good long-term outcomes and high patient satisfaction.

Introduction

The options for the treatment of urethral and bladder obstruction are diverse and range from endoscopic procedures to a multitude of complex surgical operations such as urethroplasty. While the success rate for different types of urethroplasty is typically very high, ranging from 80 to 90 % [1–3], several conditions still exist which require other options for diverting the urine such as recurrent stricture disease, lengthy strictures involving the entire urethra, strictures associated with skin disorders such as lichen sclerosus, and completely obliterated strictures that require complex staged repairs. Once considered a last and final option for the reconstructive urologist, the perineal urethrostomy (PU) is making a comeback in popularity for the management of the obstructed urethra. It is particularly useful in patients with long strictures who are unable or unwilling to undergo more complex repairs and can be quite helpful in those who may require extensive and involved reconstructive procedures with long convalescence [4].

The PU has excellent outcomes and often may offer a definitive resolution with minimal morbidity for the life of the patient. While in the past this technique was thought to be a last resort, it has proven to be very useful especially in those patients with severe urethral obstruction from various pathologic processes such as pan pendulous urethral strictures who are already accustomed to seated voiding, those who are deemed to be inappropriate surgical candidates, or those who do not have social issues precluding the creation of a PU. Recently many reports indicate high patient satisfaction when offered with this in lieu of complex, involved, and often morbid reconstructive urethral surgery such as staged urethroplasties and long flap-based repairs [5, 6]. The PU is also frequently used as the first step in

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any staged reconstruction or when total urethral reconstruction is not possible [5, 7]. So, in essence we have seemed to make a 180° turn with respect to this surgical procedure, once rejecting a definitive perineal urethrostomy as a last ditch maneuver and now embracing it as a definitive management option for patients with complex indications.

In addition to the definitive indications, the PU may also be utilized as a temporary procedure to allow access to the bladder and prostate. Many urologic surgeons advocate the PU to bypass strictures during transurethral surgery and also to facilitate maneuverability of the resectoscope in patients with a myriad of indications, such as an anteriorly based bladder tumor, an unusually long phallus, and the presence of a penile prosthesis, and in patients with urethral stricture. Other indications for the placement of the temporary PU include prolonged and refractory erections during transurethral procedures and resection of prostate glands in excess of 40 g [8]. In addition the PU is also thought to prevent distal urethral stenosis and stricture formation often seen after prolonged transurethral surgeries with large diameter resectoscopes [9]. The final indication for creation of a perineal urethrostomy is following penectomy performed for penile and urethral cancer or trauma.

There are multiple techniques for the creation of the PU described in the literature, and a comprehensive review of all of them is beyond the scope of this chapter. Herein, we review the most commonly employed procedures ranging from minimally invasive, punch techniques to the formal, first-stage, flap-based proximal urethroplasty. Each procedure has significant benefits and drawbacks. The punch-based procedures, while rapidly performed and minimally invasive, have significantly high restenosis rates. Conversely, the best patency rates are documented after the formal flap-based posterior urethroplasty, a more technically challenging procedure. Therefore, it is imperative for the surgeon to clearly define the goals of the PU (temporary vs permanent) and the desired outcomes (lower stenosis vs rapidly performed) when choosing the type of procedure for each patient.

Techniques

Percutaneous Endoscopically Guided Perineal Urethrostomy

This is a simple method of creating the PU with the aid of a resectoscope [8].

With the patient under general or regional anesthetic, the resectoscope is placed into the urethra through the meatus and advanced to the bulbar urethra. At the point where the urethra makes the cephalad turn to into the bladder, the scope is pressed against the perineum and palpated in the perineum. A small incision is then made on the area over the tip of the resectoscope, and the scope is advanced through the incision. A larger sheath is then placed over the smaller resectoscope sheath, and this is advanced antegrade into the distal urethra through the incision. The larger sheath is then slowly withdrawn while visually hugging the dorsal aspect of the urethra. It is then carefully redirected into the proximal urethra and then advanced into the bladder.

No suturing is required. At the end of the procedure, a wire is placed into the bladder under direct vision through the scope and a Foley catheter is placed over the wire through the perineal incision and the wound is allowed to mature.

This procedure has the distinct advantage of simplicity and rapid creation. However, significant re-stricture rates occur as the wounds tend to close rapidly after removal of the diverting catheter.

The End Urethral Stump Perineal Urethrostomy

With the patient under general or regional anesthesia, a vertical midline perineal incision is made. A Van Buren sound may be placed into the urethra either retrograde through a dilated urethral stricture or antegrade through a preplaced suprapubic vesicostomy, and pressure is placed from inside the urethra onto the perineal region. A vertical incision is made on the sound into the urethra, and it is then mobilized and transected proximal to the obstruction. The urethra is then spatulated and matured to the skin edges with absorbable suture. It is imperative that there exists enough good tissue distal to the membranous urethra in order to develop an adequate stump extending 1–2 cm past the perineal skin.

This technique has significant limitations in cases where there is not enough bulbar urethra to mobilize and reach the edge of the skin such as in panurethral stricture disease and other disorders such as lichen sclerosus.

The Grooved Sound Technique [9]

This procedure requires a grooved sound, three small Alice clamps, and absorbable suture.

The patient is placed in lithotomy position. The grooved sound is inserted through the meatus until the tip of it enters the prostatic urethra. The sound is then maneuvered so pressure is placed on the perineum where one can feel it through the skin. The perineum is then incised vertically until the groove of the sound is felt. The urethra is compressed between the thumb and index finger to prevent bleeding and to stabilize it. Once the urethra is opened, the edge of the urethral mucosa is grasped and matured to the skin with absorbable suture. This allows creation of a small puncture perineal urethrostomy with the option of maturing it completely to the skin with suture if desired.

The "7-Flap" Perineal Urethrostomy [10]

This technique involves creation of a laterally based perineal skin flap shaped as a seven. This allows creation of this flap that can be tailored exactly to the length necessary to reach the urethral stump, a problem in obese patients when performing a posterior-based flap urethroplasty.

With the patient in the lithotomy position, the 7-shaped skin flap is marked on the perineum, and the midline portion of the incision is developed first. The bulbar urethra is identified and mobilized, and the most distal portion of the bulbar urethra, just proximal to the obstruction, is transected. A urethrotomy is made on the right lateral side, and the previously marked lateral perineal skin flap of the seven is developed and advanced toward the urethra. The length of the lateral aspect of the perineal incision is tailored to meet the depth of the proximal bulbar urethrotomy. This is then matured to the urethra with absorbable sutures. A Foley catheter is then placed for 7 days (see Fig. 32.1a–d).

The Posterior Flap-Based Perineal Urethrostomy with Preservation of the Dorsal Plate

The inverted U-shaped flap perineal urethrostomy was originally introduced in the 1950s as the first step in a staged urethroplasty by Johanson [11]. It was further modified by Leadbetter and Blandy in the 1960s [12]. This allows the flap to be extended as far deeply as needed to include the membranous urethra while decreasing tension on the tip of the flap to preserve its blood supply.

The patient is placed in lithotomy position and an inverted U-shaped perineal incision is made (Fig. 32.2), and the bulbar urethra is fully mobilized and opened ventrally (Figs. 32.3 and 32.4). The edges of the corpus spongiosum may be ligated with a running absorbable suture, and attention is turned to the proximal opening of the urethra. A nasal speculum may be used in order to help view the proximal urethra, often opening it as far proximally as the membranous urethra and verumontanum.

The skin edges, particularly the apex of the inverted U incision, are reapproximated to the edge of the urethra with interrupted polyglycolic suture. In order to reach as far proximally as one often needs, modification of the needle as described by Webster for the posterior urethroplasty may be required [13]. The suturing should begin on the lateral edges, leaving the flap for a later suturing procedure. The apex of the U-shaped incision is attached to the urethra after the lateral edges are attached with interrupted sutures in a 360 degree fashion. This sequence of suturing the more distal aspect of the urethra to the skin first and working around both sides of

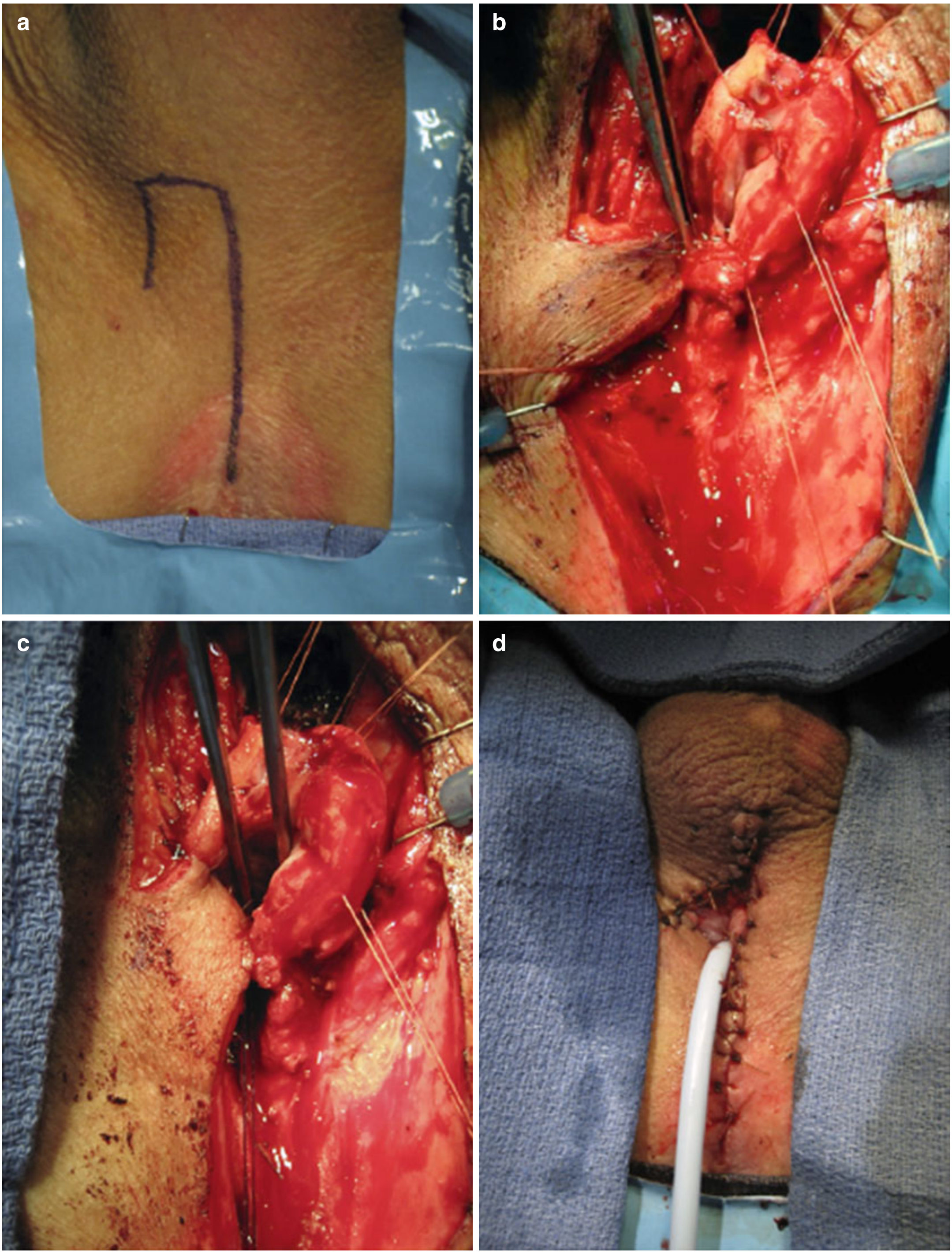

Fig. 32.1 (**a**) The 7-shaped lateral perineal skin flap is marked out. (**b**) After urethral amputation and lateral urethrotomy, the right lateral perineal skin flap is tailored and advanced down to the level of the proximal stricturotomy. (**c**) The healthy proximal urethral lumen is demonstrated before maturing the stoma to the left sided skin edge. (**d**) Completed "7-flap" perineal urethrostomy (Adapted from French et al. [10])

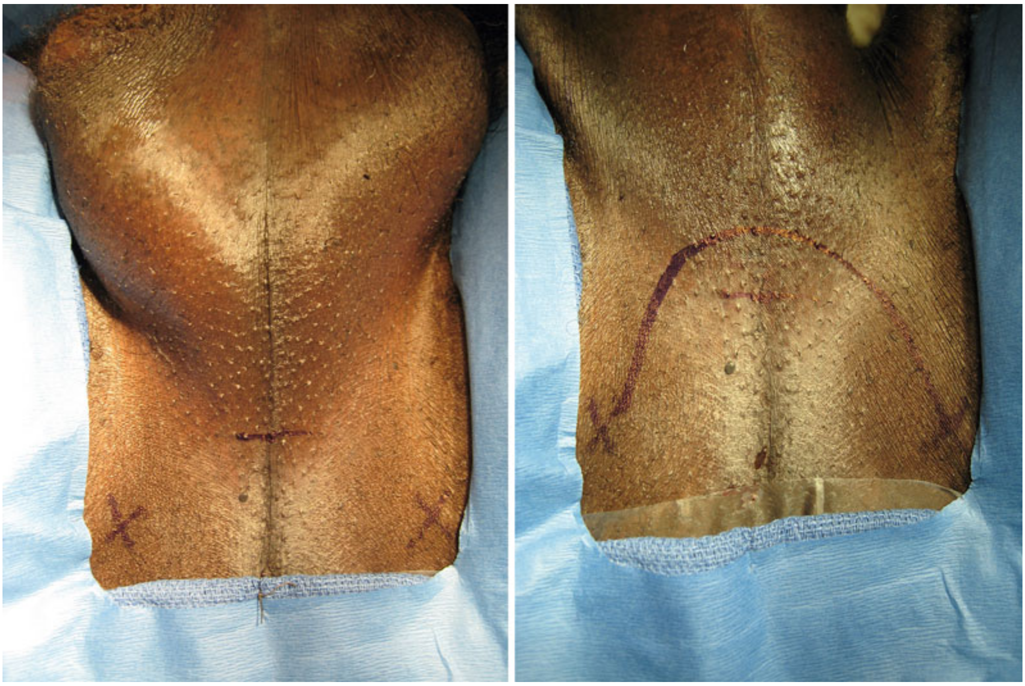

Fig. 32.2 Initial markings for the inverted U flap. The "horizontal line" marks the point at which the urethra makes the turn into the bladder and the "X", marks the inferior pubic ramus (**a**). Inverted U flap marked out on perineum (**b**)

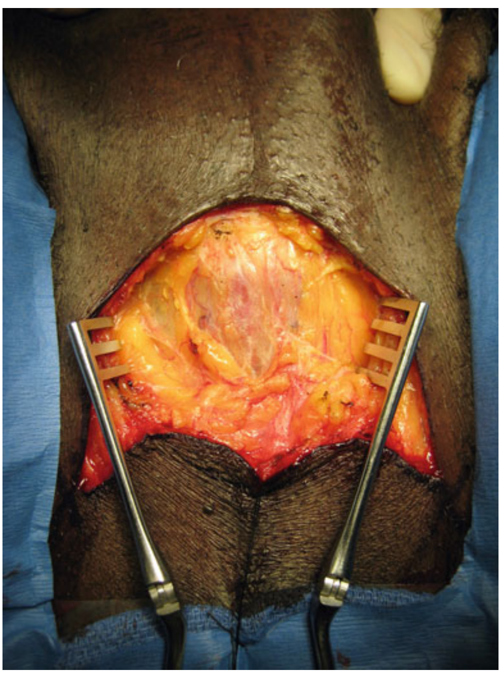

Fig. 32.3 The inverted U flap dissection, down to the level of the bulbospongious muscle. Note the Wheatlander retractors used for exposure.

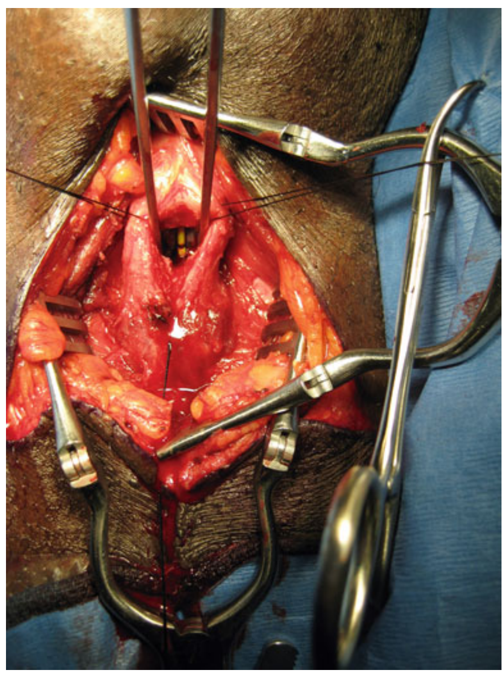

Fig. 32.4 Vertical urethrotomy noting the edges of the urethra marked with silk stay sutures and the yellow, 5 French catheter seen within the lumen

Fig. 32.5 The skin edges are matured to the urethral edge with interrupted 4-0 and 5-0 absorbable suture. After completion of the perineal urethrostomy, one is left with a wide-caliber urethrostomy which can accept a 30 French bougie à boule

the urethra and performing the posterior midline sutures at the tip of the flap last helps reduce the tension on the flap, therefore decreasing tearing and damage to the urethra while tying the sutures. It is important also to hold the flap in place with pickups in order to take the tension off of the flap while tying knots [7]. Prior to completion, a 30 French bougie is placed to ensure the opening is of wide enough caliber in order to prevent restenosis (Fig. 32.5).

A 16 French Foley catheter is placed through the opening and left in place for 1 week. After removal the patient is seen back in the clinic every 3 months for visual examination in addition to calibration with a bougie (not dilation, this is simple insertion to ensure no recurrent stenosis) and a uroflow test along with the American Urologic Association symptom score. Should there be recurrent stenosis, simple dilation is performed easily with a Van Buren sound

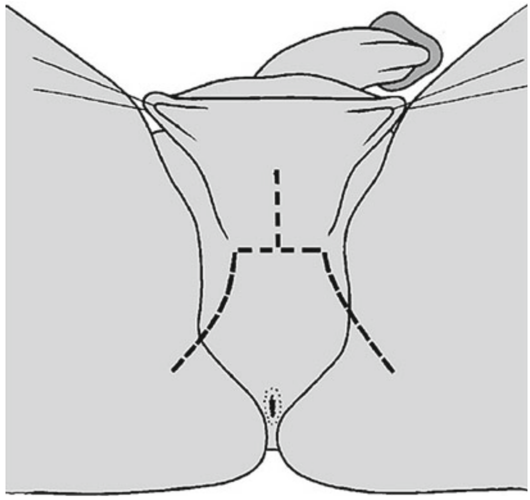

Fig. 32.6 Inverted U perineal incision with vertical scrotal extension to create an inverted Y

in the clinic and rarely requires endoscopic guidance or wire-guided dilation with serial dilators.

In contrast to the end urethrostomy or the other techniques described, it is possible that the dorsal plate left intact promotes continuation of the retrograde blood flow to the urethra. Maintenance of this blood flow theoretically improves the vascular supply to the reconstructed area and decreases the risk of subsequent restenosis. A modification of this technique has been detailed by Barbagli et al. [6]. Here, an inverted U-shaped perineal skin flap, 4 cm wide and 5 cm long, is dissected out, with the addition of a 4 cm vertical incision on to the scrotum, creating an inverted Y incision. The scrotal and perineal components of the skin flaps are then sutured to a 5 cm proximal bulbar ventral urethrotomy. A 20 Fr. Foley catheter is kept in place for 10 days (see Figs. 32.6, 32.7, 32.8, and 32.9).

A Comment on Risks and Benefits

The perineal urethrostomy is a minor surgical procedure that can be performed on an outpatient basis with early return to normal activities.

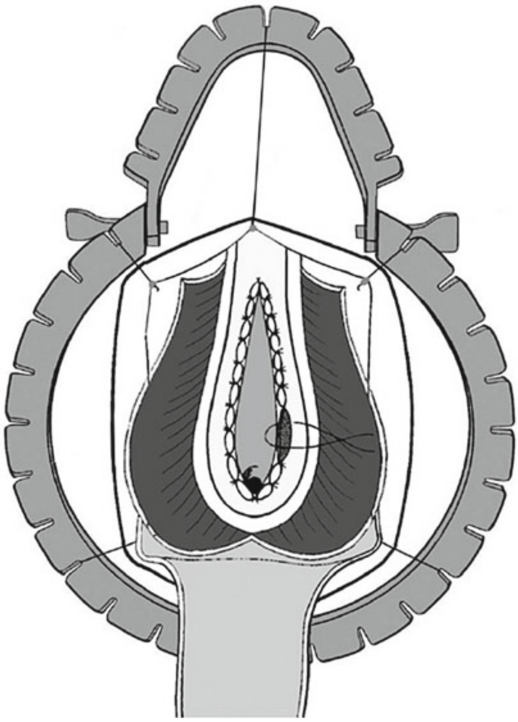

Fig. 32.7 Urethra is ventrally opened for 5 cm and spongiosal edges oversewn for hemostasis

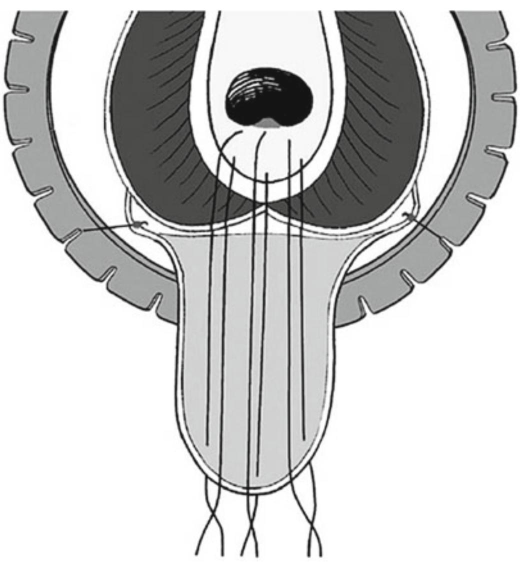

Fig. 32.8 Three sutures are pre-placed in the proximal urethra, close to the verumontanum, and then through the apex of the inverted U skin flap

The obvious perceived benefit of the flap-based perineal urethrostomy is the ability to allow voiding without the need for prolonged catheterization and repeated dilations. This flap-based repair also gives good outcomes with avoidance of prolonged convalescence often required after complex staged repairs or other flap-based repairs. Often this procedure is chosen in men who are already accustomed to seated voiding, so a change in behavior is not often required nor perceived to be problematic in this population [5, 6]. In addition, the creation of a proximally based perineal urethrostomy in certain disease processes such as lichen sclerosus (LS) may actually aid in regression of the disease by diversion of the urine away from the diseased segment, thus helping with further reconstructions down the road should they be warranted [14].

In morbidly obese patients the urethra may not be able to be advanced to the skin edge as needed in the end urethral stump perineal urethrostomy. In this instance the flap-based perineal urethrostomy or the "7-flap" may be the ultimate solution.

Complications are uncommon and may include postoperative bleeding, infection, and recurrent stenosis. Bleeding typically is prevented with appropriate management of the sponge tissue. This is completely matured to the skin edge, preventing troublesome bleeding from the cut edge of the sponge tissue. Infection is rare when the urine is deemed sterile with a negative urine culture and appropriate perioperative antibiotics given. However, when infection does set in, it may lead to wound breakdown and dehiscence. In these cases, no attempt should be made to close the wound as it will invariably granulate with time. The most feared complication of these procedures is recurrence of stenosis or obstructive uropathy despite creation of a wide-based, wide-caliber perineal urethrostomy. While the true rates of stenosis after definitive perineal urethrostomy is not clearly documented in the literature, it seems to occur rarely. The rate of stenosis in patients who undergo a first-stage urethroplasty with creation of a temporary perineal stoma is very low with rates ranging from 0 % [7] to less than 28 % [15]. Again, the risk of this can

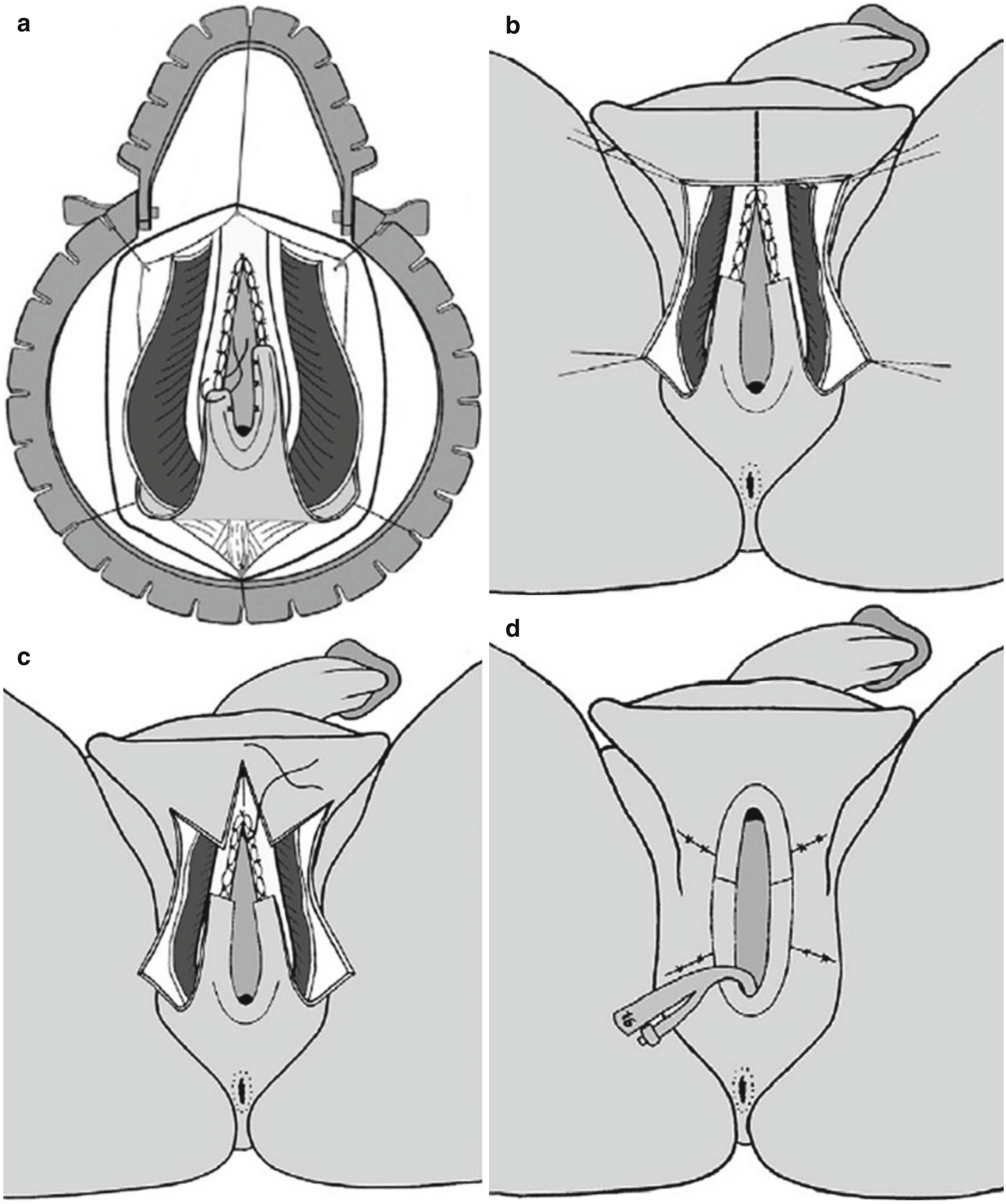

Fig. 32.9 (**a**–**c**) Perineal and scrotal skin margins are sutured to the urethral margins. (**d**) Completed perineal urethrostomy

be minimized with the use of skin flaps rather than a puncture technique. However, in cases with restenosis one may be relegated to placing patients on serial calibrations and self-calibration which is often much easier to perform and better tolerated through the PU as it bypasses the majority of the urethral stricture disease.

Definitive treatment of recalcitrant PU stenosis can be challenging, especially in the obese patient, those with skin disorders such as lichen sclerosus, and those who have had prior multiple proximal stricture dilations with resultant scar tissue. The buccal mucosal graft has been described for the repair of urethral strictures and has been used successfully since its inception in the mid-1990s [16–19]. In 2008 Kamat described their results with four cases of recurrent stricture at the perineal urethrostomy repaired successfully with buccal mucosa [20]. In this technique, the graft is harvested from both cheeks with sufficient amount of tissue in order to create three triangular-shaped patches measuring 2 × 1 cm. These are defatted and fenestrated in preparation for grafting. Incisions are made in the perineum centered about the stenotic perineal urethrostomy, radiating laterally at the 4, 7, and 12 o'clock positions. The stoma is then calibrated to at least 21 French, and cystoscopy performed to ensure the stoma is adequately open. The grafts are then quilted into these areas creating a cloverleaf appearance, and a Foley catheter is left in place for 1 week. They report that their results are excellent with success in three of the four cases with only one requiring serial calibration.

Other common complications occurring after surgery may be related to positioning such as deep venous thrombosis, hip and back pain, and compressive neuropathy. All of these can be minimized with the use of soft stirrups and appropriate pressure point padding along with avoidance of prolonged surgical times. Blood loss should be minimal; however, it can occur especially in the morbidly obese patients where control of the sponge tissue is difficult. In these instances use of the perineal (Jordan) Bookwalter retractor is invaluable.

Outcomes

Barbagli reviewed the results of all men undergoing definitive perineal urethrostomy at their facility [6]. The median follow-up was 62 months (range 12–361 months). Of the 173, 121 (70 %) were defined as successful and 52 (30 %) had failures that required revision of the perineal urethrostomy. These failures included restenosis and all required revision of the perineal urethrostomy. Of these 52, 32 (61.6 %) needed one subsequent operation, 13 (25 %) needed two operations, five (9.6 %) required three operations, one (1.9 %) needed four operations, and one other patient (1.9 %) required up to five surgical revisions. When given a non-validated 12-question questionnaire from the authors, an overwhelming majority of the patients stated that they would have the operation again (168, 97.1 %). Interestingly, 145 (84 %) stated that they had no problems with their partner with relation to sexual or psychological problems after this procedure.

Peterson also reviewed their results with the definitive perineal urethrostomy. These were performed in men who were undergoing a first-stage urethroplasty and elected not to complete the second portion of that procedure, thus leaving them with a functional permanent perineal urethrostomy [5]. They found that of 63 patients, 19 underwent a staged repair with buccal graft or split-thickness skin or penile skin graft in preparation for future closure. Of those 19, 11 completed the second stage and the other eight did not. Parallel with the abovementioned staged repairs, 44 additional patients underwent a definitive perineal urethrostomy alone with the inverted U incision flap-based urethrostomy. None of the 52 patients required any reoperation or dilations, and all 52 patients (100 %) indicated that they were happy with their choice of management for their stricture disease with the perineal urethrostomy. There were no other complications in this group as well.

Recently, Myers reviewed their results for the definitive perineal urethrostomy performed in 45 men from 1989 to 2009 [21]. They defined primary success as the need for no additional treatment and reported a success rate of 83 % after the perineal urethrostomy. The majority of patients who had failures underwent successful management with one to three dilations. On further analysis, they found that risk factors for failure (stenosis after perineal urethrostomy) included a history of prior pelvic radiation and went on to suggest that their technique whereby the dorsal segment of the urethra is left intact to help maintain blood supply theoretically decreases the risk of recurrent stenosis.

Many have argued against definitive use of the perineal urethrostomy because of the perceived problems with sexual function. While erections may not be affected, the act of ejaculation with the perineal urethrostomy will obviously lead to fertility issues with some patients also complaining of the perceived loss of antegrade ejaculation or the problem with perineal ejaculation during intercourse or masturbation. While these problems must be discussed prior to surgery with the patient, recent reports indicate that most patients do not find these bothersome. Barbagli and his group reported their results in 173 patients who underwent a definitive perineal urethrostomy followed with a non-validated questionnaire to establish patient satisfaction. They found that an overwhelming majority (97.1 %) would undergo this type of operation again and that 82 % stated that they had no problems with their partner with regard to sexual activity or psychological problems [6].

Conclusion

The perineal urethrostomy produces unobstructed voiding with minimal complications in potentially high-risk patients. It can be used in cases where complex staged repairs may produce significant morbidity and prolonged convalescence. It is well accepted by patients and has good long-term patency when performed as described above with careful, meticulous creation of a flap-based urethrostomy.

Surgical Pearls and Pitfalls

Key Intraoperative Surgical Points

- The patient is placed in lithotomy with adequate padding, ensuring the buttock is at the edge of the surgical table. There is no need for exaggerated lithotomy as this tends to increase the problems associated with positioning.
- The urethra is instilled with undiluted methylene blue. This helps in identifying the normal urethra during the surgical exploration.
- A 5 French catheter is placed into the urethra to aid in digital identification of the lumen of the urethra during creation of the urethrostomy.
- Once the lumen is identified, silk stay sutures are placed into the edge of the incised sponge tissue to aid in manipulation and to decrease bleeding.
- Cystoscopy is performed with a rigid 30° and 70° 21 French scope both to inspect the bladder for lesions, foreign bodies, and tumors and to ensure there is no significant stricture disease proximal to the urethrostomy.
- The posterior-based flap is sized carefully to ensure it reaches to the proximal portion of the urethrotomy without tension while ensuring it has minimal redundant folds to help decrease spraying while urinating. A good rule of thumb is to place the tip of the flap at the site in the perineum where the catheter in the urethra is felt to turn cephalad to enter the bladder.
- The base of the flap should be wide to ensure good blood flow to the tip. Use the inferior pubic rami as guides to the lateral extent of the incision.
- The entire PU is matured with a combination of 4-0 and 5-0 absorbable Vicryl sutures. Start with sutures placed in the lateral aspects of the urethrotomy, placing the proximal and distal apical sutures last. This allows the urethra to be pulled to the skin and held open, making placement of the deep sutures easier.
- Placement of the sutures in the proximal urethra may be aided with the help of modified SH needles, bent into a "J". Visualization is helped with the aid of a long nasal speculum and narrow sucker tip suction.
- A 16 French Foley catheter is left in place for a week to 10 days to allow the skin edges to mature and obtain a watertight seal.
- Postoperative inspection should take place 1, 3, and 6 months and then yearly. The PU should be calibrated with a bougie à boule at each visit to ensure it accepts a 20 French or larger size.

Potential Intraoperative Problems

- If a 5 French catheter cannot be placed through to the proximal urethra because of obliterative stricture, use a floppy-tipped, hydrophilic-coated guidewire. If the patient has a suprapubic tube in place, scope the urethra antegrade with a flexible cystoscope using the tip of the scope as a guide to perform the urethrotomy.

- Exposure may usually be obtained with the help of serially placed Wheatlander retractors. When exposure is difficult as in the morbidly obese, the use of the Lone Star retractor or the Jordan-Bookwalter perineal retractor may be needed.
- When encountering bleeding after incising the urethra, control the edge of the cut sponge tissue with 3-0 GI silk stay sutures placed on tension. For particularly troublesome brisk bleeding, place a running 4-0 Vicryl continuous suture along the edge of the cut sponge tissue. If not controlled through the operation, this may lead to significant bleeding.
- If the wound opens postoperatively, make no attempt to perform delayed closure. These wounds will heal and close on their own with time possibly necessitating prolonged Foley catheter placement.

Preferred Surgical Instruments of AC Peterson

- Turner-Warwick curved off-set needle driver (enables proximal suture placement)
- Lone Star retractor (if needed when obese)
- Jordan-Bookwalter perineal retractor (when really obese)
- Long nasal speculum
- Rigid cystoscope (to inspect proximal urethra, ensuring no further stricture disease exists proximally)
- Bougie à boule set (should calibrate opening up to 30 French in size)
- 4-0 and 5-0 Vicryl suture with an SH and RB1 needle

Editorial Comment

Although most strictures are reconstructable orthotopically, definitive perineal urethrostomy has a valuable role in the reconstructive armamentarium. Appropriate candidates are elderly men with advanced stricture disease of the penile and/or distal bulbar urethra. Most patients fitting this profile do already sit to void since their stream has long been too weak and erratic to direct confidently. Many also have lichen sclerosus with cutaneous manifestations accompanying their extensive strictures, thus presenting a Herculean challenge for primary reconstruction. The benefit of definitive perineal urethrostomy is to offer a simple, reliable, single-stage resolution. Even in extensive lichen sclerosus cases, the perineal skin tends to be supple and ample, readily conformable into a proximal or lateral skin flap. Hair in the perineal skin has not been a problem since the lumen is quite large and the flap is of short distance. For sexually active patients, the perineal urethrostomy may be advantageous since the penis is not disturbed as it is during two-stage reconstruction. For obese and diabetic patients, where wound healing may be an issue, perineal urethrostomy circumvents these concerns, avoiding grafts.

One benefit of the 7-flap laterally based perineal flap is that it can be easily converted from a standard midline perineal incision when extensive fibrosis is identified intraoperatively. Although the urethra is amputated and rotated toward the skin to reduce tension, the dual proximal blood supply from the bulbar arteries has proven to be quite robust. We favor the use of Monocryl suture over Chromic for flap fixation to the urethra and skin since it is less prone to early degradation and wound separation. Appropriate patients for perineal urethrostomy should have a normal proximal bulbar urethra; those with concomitant bulbomembranous obliterative strictures will present considerable challenges and may be better served with other techniques or chronic SP tube diversion.

—Allen F. Morey

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Double Overlapping Buccal Grafts 33

Enzo Palminteri and Elisa Berdondini

Summary

Traditionally, anastomotic procedures with transection and urethral excision are suggested for short bulbar strictures, while longer strictures are treated by patch graft urethroplasty, preferably using the buccal mucosa as gold-standard material due to its histological characteristics.

However, one-sided graft procedures, using either dorsal or ventral graft location, could be insufficient in providing a lumen of adequate width in strictures with a particularly narrow area.

The double buccal graft urethroplasty is a new technique that aims to obtain a sufficient "two-sided" augmentation of the urethra avoiding its transection and preserving the urethral plate.

In this chapter we discuss the rationale for utilizing our procedure and describe in detail the surgical technique.

Introduction

Bulbar urethral strictures are treated by various reconstructive techniques. Generally, short strictures (<2 cm) are treated with excision and anastomotic urethroplasty (*AU*), while longer strictures are repaired by patch graft urethroplasty preferably using buccal mucosa (*BM*) as gold-standard graft material [1, 2].

The advantages of BM grafts, compared to penile skin flaps or other kind of grafts such as genital/extragenital skin or bladder/intestinal mucosae, include a cosmetically superior incision, decreased operative time, low harvest morbidity, and better histological graft characteristics [2].

The grafting techniques are various and the dorsal or ventral location of the patch in the urethra, as well as the dorsal or ventral approach to urethral lumen have become a contentious issue [2, 3].

Recently, we described a new technique for the repair of tight bulbar strictures, consisting of a combined dorsal plus ventral graft (*DVG*) urethroplasty using a ventral urethrotomy approach. This procedure allows adequate augmentation of the preserved narrow urethral plate without transecting the urethra [4].

Historical Background

The dorsal plus ventral oral graft urethroplasty builds on previous steps in the urethral surgery:

- The introduction of *buccal mucosa grafts* in urethral reconstruction in 1992 [5]
- *Ventral grafting* using a ventral urethrotomy approach as popularized by Morey, Wessels, and McAninch in 1996 [6, 7]
- *Dorsal grafting* using a ventral urethrotomy approach as described by Asopa in 2001 [8]

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Development of Dorsal Plus Ventral Double Buccal Grafting in Bulbar Urethroplasty

The bulbar urethra is characterized by a corpus spongiosum which is thicker in its ventral aspect and thinner in its dorsal surface. Based on these anatomical remarks, Barbagli introduced the novelty of dorsal grafting using a dorsal urethrotomy in 1996. This approach consists of dissecting the urethra from the corpora cavernosa and rotating it 180°. The exposed dorsal urethral surface is opened and augmented with the graft splayed on the corpora [9]. This access has been very successful as it was considered “corpus spongiosum sparing” as it may be more likely to preserve the blood supply of the abundant ventral spongiosum tissue. Furthermore, it gives a good mechanical and vascular support for the graft. However, it should be noted that this approach may compromise the dorsal blood supply (circumflex and perforating arteries) and damage erectile function and the bulbar arteries when the dissection from the corpora needs to be very proximal [10, 11]. Furthermore, dorsal urethral mobilization may be quite difficult in cases having marked periurethral fibrosis following prior treatments, obese patients with flat and deep perineum, or proximal bulbar strictures located near the external distal sphincter [12]. In all these patients, a ventral approach to the urethral lumen could be more advisable.

In 2001, Asopa suggested the dorsal grafting using the ventral approach. Following the ventral opening, the dorsal urethra is medially incised to create an elliptical area over the corpora where the graft is placed. This approach is easy to perform because the scarred urethra with marked spongiofibrosis is not mobilized; there is less harm for the urethral plate because the space for grafting is created without lifting the two urethral halves from the corpora and thereby the blood supply is guaranteed by the saved circumflex and perforating arteries. Nevertheless, the technical limit of this method is that the dorsal urethral augmentation is less wide than with Barbagli’s procedure [8].

In 1953, Presman first introduced the use of ventral grafting using the ventral-sagittal urethrotomy [13]. In 1996, the technique was revived by Morey, Wessels, and McAninch based on the fact that in the bulbar urethra, the abundant ventral spongiosum provides adequate vascularization and support for the graft [6, 7]. However, the graft may be inadequate to augment a very narrow urethral plate. In these cases, a wider graft may be advisable but with a potential increased risk of urethral diverticula [14].

Barbagli stated that his technique offers a wider augmentation than ventral or dorsal grafting using the ventral approach. He suggests that the surgical procedure (ventral or dorsal graft and ventral or dorsal access) should be selected according to the width of the urethral plate [15]. In reality, the urethral plate can be assessed only after the urethral opening because the urethrogram often underestimates the severity of the stricture [16]. From this standpoint, it should be stressed that the ventral urethrotomy is a more versatile approach because, providing a good visualization of the urethral plate, it allows us to establish whether a dorsal or a ventral graft would be more appropriate. Furthermore, in tight strictures, with a very narrow urethral plate, in which a single patch may be insufficient for reconstruction of an adequate lumen, the ventral access permits converting the single into the double dorsal-ventral grafting.

In 2008, we described the dorsal plus ventral graft urethroplasty for tight bulbar strictures, postulating some advantages [4, 17]:

1. The fibrotic tissue is partially excised while preserving the remaining urethral plate.
2. Avoiding an excessively wide single ventral graft, the double graft may reduce the possibility of fistula and diverticula.
3. The dorsal augmentation could be small due to reduced mobilization of the urethral plate that the ventral approach entails; thus, the additional second graft could correct the initial use of a single dorsal graft that was intraoperatively considered to be insufficient for adequate augmentation.
4. Avoiding the complete section of the spongiosum that an anastomotic urethroplasty entails, the DVG preserves the urethral plate and the urethral vascularity [16]. The aim is to maintain the urethral axial integrity and the

original urethral length, reducing the hypothetical sexual complications related to the AUs [18–22].

Finally, we point out that, in the last decade, the BM has become the preferred graft source in urethroplasty. Its thickness and elasticity make it a tough tissue and therefore suitable to support the urethral reconstruction either dorsally or ventrally [2].

Preoperative Evaluation

Preoperative evaluation includes clinical history, physical examination, urine culture, uroflowmetry, retrograde-voiding cystourethrography, and urethroscopy.

The patient's interview includes a detailed clinical history of urethral disease and its previous treatments as well as an examination to define problems or contraindications in performing oral harvesting: oral infections, a previous oral surgery which hinders a wide mouth opening, patients who are professional singers, or those who play wind instruments.

Retrograde urethrography evaluates the site, number, and length of stricture, while voiding cystourethrography evaluates continence of the bladder neck and degree of urethral dilatation proximally to the stenosis.

Urethroscopy using small-caliber instruments (7 Ch) often allows passage through the stricture and collection of more detailed information on its characteristics and on the conditions of the entire urethra.

Patients were informed that bulbar patch urethroplasty is a safe procedure as far as sexual function is concerned.

A broad-spectrum antibiotic is administered intravenously during the procedure and for 3 days afterward.

Surgical Technique

Aiming to save time during surgery, we used a two-team approach, with the first team harvesting the BM graft while the second team exposed the stricture.

Preparation of the Bulbar Urethra

The patient's legs are carefully placed on the Allen stirrups and patient is placed in lithotomy position. Proper positioning reduces the risks of complications such as compression of the calf muscles and peroneal nerve injury due to an incorrect position.

The urethra is intubated with a guide wire by endoscopical vision. Methylene blue is injected into the urethra. The guide wire and methylene blue avoid losing the lumen and does not damage the urethral plate during the subsequent urethral opening.

A Y-inverted perineal incision is made. A self-retractor with atraumatic plastic hooks is positioned, and the bulbocavernosus muscles are separated in the midline, exposing the bulbar urethra (Fig. 33.1).

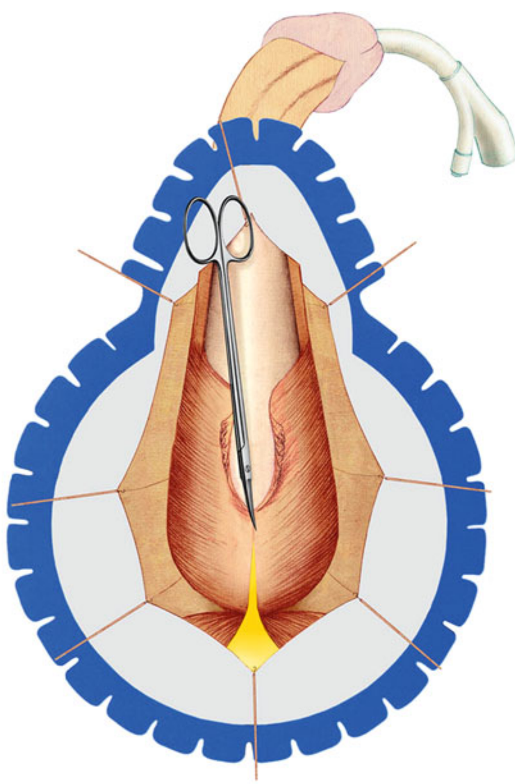

Fig. 33.1 The self-retractor with atraumatic plastic hooks is positioned; the bulbocavernosus muscles are separated in the midline, exposing the bulbar urethra

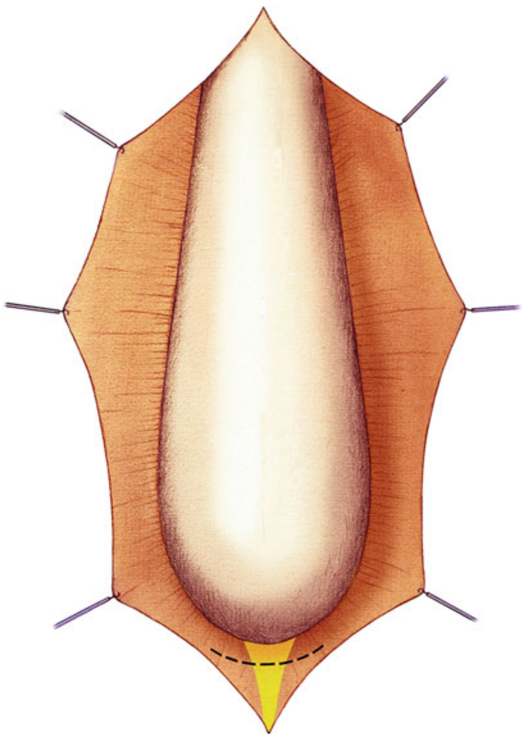

Fig. 33.2 The partial section of the central tendon of the perineum may improve the mobilization of the bulb, making it easier to access the very proximal bulbar strictures

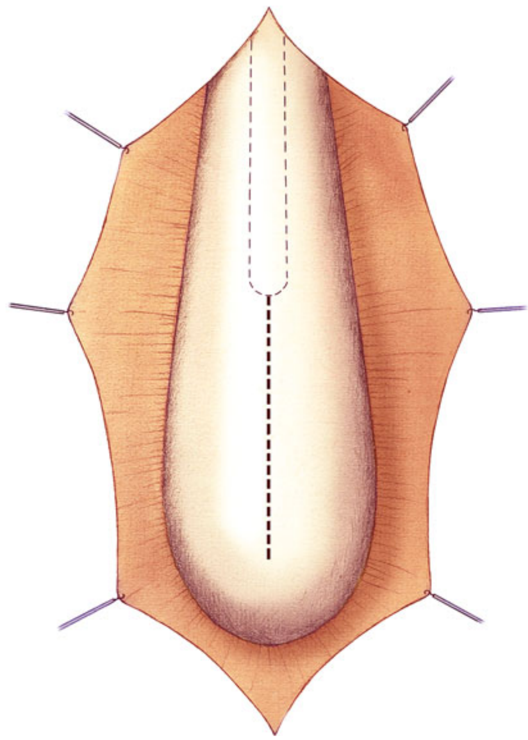

Fig. 33.3 The distal extent of the stenosis is identified by gently inserting an 18 F catheter. The incision line of the ventral urethrotomy approach is outlined

After the opening of muscles, sometimes the partial section of the central tendon of the perineum may improve the mobilization of the bulb, making it easier to access the very proximal bulbar strictures (Fig. 33.2).

Ventral Urethrotomy Approach

The distal extent of the stenosis is identified by gently inserting an 18 F catheter with a hard tip until it meets resistance (Fig. 33.3).

The urethra is incised in the ventral midline until the catheter tip and urethral lumen are exposed.

Then, using a ventral-sagittal urethrotomy, the strictured urethra is opened, following the guide wire and methylene blue previously injected to define the narrow lumen. The urethra is laid open for 1 cm both proximally and distally into the healthy urethra (Fig. 33.4).

The distal and proximal urethra is calibrated by an 18 F catheter.

Dorsal Graft

As suggested by Asopa, the exposed dorsal urethra is incised in the midline down to the tunica (Fig. 33.5); the margins of the incised dorsal urethra are dissected from the *tunica albuginea* by sharp dissection with a scalpel, without lifting the two halves of the bisected urethra: an elliptical raw area is created over the tunica (Fig. 33.6). The first graft is placed into this recipient elliptical area, quilted to the underlying tunica, and fixed to the urethral mucosal margins with a 6-0 polyglactin interrupted suture (Fig. 33.7) [8].

Ventral Graft

Following dorsal augmentation, the urethra is also graft-enlarged ventrally. The second graft is sutured laterally to the right mucosal margin of the urethral plate with a 6-0 running suture (Fig. 33.8). The catheter is inserted; the graft is rotated and sutured laterally to the left mucosal margin of the

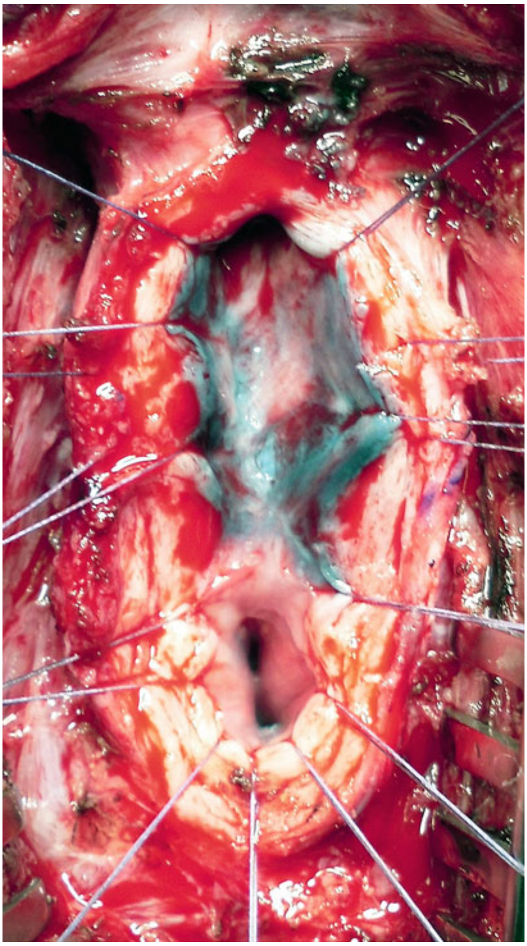

Fig. 33.4 Using a ventral-sagittal urethrotomy approach, the urethral plate is well exposed

urethra (Fig. 33.9). An inverted ventral graft quilting is made with few stitches fixing the spongiosum to the graft (Fig. 33.10). Finally, the adventitia of the spongiosum is closed over the graft with a 4-0 running suture (Fig. 33.11) and the bulbocavernosus muscles are sutured on the midline.

Thus, the neourethra is finally created by anastomosis of the BM grafts in double-patch fashion to the mucosal margins of the bisected urethral plate (Fig. 33.12).

A 16–18 F silicone Foley catheter is left in situ for 3 weeks. A suction drain is left in place for 2 days.

Buccal Mucosa Harvesting

The Kilner-Doughty oral retractor is positioned, providing an excellent inner cheek exposure

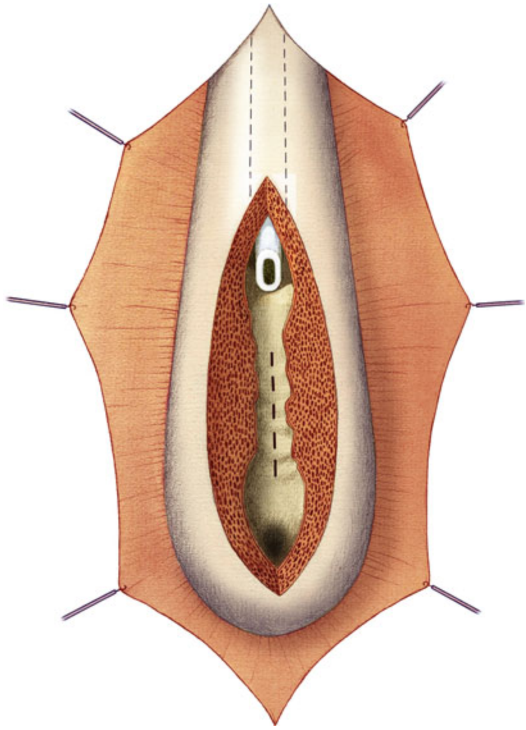

Fig. 33.5 The exposed dorsal urethra is incised in the midline down to the tunica albuginea

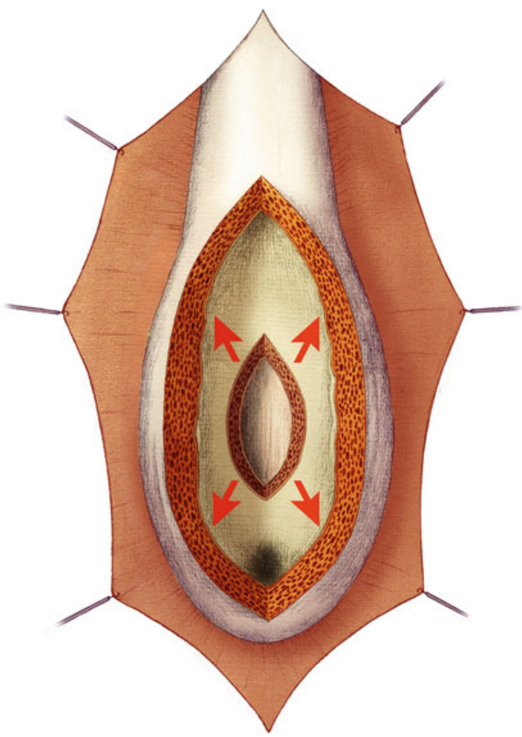

Fig. 33.6 The margins of the incised dorsal urethra are dissected from the *tunica albuginea* without lifting the two halves of the bisected urethra: an elliptical raw area is created over the tunica

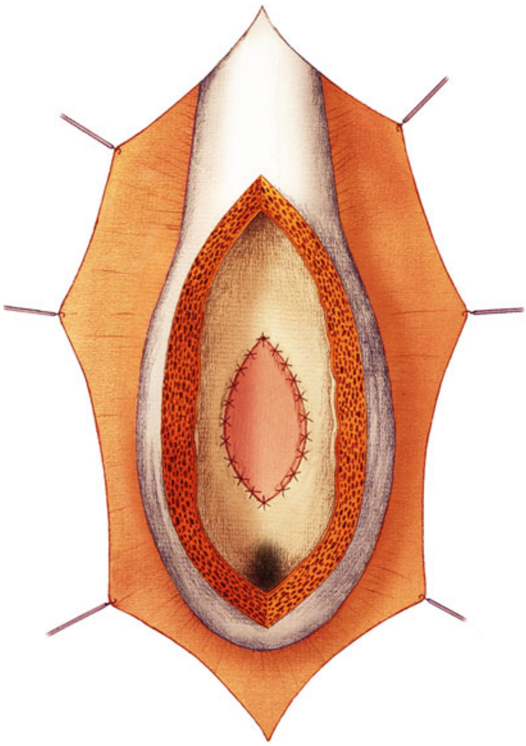

Fig. 33.7 The first BM graft is placed into the recipient elliptical area, quilted to the underlying tunica, and fixed to the urethral mucosal margins

(Fig. 33.13). We initially used a nasotracheal intubation but we noticed that this may result in more postoperative discomfort and provided no greater access to the inner cheek. Now, we prefer an orotracheal tube taped over to the contralateral side.

In most patients it is sufficient to harvest a single ample (6×2 cm) and ovoidal BM graft from the right cheek and subsequently tailor it into two smaller grafts according to the length of the dorsal and ventral urethral openings. In some cases it could be necessary to harvest two BM grafts bilaterally from both cheeks.

The donor site is closed with 4-0 polyglactin interrupted stitches or running suture.

Postoperative Care and Follow-Up Methods

Two ice packs are immediately applied on the cheek and genitalia to reduce edema, hematoma, pain, and erections. The patient consumes a liquid diet and ice cream in the first postoperative day and then advances to a soft regular diet.

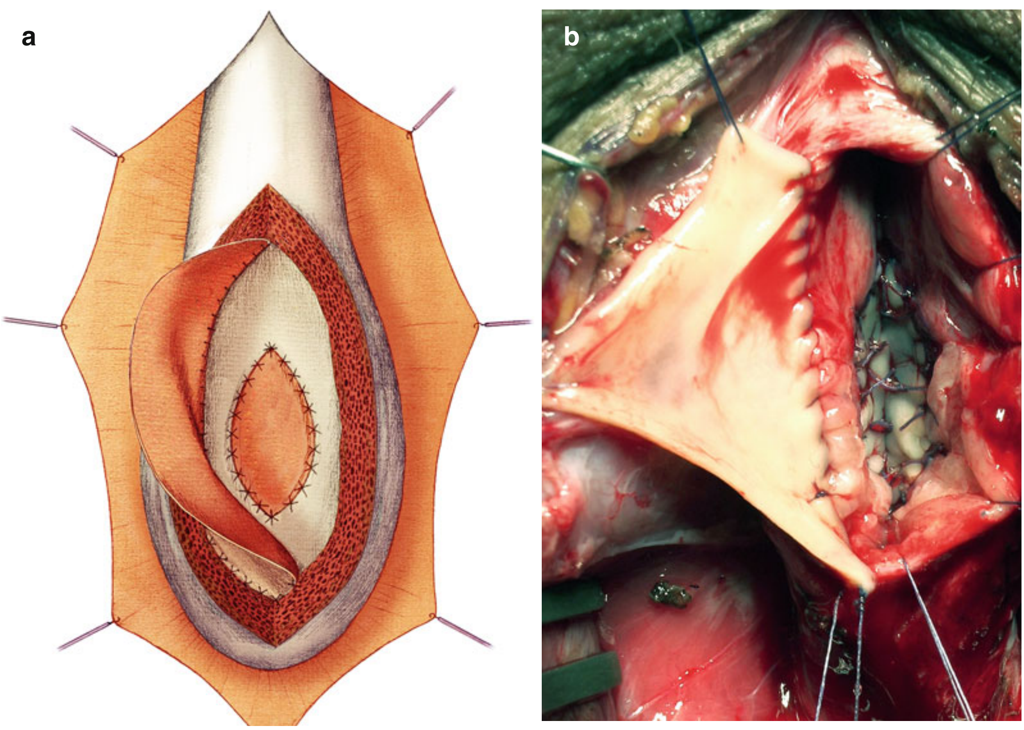

Fig. 33.8 (**a**, **b**) The second BM graft is sutured laterally to the right mucosal margin of the urethral plate

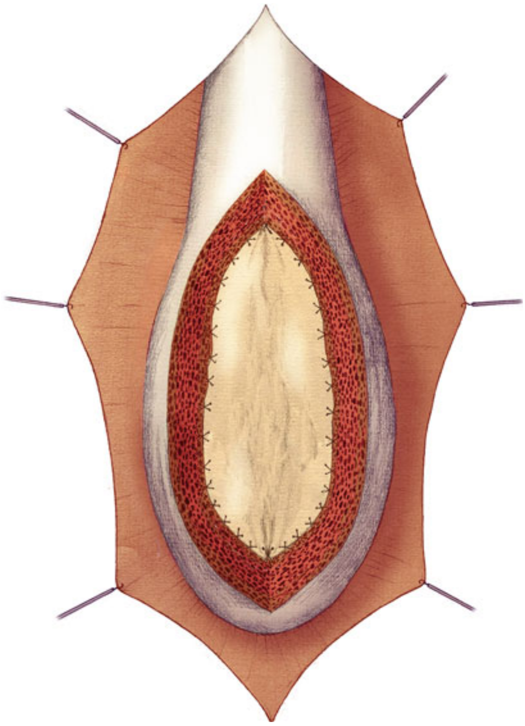

Fig. 33.9 The ventral graft is sutured laterally to the left mucosal margin, completing the ventral enlargement of the urethra

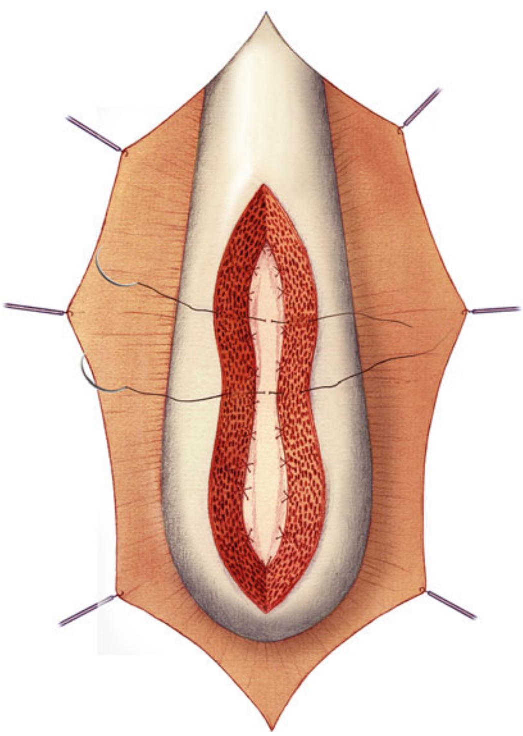

Fig. 33.10 An inverted ventral graft quilting is made with few stitches fixing the spongiosum to the graft

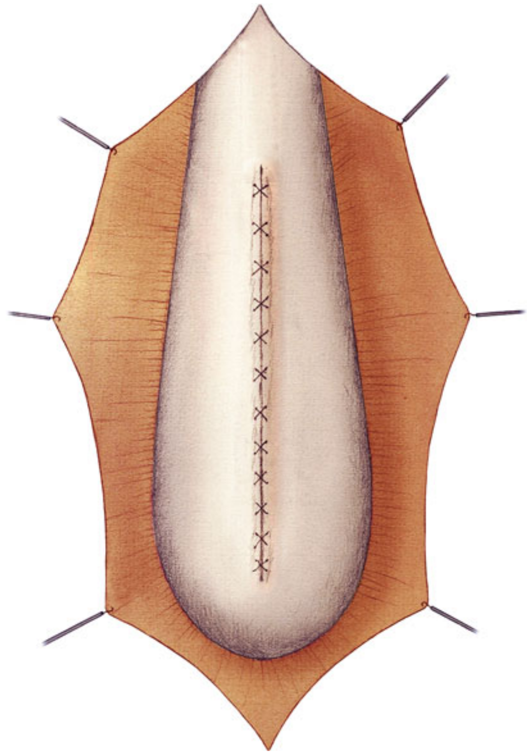

Fig. 33.11 Finally the adventitia of the spongiosum is closed over the graft

The patient is discharged after 3 days. An oral antibiotic is maintained until the catheter is removed.

Voiding cystourethrography (VCUG) is performed upon catheter removal, 3 weeks after surgery.

Follow-up assessment includes uroflowmetry and urine culture every 4 months in the first year and annually thereafter. Urethrography and urethroscopy are performed in patients presenting obstructive symptoms or peak flow rate (Q_{max}) <14 mL/s. Clinical outcome was considered a failure when any postoperative procedure was needed, including dilatation.

Complications

In few cases, at catheter removal, the VCUG showed a leakage at the graft anastomosis that resolved spontaneously with a 14 F catheter for two additional weeks.

Possible complications are post-voiding dribbling, temporary (few months) scroto-perineal numbness, and light oral discomfort.

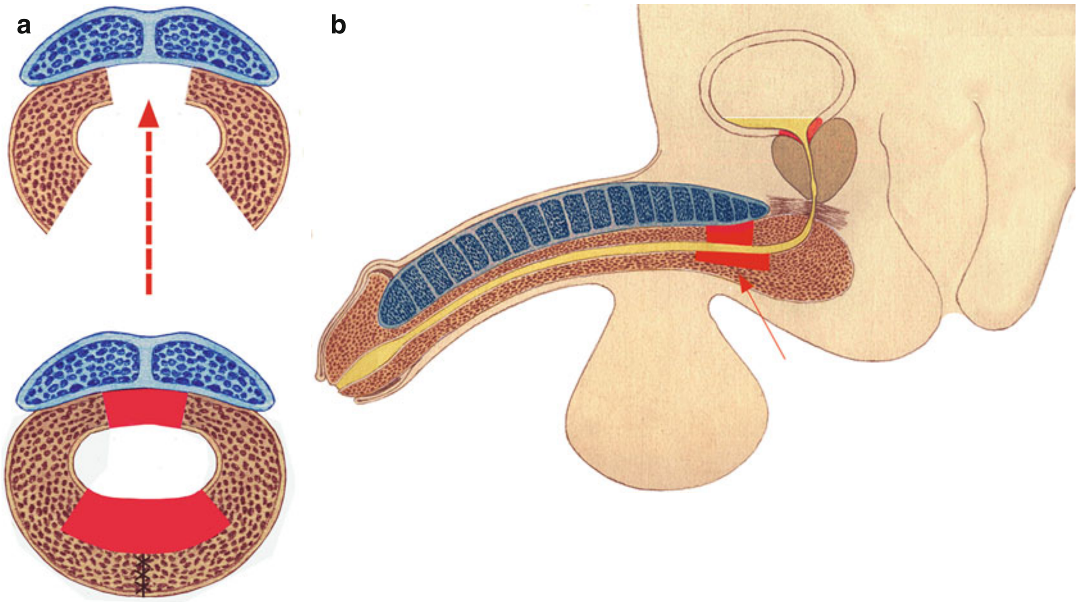

Fig. 33.12 (**a**, **b**) The drawing shows the double enlargement of the urethra with the dorsal and ventral BM grafts in transversal section (**a**) and in sagittal section (**b**)

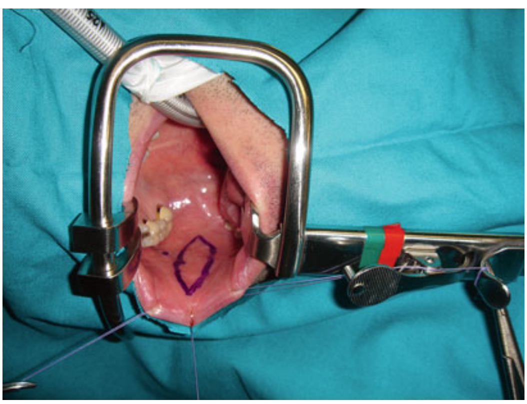

Fig. 33.13 The Kilner-Doughty oral retractor provides an excellent inner cheek exposure

Discussion

Ease and Versatility of the Ventral Urethrotomy Approach

Traditionally, the ventral urethrotomy has been considered an easy access to the urethral lumen which gives a good visualization of the strictured tract [6, 7, 13]. As there is no mobilization-rotation of the urethra, it is very safe and simple to perform, particularly for reconstructive urologists in training with little experience.

The urethral plate (size, mucosal edges, and urethral lumen) is better visualized, allowing a watertight graft-urethra anastomosis.

Furthermore, the ventral opening, following the evaluation of the stricture and its length, may allow either dorsal or ventral or dorsal-ventral graft augmentation and, if necessary, excision of the scarred urethra with conversion in an anastomotic procedure [16].

Double Graft Versus Single Graft

Usually dorsal or ventral single-graft urethroplasties are performed without resection of any diseased tissues, while the double dorsal-ventral graft enlargement allows the partial removal of the fibrotic tissues without jeopardizing the creation of a sufficiently wide lumen in very tight strictures and reducing the risk of stenotic rings at the distal or proximal graft anastomotic sites [10, 23]. Furthermore, reducing the width of a hypothetical single ventral graft, the double grafting may decrease the chance of fistulas and diverticulum.

However, to date, recent overviews have showed that ventral or dorsal single-grafting procedures have a similar success rate [2, 3], while there are no comparative studies that can demonstrate the advantages of the double-graft versus single-graft techniques.

Double-Patch Graft Versus Tube Graft

In the past, full circumferential urethral reconstruction using graft tubes has demonstrated a high rate of complications due to diverticulum, short restricture at the anastomotic sites, or long restricture resulting from complete collapse of the entire tube [2]. Differently, the double-patch grafting with the support of the residual lateral strips of the urethral plate allows a more stable and solid semi-circumferential reconstruction preserving the axial structure of the urethra and avoiding a circumferential graft-urethra anastomosis.

Double Graft Versus Anastomotic Procedures

In tight strictures the double graft allows avoiding the more aggressive anastomotic procedures with urethral transection that may compromise the spongiosum vascularity. Avoiding the complete transversal section of the spongiosum, we stick to the important concept of preserving the urethral plate and urethral vascularity [16, 24]. We also retained the original length of the urethral tube. Therefore our aim was to maintain the urethral axial integrity as much as possible and to reduce potential sexual complications related to the anastomotic procedure, such as penile curvature and shortening, decreased glans sensitivity, glans not full during erection, and impaired erection. Some of these complications are related to the wide mobilization and shortening of the urethra. Others are perhaps related to vascular injury in the spongiosum distally to the urethral section. Overall, AUs showed a more significant impact on sexual life than that of graft techniques [17–22, 25, 26].

However, in obliterative or traumatic strictures with hard scarring, the urethral plate may be ill suited for enlargement, forcing its complete resection by an anastomotic procedure. Thereby, the choice of technique is always determined by the quality of the urethral plate.

Urinary and Sexual Results of Dorsal Plus Ventral Double Graft

Recently, we reviewed 73 patients who underwent dorsal-ventral BM graft urethroplasty for tight bulbar strictures between 2002 and 2010. The mean patient age was 39 years. Mean follow-up was 48.9 months. Mean stricture length was 3.3 cm (range 1–10). Of these 73 cases, 64 (88 %) were successful and 9 (12 %) were failures with restricture. In 4 (5 %) cases, the VCUG at catheter removal showed a mild urethral leakage that resolved spontaneously with a prolonged catheterization.

The prevalence of postoperative sexual disorders was investigated using the validated questionnaire, previously adopted by Morey [19] and Coursey [25] in their series of urethroplasties. The questionnaire was administered 1 year after surgery to 49 sexually active patients. None of these men reported postoperative penile curvature or shortening, impaired erection, and dissatisfaction regarding erection or sexual activity compared to the preoperative status. Moreover, erectile improvement was reported by 7 patients (14 %), and all 49 (100 %) patients reported overall satisfaction following urethroplasty. When compared to data reported by other authors using the same erectile function questionnaire following AUs, our data on DVGs showed better sexual results [17, 19]. Larger series and adapted validated questionnaires reporting patient perception after urethroplasty will be necessary to establish whether dorsal-ventral double-grafting techniques represent a valid alternative to either single-grafting or traditional anastomotic techniques which are now supported by the current evidence as the method of choice.

Surgical Pearls and Pitfalls

Key Surgical Points

1. Insert a urethral guide wire and inject methylene blue to avoid losing the lumen and prevent damaging the urethral plate during the ventral urethral opening.
2. Incise the exposed urethral plate in the midline; Lateralize the margins of the incision, taking care to find the exact dissection plane between the spongiosum and the corpora cavernosa.
3. Partially excise the fibrotic tissue is partially preserving the remaining urethral plate.
4. Carefully lay and quilt the dorsal graft onto the denudation area of the corpora cavernosa using interrupted stitches.
5. Following suture of the ventral graft, quilt the inverted graft with sutures, in order to fix the spongiosum to the ventral graft.

Potential Surgical Problems

6. *Very proximal bulbar strictures*: Incise the urethral attachments to the central tendon of the perineum to improve the mobilization of the bulb, making it easier to access to the urethral lumen.
7. *Accidental injury of the corpora cavernosa during incision of the urethral plate*: Recognition of injury and suture close corportomy.
8. *Excessive bleeding from the spongiosum*: Place multiple temporary stay sutures.

Preferred Surgical Instruments of Enzo Palminteri

Allen Stirrups (Allen Medical System, The Org Group, Canton, MA, USA)

Kilner-Doughty mouth retractor (Bontempi, Italy)

Plastic ring retractor with atraumatic plastic hooks (Lone Star Medical Products, Houston, TX, USA)

Microsurgical scissors (Lawton GmbH and Company, Fridingen, Germany)

Methylene blue

Sensor guide wire (Boston Scientific, USA)

Foley grooved silicone catheter (Rush GmbH, Kernen, Germany)

Polyglactin suture (Vicryl) (Ethicon, Johnson & Johnson Intl., St-Stevens-Woluwe, Belgium)

Editorial Comment

The combination of dorsal and ventral grafting for urethral reconstruction has proven to be an invaluable advance in the reconstructive armamentarium at our center. We use it for obliterative strictures too long to be excised completely (usually distal bulb or penile) and for those with focal areas, nearly or completely obliterative, within a longer area of moderate stricture. In hypospadiac strictures, we combine it with a tunica vaginalis blanket wrap to provide waterproofing and vascular support ventrally. In the distal bulb where the spongiosum is less robust, "pseudospongioplasty" may be achieved by advancing Buck's fascia bilaterally. Although dorsal incision with thin elliptical graft is preferred (Asopa), complete focal excision with wide graft (Barbagli) may be readily combined with ventral grafting in severe cases with obliterative segments.

—Allen F. Morey

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Muscle-, Nerve-, and Vascular-Sparing Techniques in Anterior Urethroplasty

34

Sanjay B. Kulkarni and Pankaj M. Joshi

Summary

Augmentation urethroplasty with oral mucosa patch is the treatment of choice for bulbar urethral strictures where anastomotic urethroplasty is considered inappropriate. Although rare, such surgeries can result in complications in erectile function and sensation, incontinence, and voiding function. The bulbospongiosus muscle surrounds the bulbar urethra in its proximal two-thirds, circumferentially. Its function is to help expel urine and semen. Incision of the muscle may lead to post micturition dribble and decreased force of ejaculation. To minimize morbidity, ventral onlay oral mucosa graft urethroplasty can be performed by retracting the muscle inferiorly without incising it.

During dorsal onlay oral mucosa graft urethroplasty, it is unnecessary to incise the muscle twice – once, ventrally to expose the bulbar urethra and, again, dorsally to open the urethra for grafting. Instead, the urethrotomy can be made laterally and the bulbospongious muscle only mobilized on one side, lateral to medial. The one-sided dissection of the urethra allows for preservation of the neurovascular tissue. For pan-urethral strictures, the penile invagination technique avoids the morbidity of a penile incision, by repairing the whole urethra via only a perineal incision. Vessel-preserving urethroplasty has some distinct advantages in patients who require both a staged artificial sphincter and a staged anastomotic urethroplasty.

Introduction

Minimally invasive surgery (MIS) has transformed the way we perform surgery from laparoscopy to percutaneous ablative surgery. By minimizing the tissue trauma during surgery, we can achieve the goal with less morbidity and complications to improve the quality of life. MIS also has a role and place in urethroplasty.

The anterior urethra is surrounded by the corpora spongiosum. It starts at the membranous-bulbar junction and includes the bulbar and penile urethra, navicular fossa, and meatus. The bulbospongiosus muscle surrounds the proximal half of the bulbar urethra. The muscle helps in elimination of urethral contents like urine and semen. It lies as a bystander during bulbar urethroplasty, typically in the way and thus incised in order to gain access and exposure to the urethra. Incising the bulbospongiosus muscle may result in muscle paralysis or dysfunction and result in semen or urine pooling and thus post void dribbling or decrease in ejaculating force and volume.

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To minimize morbidity, muscle- and nerve-sparing urethroplasty has been developed.

This muscle- and nerve-sparing technique can be applied in two situations of urethroplasty:

1. Ventral onlay urethroplasty used for proximal bulbar urethral strictures
2. Dorsal onlay urethroplasty for bulbar stricture and pan-urethral stricture

To understand the concept of this technique, it is essential to highlight and revisit the anatomy and function of the bulbospongiosus muscle.

Anatomy and Function of Bulbospongiosus Muscle

The words bulbospongiosus and bulbocavernosus have been used interchangeably for the same muscle. In Gray's textbook of anatomy, the bulbospongiosus is the modern name, while bulbocavernosus is the older name. Bulbospongiosus, as per Gray's textbook of anatomy, is the midline muscle in the perineum, which arises from the central tendinous point of the perineum from the median raphe [1].

The bulbospongiosus has three types of fibers:

1. Posterior thin fibers that merge with the inferior fascia of urogenital diaphragm.
2. Anterior fibers that are spread over the bulbar urethra and attach in the midline. This covers the bulb of the urethra. It is these fibers which are incised longitudinally to gain access to the urethra.
3. Lateral fibers, which attach to the corpora cavernosa (Fig. 34.1).

The proximal two-thirds of the bulbospongiosus muscle surrounds the bulbar urethra circumferentially. Its function is to expel last drops of urine and semen ejaculation.

The distal one-third of the muscle spreads laterally to surround at the base of the corpora cavernosa. It compresses the deep dorsal vein of the penis and base of the cavernosa to aid in erection. I call this part the bulbocavernosus muscle (while others prefer the term ischiocavernosus) (Fig. 34.2). To go to the dorsal part of the urethra for dorsal onlay oral mucosa graft urethroplasty, this part of the muscle needs to be incised. In so doing, the incision of the ventral muscle can be avoided.

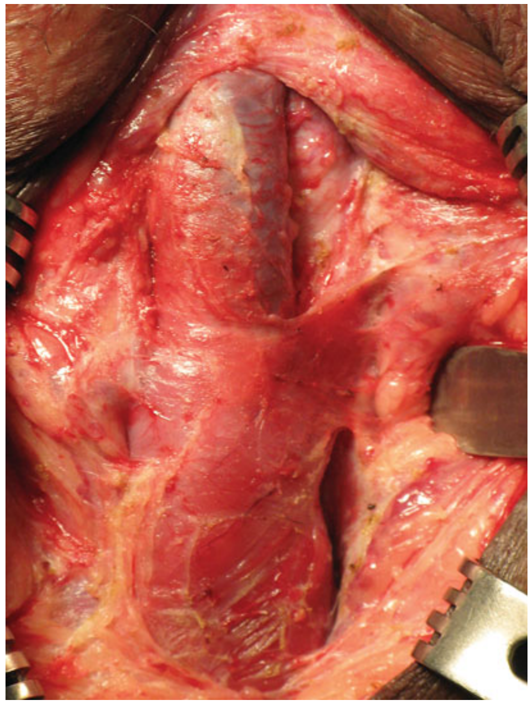

Fig. 34.1 Bulbospongiosus muscle

Nerve Supply

The main nerve supply to the male genitalia comes from the pudendal nerve. The nerve divides into three branches: dorsal nerve of penis, inferior rectal nerve, and the perineal nerve. The perineal nerve innervates the structures in the pelvic floor. The bulbospongiosus and ischiocavernosus muscles derive its motor supply from the perineal nerve.

Yang and Bradley in their study highlighted the role of the perineal nerve in bulbospongiosus muscle contraction [2] (Fig. 34.3). They suggested that ejaculatory disturbances may arise due to interruption of one or more reflex pathways providing innervations to bulbospongiosus muscle. These disorders manifest as decreased force of semen expulsion and possible urine and semen sequestration in the bulbar urethra. Yucel and Baskin suggested that perineal nerves inner-

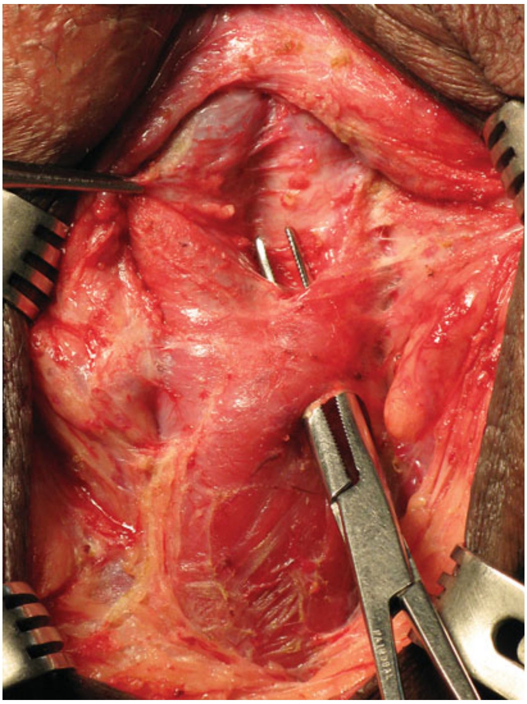

Fig. 34.2 Bulbocavernosus muscle elevated by hemostat

vate the bulbospongiosus [3]. It sends fine branches which penetrate corpora spongiosa (Fig. 34.4). As per the anatomy of nerves that is suggested, these nerve fibers are injured during incising the bulbospongiosus muscle while gaining access to the bulbar urethra (Fig. 34.5). The perineal nerve can also be damaged during retraction of the incised muscle and during dissection of the central tendon of the perineum, near its emergence from the ischiorectal fossa, when the muscle is incised completely. The fine branches to the corpora spongiosa may also be damaged. Resuturing of the muscle in the midline does not necessarily return muscle function to baseline as there is still damage to the nerve fibers. Ejaculatory disorders may result from disruption of one or more of the reflex pathways providing innervation of the bulbospongiosus muscle. These disorders may manifest as decreased force of semen expulsion and low semen volume caused by inefficient bulbospongiosus contractility. Hence, the need for muscle- and nerve-preserving urethroplasty was developed in order to minimize morbidity in terms of ejaculatory function, expulsion of terminal urine, and possibly rigidity of erection.

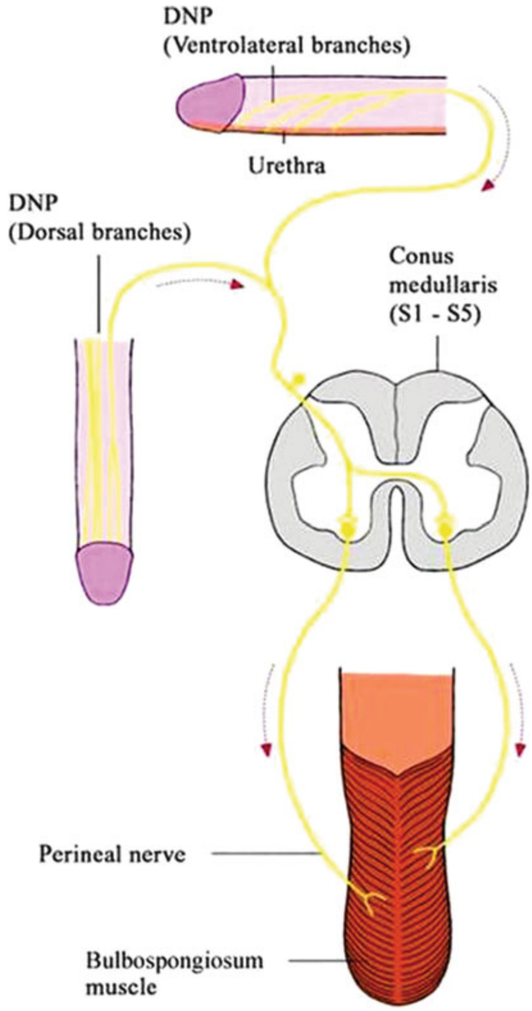

Fig. 34.3 Bulbospongiosus muscle contractions are elicited by stimulation of the dorsal nerve of the penis and following stimulation of the perineal nerve. Rhythmic contractions of the bulbospongiosus muscle help expel semen and urine from the urethra (Image courtesy Claire Yang)

Barbagli et al. first described the muscle- and nerve-sparing ventral and dorsal onlay bulbar urethroplasty in 2008 [4]. In their study of 12 patients who underwent muscle- and nerve-sparing urethroplasty, none had postoperative urinary dribbling or ejaculatory dysfunction. Kulkarni and Barbagli later combined their experience and first published the dorsal onlay, one-sided dissection of the urethra, muscle- and

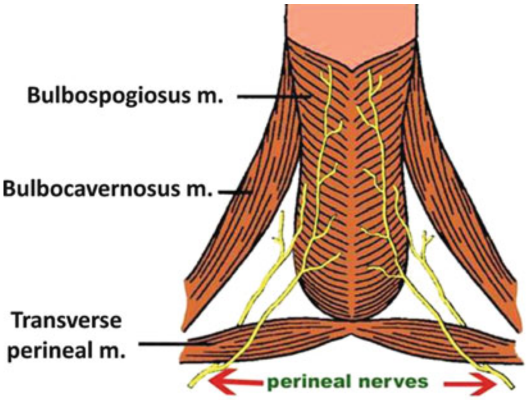

Fig. 34.4 Perineal nerves innervate the bulbospongiosus muscle and have fine branches that penetrate the corpus spongiosum (Image courtesy G. Barbagli)

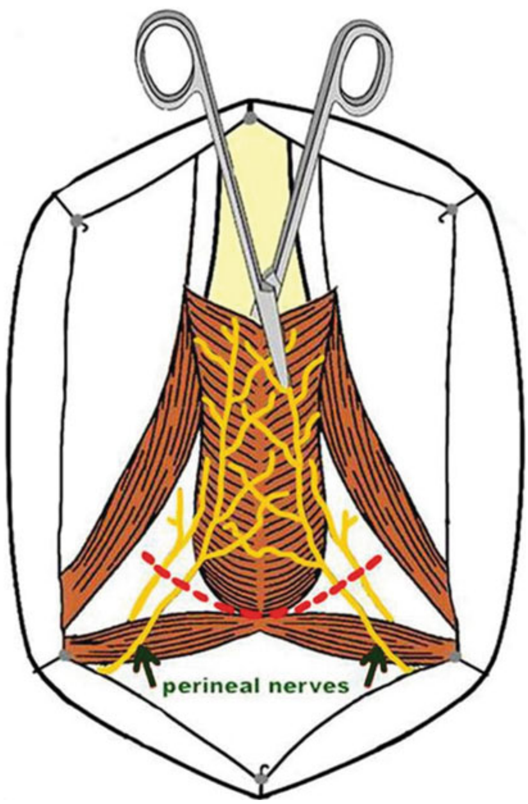

Fig. 34.5 Perineal nerve anatomy. These nerve fibers can be injured during incision of the bulbospongiosus muscle while gaining access to the bulbar urethra (Image courtesy G Barbagli)

nerve-preserving buccal mucosa graft urethroplasty for bulbar, and pan-urethral strictures through a perineal incision [5].

The key steps for one-sided dissection of the urethra are as follows:

Ventral Onlay Muscle and Nerve-Sparing Bulbar Urethroplasty

A 6 French endoscope is used to assess the stricture. Dilute methylene blue is injected in the urethra. A midline perineal incision is made. The bulbospongiosus muscle is identified. The upper margin of the bulbospongiosus muscle is identified (Fig. 34.6).

Sharp dissection is performed to separate the bulbospongiosus muscle from the corpora spongiosa and bulbar urethra. Small right-angle retractors are used to retract the muscle down (Fig. 34.7). Stay sutures with 4-0 polyglactin are also used to retract the muscle.

The stricture is identified after passing a 16 Fr catheter into the urethra. The bulbar urethra is incised ventrally over the catheter distal to the stricture. The urethra is opened ventrally proximally into the normal urethra through the stricture. The width of urethral plate is then assessed. A nasal speculum is a useful instrument to assess the proximal extent of the urethra (Fig. 34.8). Alternatively, one can use Debakey atraumatic forceps as a urethral retractor inside the urethra (Fig. 34.9).

The buccal mucosa graft (BMG) is trimmed and sutured as a ventral onlay graft. Suturing of the BMG to the urethra is performed on one side with 4-0 polygalactin (Fig. 34.10). A 14 French silicone Foley catheter is inserted into the urethra. The other side of suturing is then completed (Fig. 34.11). Once the graft is sutured to the urethral plate, the overlying spongiosa is closed with continuous suture. Each of these sutures takes a small bite of the graft on its backside to prevent graft protrusion into the urethral lumen. The bulbospongiosus muscle is pulled back into the normal position (Fig. 34.12). At times, additional sutures are needed in the upper margin of the muscle to tack it to the corpora spongiosa. The wound is then closed in layers, typically without drain.

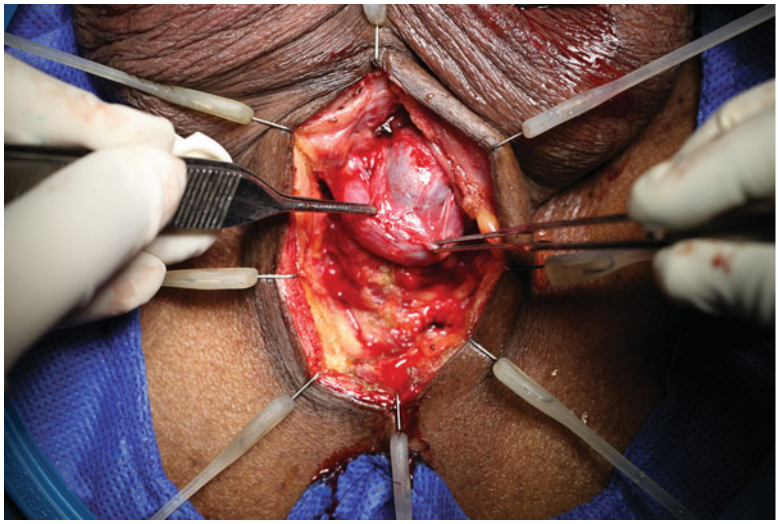

Fig. 34.6 Upper edge of bulbospongiosus muscle

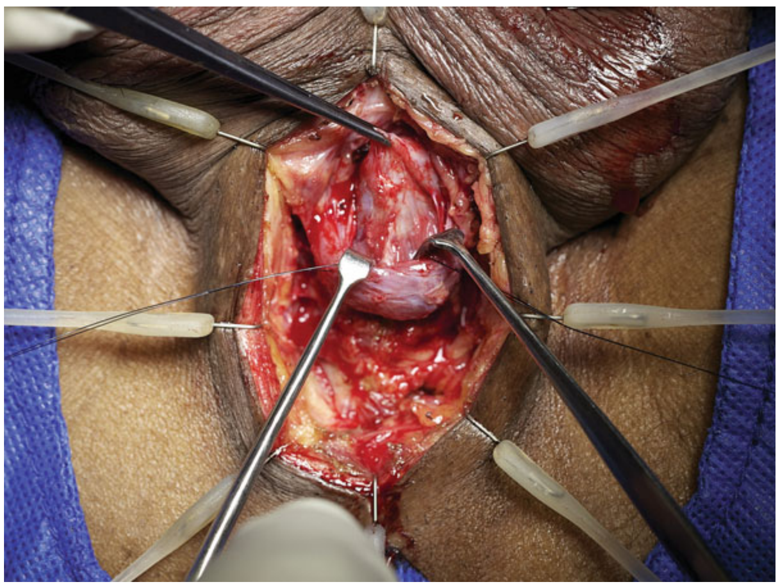

Fig. 34.7 Retraction of bulbospongiosus muscle

Dorsal Onlay Muscle and Nerve-Sparing Bulbar Urethroplasty

A 6 French endoscope is used to assess the stricture. Dilute Methylene blue is injected in the urethra. A midline perineal incision is made. The bulbospongiosus muscle is identified.

Dissection is performed between the bulbospongiosus muscle and the corpora cavernosa on one side. We prefer using the left-sided dissection (patient's left side, surgeon's right side). Thus, the muscle is spared and there is no need to incise the bulbospongiosus muscle and the central tendon of the perineum. Once the corpora are identified, the urethra is dissected on one side from the corpora. One important landmark here is the distal one-third of the bulbospongiosus muscle on to the corpora cavernosa – what we would like to actually call as bulbocavernosus muscle. This needs to be incised to gain an access to the dorsal aspect of the urethra.

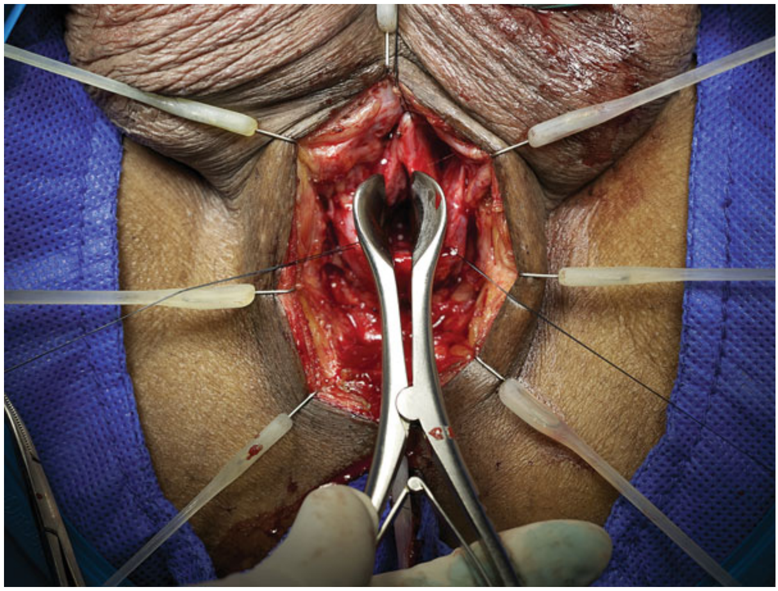

Fig. 34.8 Use of nasal speculum to visualize proximal normal bulbar urethra

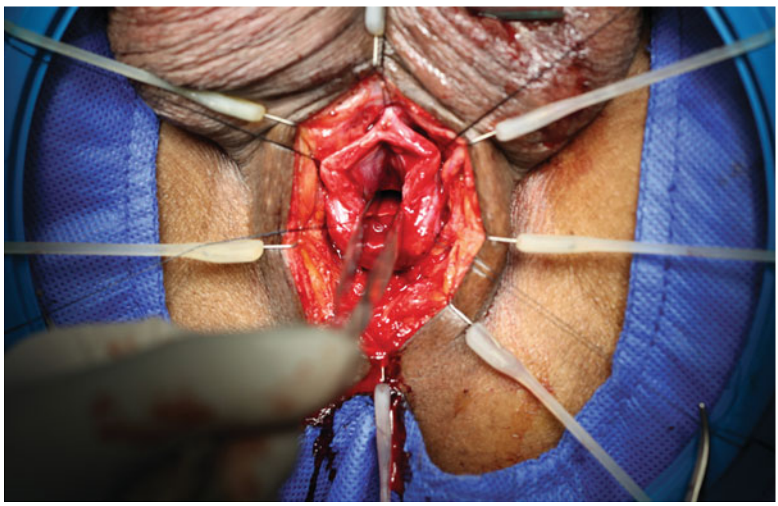

Fig. 34.9 Use of Debakeys atraumatic forceps to visualize proximal normal bulbar urethra

The urethra is rotated 180° to expose the dorsal surface (Fig. 34.13). The urethra is incised and stricture identified. The urethra is incised proximally and distally into the normal urethra (Fig. 34.14). The oral mucosa graft is spread and fixed as a dorsal onlay graft. Suturing is performed on one side with 4-0 polygalactin. Quilting sutures are taken between the graft and corpora cavernosa to prevent serous fluid collection below the graft. A 14 French silicone Foley catheter is inserted into the urethra. The other side of suturing between BMG and urethra is then completed. The bulbospongiosus muscle is derotated back in position. Few stitches are taken to bring together the incised fibers of bulbocavernosus muscle. The wound is closed in layers usually without a drain.

One-Sided Dissection, Dorsal Onlay Muscle-, Nerve- and Vascular-Sparing Urethroplasty for Pan-urethral Strictures

Initial steps are the same as in dorsal onlay graft urethroplasty as in bulbar urethroplasty.

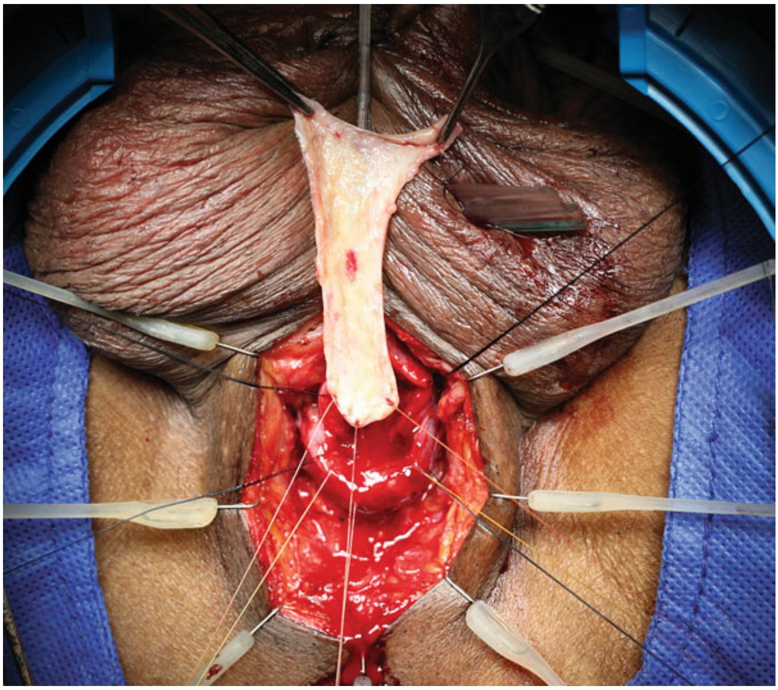

Fig. 34.10 Application of buccal mucosa graft ventrally. Sutures tied simultaneously and graft parachuted in place

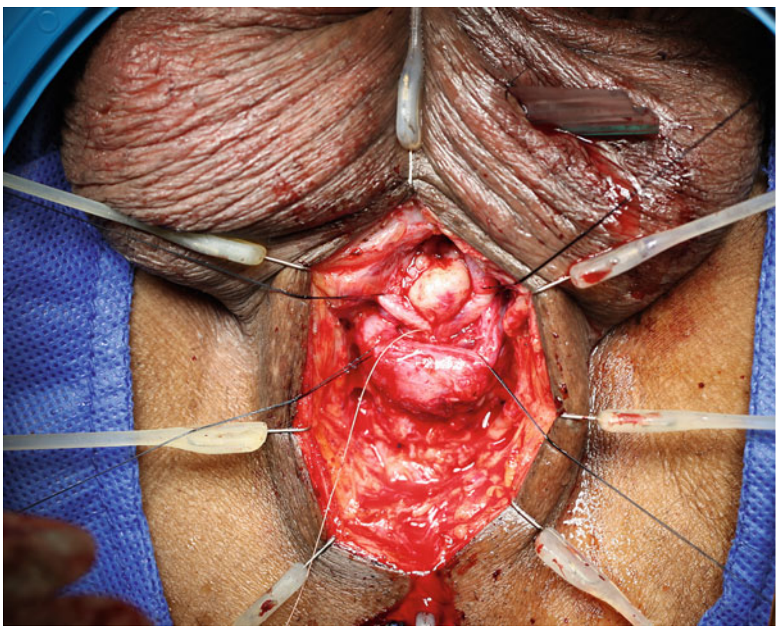

Fig. 34.11 Completed suturing of buccal mucosa graft ventrally

The penis is invaginated into the perineum. The whole anterior of urethra is now identified as a single unit. The dissection is carried out on one side of the urethra between spongiosa and cavernosa, while the other side is intact. This preserves the blood and nerve supply to the urethra and corpora spongiosa (Figs. 34.15 and 34.16). The urethra is rotated 180° to expose the dorsal surface. A dorsal meatotomy is performed through the glans urethra. First the BMG is sutured to the dorsal edge of the meatus by three sutures. The BMG is then pushed into the urethral lumen. The penis is reinvaginated and the BMG is pulled down and applied from the coronal sulcus to the penile region, quilted on to the corpora. A second

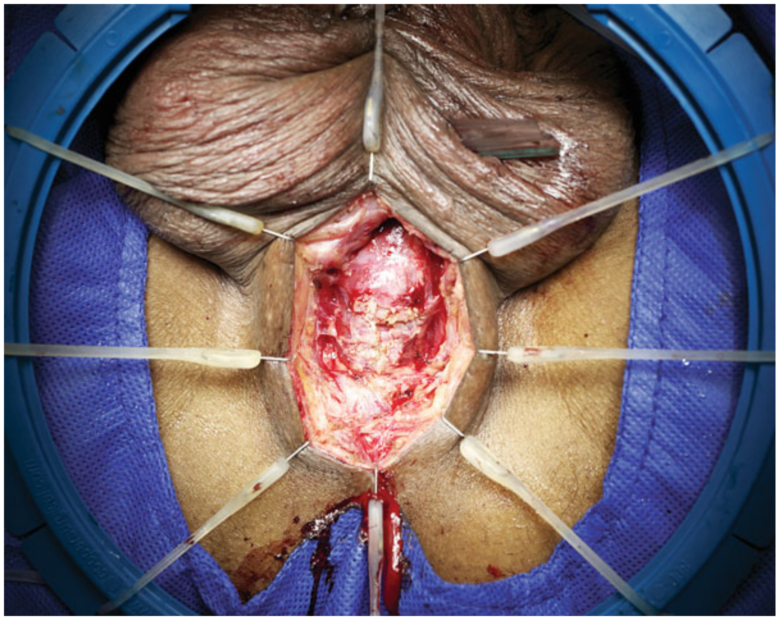

Fig. 34.12 Bulbospongiosus reverted back to its normal anatomical position

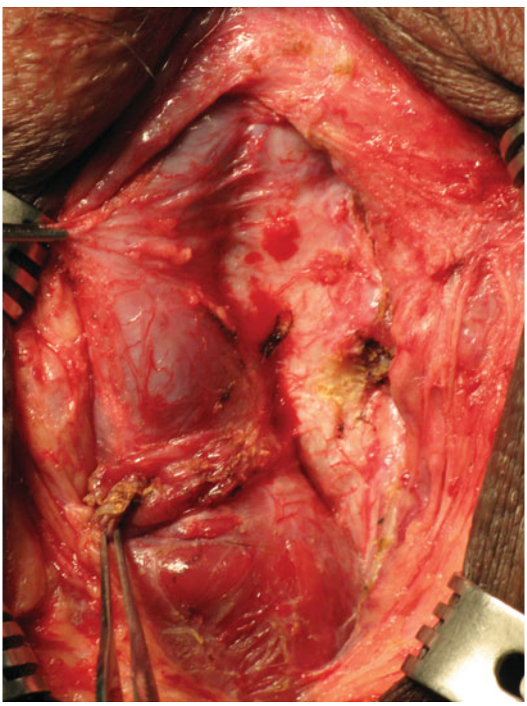

Fig. 34.13 Urethra rotated to expose the dorsal surface

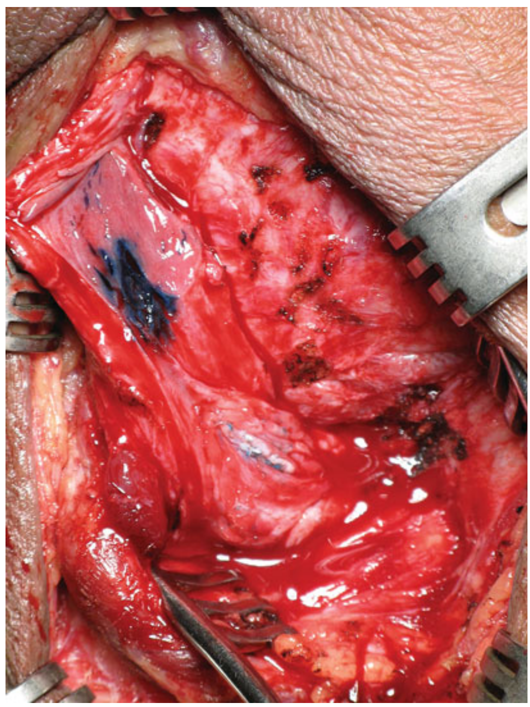

Fig. 34.14 Urethra incised dorsally

graft is applied opposite the bulbar urethra. Rarely a third graft is necessary and is usually harvested from the lingual mucosa. Margins of the oral mucosa graft are sutured to the urethra. A 14 French silicone Foley catheter is placed. The penis is brought back to its normal anatomical position. The bulbospongiosus muscle is also allowed to revert back into its normal position. The incised fibers of bulbocavernosus muscle are then sutured together. The wound is closed in multiple layers. This procedure is an example of muscle-, nerve-, as well as vessel-sparing urethroplasty.

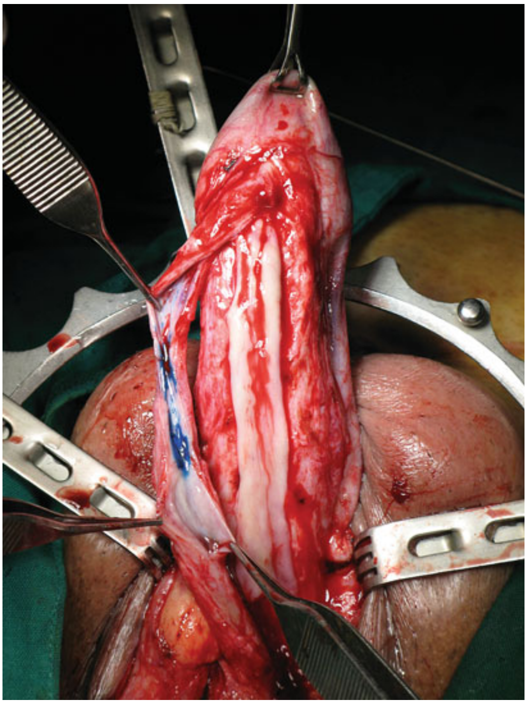

Fig. 34.15 Old technique where the urethra was mobilized circumferentially, potentially compromising the vascular supply

Vessel-Preserving Urethroplasty

In 2007, Gerry Jordan introduced a novel concept of not transecting the bulbar arteries for short proximal bulbar urethral strictures. Whenever one transects the proximal bulbar urethra for anastomotic urethroplasty, the bulbar arteries are often transected. The distal bulbar urethra acts then as an advancement flap, based on retrograde blood supply through the glans and penile urethra. This retrograde flow may be inadequate in patients with hypospadias and those with arteriogenic erectile dysfunction. With prostate cancer reaching epidemic levels, more and more patients suffer from post prostatectomy urinary incontinence and intrinsic sphincter deficiency, thus requiring more artificial urinary sphincters (AUS). With the preservation of the bulbar arteries, there is a reduced risk for ischemic urethral erosion after the placement of an AUS.

For a short proximal bulbar urethral stricture, the bulbar urethra is mobilized from the cavernosa (Fig. 34.17). Both the bulbar arteries are preserved. The urethra is opened distally and dorsally. The urethrotomy is continued proximally through the stricture until a normal caliber urethra is encountered. The urethral stricture is excised without transecting the corpora spongiosa. Ten to twelve anastomotic sutures are placed (Fig. 34.18). The sutures are tied after inserting 14 Fr silicone Foley catheter. Although

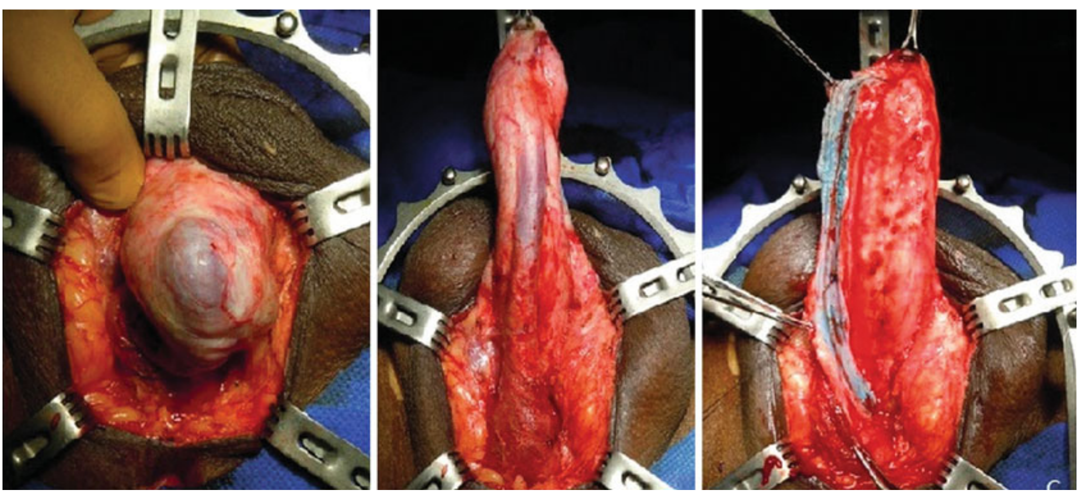

Fig. 34.16 Penile invagination, one-sided dissection, and incision of urethra dorsally. Note penis is on stretch

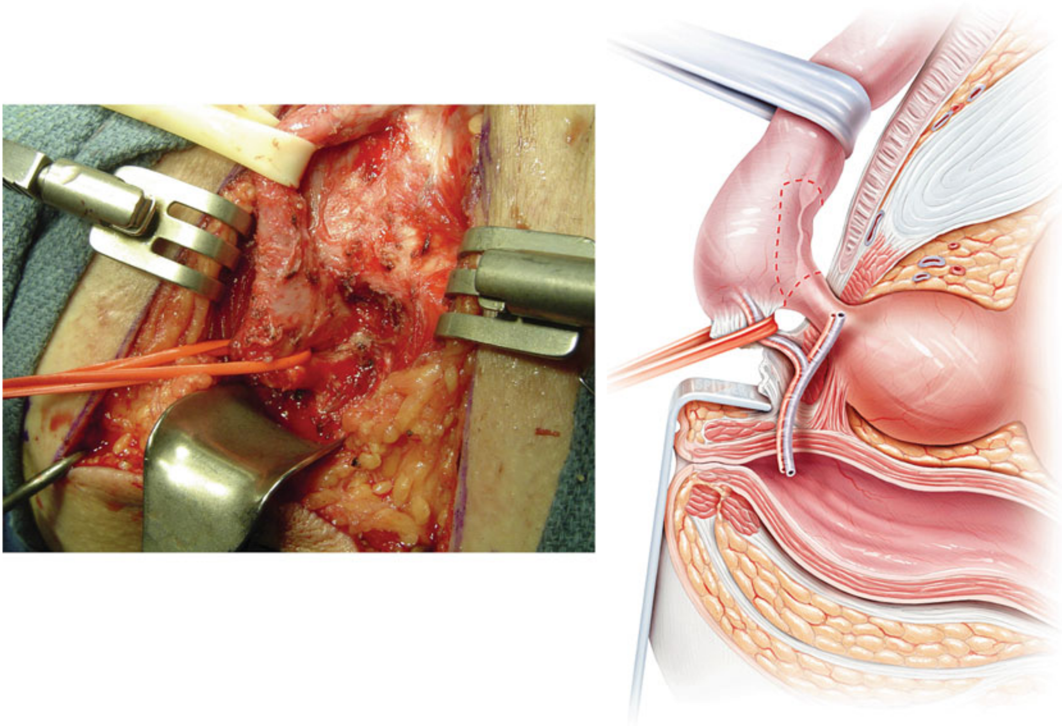

Fig. 34.17 Vessel-sparing anastomotic urethroplasty

this technique was used initially for bulbar urethral strictures, it can also be used for short traumatic stenosis following pelvic fracture-associated urethral injury. Thankfully, membranous urethral strictures following treatments like HIFU and radiation are rare. Vessel sparing can be of value here, since severe incontinence often occurs after such urethroplasty, and will require an artificial sphincter in a delayed fashion.

Conclusion

It is time to salute the era of minimal invasive surgery, so as to reduce morbidity and help maintain quality of life. Muscle-, nerve-, and vessel-sparing urethroplasties are a step in this direction. Long-term follow-up is needed, so as to ascertain the usefulness of these techniques.

Surgical Pearls and Pitfalls

Key Intraoperative Surgical Points

- Use diathermy as minimal as possible.
- Handle the urethra and spongiosa with great respect.
- Use stay sutures for retraction.

Ventral Onlay BMG

- Start dissection distal to the bulbospongiosus muscle between the muscle and the urethra.
- Create a space between the muscle and urethra proximally by retracting the muscle downward with stay sutures and small retractors.
- On one side, suture the BMG to the urethral mucosa. After catheter insertion, suture the other side of the BMG to the corpora spongiosa and not to the urethral mucosa.
- Closure of the spongiosa is performed by taking bites of the back of the BMG each time, to quilt the BMG to the spongiosa.

Dorsal Onlay BMG

- Start dissection proximally on the left side of the patient for a right-handed surgeon between the bulbospongiosus muscle and left corpora cavernosa.

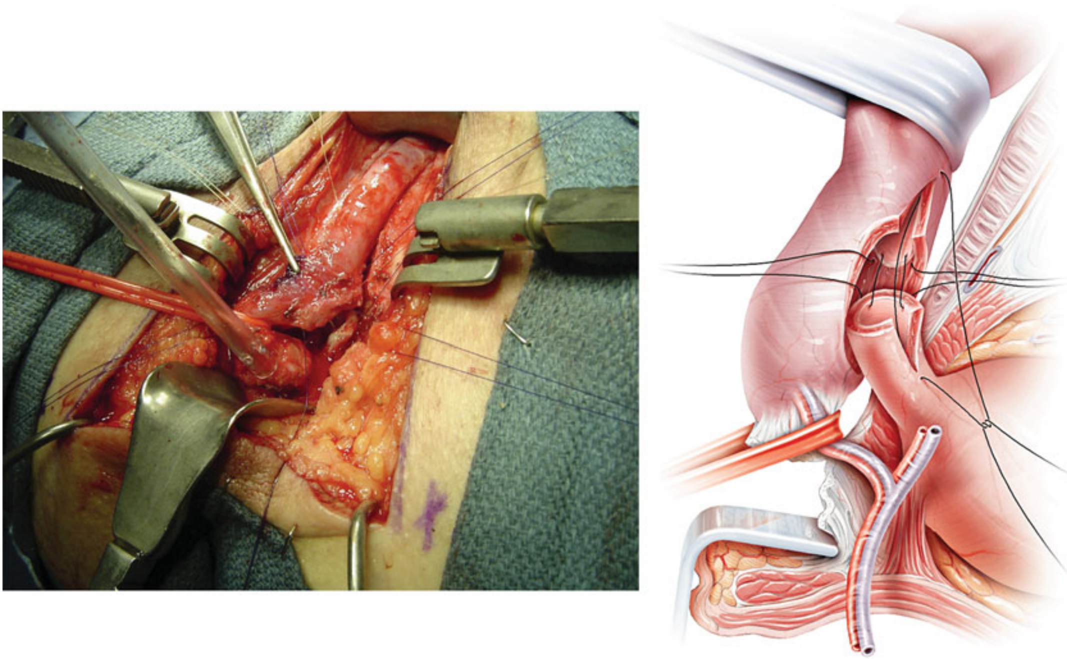

Fig. 34.18 Vessel-sparing anastomotic urethroplasty. Note interrupted sutures

- Incise the bulbocavernous part of the muscle laterally to approach the urethra dorsally.
- Dissect across the midline, to expose the right corpora cavernosa.
- The circumflex vessels that one has to coagulate on the left side are preserved on the right side while dissecting the urethra by the one-sided dissection.
- After BMG suturing, reapproximate the bulbocavernosus muscle in the midline with two to three interrupted sutures.

Pan-urethral Stricture Repair

- Invaginate the penis into the perineum and keep it on stretch.
- Dissect the urethra off the cavernosa (on one side) up to the coronal sulcus.
- Open the urethra dorsally at 12 o'clock.

Preferred Surgical Instruments of SB Kulkarni

- 6 Fr ureteroscope to assess the urethra intraoperatively
- Methylene Blue intraurethral instillation before incision
- Turner Warwick retractor with six blades
- Scott retractor with elastic hooks
- Debakey forceps for intraurethral insertion and retraction
- Jarit fine scissors for sharp dissection
- Fine needle holders
- ENT suction – three sizes
- Fine mosquito forceps 12
- 14 Fr silicone Foley catheter

Preferred Suture

- 4-0 polyglactin (Vicryl number 2,443 in India) 70 cm long on a 3/8 circle-cutting needle for urethra
- 5-0 clear monofilament absorbable suture (Monocryl) for continuous quilting of dorsal BMG

Editorial Comment

The morbidity of urethroplasty is underreported, underrecognized, and underrepresented in the published literature. Such morbidities of urethroplasty are stress urinary incontinence, post void dribbling, erectile dysfunction, ejaculatory sequestration and dysfunction, climaturia, glans sensation impairment, and so on. Most studies only address surgical outcomes as to success versus failure as to an open urethra, as to voiding function, such as flow rate, post void residual, and AUA SS. Urethroplasty is quality of life surgery – and not life or death. So the aim of urethroplasty is to improve quality of life. Fixing voiding function but causing erectile dysfunction or glans sensation issues does not really improve overall quality of life. In fact, such morbidities worsen it, in the scheme of things.

We need randomized and prospective studies in reconstructive urology, to better assess the potential morbidities of urethroplasty. First we need to know the incidence of the problems and then we can work on eliminating them. One-sided dissection, not splitting the bulbospongiosus, penis invagination, avoiding penile incisions, and vessel sparing are all steps in the right direction. Another method to reduce morbidity is better patient selection. In other words, I typically avoid anastomotic urethroplasty unless the etiology is traumatic or the lumen is obliterated or near obliterated. Instead I prefer grafting, which has less of a chance for causing erectile, ejaculatory, or sensory dysfunction. In this era of robotic surgery and ever increasing minimally invasiveness of surgery, we need to do a better job with urethroplasty.

—Steven B. Brandes

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35 Primary and Secondary Reconstruction of the Neophallus Urethra

Miroslav L. Djordjevic

Summary

Neophalloplasty is one of the most difficult surgical procedures in genital reconstructive surgery. It is indicated in men where the penis is missing due to either congenital or acquired reasons, as well in women with gender dysphoria. Many different tissues have been applied such as local vascularized flaps or microvascular free transfer grafts. The main goal of the neophalloplasty is to construct the functional and cosmetically acceptable penis. Urethral reconstruction in neophalloplasty presents a great challenge for surgeons who manage genital reconstruction. Different flaps (penile skin, scrotal skin, abdominal skin, labial skin, vaginal flaps, etc.) or grafts (skin, bladder, buccal mucosa) have been suggested for urethral lengthening. Although serious complications were reported in the past, new techniques and modifications for primary and secondary neophallus urethroplasty seem to be safe in experienced hands.

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Introduction

Many different surgical techniques for neophallic reconstruction have been reported using either available local vascularized tissue or microvascular tissue transfer. However, none of them satisfy all the goals of modern penile construction, i.e., reproducibility, tactile and erogenous sensation, a competent neourethra with a meatus at the top of the neophallus, large size that enables safe insertion of penile implants, satisfactory cosmetic appearance with hairless and normally colored skin. Normal penis has some unique characteristics and restoring its psychosexual function in both the flaccid and erectile state, and the possibility of sexual intercourse with full erogenous sensations, is almost impossible. The indications for neophalloplasty were initially limited to trauma victims who required surgery to restore their male anatomy. Today, surgical indications are expanded to many other disorders such as penile agenesis, micropenis, disorder of sexual development (intersex conditions), failed epispadias or hypospadias repair, penile cancer, as well female transsexuals.

Bogoras first described phallic reconstruction in 1936 [1]. Neophalloplasty options have followed the advances made in genital reconstructive surgery. Usually, it was a complex, time-consuming, multistage procedure with variable and suboptimal results. The development of microsurgical techniques was followed in phallic reconstruction, and

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Chang completed the first microvascular transfer of radial forearm free flap [2], which today represents the gold standard of this procedure. Other techniques have been also described, but none of them presents the ideal solution with low complication rate. Perovic [3] reported phalloplasty in 24 patients using the extended island groin flap. Senzeger et al. [4] suggested total phallic reconstruction using sensate osteocutaneous free fibula flap with promising results in 18 cases. Bettocchi et al. [5] recommended pedicled pubic phalloplasty in gender dysphoria patients as acceptable solution without disfiguring the donor skin site. Based on favorable experimental and clinical experiences [6], we started to use the musculocutaneous latissimus dorsi flap for total phalloplasty [7, 8]. Due to its workable size, ease to identification, long neurovascular pedicle, and minimal functional loss after removal, the latissimus dorsi flap has been used for a variety of reconstructions.

Since congenital defects constitute one of the indications for neophalloplasty, questions arise about age for reconstruction as well size of the neophallus and neophallic growth during puberty. There are only few data about this surgery in children. Gilbert et al. were the first to describe phallic reconstruction in boys without functioning penis [9]. We recommended this surgery before puberty to ensure optimal psychosexual development. Performing genital reconstruction in this period is important to minimize any psychological impact of this surgery. Since genitals have an important role in creating body image and, without any doubt, determine future mental image, we assumed that phalloplasty with normal-looking external genitalia and physical appearance before the delicate period of puberty is of utmost importance in order to prevent psychological stress related to genital inadequacy. Furthermore, it provides a good basis for stable masculine identity in adolescence and adulthood [7].

Possible disadvantages in children inspired us to find another option for neophalloplasty. It was for this reason that we started to use musculocutaneous latissimus dorsi flap for neophallic reconstruction. It has provided excellent length and circumference, follows somatic growth patterns, and is not influenced by pubescent hormonal effects that make them suitable for all of phalloplasty indications. Phallic retraction with muscle-based grafts seems less likely to occur than with use of fasciocutaneous forearm flap, since denervated well-vascularized muscle is less prone than connective tissue to contract.

Techniques of Phalloplasty

The most widely used flap for total neophalloplasty is the radial forearm flap [2]. However, it has many drawbacks, e.g., an unsightly donor site scar, very frequent urethral complications, and small-sized penis that does not allow the safe insertion of penile prosthesis in majority of cases. This was the main reason that we developed new technique using the musculocutaneous latissimus dorsi free transfer flap, which mostly satisfies the requirements noted above. It has a reliable and suitable anatomy to meet the esthetic and functional needs for phallic reconstruction. It can be also used successfully in children [7].

Radial Forearm Free Flap Phalloplasty

In the classic surgical procedure, three surgical teams operate at the same time: (1) the vascular surgeon prepares recipient blood vessels, (2) the urologist is operating in perineal area and prepares recipient site for neophallus, and (3) the plastic/genital surgeon is dissecting the free vascularized flap of the forearm for tubularization and creation of the neophallus. Neophallus is transferred to the pubic area and fixed at the proper position (Figs. 35.1 and 35.2). The radial artery is miscrosurgically connected to the common femoral artery in an end-to-side fashion. The venous anastomosis is performed between cephalic vein and the greater saphenous vein. One forearm nerve is connected to the ilioinguinal nerve for tactile sensation, and another nerve is anastomosed to the dorsal clitoral nerve for erogenous sensation. The defect of the donor area is covered either by full-thickness or split-thickness skin grafts [10–13].

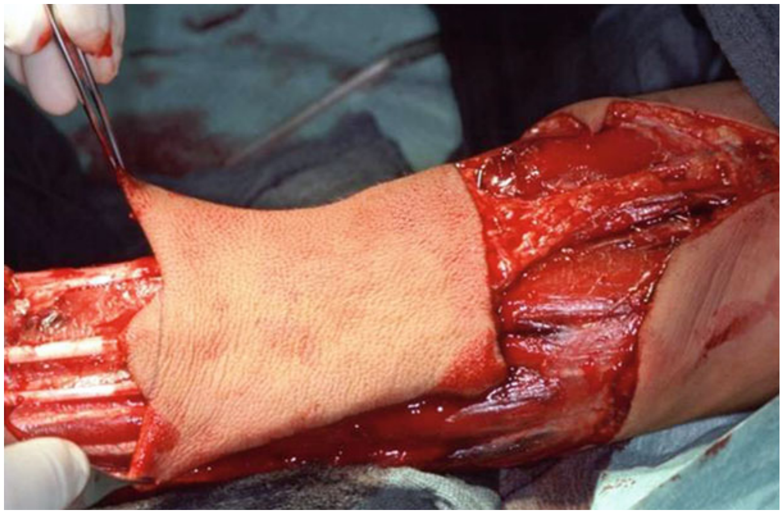

Fig. 35.1 Harvesting of the radial forearm free flap

Fig. 35.2 Appearance at the end of phalloplasty and microvascular transfer of the forearm free flap

Musculocutaneous Latissimus Dorsi Free Flap Phalloplasty

A latissimus dorsi musculocutaneous flap of the nondominant side is designed and harvested with thoracodorsal artery, vein, and nerve. The surface of the flap is templated in two parts: (1) a rectangular part for neophallic shaft to be approx. 15 × 14 cm and (2) additional circular or semilunar component for glans reconstruction (Fig. 35.3). The flap is completely elevated except for the neurovascular bundle, which was not transected until the recipient vessels and nerve had been prepared for microanastomosis. The neophallus is created while the flap is still perfusing on its vascular pedicle; the flap is tubularized in the midline and the neoglans formed by folding over and approximating to the penile shaft. The new constructed phallus is detached from the axilla after clamping dividing neurovascular pedicle with aim to achieve maximal pedicle length. The donor site defect is closed by direct skin approximation. If the impossible, remaining donor site defect is grafted with split-thickness skin graft. Simultaneously, another team dissects the recipient area together with femoral artery, saphenous vein, and ilioinguinal nerve. Additional "Y" incision is made in the pubic area, and a wide tunnel is created to place the flap pedicle. The neophallus is transferred to

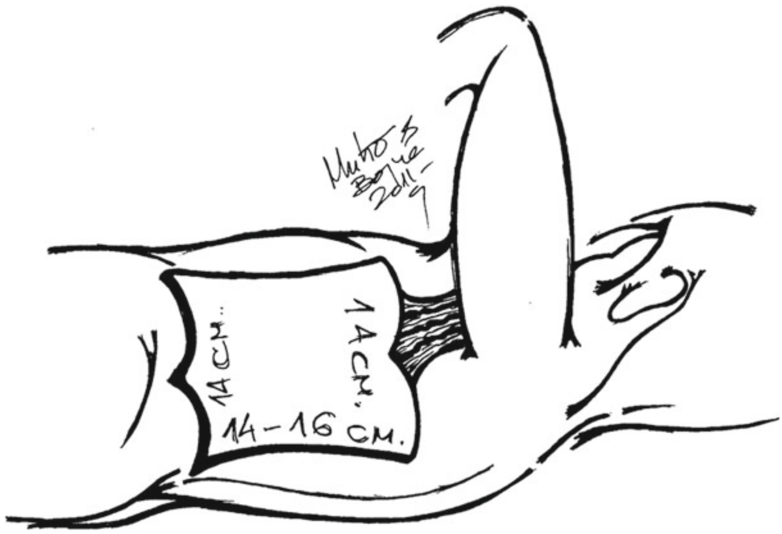

Fig. 35.3 Design of the musculocutaneous latissimus dorsi flap

the recipient area, and microsurgical anastomoses are created between thoracodorsal and femoral artery, thoracodorsal and saphenous vein, and thoracodorsal and ilioinguinal nerve. Specially constructed dressing is used to keep the neophallus in an elevated position for approximately 2 weeks [7, 8].

Urethral Reconstruction

Construction of the neourethra in neophalloplasty is necessary to achieve the goal of voiding while standing. In men, it remains a complex problem, particularly in patients who have had previous penile amputation due to tumor or trauma and patients with micropenis or who have undergone gender reassignment. Many different techniques currently in use recreate the urethra but are prone to recurrent complications and fail to achieve voiding with a good stream when standing. Primary reconstruction of the neophallic urethra depends on indication for phalloplasty. Generally, there are some principles on how to create neophalloplasty urethra. It is possible to make in first stage, using a "tube-in-a-tube" technique, or to perform staged urethroplasty. Additionally, the urethral part of the neophallus should be lengthened and tubed more to bridge the gap between the neourethra and normal urethra.

Tube-in-a-Tube Technique

This principle is described in radial forearm flap phalloplasty, modified by Chang [2] and Gilbert [9], and in groin flap phalloplasty described by Perovic [3]. It includes design of additional part of the flap that will be tubularized over the 18 Fr catheter and insert into the new created phallus. The urine is diverted by means of a suprapubic tune, and 14 Fr Foley catheter is left in place in the newly formed urethra. This way, urethra inside the neophallus is created by a tube-in-a-tube technique and is anastomosed to the native urethral stump when applicable (Fig. 35.4). In opposite, additional tissue is necessary to bridge the gap between neophallic and native urethra. Transurethral catheter is left for 2 weeks. After that, the patient is started with voiding (Fig. 35.5). Suprapubic catheter is removed once the patient is able to void without significant residual volume.

Urethral Reconstruction with Radial Forearm Free Flap

This technique is based on original forearm free flap and reserved for cases after penile amputation or who have undergone gender reasignment [14]. Because all patients required a subtotal urethra reconstruction extending from the perineum

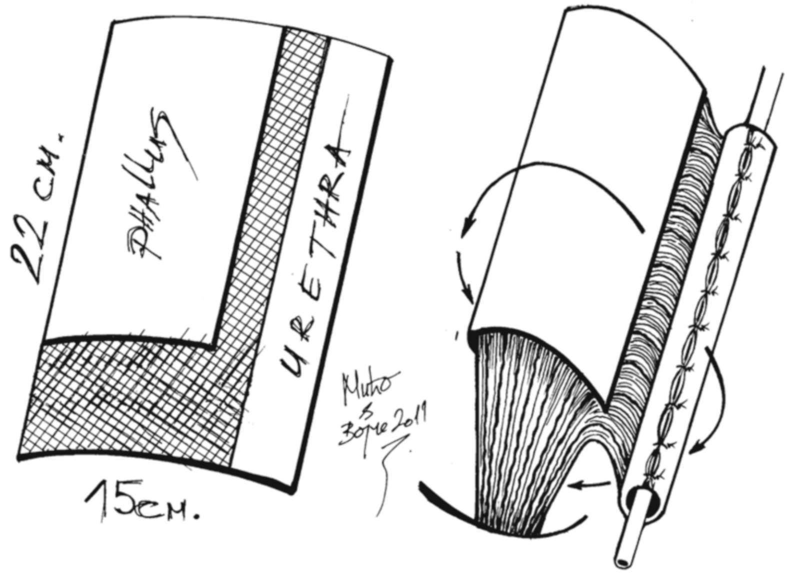

Fig. 35.4 A tube-in-a-tube technique for reconstruction of neophallus urethra

Fig. 35.5 Outcome after total phalloplasty and urethral lengthening. Normal voiding while standing is achieved

area to the tip of the glans, a neourethra length up to 22 cm should be planned. A radial fasciocutaneous free flap is raised on the non-hair-bearing part of the forearm. The flap is tubed in situ to form a neourethra. The fascia is sutured separately around the neourethra to provide additional "waterproofing" layer. Penile stump is prepared ensuring that an adequate tunnel was created for insertion of the tubularized urethra while avoiding compression of the flap. The base of the neourethra is placed proximally to anastomose with the native urethral stump. Microsurgical anastomosis is done between donor and recipient blood vessels.

The principle of using radial forearm free flap is potentially applicable but should be used only in a very selected cases in whom the initial phalloplasty has failed with regard to urethroplasty or penile size and in men who do not desire a later penile prosthesis implantation.

Staged Neophallic Urethroplasty

This is the most promising technique for the reconstruction of the neophallus urethra and based on two-staged procedure. This principle introduced by Johanson [15] in the 1950s is still in use today, directly or indirectly. The first stage includes creation of the new "urethral plate" using buccal mucosa graft. The use of buccal mucosa graft that was first described seven decades ago has been the gold standard for urethral reconstruction. It is tough, elastic, simple to harvest, and easy to handle and leaves no noticeable scar at the donor site. It is also attractive when there may be a paucity of available genital skin, such as after multiple failed urethral reconstructions. Using the Johanson principle, buccal mucosa graft presents the optimal option in staged urethroplasty [16].

The principles of the harvesting and transfer are the same as described previously. Buccal mucosa grafts (either pairs or single, depending on the width and length of neourethra needed) are placed on the ventral side of the penis. When the healed grafts are ready for final stage tubularization and closure, it is important to incise the underlying tissue that will support the neourethra and avoid ischemia at the neourethral suture line. It is recommended to create second layer from surrounding tissue to cover and support the new created urethra. The key for successful repair is waiting long enough until the skin is supple. The classic mistake is to perform second stage too early. Second stage should be performed when the "urethral plate" has matured enough to be supple and thus more easily mobilized for a tubularization. If it is necessary, additional buccal mucosa grafts can be used for urethral plate augmentation and easier tubularization (Fig. 35.6).

Neophalloplasty with Urethroplasty in Female-to-Male Transsexual

Creation of the neophallus is one of the most difficult parts in the treatment of female-to-male transsexuals. Although a variety of surgical techniques are available, their results are not similarly acceptable to all patients. Metoidioplasty represents a technique for creating a neophallus from hormonally hypertrophied clitoris in female-to-male transsexuals who do not wish to have sexual intercourse [17–19]. In patients who desire a larger phallus, already described techniques of phalloplasty can also be used. Urethral reconstruction presents the main problem in this type of sex reassignment surgery and includes creation a very long neourethra, since the native urethral meatus in females is positioned too far from the tip of the glans.

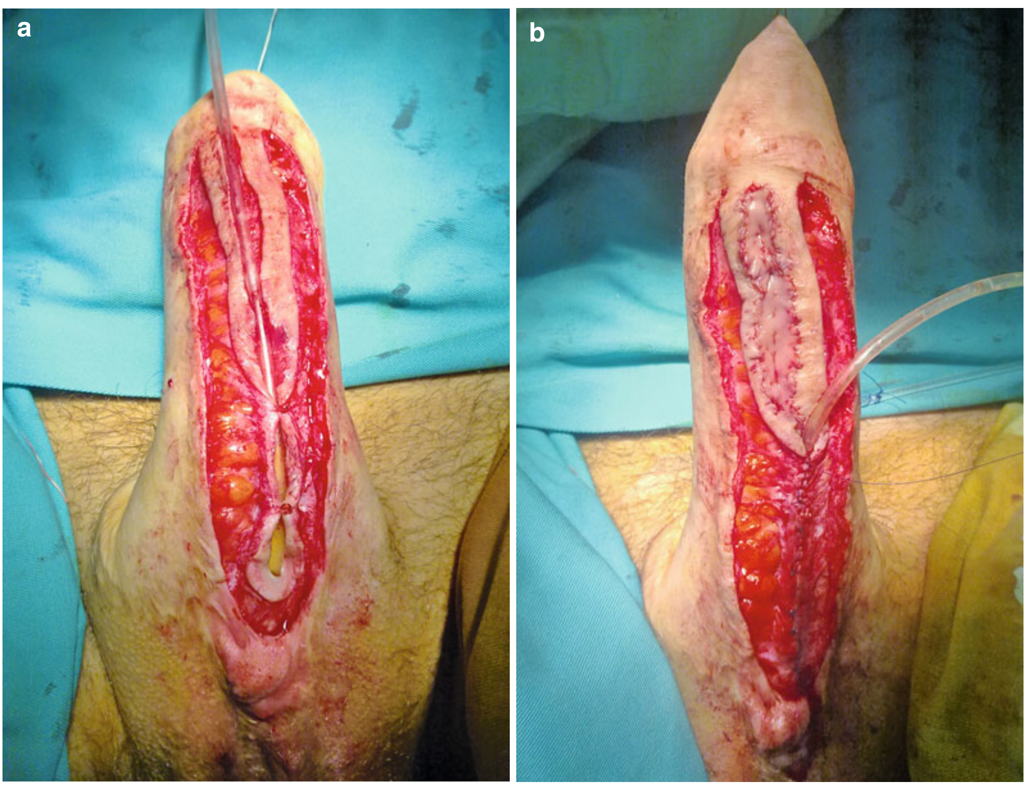

Fig. 35.6 Reconstruction of neophallus urethra: (**a**) Urethral plate is dissected from the penile skin. (**b**) Distal part is incised in the midline, and additional buccal mucosa graft is interposed for its augmentation. (**c**) Tubularization of the phallic urethral plate is done. (**d**) Final appearance after urethral reconstruction and glanuloplasty

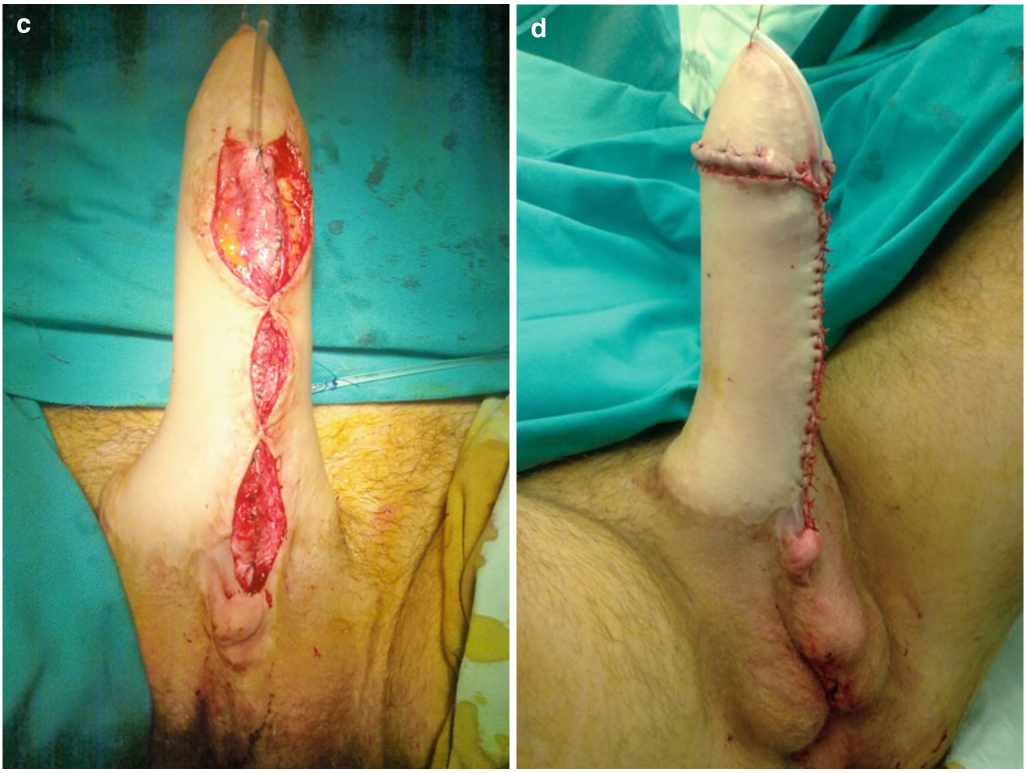

Fig. 35.6 (continued)

Lengthening of the native urethra presents a great challenge, especially first part that should be the bridge between native meatus and neophallic urethra.

Urethral Reconstruction in Metoidioplasty

The operative technique starts with straightening and lengthening of the hormonally enlarged clitoris (Fig. 35.7a). Fundiform and suspensory clitoral ligaments are detached from the pubic bone to advance the clitoris. Ventrally, short urethral plate is dissected from the clitoral bodies and divided at the level of glanular corona to correct the ventral curvature. Reconstruction of the neourethra starts with reconstruction of its bulbar part. A vaginal flap is harvested from the anterior vaginal wall with the base close to the female urethral meatus. This flap is joined with the remaining part of the divided urethral plate forming the bulbar part of the neourethra (Fig. 35.7b). Additional urethral lengthening was done using the buccal mucosa graft and vascularized labia minora flap. The buccal mucosa graft is always use to cover the gap after division of short urethral plate. The length of the graft depends on the distance between the tip of the glans and urethral meatus. The graft is fixed and quilted to the corporal bodies ventrally, completing the dorsal aspect of the urethra. The ventral part is created as an onlay flap from the labia minora. The inner surface of the one of the labia minora is dissected to create a flap with dimensions appropriate to cover dorsal part of the neourethra. Outer labial skin is de-epithelialized forming good vascularized and mobile flap. This flap is joined to the buccal mucosa graft by two lateral running sutures. The urethra was calibrated before closure to be not <18 F in diameter. A 14 F silicone tube is placed into the new urethra as a small

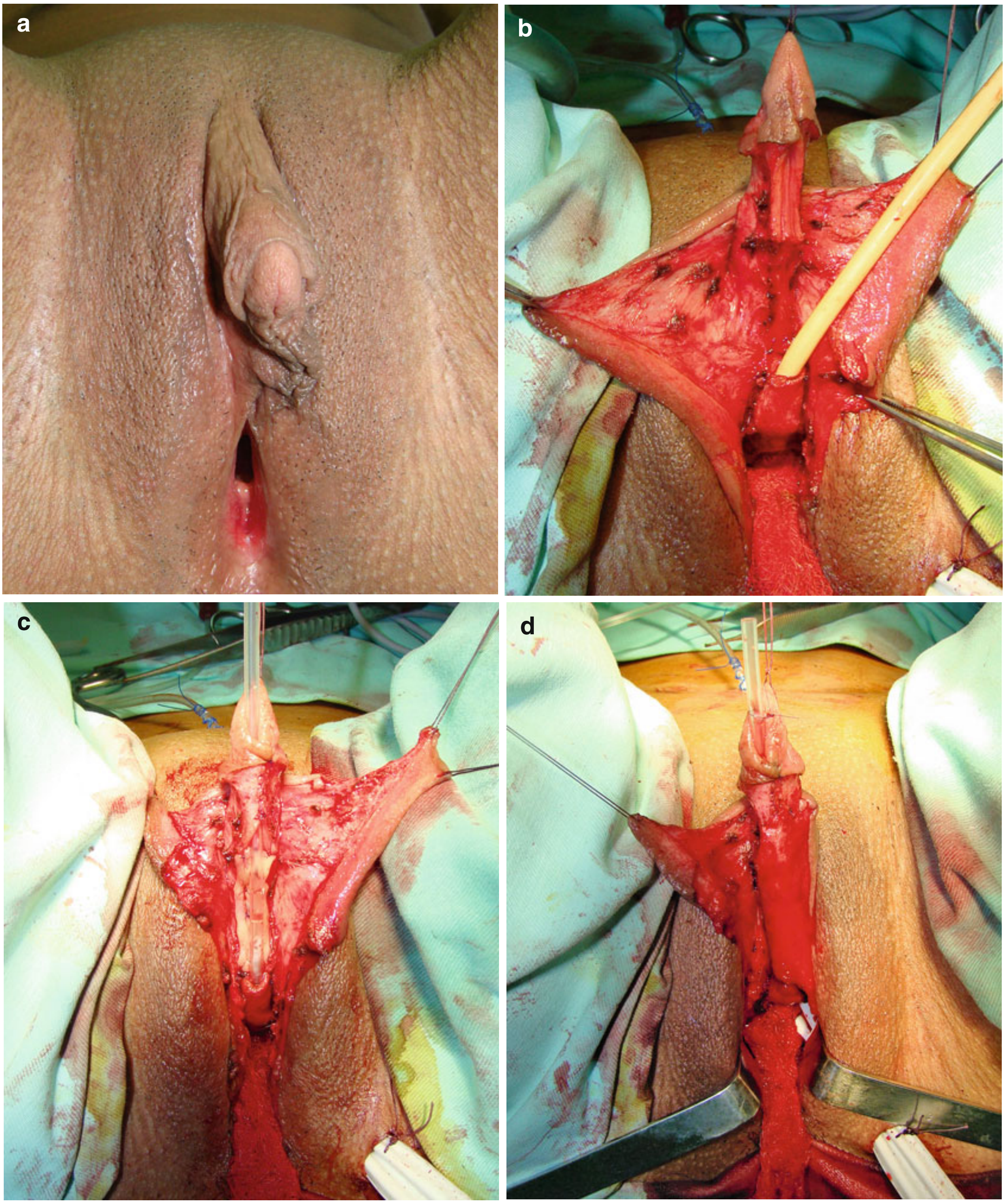

Fig. 35.7 Urethral reconstruction in metoidioplasty: (**a**) Preoperative appearance. Clitoris hormonally enlarged. (**b**) Bulbar part of new urethra created by joining anterior vaginal wall flap and proximal part of urethral plate. (**c**) Long flap designed at inner surface of labia minora to be harvested and mobilized by simple de-epithelialization of outer surface of labia minora. Buccal mucosa is placed on the ventral corpora cavernosa and quilted. (**d**) Labial flap anastomosed with buccal mucosa graft, creating neourethra. Abundant pedicle of the flap completely covering all suture lines. (**e**) Appearance at the end of surgery. Penile skin reconstruction performed using remaining clitoral and labial skin. Two testicular implants inserted into scrotum created from both labia majora. (**f**) Outcome 2 months later. Voiding while standing achieved

Fig. 35.7 (continued)

caliber stent to be used for buccal mucosa moisturizing and to maintain the urethral lumen (Fig. 35.7c, d). The glans is opened by two parallel incisions, and both glans wings are dissected extensively to enable glans approximation without tension after reconstruction of glandial urethra. Using this technique, the neourethra with the meatus placed at the tip of the glans is created. Covering of the penile shaft is achieved using the remaining clitoral and labial skin. Both labia majora are joined in the midline, and silicone testicular implants are inserted finalizing the scrotoplasty (Fig. 35.7e).

Postoperative care included elastic dressing around the penis in a stretched position. The buccal mucosa graft should be moistened with saline every 3 h, for the first 2 days following surgery to improve survival of the mucosa. Oral antibiotics and oxybutynin are administered to prevent postoperative infection and bladder irritation, respectively. Two weeks after surgery, antegrade urethrography was performed to exclude leaks, and the suprapubic catheter was removed (Fig. 35.7f).

Urethral Reconstruction in Total Phalloplasty

The principles of the reconstruction of the neophallus urethra are previously described. In female-to-male transsexuals gap between the neourethra and female urethral meatus is always more than 10 cm. The principle of the reconstruction is the same as in metoidioplasty. Recently, we started to use all available vascularized hairless tissue to lengthen the neourethra maximally preventing the postoperative complications. For this reason, both labia minora and available clitoral skin are used for urethral tubularization. This way, new urethral opening is placed in first half of neophallus, minimizing the requests for longer neophallus urethroplasty (Fig. 35.8).

Complications and Secondary Repair

Although the esthetic results of microsurgical phalloplasty have become quite satisfactory, the urethroplasty complication rate remains high.

Fig. 35.8 Urethral lengthening in latissimus dorsi phalloplasty. (**a**) Proximal urethra created using urethral plate and vaginal flap. Very long labia minora flap is dissected on well-vascularized pedicle. (**b**) Flap is tubularized giving the additional gain in urethral length. (**c**) Musculocutaneous latissimus dorsi flap is tubularized creating neophallus. (**d**) Appearance at the end of surgery. Neophallus is placed at the proper position. Microvascular anastomosis is done. New urethral orifice is located at the half of the neophallus. (**e**) Second stage. Penile prosthesis is inserted using dorsal approach. (**f**) Buccal mucosa graft is positioned in distal third of the neophallus, forming the new urethral plate. Glans is reconstructed by Norfolk technique

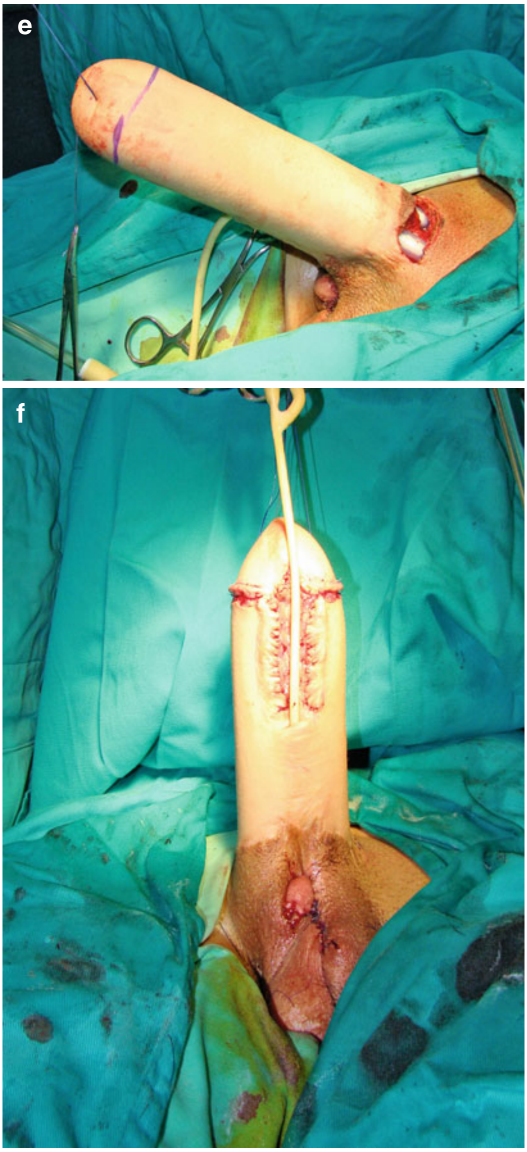

Fig. 35.8 (continued)

Complications are common after all phalloplasty surgery, and Zielinski [21], using a groin flap in 127 patients with gender dysphoria, reported urethral complications in 16 %. Rohrmann and Jakse [13] reported 58 % incidence of urethral complications in a series of 25 patients having a free radial forearm flap. Fang et al. [22] had a 41 % of fistula and 14 % stricture rate in 22 patients who underwent free radial osteocutaneous flap phalloplasty. In a review of 81 cases underwent radial forearm phalloplasty, Monstrey et al. [10] reported urethral complications in 42 %. The fistula usually formed at the junction of the native and neourethra at perineal region. In our group of 38 patients after metoidioplasty, only 3 fistulas occurred. Similar results were achieved in urethral lengthening in our total phalloplasty [7, 8, 20]. The key of success presents urethral reconstruction using good vascularized flaps.

Most of the urethral problems can be corrected with secondary procedures. It has been our experience that more than half of urethral fistulas and strictures are solved conservatively, while less than half complications need an additional surgical procedure. At least, there is still no ideal technique for phalloplasty resulting in excellent esthetic and functional outcomes. There are still problems with the neourethral reconstruction, but the incidence of complications has been reduced with new refinements of one-stage repair or by using a staged procedure.

Preferred Surgical Instruments of M Djordjevic

General Instruments

Weitlaner retractor 3×4 prongs sharp or blunt 6½″ (16.5 cm)
Ring retractor
Satinsky vascular clamp
John Hopkins Bulldog Clamp 2 1/4″ (5.7 cm)

Special Instruments

Metzenbaum scissors – Power Cut Black, 7″ (18 cm), curved
Ragnell undermining scissors, curved, 5″ (12.5 cm)
Kelly’s vascular scissors straight 6¼″ (16 cm)
Micro scissors, round handle, 5 1/2″ (14 cm), sharp straight
Adson tissue forceps 4.75″; 1×2 teeth tips
Castroviejo suture forceps tying platform, 1×2 angled teeth, 4″ (10.5 cm)
DeBakey-Adson tissue forceps, 1.5 mm, atraumatic tip, 4 3/4″ (12 cm)
Barraquer needle holder, micro jaw, 4 3/4″ (12 cm)
Sontec Mayo-Hegar needle holder, TC serrated, 5 1/2″ (14 cm)

Suture Material

6/0 and 7/0 Prolene (Polypropylene) suture, synthetic, nonabsorbable, monofilament

4/0, 5/0, 6/0 PDS (polydioxanone) suture or Monocryl (poliglecaprone 25) or Monosyn (glyconate) suture, synthetic, absorbable, monofilament

1, 0, 2/0, 3/0, 4/0 Vicryl (polyglactin 910) synthetic, absorbable suture, multifilament

3/0 and 4/0 Nylon suture, synthetic, nonabsorbable, monofilament

Surgical Pearls and Pitfalls

Key Surgical Points

Congenital/Acquired Penile Anomalies

- Penile remnants are carefully dissected.
- Corpora cavernosa stumps are used for insertion of penile prosthesis.
- Urethra is mobilized as much as possible to reach the base of the new created phallus.
- All vascularized hairless skin from genital region is used for urethral lengthening, as a fasciocutaneous flaps.
- Neophalloplasty is performed with good defined dimensions.
- Neophallic urethra is created with buccal mucosa or skin graft in staged procedure (Johanson principle).
- Subcutaneous vascularized flaps from the scrotal area are used for neourethral covering and fistula prevention.
- Urinary catheter and suprapubic tube are placed during surgery.

Female Transsexuals

- A flap from the anterior vaginal wall is created for bulbar urethral reconstruction.
- Vagina is closed in many layers to cover new created bulbar urethra.
- Both labia minora and dorsal clitoral skin are harvested with preserved blood supply to be used for urethral lengthening.
- Neophallus is placed just above the top of the labia majora creating good relationship between phallus and scrotums.
- Neophallic urethra is reconstructed as a stage procedure with buccal mucosa and skin grafts.

Potential Surgical Problems

- Multiple failed surgeries result in insufficient vascularized genital tissue that should be used for urethral lengthening: Manage with Staged urethroplasty with buccal mucosa graft.
- High recurrence of the urethral complications: Prolonged suprapubic urinary drainage (minimum 4 weeks) and postoperative dilation of the neourethra.

Editorial Comment

My surgical experience with neophalloplasty is mainly with repairing complications of urethral strictures. Strictures are typically at the meatus, mid-penile shaft, or at the anastomosis of the native urethral stump to the skin tube of the neophallus. The neophallus skin is fairly noncompliant and rigid and cannot be used as an onlay for reconstruction. Also, as the urethra is just a skin tube, there is no corpus spongiosum for spongioplasty to keep a graft alive. For that reason, I have managed neophallus strictures by a staged technique with a ventral urethrotomy as in a Johanson, and buccal grafts laid along side. I wait at least 6 months to a year and then tubularized the grafts and underlying tissue. If the skin of the neophallus is rigid, the skin edges cannot be mobilized to cover the tubed buccal graft – then I harvest a small split-thickness skin graft to cover and hold it in place with a bolster dressing. If the staged urethroplasty fails, I usually resort to a staged Cecil urethroplasty. Here I incise the scrotal or groin skin on three sides into the subcutaneous fat in rectangular shape to mirror the size of the urethral stricture. A ventral urethrotomy is made on the neophallus and then the penis is sewn to the groin or scrotum. After 3–6 weeks, the remaining skin edge is incised, and the skin freed up and transferred on to the penis. A small STSG is then placed on top. The harvest site from the groin or scrotum is primarily closed. For anastomotic stricture of the native and neourethra, urethrotomy typically fails and fails quickly. Because the neourethra strictures are so difficult to repair, I have a whole cadre of patients who are managed by urethrotomy or dilation and then daily intermittent self-catheterization. The other method that seems to work well is a ventral buccal graft. The always seems to be some subcutaneous tissue available for which can be laid over and quilted to the graft.

—Steven B. Brandes

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36 Tissue Engineering of the Urethra: The Basics, Current Concept, and the Future

Ryan P. Terlecki and Anthony Atala

Summary

Urethral reconstruction can be necessitated by congenital anomalies, infection, trauma, and cancer. In situations where the desired surgical outcome requires tissue substitution, choices have traditionally consisted of autografts of flaps and/or grafts, allografts of homologous or heterologous tissue, or synthetic materials. Unfortunately, however, these options have the potential for complications such as donor site morbidity, rejection, or suboptimal performance. Thus, there is a rationale to support development of "off-the-shelf" tissue substitutes that will allow simplified and durable restoration of urethral form and function.

Introduction

Conditions such as hypospadias, urethral stricture disease, and urethral loss often require the reconstructive urologist to be familiar with a variety of corrective strategies. Many of the techniques employed for definitive correction involve the use of tissue that lacks the structural and functional properties of native urethra and is often acquired with resultant donor morbidity. Tissue engineering holds great promise for improvements in this arena. This may involve unseeded matrices to provide a framework for the body to regenerate tissue in a desired area or cell-seeded matrices to overcome host limitations.

There are hundreds of published techniques for management of urethral strictures and hypospadias. This attests to the historical challenge of achieving optimal surgical outcomes for these conditions. Adult urethral strictures are often managed with internal urethrotomy, which has shown to be ineffective and detrimental to future attempts at definitive management [1]. While excision and primary anastomosis may offer significant rates of success, the application of this technique is restricted by length and location [2]. Substitution urethroplasty is often preferred for longer and distal defects. This may involve local flaps or grafts consisting of skin, buccal, lingual, bladder, or intestinal mucosa. Regardless of the source, graft harvest undoubtedly contributes to longer operating times as well as increased morbidity. Additionally, graft materials require competent vascularity in the recipient bed as tubularized grafts have had an unacceptably high failure rate [3, 4]. Recurrent strictures and those associated with lichen sclerosus et atrophicus may require a length of autograft in excess of what may be available and/or prudent. Similarly, children with hypospadias may have deficient penile skin for augmentation, as up to 35 % of them undergo newborn circumcision [5]. Such situations have further prompted the search for alternative materials.

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Engineered tissue for urethral reconstruction represents a promising alternative to current approaches of substitution. The principles of cell transplantation, materials science, and engineering are being employed to develop biological solutions to restore the anatomic and functional integrity of the urethra.

Cell Transplantation in Urethral Reconstruction

When cells are used for tissue engineering, donor tissue is dissociated into individual cells which are implanted directly into the host or expanded in culture, attached to a support matrix, and reimplanted after expansion. The implanted tissue can be heterologous, allogeneic, or autologous. Ideally, this approach might allow lost tissue function to be restored or replaced in toto and with limited complications [6]. The use of autologous cells would avoid rejection, wherein a biopsy of tissue is obtained from the host, the cells dissociated and expanded in vitro, reattached to a matrix, and implanted into the same host [6–20].

One of the initial limitations of applying cell-based tissue engineering techniques to urologic organs had been the previously encountered inherent difficulty of growing genitourinary associated cells in large quantities. In the past, it was believed that urothelial cells had a natural senescence which was hard to overcome. Normal urothelial cells could be grown in the laboratory setting but with limited expansion. Several protocols were developed over the last two decades which improved urothelial growth and expansion [12, 21–23]. A system of urothelial cell harvest was developed that does not use any enzymes or serum and has a large expansion potential. Using these methods of cell culture, it is possible to expand a urothelial strain from a single specimen which initially covers a surface area of 1 cm^2 to one covering a surface area of 4,202 m^2 (the equivalent area of one football field) within 8 weeks [12]. These studies indicated that it should 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. Normal human genitourinary epithelial and muscle cells can be efficiently harvested from surgical material, extensively expanded in culture, and their differentiation characteristics, growth requirements, and other biological properties studied [12, 15, 22–30].

Biomaterials for Urethral Reconstruction

Following tissue injury, the body can initiate cell ingrowth from the wound edges in order to cover the defect. The cells from the edges of native tissue are able to traverse short distances without any detrimental effects, and thus, smaller wounds can heal well. However, if the wound is large (more than a few millimeters in distance or depth), the body's regenerative response to injury can be overwhelmed, and an inflammatory response can take over in order to seal the wound. When this occurs, increased collagen deposition, fibrosis, and scar formation ensue. In the urethra, these processes ultimately manifest as a stricture.

Various strategies have been employed to promote the healing process while impeding scarring. Although some have used direct injection of cell suspensions to promote tissue development, it is difficult to control localization without an associated matrix [31, 32]. In fact, the majority of mammalian cell types are anchorage-dependent and will die if not provided with a cell-adhesion substrate. Thus, injections of cell suspension are limited as a viable strategy for improving wound healing.

Attempts to mimic the body's own tissue scaffold, the extracellular matrix (ECM), to assist with the regenerative process have proved much more successful. ECM provides the stage for cells to form tissue with a defined form and function [33]. The ECM consists mostly of collagen but also contains elastin, proteoglycans, and glycosaminoglycans (GAGs). Biomaterials are used as surrogates for ECM in the field of tissue engineering. They can facilitate localization and delivery of cells and/or bioactive factors (e.g., cell-adhesion peptides and growth factors) to desired anatomic sites and provide a three-dimensional platform to guide tissue development while providing support against in vivo forces [34]. Furthermore, biomaterial-based matrices implanted in wound beds can greatly increase the distances that cells can traverse without initiating an adverse fibrotic response.

Selection

The design and selection of the biomaterial is critical in the development of engineered urethral tissues. It must be capable of controlling the structure and function of the engineered urethral tissue in a predesigned manner by interacting with transplanted cells or host cells. Generally, the ideal biomaterial should be biocompatible, promote cellular interaction and tissue development, and possess proper mechanical and physical properties.

The selected biomaterial should be biodegradable and bioresorbable to support the reconstruction of normal urethral tissue without inflammation. Such behavior of the biomaterials would avoid the risk of inflammatory or foreign body responses which may be associated with the permanent presence of a foreign material in the body. The degradation products should not provoke inflammation or toxicity, and they must be removed from the body via metabolic pathways. The degradation rate and the concentration of degradation products in the tissues surrounding the implant must be at tolerable levels [35].

The biomaterials should possess appropriate mechanical properties to regenerate tissues with predefined sizes and shapes. The biomaterials provide temporary mechanical support sufficient to withstand in vivo forces exerted by the surrounding tissue and maintain a potential space for tissue development. The mechanical support of the biomaterials should be maintained until the engineered tissue has sufficient mechanical integrity to support itself [6]. This can be potentially achieved by an appropriate choice of mechanical and degradative properties of the biomaterials [34].

The biomaterials must be processed into specific configurations. A large surface area to volume ratio is often desirable to allow the delivery of a high density of cells. High porosity, interconnected pore structure, and specific pore sizes promote tissue ingrowth from the surrounding host tissue. Several techniques have been developed which readily control porosity, pore size, and pore structure.

Classes

Generally, two classes of biomaterials have been used for engineering of urethral tissues. The first, acellular tissue matrices, has been created from tissues such as bladder submucosa, small intestine submucosa (SIS), corpus spongiosum, amnion, aorta, and dermis [36–43]. The second class of biomaterials used in urethral tissue engineering is the synthetic polymers, such as polyglycolic acid (PGA), polylactic acid (PLA), and poly(lactic-co-glycolic acid) (PLGA). These classes of biomaterials have been tested in regard to their biocompatibility with primary human urothelial and bladder muscle cells [31]. Naturally derived materials and acellular tissue matrices have the potential advantage of biologic recognition, while synthetic polymers can be reproducibly manufactured on a large scale with controlled properties of strength, degradation rate, and microstructure.

Acellular Matrices

Acellular tissue matrices are collagen-rich and prepared by removing cellular components from tissues. The matrices often are prepared by mechanical and chemical manipulation of a segment of bladder tissue [44, 45]. The matrices slowly degrade upon implantation and are replaced and remodeled by ECM proteins synthesized and secreted by transplanted or ingrowing cells. Acellular tissue matrices have proven to support cell ingrowth and regeneration of genitourinary tissues, including urethra and bladder, with no evidence of immunogenic rejection [21, 36]. Because the structure of the proteins (e.g., collagen and elastin) in acellular matrices is well conserved and normally arranged, the mechanical properties of the acellular matrices are not significantly different from those of native bladder submucosa [46]. Additionally, these scaffolds retain other ECM features such as growth factors, GAGs, and glycoproteins, which are important for normal tissue regeneration [47]. More recently, these matrices have been seeded with a wide variety of cells, such as foreskin epidermal cells, oral keratinocyte cells, and urine-derived stem cells [48–51].

Nevertheless, collagen-based matrices also have some inherent disadvantages. First, although these constructs undergo a rigorous decellularization process, any retained cellular elements can stimulate an immunologic response that can lead to inflammation, fibrosis, and ultimately stricture formation. Second, the density of the collagen matrix, which is optimal for urothelial cell attachment and growth on the mucosal side of a tubular construct for urethral replacement, can result in impaired muscle cell penetration on the serosal side. Additionally, there is inherent variability present in each group of matrices [51].

Synthetic Polymers

Polyesters of naturally occurring α-hydroxy acids, including PGA, PLA, and PLGA, are widely used in tissue engineering. These polymers have gained approval from the Food and Drug Administration for human use in a variety of applications, including sutures [52]. The degradation products of all three compounds are nontoxic, natural metabolites that are eventually eliminated from the body in the form of carbon dioxide and water [52]. Because these polymers are thermoplastics, they can easily be formed into a three-dimensional scaffold with a desired microstructure, gross shape, and specific dimensions using various techniques. To achieve the goal of having a scaffold with high porosity and a high ratio of surface area to volume, they are processed into configurations of fiber meshes and porous sponges.

The main drawback of the synthetic polymers is lack of biologic recognition. As an attempt to incorporate cell recognition domains into these materials, copolymers with amino acids have been synthesized [53–55]. Other biodegradable synthetic polymers, including poly(anhydrides) and poly(ortho-esters), can also be used to fabricate scaffolds for genitourinary regenerative medicine with controlled properties [56].

Studies of several biomaterials, both natural [i.e., bladder submucosa, small intestinal submucosa, collagen, and alginate] and polymeric [i.e., poly(glycolic acid), poly(L-lactic acid), poly(lactic-co-glycolic acid), and silicone], found that most did not induce significant cytotoxic effects and cells grown on these materials exhibited normal metabolic function and cell growth in vitro [31, 43]. In other work, Feng and colleagues compared the biomechanical properties of bladder submucosa, SIS, acellular corpus spongiosum matrix (ACSM), and PGA to rabbit urethra [38]. All the substances tested had similar Young's modulus and stress at break values compared to the control rabbit urethra tissue, with ACSM having the highest of these.

Guided Regeneration

Various strategies have been proposed over the years for the regeneration of urethral tissue. Woven meshes of PGA (Dexon) were used to reconstruct urethras in dogs. Three to four centimeters of the ventral half of the urethral circumference and its adjacent corpus spongiosum was excised, and the polymer mesh was sutured to the defective area. After 2 weeks, the animals were able to void through the neourethra. At 2 months, the urothelium was completely regenerated. The polymer meshes were completely absorbed after 3 months. No complications occurred. However, the excised corpus spongiosum did not regenerate [57].

PGA has been also used as a cell transplantation vehicle to engineer tubular urothelium in vivo. Cultured urothelial cells were seeded onto tubular PGA scaffolds and implanted into athymic mice. At 20 and 30 days, polymer degradation was evident, and tubular urothelium formed in which cells were stained for a urothelium-associated cytokeratin [11].

PGA mesh tubes coated with polyhydroxybutyric acid (PHB) were used to reconstruct urethras in dogs. PHB is a biodegradable thermoplastic polymer produced microbially and degrades by both hydrolysis and enzyme reaction. The hydrolyzed product, 3-hydroxybutyric acid, is a natural metabolite that is contained in human blood [58]. Eight to twelve months after reconstruction, complete regeneration of urothelium and adjacent connective tissue occurred. All of the polymers disappeared after 1 year, and there were no anastomotic strictures or inflammatory reactions [45].

Finally, while synthetic materials lack certain components of natural ECM that serve as signals and anchors for overlying cells, some of these, including collagen type I and collagen type IV, can be reliably adsorbed onto certain manufactured scaffolds [59]. Recent work has demonstrated that successful urethral repairs can be performed with cell-seeded PGA/PLGA scaffolds in the pediatric population [60].

Urethral Reconstruction with Acellular Matrices

Homologous free grafts of acellular urethral matrix have demonstrated excellent incorporation in a rabbit model [44]. While all tissue components were seen in the graft after 3 months, the smooth muscle was less developed and less well oriented than native tissue. Bladder-derived acellular collagen matrix has also been extensively studied for urethral reconstruction. When applied as a ventral onlay in a rabbit model, results at 6 months showed a complete urothelial layer, normal-appearing muscle fibers, and no evidence of fibrosis [36]. Following this, Atala and colleagues used human-derived bladder acellular collagen matrix to repair urethral defects in males aged 4–20 with a history of failed hypospadias reconstruction [20]. This was done by ventral onlay of segments ranging in size from 5 to 15 cm (Fig. 36.1). At 3-year follow-up, three of the four patients had a successful outcome in regard to cosmetic appearance and function (Figs. 36.2 and 36.3). The patient receiving the longest graft (15 cm) developed a subglandular fistula [20].

Fig. 36.1 Collagen matrix is rehydrated in a saline solution and trimmed to size at the time of surgical repair

Fig. 36.2 Urethrogram of a patient 1 year after hypospadias repair shows a normal caliber urethra

Similar results were obtained in patients with urethral stricture disease [10]. Twenty-eight adults with a diagnosis of anterior urethral stricture from multiple causes underwent urethral reconstruction using collagen-based inert matrix derived from human cadaveric bladder. The procedure was performed in the same manner as the previous study, with the neourethras ranging from 1.5 to 16 cm. At 4 months postoperatively normal-appearing urethral tissues were noted in 24 patients (85 %), which included all the patients

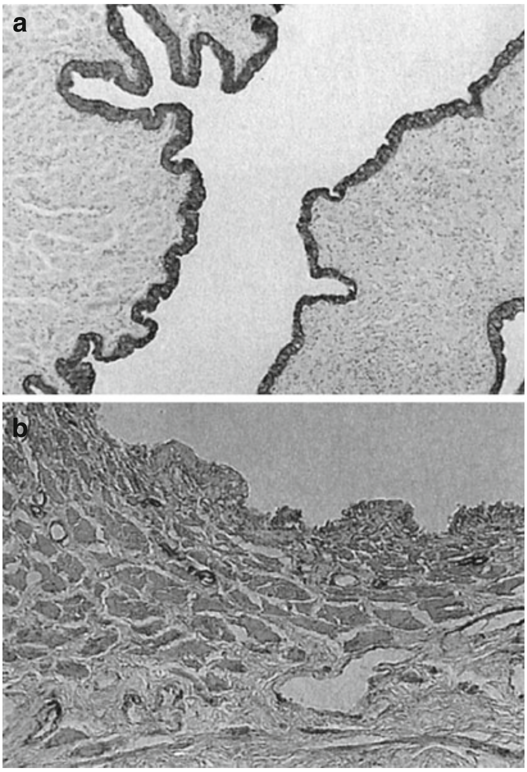

Fig. 36.3 Immunocytochemical analyses of neourethras show (**a**) normal urothelial layers staining positive for pan-cytokeratin antibodies AE1/AE3 and (**b**) normal-appearing muscle bundles which stain positively for α-actin antibodies

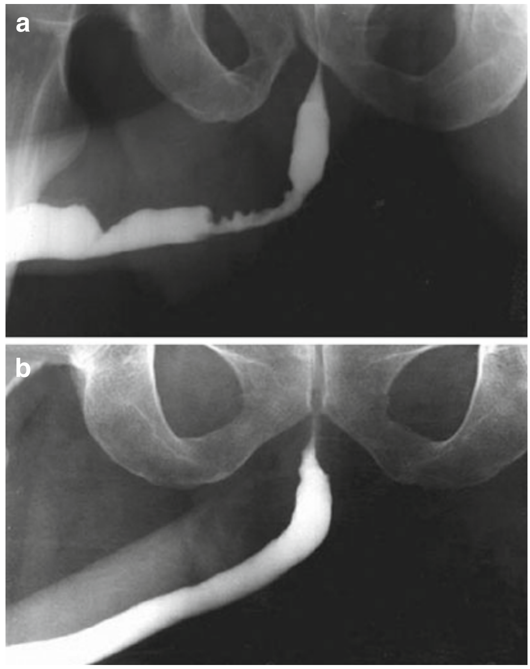

Fig. 36.4 Representative case of urethral stricture: (**a**) preoperative urethrogram and (**b**) urethrogram 6 months after repair

with only bulbar strictures. The remainder of patients demonstrated minimal strictures, including 75 % (3 of 4) of those who originally had penile and bulbar strictures and 33.3 % (1 of 3) who had penile stricture only.

Matrix materials for urethroplasty have not been limited to genitourinary sources, as seen in the case of SIS. This material has been tested in both animals and humans. In rabbits, SIS has been successfully utilized as an onlay patch graft for urethroplasty, demonstrating better characteristics when compared to full-thickness preputial skin [22]. Comparable results have been obtained utilizing SIS as the collagen scaffold in humans. One study involving 50 male patients treated with SIS in an onlay fashion for anterior strictures demonstrated higher failure rates in penile strictures (44.4 %) versus bulbopenile (16.1 %) or bulbar (10 %) strictures (length of defect ranged from 4 to 14 cm) [61]. The total success rate was 80 % (40 out of 50 patients). In another work, Palminteri and colleagues looked at 20 adult men with anterior strictures and performed urethroplasty using a dorsal inlay technique in the vast majority of cases [37]. They achieved 85 % success, noting failures in penile and penobulbar stricture repairs (mean successful and unsuccessful stricture lengths were 2.6 and 5.7 cm, respectively).

Adequate spongiosum may be crucial to the regenerative capacity of the graft in that it may function as a robust blood reservoir for the regenerating tissue, and its scarcity in the pendulous urethra, along with any concurrent ischemic fibrosis, may make that portion of the urethra poorly amenable to acellular graft repair [37, 61]. Other studies have proposed an alternate explanation. El-Kassaby and colleagues randomized 30 adult patients with penile, bulbar, or penobulbar strictures (length 2–18 cm) to substitution urethroplasty using either buccal mucosa or bladder acellular matrix (Fig. 36.4) [62]. After a 25-month follow-up period, they found that unsatisfactory

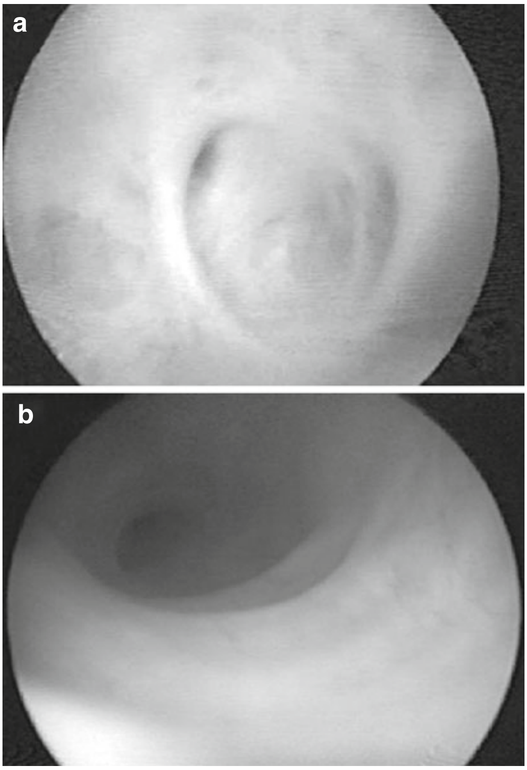

Fig. 36.5 Endoscopic view of the urethra, in a patient who presented with stricture disease, at the same location before urethral repair (**a**) and 1 year after surgery (**b**)

outcomes tended to occur in patients with a history of more than 1 prior surgical intervention, irrespective of stricture location. In addition, all patients who received a buccal mucosa graft had a successful result, as opposed to only 33 % of those receiving the acellular grafts (Fig. 36.5). This is not surprising, since collagen scaffolds require healthy tissue in order to initiate and perpetuate the regenerative process [62]. These studies confirm that the importance of a healthy, well-vascularized urethral bed for acellular collagen grafting cannot be overemphasized.

Urethral Reconstruction with Cell-Seeded Matrices

It has been shown that while unseeded acellular matrix can be useful for onlay reconstruction, it is not sufficient for tubularized urethral repairs [63]. In a rabbit model comparing replacement of the penile urethra with tubularized matrices with or without seeding of autologous bladder smooth muscle cells, strictures were unique and inherent among the unseeded cases. Gross examination of the cell-seeded urethral implants revealed normal-appearing tissue without any evidence of fibrosis. Histologically, these implanted matrices contained normal urethral tissue by 1 month, which consisted of a transitional cell layer surrounded by muscle cell fiber bundles, and the organization of the cells increased over time. Similar results have been seen when the seeding is done with autologous foreskin epidermal cells or with oral keratinocytes [48, 50].

Seeding with oral keratinocytes has also been attempted with de-epidermized dermis (DED) as a graft material. Bhargava and colleagues had initially shown that DED could be successfully seeded with *ex vivo* expanded oral keratinocytes [64]. This group later implemented this technique for substitution urethroplasty in five male patients with strictures secondary to lichen sclerosus [42]. Although initial graft take was seen in all patients, two required either full or partial graft excision, and the remainder required some form of urethral instrumentation (either dilatation or DVIU) for stricture recurrence and submeatal stenosis.

Based on the previously mentioned animal studies, cell-seeded matrices implanted as urethral replacement grafts are able to lengthen the distance over which normal tissue regeneration can occur, without initiating fibrosis. Studies in regenerative medicine have shown that very large defects (greater than 30 cm) can be successfully treated using cell-seeded scaffolds [65]. However, the maximum distance for normal regeneration over an unseeded scaffold, from any edge, is about 0.5 cm. This further explains the described experimental and clinical results noted with urethral repair. Non-seeded matrices are able to replace urethral segments when used in an onlay fashion because of the short distances required for tissue ingrowth. However, if a longer or tubularized urethral repair is needed, the matrices need to be seeded with autologous cells in order to avoid the risk of stricture formation and poor tissue development.

Future Directions

Alternative Cell Sources for Scaffold Seeding

While fascinating research is being reported using the body as a bioreactor to grow a urethral substitute [66], or performing urethral transplantation with cadaveric tissue, the practicality of these approaches is severely limited. The future lies in an "off-the-shelf" option for substitution urethroplasty. Several sources of cells for matrix seeding have been described in this chapter, but the process of harvesting these cells remains invasive and time-consuming. Zhang and colleagues recently demonstrated that voided urine specimens from patients contain urine-progenitor cells [67]. These cells express stem cell markers, including c-Kit, SSEA4, and CD44 and show genomic stability after serial cultures. Furthermore, they can be expanded to levels necessary for tissue engineering in a time frame comparable to that of biopsy-derived cells (approximately 7 weeks), and the cost to obtain them is 100 times less than that of a biopsy [67]. Continued research has confirmed that these urine-progenitor cells are, in fact, stem cells (urine-derived stem cells or USCs), as they have self-renewal capability and can be stimulated to differentiate into multiple cell types [68]. In a recent study, USCs were stimulated to differentiate into urothelial cells and smooth muscle cells and subsequently cultured in a layered fashion onto a 3D porous SIS scaffold [51]. The urothelial cells formed several layers on top of the smooth muscle cells, mimicking the histology of a normal urethra. These SIS scaffolds were then implanted into athymic nude mice without any adverse events (i.e., inflammation, extrusion), and after 1 month, the urothelial and smooth muscle cells still stained for their respective markers. These studies suggest that USCs are a novel and viable source of cells for urethral tissue engineering.

Feng et al. have described reconstruction of a three-dimensional neourethra using porcine ACSM seeded with lingual keratinocytes and corporal smooth muscle cells obtained from rabbits [69]. It must be noted, however, that the engineered tissue was only used in ventral onlay fashion. When used for urethral substitution in the rabbit model, strictures were not seen when ACSM was seeded with both types of cells, unlike the unseeded ACSM or if it had been seeded solely with keratinocytes.

Cell-Seeded Synthetic Materials

Recently, a novel study has combined several aforementioned components including synthetic matrices, autologous cellular seeding, and tubularized repair. Five males aged 10–14 with urethral stricture secondary to pelvic trauma ($n=3$) or failed posterior urethral repair ($n=2$) were selected to undergo ex vivo urethral synthesis [60]. This process involved taking a small bladder biopsy and then dissecting the urothelial cells and muscle tissue into separate culture media for expansion (Fig. 36.6). An appropriately sized piece of PGA mesh was tubularized with suture and sterilized before being seeded on the inside with urothelial cells and on the outside with smooth muscle cells. The seeded scaffolds were placed within a bioreactor and incubated in culture medium until the time of surgery (Fig. 36.7). After the diseased segment was excised, the engineered construct was sewn in place with absorbable suture, and an indwelling catheter was left, similar to traditional urethroplasty. Serial biopsies showed normal architecture, and up to 72 months later, excellent results were noted on VCUG and uroflowmetry (Fig. 36.8). One patient experienced a small stricture at the proximal anastomosis site 4 weeks postoperatively, and this was most likely secondary to premature catheter removal. This was successfully treated with transurethral incision of the stricture with no subsequent complications.

Editorial Comment

The future of urethroplasty is clearly in regenerative medicine. The preliminary studies with tissue-engineered urethras and graft material are very promising. However, it does not make much sense to me to look for the ideal "off-the-shelf graft" construct/material for a substitution urethroplasty. We already have an excellent graft

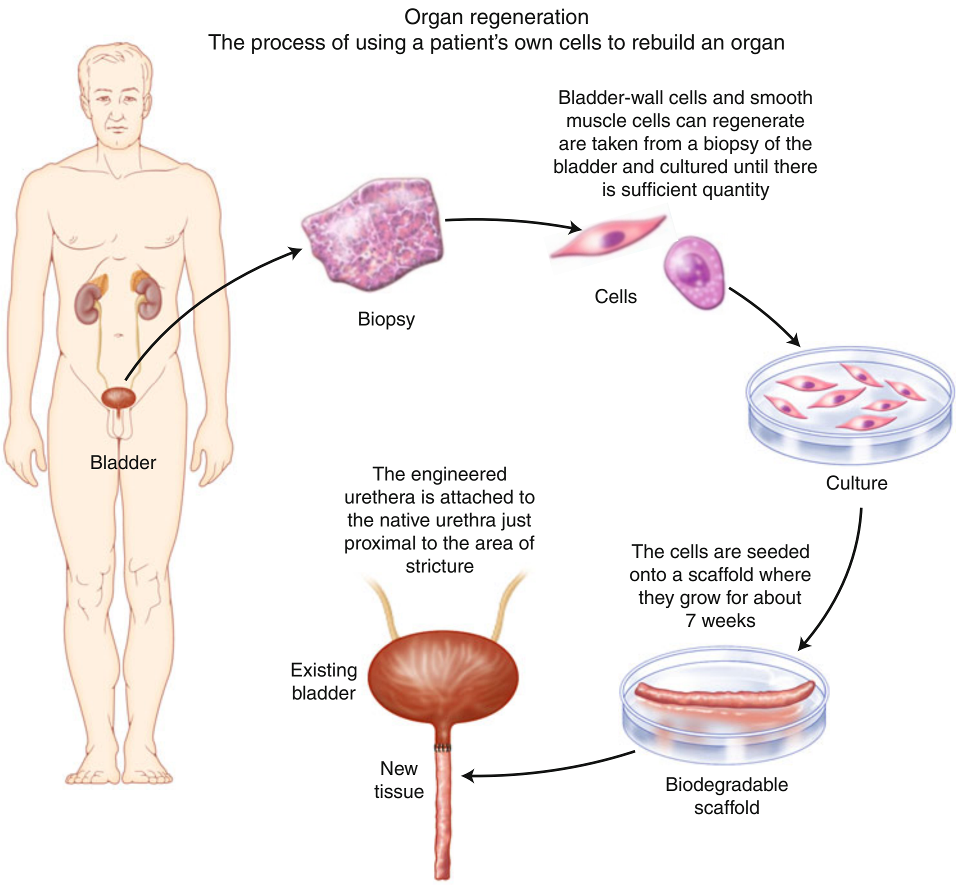

Fig. 36.6 Urethral regeneration

Fig. 36.7 Bioreactor

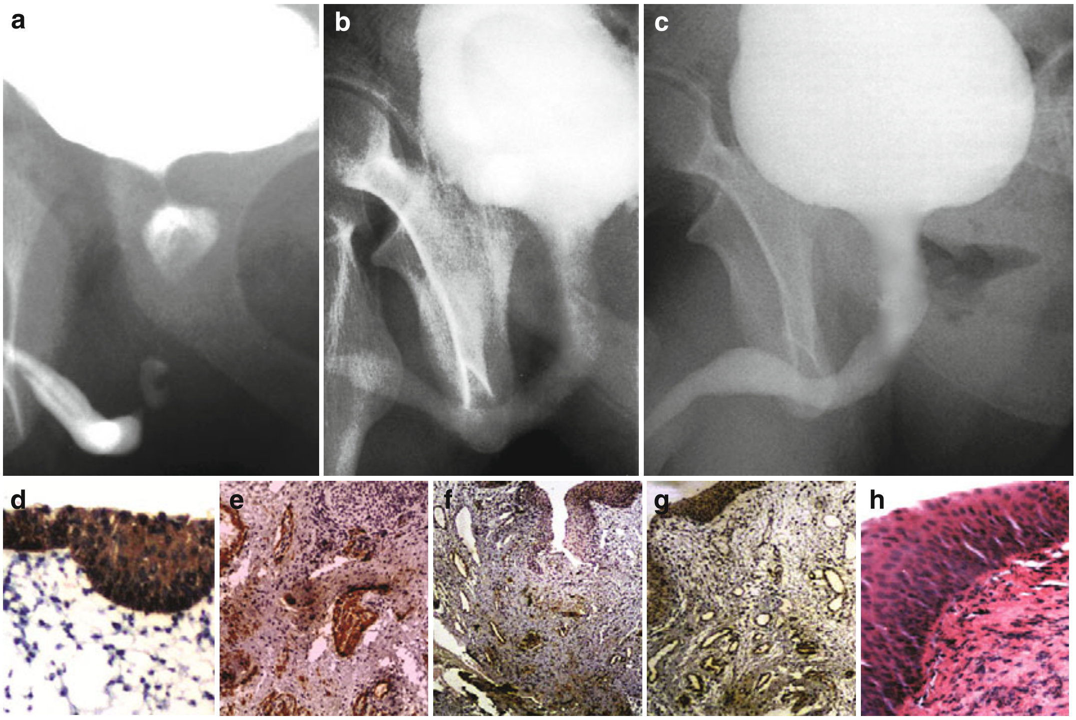

Fig. 36.8 Voiding cystourethrogram of a patient with a urethral stricture pre- (**a**) and post-op (**b**, **c**). Serial biopsies of engineered urethra for AE1/AE3 (**d**), actin (**e**), myosin (**f**), desmin (**g**), hematoxylin, and eosin (**h**)

material with excellent outcomes and durable success called oral buccal mucosa. The real future in urethroplasty is in finding a reliable replacement for the corpus spongiosum, where the diseased urethra could be removed and replaced with a three-dimensional tissue construct that is both spongiosum and urethra, seeded with both muscle and epithelial cells. There are many academic medical centers and start-up companies dedicated to regenerative medicine, but a practical and commercially available urethral replacement is still at least a decade off.

—Steven B. Brandes

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Pediatric Urethral Strictures

37

Michael H. Johnson, Steven B. Brandes, and Douglas E. Coplen

Summary

Pediatric urethral strictures are uncommon and there is a paucity of published series examining their management. Like their adult counterparts, pediatric urethral strictures can be a result of congenital, iatrogenic, inflammatory, traumatic, or idiopathic etiologies. Meatal stenosis should be managed by meatotomy or meatoplasty. Dilation typically fails and is thus discouraged.

Urethrotomy and dilation are acceptable for short bulbar urethral strictures or as salvage after failed urethroplasty with stenotic annular rings. Repeat urethrotomy is futile and potentially harmful. Anterior urethral strictures of the bulb can be successfully managed by anastomotic urethroplasty if short and substitution urethroplasty (buccal grafts) if long. Most posterior urethral strictures that result from pelvic fracture can be successfully repaired by anastomotic urethroplasty via a perineal approach. A transpubic or partial pubectomy posterior anastomotic urethroplasty is occasionally needed when the urethral defect is long or the anastomosis is under tension. Perineal urethroplasty in the child is often technically difficult because the perineal space is confined, the urethra and prostate small, and overall exposure compromised (compared to the adult). For strictures of LS etiology, hypospadias cripples, and after prior failed urethroplasty, a staged urethroplasty is often the best management.

Introduction

Pediatric urethral strictures are uncommon and there is a paucity of published series. Pediatric urethral strictures can arise from multiple etiologies, with treatment strategies depending on multiple factors. Given the relative rarity of pediatric urethral stricture disease in North America and Europe, much of the literature comes from developing countries, such as Egypt and India, where the etiologies of many strictures are pelvic fracture-associated urethral injuries. Thus, expert opinion on surgical technique stems from a combination of primary pediatric and applied experience from adult literature. Nevertheless, there are key differences in presentation and surgical management between adult and pediatric patients.

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Etiology of Strictures

Like their adult counterparts, pediatric urethral strictures can be a result of congenital, iatrogenic, inflammatory, traumatic, or idiopathic etiologies. While all strictures are a result of local microvascular ischemia with subsequent metaplasia and fibrosis, a myriad of factors may play a role in stricture formation including infection, inflammation, trauma, ischemia, and excessive instrumentation.

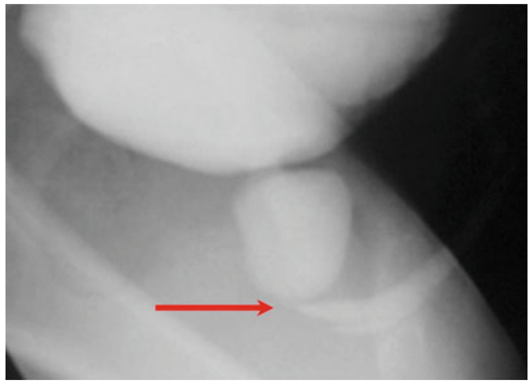

Fig. 37.1 Posterior urethral valve (note *arrow*)

Congenital

Although rare, congenital strictures have been reported, most commonly in the bulbar urethra [1]. These are not truly strictures but are a diaphragmatic narrowing. These are believed to be a result of a failure of the urethra to fully canalize at the juncture of the ectodermally based urogenital membrane and endodermally originating proximal urethra [2]. This obstruction is often referred to as a type III posterior urethral valve. Disruption of the thin membrane can be successfully performed endoscopically with a pediatric resectoscope with pure cutting current. The risk of recurrence is very small. The remnant and persistent urogenital membrane is distal to the external urethral sphincter, differentiating it from posterior urethral valves.

The most common form of congenital urethral obstruction is a type I posterior urethral valve (Fig. 37.1). The incidence is 1/5,000–10,000 males. Most are identified prenatally on the basis of bladder distension and hydroureteronephrosis. Anterior urethral valves (Fig. 37.2) may not present prenatally but with the parental observation of strangury. Urethral atresia is identified of prune belly syndrome (Fig. 37.3) and is typically associated with severe renal dysplasia and prenatal identification of oligohydramnios.

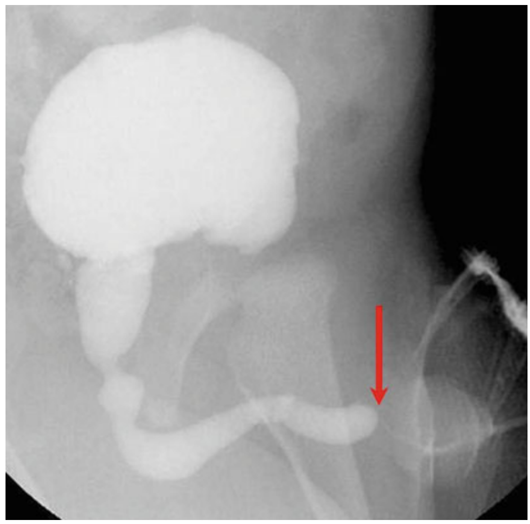

Fig. 37.2 Anterior urethral valve (note *arrow*)

Infection/Inflammation

Lichen sclerosis (LS) is a chronic inflammatory disease that, in urethral stricture disease, is associated with urinary tract infection. A literature review of publications from 2004 to 2008 revealed 225 cases of histologically proven lichen sclerosis in males (age 2–23 years, mean 7 years) [3]. This likely represents an underrepresentation of the true prevalence, as this commonly presents as phimosis and with no subsequent histopathologic analysis of the skin. Indeed, prospective studies suggest that surgically treated phimosis may be attributable to lichen sclerosis in 10–40 % of cases [4, 5]. When left untreated, the disease process may extend into the urethra, causing meatal stenosis, and progress in a retrograde manner (Fig. 37.4). LSA is a rare but significant cause of pediatric meatal and urethral narrowing

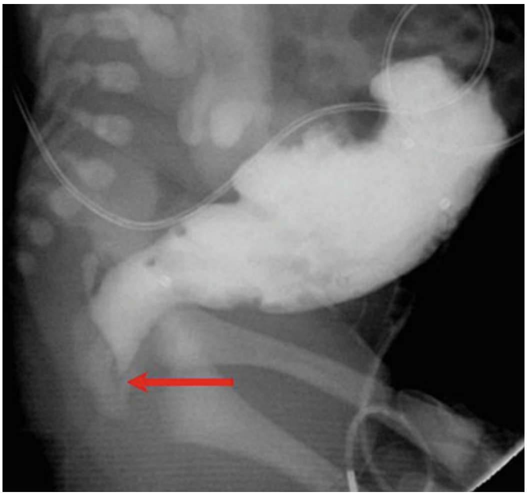

Fig. 37.3 Urethral atresia associated with prune belly syndrome (see *arrow*)

Fig. 37.4 Lichen sclerosis after hypospadias repair in a 2-year-old boy

after hypospadias repair. Adjacent tissues are not suitable for reconstruction. See Chap. 4 in this text for more details as to the histology and medical/surgical management of LS.

Iatrogenic

Meatal "stenosis" can occur after neonatal circumcision. It is unknown if this occurs because of irritation of the meatus in the diaper ("diaper dermatitis") or is related to division of blood vessels at the time of circumcision. The "stenosis" is typically a ventral flap of tissue that deflects the urinary stream but is rarely associated with dysuria, incomplete bladder emptying, or other voiding symptoms, like decreased urinary stream or prolonged voiding time.

Indeed, any transurethral intervention has the potential for stricture formation. Inadvertent inflation of a Foley balloon in the bulbar urethra is commonly seen in the pediatric setting. If the child is able to void after such trauma, we typically do not further instrument the urethra. Fortunately, subsequent iatrogenic stricture development after Foley trauma is rare in children. In the past, valve ablation could lead to a membranous or proximal bulbar urethral stricture years later. However, with the advent of newer small diameter rigid and flexible endoscopes, endoscopy and neonatal valve ablation rarely lead to a urethral stricture today.

After Hypospadias Surgery

Hypospadias is the most common procedure associated with subsequent stricture formation. Following hypospadias repair, urethral strictures are most commonly seen within the first year after the repair (Fig. 37.5). Strictures are most commonly at the level of the urethral meatus, although strictures can be seen anywhere along the surgically reconstructed urethra [6]. A proximal stricture can occur when preputial or ventral skin flap repairs are utilized.

Trauma

Anterior Urethra

A common etiology of anterior urethral strictures in boys is secondary to straddle injury or a kick or blow to the perineum, wherein the bulbar urethra is crushed against the pubic bone [7, 8] (Fig. 37.6). In most cases, the adolescent presents with symp-

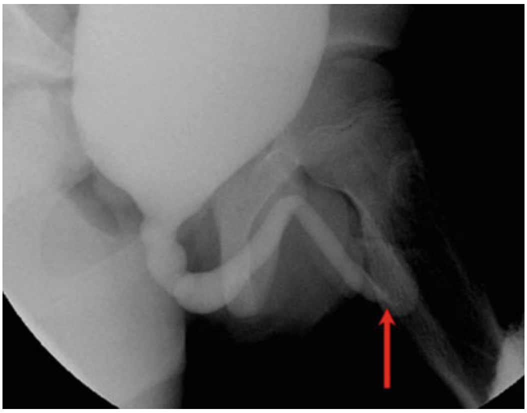

Fig. 37.5 Distal urethral stricture following hypospadias repair (see *red arrow*)

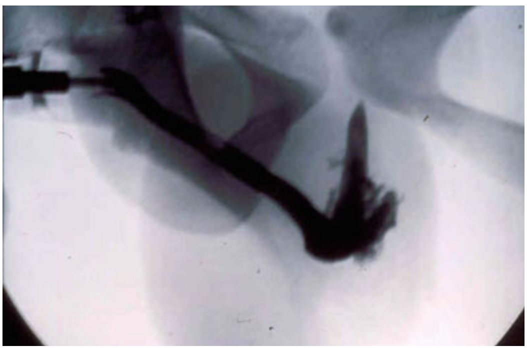

Fig. 37.6 Retrograde urethrogram in a 12-year-old boy, demonstrating a mid bulbar urethral injury after a straddle injury while jumping on a trampoline (Image courtesy of SB Brandes)

toms of bladder outlet obstruction but there is usually no recollection of recent or remote urethral trauma. The anatomical differences between adults and pediatric patients predispose children to different urethral injuries from pelvic trauma. The shallow pelvis of the pediatric patient results in a more abdominally located urinary bladder and prostate, making these structures more susceptible to injury. The physical forces applied to these structures in the pediatric patient are relatively greater and can cause more extensive injuries [9].

Posterior Urethra

Trauma-induced posterior urethral strictures are commonly a result of pelvic fracture. Compared to the adult pelvis, the pediatric pelvis is more elastic at the SI joints and symphysis. This

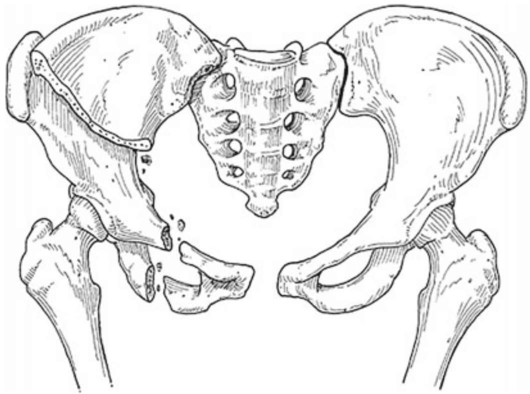

Fig. 37.7 Cartoon of a Malgaigne fracture – a complex, unstable pelvic fracture involving one side of the pelvis with both anterior and posterior disruptions of the pelvic ring (Courtesy of Dr. Tim Hunter)

increased bone plasticity translates to a greater degree of force needed to produce a pelvic fracture and thus lowers the incidence to 5 % (vs. 10 % for adults). However, when pediatric pelvic fractures do occur, the generating force often results in severe-associated soft tissue and vascular injury. Malgaigne fractures, which involve disruption of the anterior and posterior pelvic ring, are the most commonly reported pelvic fracture in boys, followed by straddle fracture with or without sacroiliac joint diastasis [10]. These three fracture types make up 56 % of pediatric pelvic fractures, compared to 24 % in adults. Patients sustaining straddle pelvic fracture with sacroiliac joint diastasis are 24 times more likely to have a concomitant urethral injury than any other pelvic fracture [9]. Straddle fracture without sacroiliac joint diastasis is associated with a 3.85 times increased risk, whereas Malgaigne fractures have a 3.4 times increased risk (Fig. 37.7).

The poorly developed soft tissues also predispose pediatric patients to different injuries than in adults. The prostate is not anchored well by underdeveloped puboprostatic ligaments, which are easily sheared. This can result in profound displacement of the prostate. These injuries can extend proximally to the level of the bladder neck and as far distally as the bulbar urethra [11, 12]. In fact, pubic rami fractures can carry up to a 44 % incidence of proximal dislocation of the prostate [13]. Of note, mid prostatic injuries are often longitudinal tears along the anterior aspect of the urethra rather than transverse-oriented tears. This typically does not lead to stricture formation, however [9].

Evaluation of Strictures

Patient Presentation

Patients with urethral strictures will almost invariably present with voiding dysfunction from urinary outlet obstruction. Pediatric patients will not necessarily report a weak urinary stream, straining to void, or incomplete emptying, as is often found in adults with stricture disease. Instead, concern for a urethral stricture should be increased in patients reporting the following:

- Blood spotting in underwear (urethrorrhagia)
- Urinary tract infection
- New onset enuresis or nocturia
- Dysuria
- Urinary frequency
- Sitting to void, when previously standing
- Trouble directing urinary stream and wets floor/toilet seat

An accurate patient history is essential and effective in determining the etiology of the stricture. Relevant information includes:

- Prenatal history, hydronephrosis, poly-/oligo hydramnios
- Genital exams on routine physical exams
- Age of toilet training
- History of febrile versus afebrile urinary tract infections
- Urinary frequency, bowel function
- Strong urinary stream
- Malodorous, discolored, or bloody urine
- History of perineal trauma/injuries
- Prior urologic surgery

Of note, pediatric patients with strictures suggestive of trauma or injury will often have no recollection of any such insult.

Urine Studies

Urine flowmetry with a subsequent post-void residual is commonly screening tool in the initial evaluation of voiding symptoms and dysfunction in children. A flattened or mesa-shaped tracing flow rate, in the presence of an adequate voided volume and/or large post-void residual, is consistent with bladder outlet obstruction from either detrusor-sphincter dyssynergia (DSD) or stricture disease (less common). Flow rate is used for diagnosis, as well as documenting posttreatment improvement. There are several published nomograms for determining normal flow rate in children by age. EMG electrodes help differentiate anatomical and neuromuscular (DSD) causes of an abnormal flow rate. A borderline flow rate, in the setting of strong clinical suspicion or patient symptoms, should not curtail further evaluation.

Urinalysis and urine culture are easy to perform and may reduce postoperative complications and treat infectious causes for voiding dysfunction. Patients with post-traumatic strictures may have suprapubic cystostomy tubes that will be colonized with bacteria. Unless the patient is symptomatic, a therapeutic course of antibiotics is not needed. For patients without cystostomy tubes, at least 24 h of preoperative antibiotics should be given for positive urine cultures.

Preoperative Assessment

Imaging

As in adult urethroplasty, properly performed imaging studies are critical to assessing the length, location, and degree of stricture and in determining the proper method of pediatric stricture repair. Urethrography is the gold standard of imaging in both adults and children. Retrograde urethrography (RUG) provides an anatomical (road map) assessment of the urethra, voiding cystourethrography (VCUG) provides a functional urethral analysis, and cystography evaluates the bladder (see Chap. 5 in this text for more details on urethrography). When evaluating the imaging studies, there are potential pitfalls in interpretation, especially in the setting of a post-traumatic posterior urethral injury. Incomplete filling of the urethra proximal to the injury, perhaps secondary to patient discomfort or decreased urethral distensibility, may result in overestimation of stricture length [11] (Fig. 37.8). Underestimation of the urethral stricture length may also occur with an overlapping urinoma or

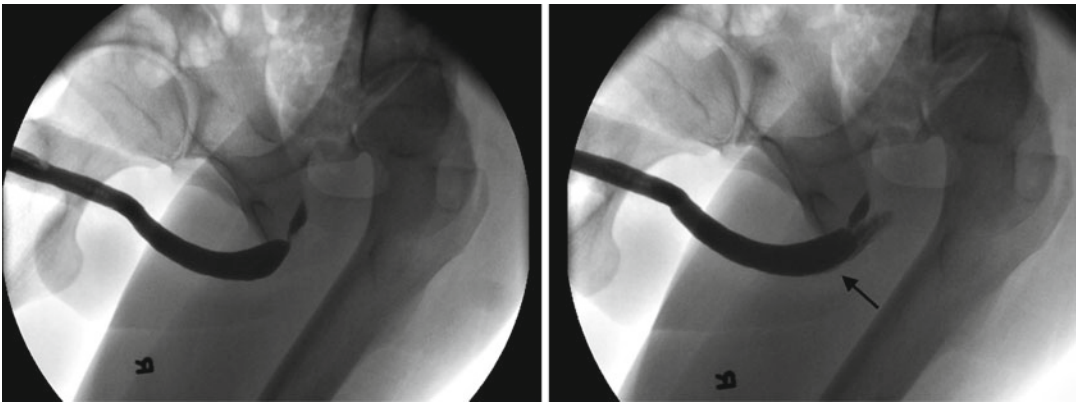

Fig. 37.8 Extravasation of contrast (see *arrow*) during retrograde urethrography, following aggressive attempts to delineate the proximal urethra

hematoma, where the urethra may be obscured underneath.

Urethrography may be performed either while awake or under sedation (anesthesia) in children. If the child has had a prior history of urethral surgery or injury, young age, or has a low pain threshold or overly anxious, urethrography is often best performed under conscious sedation. If the child has not had prior surgery and is old enough (typically an adolescent) to tolerate the stress and pain urethrography, an RUG and VCUG should be performed, in order to develop a surgical plan.

Magnetic resonance imaging can be a useful imaging modality in the evaluation of adult pelvic fracture-associated urethral injuries, where conventional urethrography is confusing. The role of MR in pediatric strictures is evolving. It can define the prostatic apex, stricture location, stricture length, and presence of scar tissue with unparalleled accuracy in a noninvasive manner [14]. This can allow for more accurate and informed preoperative surgical planning [15]. Within the pediatric population, however, magnetic resonance imaging use has been limited, as the child has to remain still with a full bladder and often needs to be sedated to prevent excessive motion artifact.

Ultrasound is primarily used in evaluating the anterior urethra, especially when the conventional urethrography is equivocal [16]. It is very successful in identifying stricture length, location, and caliber. However, it is poorly tolerated in children, is time intensive, and thus is rarely used in surgical decision making in children with urethral strictures.

Cystoscopy

Pediatric endoscopic evaluation is a useful adjunct to imaging studies to evaluate the how obliterative or near obliterative the stricture is, as well as the coloring and distensibility of the mucosa. Endoscopy is also useful, as the extent of fibrosis (white and blanched mucosa) is often longer than the segment of urethral narrowing visualized on urethrography.

Surgical Management of Pediatric Urethral Strictures

The treatment algorithm for pediatric urethral strictures closely resembles stricture repair in adults. The surgical approaches to urethral stricture repair are complementary to one another and must be tailored/individualized to address each patient's stricture. Generally, reconstruction should be performed using the least invasive approach with a reasonable opportunity for durable success. Should the initial treatment modality fail, more definitive procedures should be performed rather than duplicating the failed procedure. Prior to surgery, patients and their families should always be counseled that more invasive procedures may be required to achieve a definitive repair.

Endoscopic Repairs (Dilation/Urethrotomy)

Dilation and direct vision internal urethrotomy (DVIU) are generally the first-line treatment modalities for short anterior urethral strictures, including congenital strictures. Despite the ease of performing endoscopic management, long-term (≥5 years) follow-up stricture recurrence rates are very high [17–21] and thus should be limited to bulbar urethral strictures <1 cm in length, with minimal spongiofibrosis. Endoscopic methods also have poor success rates with traumatic strictures. Hafez et al. [35] reported a success rate of 35 % with urethrotomy for traumatic strictures, with mean time till stricture recurrence of 26 months. Ultimately, half of these patients within 6.6 years of follow-up required open urethroplasty.

Dilation almost never gives a durable result after hypospadias repair, and its use is discouraged. Urethrotomy has some utility in managing proximal strictures after hypospadias repair, but has no utility in glandular or meatal stenosis. Meatal stenosis is best managed by meatotomy or meatoplasty. Urethrotomy also has reasonable success and utility in salvaging urethroplasties that have short stenotic recurrences. Here, the short recurrences are typically annular and at the proximal or distal ends of the prior onlay flap or graft urethroplasty. As with adult urethral stricture, repeat urethrotomy or dilation is futile and unlikely to be successful, and thus, formal urethroplasty is the next step after a failed endoscopic treatment.

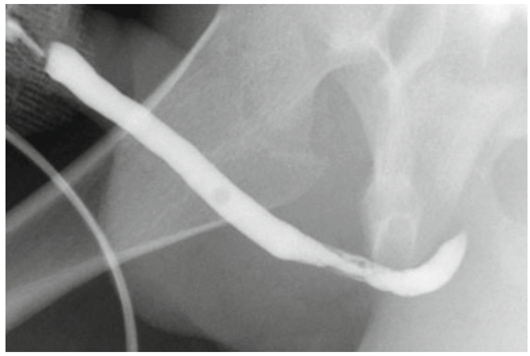

Fig. 37.9 Retrograde urethrogram of a mid bulbar urethral stricture following a MAGPI hypospadias repair

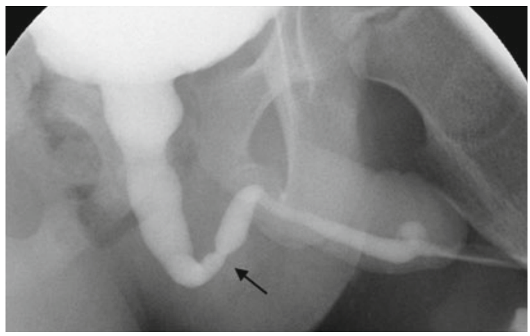

Fig. 37.10 Voiding cystourethrogram of a short bulbar urethral stricture (see *arrow*) following a MAGPI hypospadias repair

Penile/Anterior Urethral Strictures

Most anterior urethral strictures in the pediatric population occur after hypospadias repair (Figs. 37.9 and 37.10).

An anastomotic repair is typically not feasible in the hypospadias patient with a stricture, because the urethral blood supply is often not normal after the prior surgery, and the good bipedal and retrograde blood flow through the corpus spongiosum is often compromised. If a penile skin flap is considered for repair, the skin should be carefully assessed for the presence of occult LS. Staged repairs using buccal mucosal free grafts are very popular for stenoses after hypospadias, because of graft availability, ease of harvest, concealed scar, and excellent and durable outcomes. See Chap. 27 in this text for details on the management of reoperative hypospadias surgery. In general, anastomotic urethroplasties should be limited to short strictures (<1 cm) of the bulbar urethra, of traumatic origin, and/or of obliterative or near obliterative lumens. Extending limits for anastomosis should only be done for proximal bulbar strictures, but increases the risk for penile foreshortening and/or chordee.

Substitution urethroplasty with buccal mucosa grafts for bulbar urethral strictures has a reported success rate of 87–100 % in children [22]. As the pelvis is narrow and confined and the bulbar urethra and urethral plate often very small in children, we find it technically much easier to place the BMG ventrally (covered by spongioplasty) rather than dorsally. Even in the adult, dorsal grafting is technically more demanding and requires more extensive urethral mobilization. Objective measures (flow rate, cystoscopy, imaging) are not typically utilized in children to assess surgical success or failure. Instead, what is used to define success here is often just a report of a good urinary flow and no urinary tract infection.

Posterior Urethral Strictures

As for adult patients, the optimal treatment for posterior urethral strictures in children is excision of the stricture with a tension-free end-to-end bulboprostatic anastomosis. Unfortunately, the reported experience is limited (mainly small retrospective studies) [21–25]. The largest of these series includes 68 patients over 20 years, treated by a single physician in Egypt [26]. Perineal urethroplasty, regardless, carries an excellent 93–100 % success rate in children [26, 27].

For acute post-traumatic urethral injuries in children, primary urethral realignment is generally discouraged, as the degree of distraction is typically much greater than in postpubertal patients, often leads to more problems (especially in inexperienced hands), and because there are limited reports as to its efficacy in children. In infants with devastating urethral injury, a cutaneous vesicostomy with diaper drainage is the preferred initial option. In older children, placement of a suprapubic cystostomy alone is sufficient initial treatment. As in the adult patient, definitive posterior urethroplasty should be delayed for at least 3–6 months after the initial injury [26, 28, 29]. "Cut-to-the-light" procedures are uniformly unsuccessful and thus highly discouraged. Urethrotomy or dilation over a wire is not recommended as primary treatment for posterior urethral strictures, but has reasonable short-term success with recurrent strictures after original repair (in particular if the stricture is short and non-obliterative).

As with adult posterior urethroplasty, a transperineal approach to a one-stage bulboprostatic anastomotic urethroplasty is the preferred technique in children [30]. The overall contemporary reported success rates are from 75 to 92 %. The progressive approach advocated in adult posterior urethroplasty, of corporal splitting, corporal rerouting, and anterior pubectomy, however, is rarely, if ever, needed in children and, as well, unduly risks untoward side effects. When a tension-free anastomosis cannot be made despite extensive circumferential urethral mobilization, or there are concerns for penile foreshortening or chordee, the typical next step is the length-gaining maneuvers of transpubic (abdominoperineal) or partial pubectomy (through the perineum). The male child's perineum is confined and hard to operate in, and the urethra and prostate are small. Adequate exposure is thus often lacking in these perineal cases and performing a pubis-removing (partial or total) maneuver often greatly improves visualization and eases suturing. For this reason, reports of posterior urethroplasty in children more liberally utilize pubectomy (in up to 32 %) than in adults [26]. In prepubertal patients, the pubic rami can often be separated with electrocautery. A laminectomy spreader is placed and such facilitates excellent exposure of the bladder neck and urethra. Pubectomy or symphysiotomy may be required in postpubertal patients. Long-term stricture outcomes comparing transpubic, transperineal, or abdominoperineal approaches have not been well studied, but results appear to be comparable [31, 32].

Surgical Technique Specifics of Posterior Urethroplasty

See Chap. 19 for detailed cartoons of the surgical technique.

1. General anesthesia, legs in stirrups, preoperative antibiotics based on recent urine culture.
2. Infants and small children can be positioned supine with legs spread. The bulbar urethra is easily exposed via this approach in small children. In complex cases, the anterior transpubic approach can be utilized without repositioning the patient. For larger children, lithotomy is typically required.
3. For more proximal strictures, a urethral catheter can be passed to identify the course of

the urethra and aid in determining the extent of the perineal incision.

4. A midline incision is created. Care should be taken not to incise into the scrotal skin or the anus. Inverted Y incisions and inverted U incisions have been described, but we have generally found these unnecessary and that adequate exposure can be achieved by a midline incision [33]. The bulbospongiosus muscle is often underdeveloped compared to postpubertal patients. This is divided using fine scissors and the corpus spongiosum dissected out.
5. Passage of a urethral catheter may aid in delineating the distal end of the stricture. If a suprapubic catheter is already in place or the imaging studies are of questionable quality, antegrade flexible cystoscopy can be performed to identify the proximal aspect of the stricture. In general, preoperative urethrography is adequate to determine the stricture location and size.
6. Once the stricture has been indentified, the boundaries are marked and the corpus spongiosum is circumferentially dissected free from the underlying corpora. Mobilize the bulb by separating it from the central tendon. Transect the urethra through the scar from posterior to anterior. We prefer to use Jorgenson scissors, as the curved tips facilitate dissection around the bulb.
7. Inject methylene blue via the urethra to stain the mucosa to facilitate subsequent suture placement. The stricture is then widely and liberally excised. As in adults, there needs to be a 1 cm overlap of spatulated tissue for a successful repair. Compared to adults, this required overlap has a profound impact on the limits of stricture length that can be repaired in children.
8. Distal dissection is useful to generate additional urethral length, but not beyond the penoscrotal junction [34].
9. If a tension-free anastomosis cannot be easily performed, we do not advocate corporal splitting or rerouting as is done in adults. Instead, consider pubectomy or partial pubectomy.
10. Both a urethral catheter and suprapubic cystostomy tube are left postoperatively. No other drains are typically placed.

Staged Repairs

Within the pediatric population, staged repairs are often more commonly utilized than one-stage repairs. Staged urethroplasty has particular roles for strictures of LS etiology, failed prior urethroplasty, or hypospadias cripples. The urethra is exposed, marsupialized, and grafted on its sides with buccal mucosa. The grafts are given 6 months or more to soften and mature – so as to be pliable enough for tubularization. During this interval time period, voiding occurs via a proximal or perineal urethrostomy. See Chap. 20 in this text for further details on staged urethroplasty.

Postoperative Care

All patients leave the hospital with a urethral catheter. Patients also required a suprapubic cystotomy placed to gravity drainage and the urethral Foley plugged. A pericatheter RUG is typically obtained at 10–14 days for anastomotic urethroplasty and 3 weeks for substitution urethroplasty. If there is any extraluminal contrast extravasation, the catheter is maintained for 2 additional weeks. Following removal of the urethral catheter, the suprapubic tubes may be removed if the patient voids properly. Renal/bladder ultrasound and urine flowmetry are performed at 3 months and then yearly – with a goal of a bell-shaped flow curve and minimal voiding symptoms. Restenoses typically occur within the first year of follow-up [35].

Preferred Surgical Instruments of D. Coplen for Pediatric Urethroplasty

1. Optical loupe magnification
2. Self-retaining retractor, such as Lone Star Retractor System (Cooper Medical©)
3. Fine-toothed forceps, such as Castroviejo 0.5 mm or Westcott
4. Fine Iris scissors
5. Eye calipers

6. Bougie à boule for urethral calibration
7. 7 French flexible pediatric cystoscope
8. Vicryl 5-0 or 6-0 with a TG or TF needle based on age

Surgical Pearls and Pitfalls

- Meatal stenosis should be managed by meatotomy or meatoplasty. Dilation is highly discouraged.
- Urethrotomy and dilation are acceptable for short bulbar urethral stricture or as salvage after failed urethroplasty with stenotic annular rings.
- Anterior urethral strictures of the bulb can be successfully managed by anastomotic urethroplasty if short and substitution urethroplasty (buccal grafts) if long.
- Ventral placement of a buccal graft is technically easier in children (than dorsal).
- Most posterior urethral strictures that result from pelvic fracture can be successfully repaired by anastomotic urethroplasty via a perineal approach.
- A transpubic or partial pubectomy posterior anastomotic urethroplasty is often needed when the urethral defect is long or the anastomosis is under tension.
- Primary realignment has little role nor success in the pediatric urethral injury patient.
- Staged urethroplasty is preferred for strictures of LS etiology, hypospadias cripples, and after prior failed urethroplasty.

Editorial Comment

The pediatric urethra is exceedingly delicate, and urologists must take care not to inflict additional trauma by aggressive endoscopic maneuvers. Traumatic stenosis from pelvic fractures injury occurs not uncommonly in developing countries where pedestrian and vehicular traffic are not well partitioned. Posterior urethroplasty in small children is quite challenging, even in experienced hands. Such cases should be referred to tertiary centers where they are usually best tackled by adult reconstructive urologists working together closely with pediatric urologists. Small catheters, small sounds, small sutures and needles, headlights, and magnifying loupes are essential. I have had good luck using an abdominoperineal approach in reoperative cases, which promotes lysis of retropubic adhesions between the anterior prostate and pubis. The wide exposure gained to the proximal urethral stump enables complete resection of fibrotic tissue and precise suture placement. I often prefer 6-0 PDS sutures on TF needles in this setting, and I avoid catheters smaller than 10 Fr. The thin spongiosum of prepubescent boys is less elastic than the robust tissues of adults, and mobilizing spongiosum to bridge gaps is therefore less reliable.

—Allen F. Morey, MD

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38 Non-transecting Bulbar Urethroplasty

A.R. Mundy and Daniela E. Andrich

Summary

Non-transecting bulbar urethroplasty seeks to replicate the results of traditional bulbar urethroplasty and particularly of excision and end-to-end anastomosis but without the need for transection of the corpus spongiosum and its vasculature, with a view to minimising the short-term and long-term morbidity of the procedure.

Introduction

The commonest site for a urethral stricture in the developed world is in the bulbar urethra, and the commonest location is at the junction of the proximal and middle thirds. Generally these are short strictures – sometimes little more than a membrane – particularly at first presentation. Short strictures at this site in the urethra may be amenable to treatment by direct vision internal urethrotomy or urethral dilatation (controversially), but there is little doubt that if one attempt at endoscopic management has failed then the best form of treatment is excision and end-to-end anastomosis [1, 2].

The primary goal of excision of the stricture and end-to-end anastomosis of the two ends is to excise the stricture and the surrounding corpus spongiosum in its entirety and join together healthy urethral to secure the most durable result. The results of this procedure are indeed impressive. Success rate approaching 100 % has been quoted [3, 4].

In practice however, in most patients, the actual degree of fibrosis and total volume of the stricture are often little more than 10 % or so of the substance of the segment of the urethra excised. In other words a large amount normal tissue is excised in the process including segments of the bulbar arteries. The degree of blood loss, although by no means life-threatening, is significant. More to the point is not the volume of blood loss by damaging the urethral arteries but the potential long-term damage to the structure and function of the corpus spongiosum and the potential long-term complications as a consequence.

In 2007 Jordan described a technique of proximal urethroplasty that avoids transection of the urethra and, independently, we have developed our own approach – which we believe is simpler and more flexible [5, 6]. Kodama has reported another modification of this approach [7].

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Technique

Principles

The main principles are the following:

1. Most strictures occur in the proximal bulbar urethra.
2. Most are short and amenable to local excision.
3. Most are not associated with gross spongiofibrosis.
4. It is possible to excise the spongiofibrosis and leave the bulk of the corpus spongiosum behind and avoid damaging the bulbar arteries.
5. The bulbar urethra can be stretched.
6. Operative trauma should always be minimised where possible.
7. It is not the aim to get better results in terms of long-term stricture-free survival but to achieve the same results but with a lower morbidity both immediately and in the long-term.

The procedure is performed with the patient in lithotomy. The exact nature of the position is a matter for the surgeon to decide according to his personal preference; we prefer "social lithotomy" [8]. Likewise as a personal preference, we perform a midline perineal incision which is then deepened down through the superficial fascia, Colles' fascia and the bulbospongiosus muscle which is then reflected to expose the bulbar urethra throughout its length. No attempt is made to mobilise the bulb of the corpus spongiosum posteriorly and posterolaterally from its attachment to the perineal body. The main bulbar vessels and the smaller subsidiary branches to the corpus spongiosum are therefore left intact. The urethra is mobilised from its dorsal attachment to the tunica albuginea of the corpora cavernosa on the proximal part of the shaft of the penis and between the two crura by dividing Buck's fascia and the associated circumflex branches of the dorsal arteries of the penis and the perforators from the corpora cavernosa. The bulbar urethra is therefore mobilised on its dorsal aspect from the distal margin of the bulbospongiosus muscle back to the perineal membrane (Fig. 38.1).

The dorsal aspect of the proximal bulbar urethra is devoid of corpus spongiosum – anatomically and technically speaking it is therefore actually part of the membranous urethra even though it is below the perineal membrane [9]. This is not the place to discuss the details of anatomical nomenclature – suffice it to say that this is the least vascular aspect of the urethra and so we choose to operate through this approach. The site of the stricture is identified by passing a catheter down the urethra from the meatus and palpating the point at which it can progress no further – at the site of the stricture. An incision is then made down on to the tip of the catheter opening the urethral distally into apparently healthy urethra of normal calibre and then through the stricture proximally into healthy urethra as well. At this stage the final decision is made about exactly how to proceed:

1. If the stricture is literally no more than a membrane then at this point, having opened up the stricture, there will be a very short length of the urethra where the urothelium will be no more than a millimetre or two wide (the stricture opened up), and on either side of it, there will be a correspondingly narrow strip of denuded spongiosum where the urothelium on either side is very close together (Fig. 38.2). In this situation we would sew the contiguous epithelial margins on either side of the central "preserved" strip and then close the longitudinal incision transversely. This is, essentially, a Heineke-Mikulicz stricturoplasty.
2. If the stricture is longer than just a membrane – up to a centimetre or two long (and sometimes longer) – there will be a central scarred strip which is the site of the stricture with bare corpus spongiosum on either side between the two normal calibre ends of the urethra. In this situation we would excise the scarred epithelium and the underlying spongiofibrosis (Fig. 38.3) with a view to bringing together the two epithelial margins by simple suture (Fig. 38.4). We would then close the longitudinal incision transversely, as above, supplementing the stricture incision and mucosal anastomosis with a Heineke-Mikulicz stricturoplasty (Fig. 38.5). The critical length for this

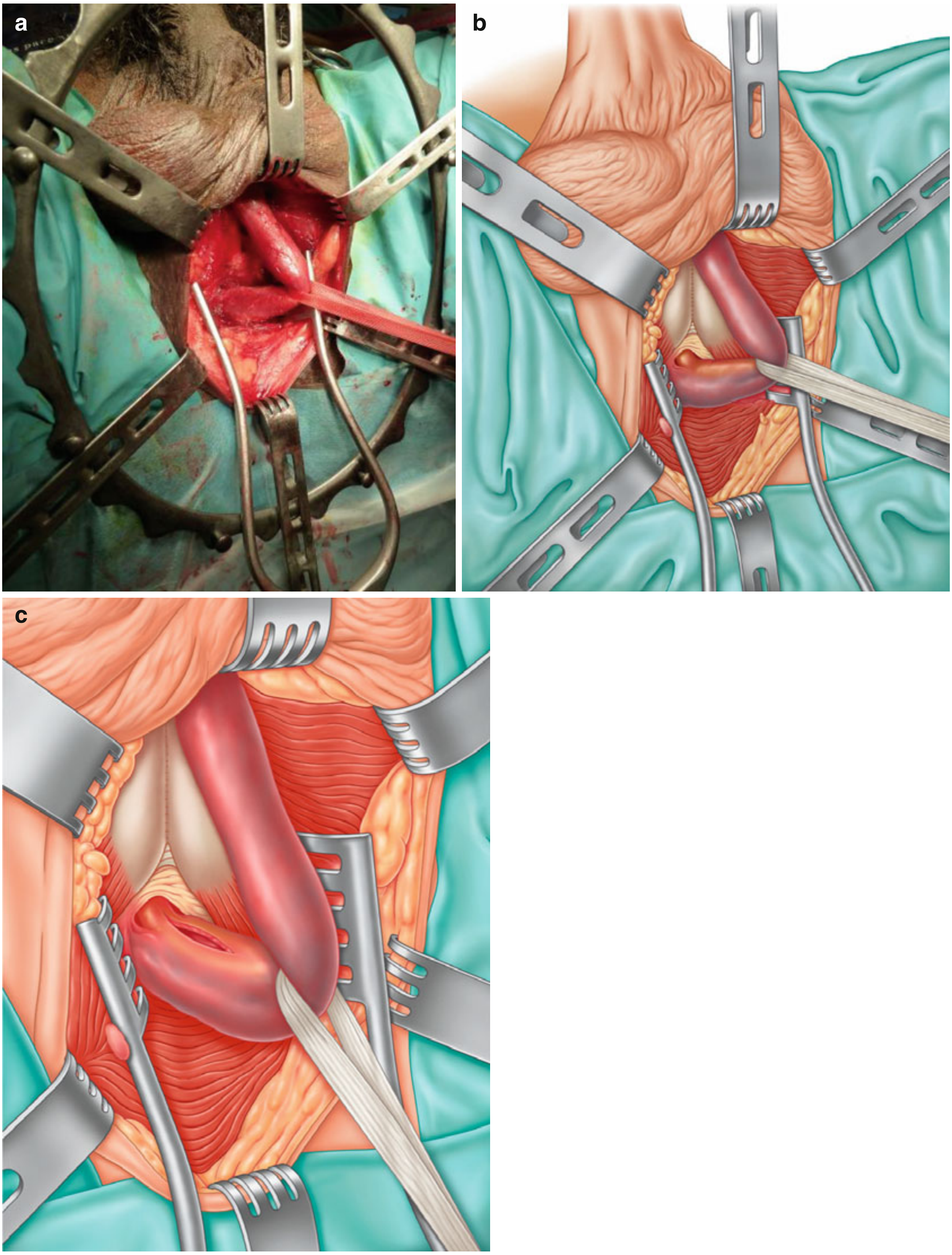

Fig. 38.1 Exposure of the bulbomembranous urethra (**a**) photograph and (**b**) diagrammatic representation. Exposure: (**a**) operative photograph; (**b**) diagrammatic representation; (**c**) longitudinal stricturotomy

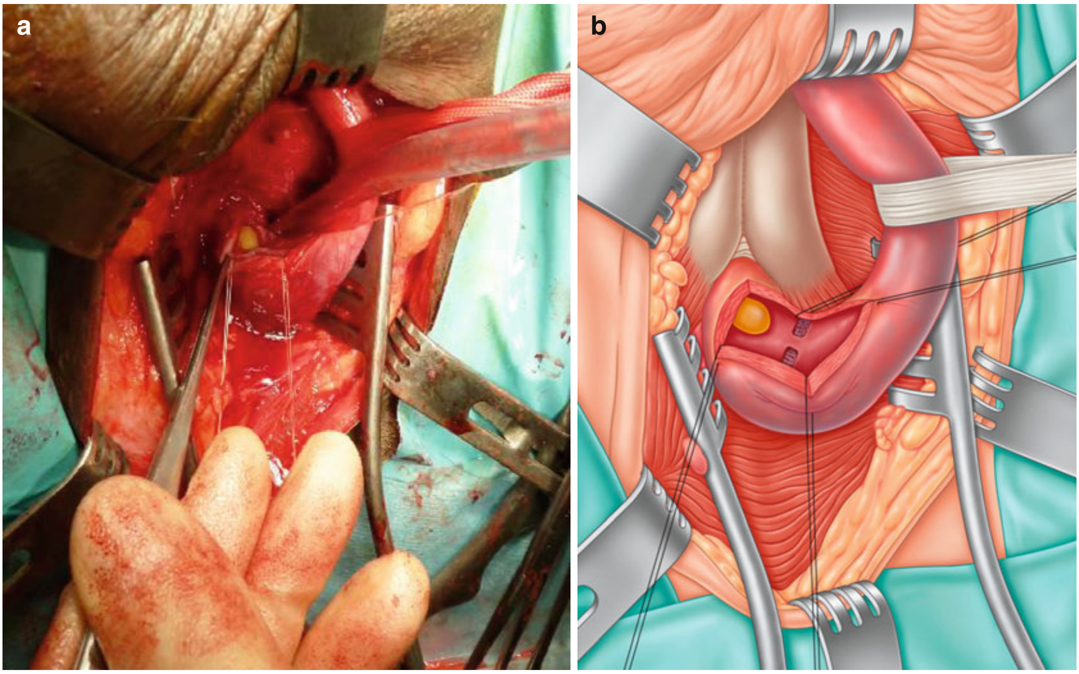

Fig. 38.2 Dorsal stricturotomy of a short, sharp membrane-like stricture (**a**) photograph; (**b**) diagrammatic representation. There is a catheter in the proximal urethra to demonstrate the lumen more clearly. The epithelial defects on either side of the preserved strip can clearly be closed primarily as in Fig. 38.4

is when it is no longer possible to bring the two ends of the longitudinal stricturotomy together comfortably for a horizontal closure (bringing point B to point A in Fig. 38.3).

3. If there is an even longer stricture, several centimetres, we would simply perform a dorsal patch urethroplasty as described elsewhere in this volume.

Kodama has described, in either situation 2 or 3, doing a local excision of fibrotic tissue and then quilting on a buccal mucosal graft to produce an even calibre reconstructed urethra ventrally (Fig. 38.6) which will then be patched dorsally [7].

5/0 Vicryl or 6/0 Vicryl is our preferred suture material. At the end of the procedure, 16 F silicone Foley urethral catheter is passed and the wound is closed in layers with Vicryl. Wound drainage is not usually necessary.

Routine antibiotic prophylaxis is given with premedication, an hour or so before surgery starts, and then again 12 h later. No further antibiotics are prescribed.

The catheter is retained for 2 weeks at which time a peri-catheter urethrogram is performed. If there is no evidence of extravasation, the catheter is then removed. If there is extravasation, the catheter is retained for a third week, and the peri-catheter urethrogram is again performed in the expectation that there will be complete healing at this stage.

Results

All our patients are assessed pre- and postoperatively with a Patient Reported Outcomes Measure questionnaire (PROM) [10], a urinary flow rate study and a retrograde urethrogram and voiding cystogram. Postoperative studies are performed at variable time intervals after the operation according to the patients' circumstances. For the purposes of further discussion, however, satisfactory outcome means significant improvement on the PROM questionnaire, a flow rate within the normal range and a urethra with a radiological normal calibre. Failure to achieve an improvement in the PROM represents subjective failure; inadequate flow rate or a

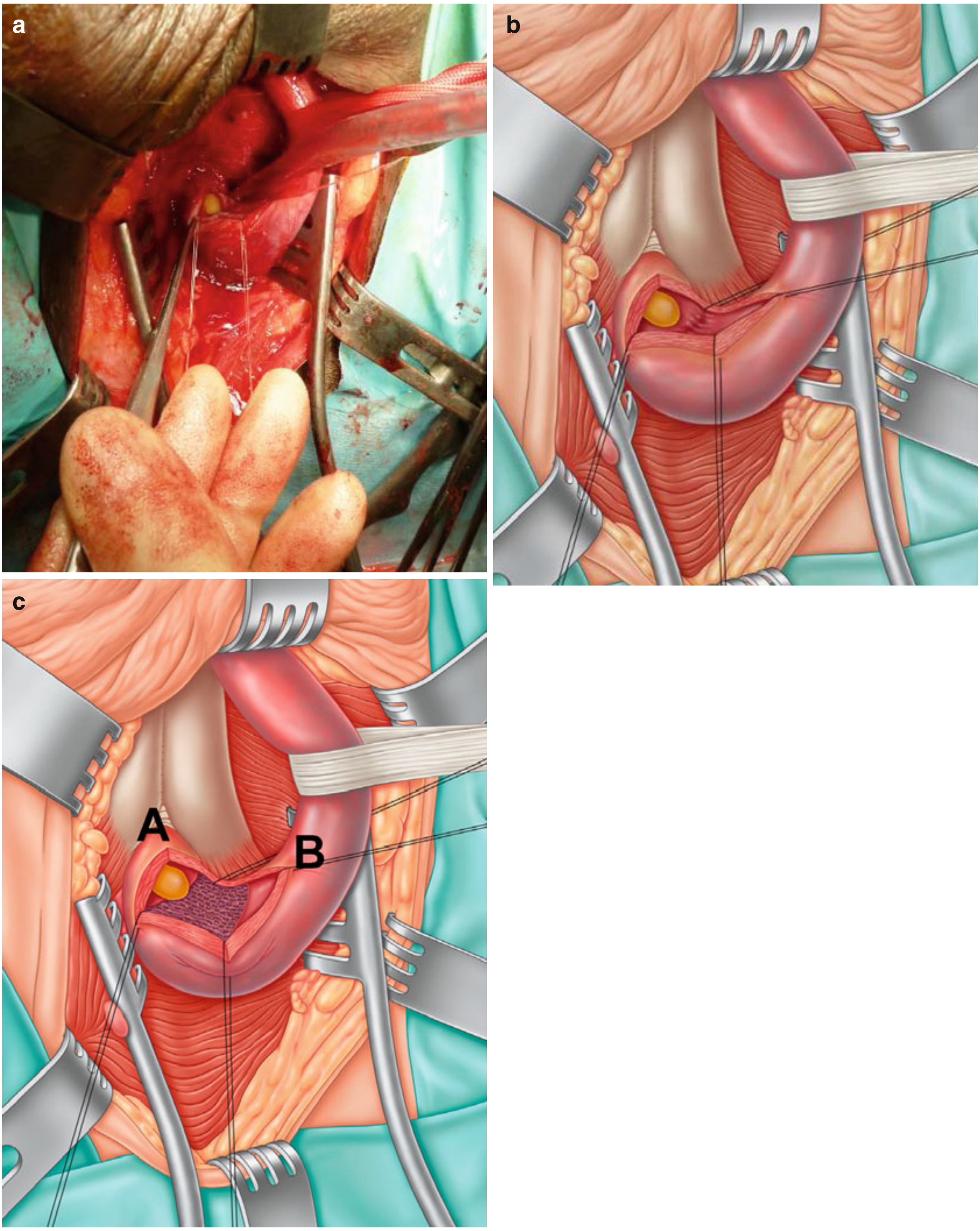

Fig. 38.3 Dorsal stricturotomy of a longer stricture with association spongiofibrosis (**a**) photograph; (**b**) diagrammatic representation; (**c**) after excision of the epithelial and spongiofibrotic components of the stricture. It may or may not be possible to close the epithelial defect primarily as in Fig. 38.4, but it usually is if it is possible to bring *point B* to *point A* comfortably

restriction of urethral calibre represents objective failure. These two do not necessarily occur together; some patients are asymptomatic with a radiological recurrence and others with a normal urethral calibre do not have the symptomatic improvement they wish.

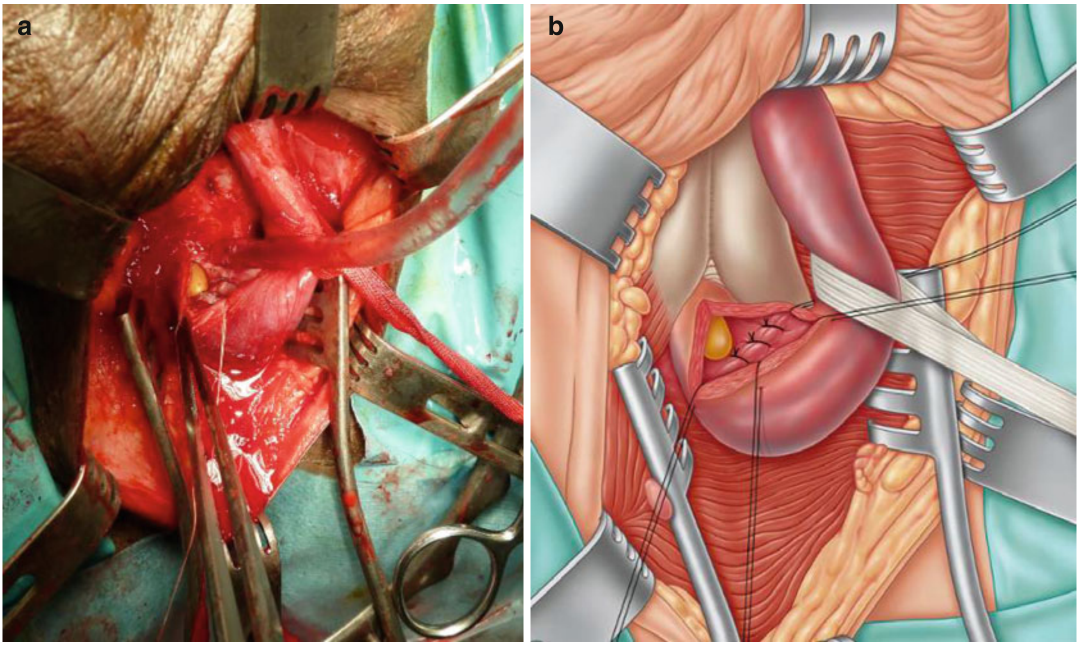

Fig. 38.4 Stricture excised and urethra sutured: (**a**) operative photograph; (**b**) diagrammatic representation

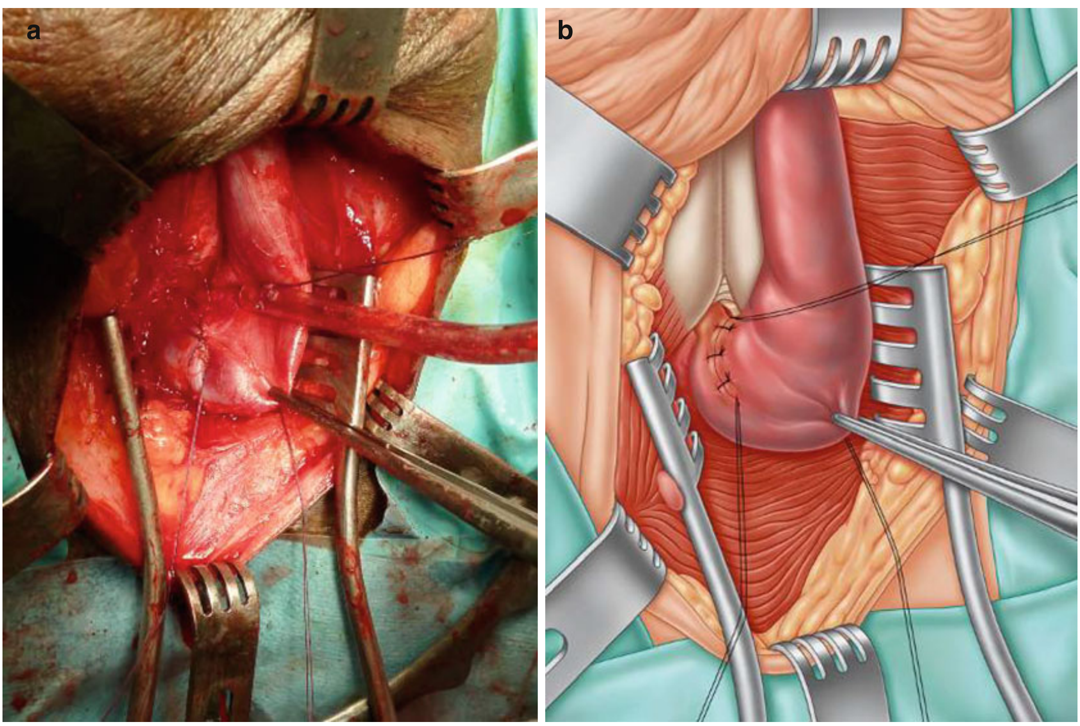

Fig. 38.5 Horizontal closure of stricturotomy incision (**a**) operative photograph; (**b**) diagrammatic representation

We have reported an early series of 22 patients with strictures that were either idiopathic or following TURP or following a previous hypospadias repair [11]. At the time of publication, 16 patients had 1-year follow-up and were free of obstructive symptoms of whom 12 had undergone excision and stricturoplasty and 4 had undergone stricturoplasty alone. All were subjectively improved and 15 out of 16 were objectively improved – 1 patient had a urethral calibre that was only 80 % normal but was symptomatically improved and had a normal flow rate. At that time there were 6 patients with a follow-up of less than 1 year. They have now reached 1 year of follow-up and all have a normal flow rate and a normal postoperative urethral calibre. A common, if not characteristic, feature of these patients is that they appear to have buckling of the ventral aspect of the urethra as a result of the longitudinal shortening of the dorsal of the urethra produced by the stricturoplasty (Fig. 38.7).

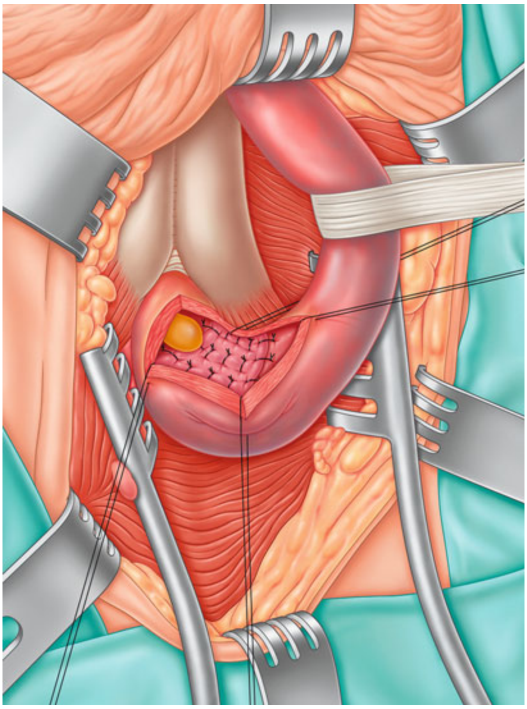

Fig. 38.6 Epithelial defect replaced by a buccal mucosal graft quilted onto the spongiofibrosis when the defect is too long for primary anastomotic closure. The urethra can then be closed with a dorsal patch

Discussion

The essence of our experience thus far is that we have a procedure that, at least at 1 year, has objective evidence of a 95 % success rate with a subjective improvement in all patients. It is therefore at least as good as excision and end-to-end anastomotic urethroplasty with potentially a lower morbidity. The follow-up is short but most patients who are going to have a recurrent stric-

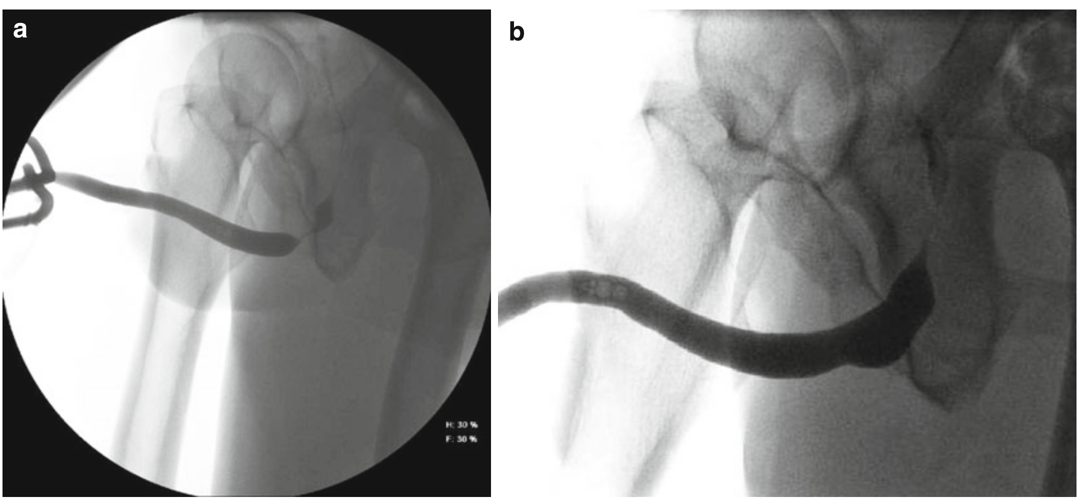

Fig. 38.7 Radiological appearance (**a**) before and (**b**) after surgery. The buckled appearance of the inferior margin of the urethra after surgery is characteristic

ture do so symptomatically within 2 years [12]. We feel that objective normality at 1 year probably indicates a longer term satisfactory result.

Some clinicians might object that in some of our patients, the stricture was not excised and that in these patients, the procedure was a "stricturoplasty" rather than a urethroplasty. We would argue that in some patients there is little to excise, that excision in some patients causes as much fibrosis as it has excised, and that urethral calibre can often be more than adequately restored by "stricturoplasty" without any further trauma. Indeed we are coming to regard "stricturoplasty" as the procedure of choice in the short sharp membrane-like strictures of the proximal bulbar urethra.

The key to the technique used is the anatomy of the bulbomembranous urethra. It is generally accepted in urological practice that the membranous urethra is not surrounded by corpus spongiosum at the perineal membrane and continues on the perineal aspect of that membrane as the bulbar urethra, which is completely enclosed by the corpus spongiosum. By contrast, in anatomical descriptions, the anterior aspect of the membranous urethra is described as being longer than the posterior aspect, despite being on the concavity of the curvature of the membranous urethra because there is a 1–2 cm component of the anterior or dorsal aspect of the membranous urethra immediately below the perineal membrane subadjacent to the point of fusion of the crura of the corpora cavernosa that is not enclosed by the corpus spongiosum and is, therefore, technically, the membranous urethra (Figs. 38.8 and 38.9). Indeed, the Terminologia Anatomica does not recognise the term "bulbar" and "penile" or "pendulous" or any other subdivisions of the anterior urethra – which it calls the spongiose urethra – and it regards the term "membranous urethra" as a misnomer because the existence of a urogenital diaphragm has been refuted [13].

Furthermore, although the membranous urethra is described as being only 1–2 cm long in anatomical texts, it seems to be longer in life [14]. It can also be stretched. Indeed, it can stretch considerably, e.g. when the bladder is displaced vertically by an expanding haematoma after a pelvic fracture or when the prostate is retraced upward

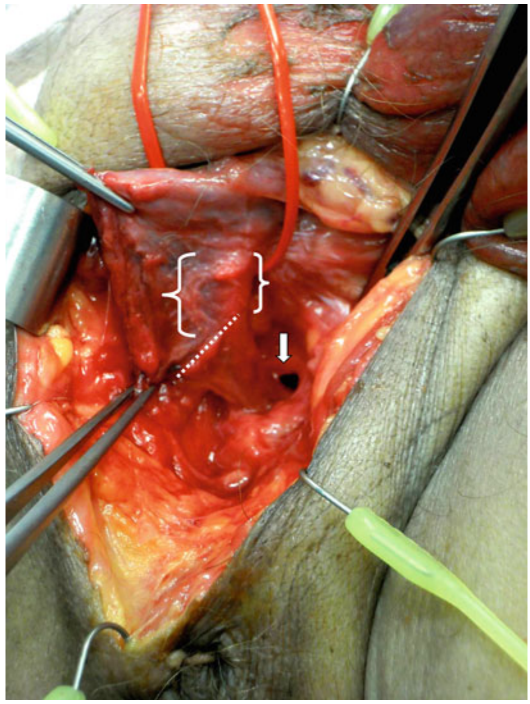

Fig. 38.8 Cadaveric dissection of the bulbomembranous urethra. *Arrow* indicates the anterior margin of the perineal membrane; *dotted line* indicates the original relationship of the urethra to the perineal membrane; *brackets* indicate that part of the urethra below the perineal membrane that is not covered by the spongiosum on its dorsal aspect. The corpus spongiosum is retracted by the two pairs of forceps

before urethral transaction during a radical retropubic prostatectomy. These detailed anatomical features of the bulbomembranous urethra and principally its concavity, lack of corpus spongiosum and stretchability allow this non-transecting approach to proximal bulbar and bulbomembranous urethroplasty.

In principle, this technique of longitudinal stricturotomy and transverse closure is a form of Heineke-Mikulicz stricturoplasty, best known in intestinal surgery [15]. The Heineke-Mikulicz approach to urethroplasty has been described previously, albeit many years ago, applied to the central aspect of the proximal bulbar urethra and after division of the bulbar arteries [16–18]. It is also the technique used for the initial meatoplasty in a MAGPI repair for hypospadias [19].

The original idea of a non-transecting approach to proximal bulbar urethroplasty was

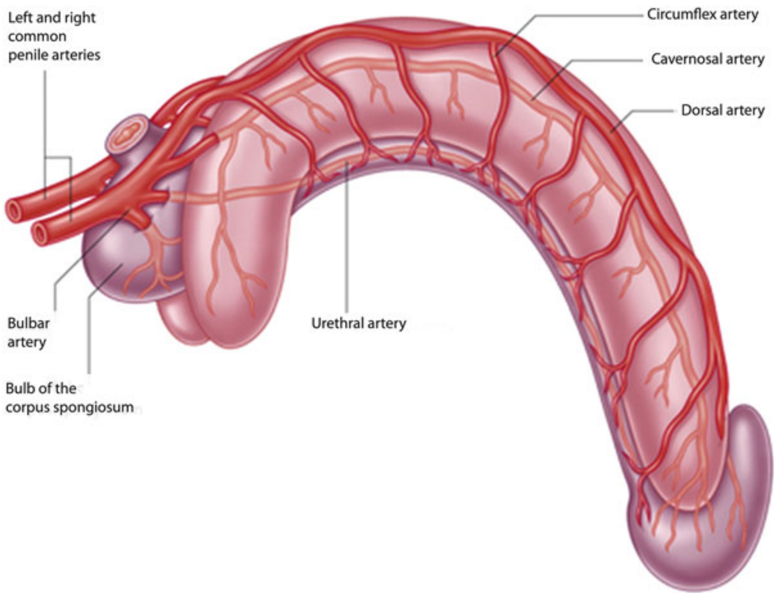

Fig. 38.9 Arterial blood supply of the urethra, corpus spongiosum and corpora cavernosa

developed by Jordan [5, 6]. His technique differs from ours principally in that he mobilises the posterior aspect of the corpus spongiosum from the perineal body and specifically defines the bulbar arteries to be able to retract them out of the way, which we believe is unnecessary and may cause them to be damaged unintentionally.

The reason the non-transecting approach may be valuable is not just the hypothetical value of minimising surgical trauma. The current approach to bulbar urethroplasty is based on our understanding of the blood supply of the urethra [17]. There are three components (Fig. 38.9). Firstly, there are the bulbar arteries that supply the bulb of the corpus spongiosum posterolaterally that come from the pudendal arteries deep in the perineum. Secondly, there is the retrograde blood flow from the glans into the corpus spongiosum that comes from the dorsal arteries of the penis. Thirdly, there are the circumflex branches of the dorsal arteries that run around the shaft of the penis from dorsal to ventral, within the Buck's fascia, at 1 cm intervals. If the corpus spongiosum of the bulbar urethra is mobilised and transected to excise a stricture, the proximal mobilised end survives on the bulbar arteries and the distal mobilised end survives on the retrograde blood flow that comes from the glans. When this is critically impaired, as when there is coexisting hypospadias, the mobilised distal segment of the urethra may not be sustained by the circumflex vessels alone and ischemia may occur [20].

There may not be a problem if the patient has a normal vascular anatomy at the time of urethroplasty and the surgery is successful, but some patients may have further problems later in life such as another stricture requiring further urethroplasty or urinary incontinence after a radical prostatectomy for cancer for which they might need implantation of an artificial urinary sphincter. In such patients, intact vascularity of the corpus spongiosum may be critical for the success of further surgery.

The non-transecting approach, when feasible, is all part of a general approach to minimise the morbidity of traditional urethroplasty. Excision and end-to-end anastomotic urethroplasty has good and durable outcomes, while stricturotomy and patch urethroplasty, using a buccal mucosal graft seems to give excellent results, with a decreased potential for post operative side effects. If a stricture turns out, at the time of surgery, to be longer than anticipated from the preoperative imaging, it is a simple matter of converting from a non-transecting anastomotic urethroplasty to a (non-transecting) dorsal patch urethroplasty. We therefore recommend to our patients with short bulbar strictures, except those whose strictures are the results of fall-astride or straddle injuries, that they undergo non-transecting bulbar urethroplasty. We inform them that we will expose and mobilise the urethra and make a longitudinal stricturotomy into the healthy, normal-calibre urethra on either side of the stricture. If we find a short stricture, we will excise and perform an intraluminal anastomotic repair, as described above; if we find a membrane-like stricture, we will perform a "stricturoplasty" as also described above. If the stricture is longer than expected, we will perform a dorsal patch bulbar urethroplasty using a buccal mucosal graft. All patients understand that the definitive decision on the type of procedure is made at the time of surgery.

We now reserve excision and end-to-end anastomosis for those patients who have had fall-astride or straddle injuries or who otherwise have severe full-thickness spongiofibrosis if not complete urethral transaction as a result of trauma.

Surgical Pearls and Pitfalls

Important Intraoperative Surgical Points

- Adequate mobilisation to give a tension-free anastomosis.
- Progress from simple mobilisation, to developing the intercrural plane and crural separation, to inferior pubectomy, to crural rerouting, to abdomino-perineal repair as necessary to avoid tension at the anastomosis.
- Incision or excision of sufficient fibrosis to allow a satisfactory anastomosis. Usually incision at 12 o'clock and 6 o'clock will allow the fibrosis to spring open and nothing more radical is required. Sometimes, after severe trauma or in revisional surgery, much more extensive excision is required. Excision of all the fibrosis is not the goal; creating the space to allow a satisfactory anastomosis is the goal.
- The anastomosis should give a good bite of all layers of both ends of the urethra and bring the epithelium of the two ends into direct apposition.

Potential Intraoperative Surgical Problems

- Bleeding – bleeding comes predictably from the bulbar arteries and veins and from the venous sinuses that run under the inferior pubic arch. These are best dealt with by suture-ligation rather than by diathermy.
- Tension-free anastomosis was one of the key points mentioned in the adjacent column, and taking steps to reduce tension is critical. Unfortunately judging tension is entirely subjective and there are no hard and fast rules.
- Orientation is critical for a successful outcome. Always make sure you see the verumontanum before completing the anastomosis.
- Difficult access to the proximal bulbar urethra in some patients may be improved by developing the intercrural plane.
- There may be difficulty with horizontal closure of the longitudinal stricturotomy if the stricture has proved to be longer than expected, in which case a dorsal buccal mucosal graft patch would give a better outcome.

Important Patient Selection Points

- A short proximal stricture with limited spongiofibrosis and periurethral fibrosis.
- The technical approach to bulbar urethral strictures is a progressive approach: stricturoplasty for membrane-like strictures, excision and epithelial end-to-end anastomosis combined with stricturoplasty for strictures of 1 mm to (approximately) 2 cm and a dorsal patch urethroplasty without excision of the stricture for longer strictures. In selected cases, the excision of the stricture and ventral patching with a buccal mucosal graft to cover the exposed corpus spongiosum, as well as dorsal patching, may be appropriate.

Preferred Surgical Instruments and Sutures

- Perineal ring retractor
- A gorget
- DeBakey forceps, Mcindoe scissors and needle holder (generally 7″)

- 5/0 Vicryl in most instances but 6/0 Vicryl for an intraurethral epithelial anastomosis
- 16 F silicone Foley catheter

Editorial Comment

The non-transecting stricturoplasty described here is an important advance in the urethral reconstruction armamentarium. I have found this approach to be most useful in complex cases, such as synchronous strictures or those who may be in need of an artificial urinary sphincter subsequently, where preservation of spongiosal continuity is paramount.

–Allen F. Morey

Acknowledgement Philip Wilson prepared the illustrations.

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39 Genital Skin Loss and Scrotal Reconstruction

Daniel Rosenstein

Summary

Genital skin loss is an unusual condition, which in addition to obvious physical deformity can lead to significant psychological and emotional distress. A variety of causes have been described, including external trauma, burns, infections, self-mutilation, constrictive devices, and lymphedema. Each of these has a different underlying mechanism leading to eventual skin loss. Initial management depends on the underlying etiology and ultimately directs the timing and appropriate surgical choice for definitive reconstruction. Extensive skin loss poses a considerable challenge for the urologic surgeon. Several different surgical techniques have been described, all of which share the goal of restoring functionality and cosmesis while at the same time minimizing morbidity. In recent years skin grafting has become the most commonly used reconstructive technique with good functional and cosmetic outcomes.

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Epidemiology

Genital skin loss is a relatively rare and infrequently encountered medical condition. To date, no large, comprehensive epidemiologic study has been conducted to assess the precise incidence and prevalence of such injuries. The paucity of epidemiologic data is likely due to the rarity of genital skin loss as well as the wide variety of mechanisms that can lead to such injuries, including external trauma, burns, infections, self-mutilation, constrictive devices, and lymphedema. The first three aforementioned causes are the most common. Traumatic genitourinary injuries account for 1.5–11 % of all traumas, with somewhat higher rates in the developing world and with over half of patients having concomitant injuries [1, 2]. Some of the largest series, including between 100 and 250 patients, report data from a single institution or the military [1–3]. These series examine external male genital trauma as a whole, including penile, scrotal, and testicular injuries all of which can present with genital skin loss. The traumatic injuries are divided into blunt and penetrating, with the latter prevailing. In industrialized nations gunshot wounds are the most common reason for external genital trauma, whereas traffic accidents account for the majority of genital injuries in the developing world [1, 2]. Farming and industrial accidents now account for only a minor fraction of genital skin avulsion injuries due to improved safety measures. Even more infrequent causes for traumatic genital skin loss

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are animal/human bites as well as vacuum devices used for sexual arousal [4, 5].

Burns to the genital area account for 2.8–13 % of admissions to burn centers [6]. The most common types of burns are thermal in nature, including flame and scald burns, followed by chemical and lastly by electrical burns. Children are most commonly afflicted with scald burns from hot liquids, whereas adults suffer more often from flame burns [6]. Care must be taken to decrease the risk of infection of the burned area, as infection may lead to further skin loss.

Genital skin loss from necrotizing soft tissue infections, (i.e., Fournier's gangrene) has been well documented in case reports and case series, but the exact incidence of this devastating infectious process has not been reported. When Fournier initially described the necrotizing skin infection in 1883, the process was thought to be idiopathic and found only in young healthy men [7]. It is now recognized that the condition can occur at any age and in either gender, with the majority of patients between 20 and 50 years old and an estimated male to female ratio of 10:1 [8]. Several risk factors have been identified, including diabetes mellitus, chronic alcoholism, smoking, renal/liver failure, malignancy, paralysis, HIV, steroids, and chemotherapy, all of which lead to impaired microcirculation and/or immunosuppression. The mortality rate for this disease ranges from 3 to 67 % [8–10].

Granuloma inguinale or donovanosis, caused by the bacteria *Calymmatobacterium granulomatis*, is another infection of the genital area which can lead to ulceration and dramatic skin loss. While primarily endemic in tropical and subtropical areas of the world, approximately 100 cases per year are reported in the United States, mostly between 20 and 40 years of age with men more often affected than women [11].

Reports of self-mutilation involving the male external genitalia are rare, with only 110 cases reported [12]. The majority of auto-mutilations are performed by men with underlying psychosis or personality disorders, especially of the borderline type. Another mostly self-inflicted injury that can lead to genital skin loss is the unusual condition of penile/scrotal strangulation. Since this entity was initially described in 1755, approximately 60 cases have been reported in the literature [13]. In adults strangulation is most commonly caused by constrictive devices (e.g., metal rings) applied for sexual arousal or to achieve/maintain an erection. In children, strangulation can occur due to a hair that inadvertently becomes wrapped around the penis, but threads or strings used by caretakers to overcome enuresis are also causes of incarceration which may lead to necrosis and gangrene [13, 14].

Genital lymphedema, which can have many different causes, is included in this chapter because treatment for severe cases involves reconstructive techniques which are similar to those employed for major genital skin loss. Primary/congenital lymphedema which presents either at birth or puberty is a very rare condition caused by lymphatic dysplasia, whereas secondary/acquired penoscrotal lymphedema is quite common and can be classified as neoplastic, infectious, granulomatous, reactive, disorder of fluid balance, and idiopathic [15]. Parasitic infections are the most common cause of genital lymphedema, affecting an estimated 90 million people worldwide [16].

Mechanism/Etiology

Genital skin loss is an infrequent medical condition most often due to external trauma, burns, or infections. The anatomy of the male external genitalia offers protection to the penis and scrotum, being located between the thighs and being mobile enough to avoid most adjacent blunt or penetrating forces. The anatomic location of the genitals usually shields them from trauma due to thermal, chemical, or electrical burns, most of which are not limited to the genital area but involve other parts of the body such as the inner thighs and perineum. Furthermore, the laxity of the skin that covers the external genitalia makes the penis and testicles less susceptible to penetrating trauma [17]. Nevertheless, the looseness of the genital skin can predispose to avulsion injuries, most often occurring along avascular fascial planes as seen in trauma caused by traffic accidents, industrial machinery, animal/human bites, and vacuum devices. Skin loss of the scrotum is usually deep to the dartos layer but superficial to the external spermatic fascia, whereas the penile shaft skin is separated superficial to Buck's fascia [5]. Avulsion injuries can lead to complete penile and/or testicular amputations in unusual cases of extreme or deep shearing forces.

Self-mutilation injuries, most often seen in patients with an underlying psychosis or personality disorder, can vary from minor skin lacerations involving a razor blade or other sharp object to complete auto-emasculation with penile and/or testicular amputations [18]. Patients at highest risk for auto-mutilation to the genitalia typically have a history of delusions, sexual conflict, and severe childhood deprivation or suffer from depression with suicidality and self-destructive behavior [12]. Another mechanism of self-inflicted scrotal skin loss is penile/scrotal incarceration with constriction devices. Constriction device use varies among age groups; whereas middle-aged and elderly populations seek to increase sexual performance and arousal, adolescents apply the devices out of curiosity and for masturbation. In infants penile strangulation can occur from a hair being wrapped around the penis or by intentional placement of a string or thread by a caregiver to prevent enuresis [13]. In typical usage, individuals place metallic or nonmetallic strangulation objects around the base of the penis while in a flaccid state and sometimes include the scrotum. Following erection, venous backflow is blocked due to the constriction at the base. If the erection is maintained for an extended period of time, lymphedema of the soft tissue results and the device can no longer be removed by the patient. Elevated pressure in the corpus spongiosum and corpora cavernosa causes reduced arterial flow leading to hypoxia, skin necrosis or gangrene, and eventual corporal fibrosis.

Bacterial infections are another cause for genital skin loss due to hypoxia resulting in skin necrosis and gangrene. While most cases of necrotizing fasciitis of the genitals and perineum (e.g., Fournier's gangrene) are polymicrobial, some are also monomicrobial, involving aerobic and/or anaerobic species including *Escherichia coli*, *Streptococcus* spp., *Staphylococcus aureus*, *Enterococcus* spp., *Pseudomonas aeruginosa*, *Bacteroides* spp., *Klebsiella*, and *Proteus spp* [8]. The involved organisms frequently have a colorectal, genitourinary, or dermatologic origin and opportunistically enter the skin of patients with impaired cellular immunity or microcirculation [9]. The infection leads to thrombosis of small vessels, which in turn causes hypoxia, necrosis, and gangrene. Hence, Fournier's gangrene is not idiopathic as initially described, but an invasion of bacteria resulting in critical ischemia of the soft tissue [19]. It can cause major skin destruction along the anatomic fascial planes of dartos, Colles, and Scarpa, often sparing the deeper layers, and has the potential of expanding from the perineum along the anterior abdominal wall up to the clavicles.

Much like necrotizing fasciitis, lymphedema of the external genitalia can give rise to major physical and psychological disability. Three types of lymphedema are described in the literature: primary/congenital, secondary/acquired, and idiopathic. Congenital lymphedema, affecting infants and young adults, is caused by aplastic, hypoplastic, or hyperplastic abnormalities of the lymphatic vessels. Such malformations result in nonfunctioning lymphatic transport and accumulation of large protein molecules in the interstitial space, causing increased osmotic pressure, fluid stasis and accumulation in the interstitium, and swelling of affected tissues [20]. In contrast, secondary/acquired lymphedema is caused by obliteration of the lymphatic vessel lumen by neoplastic, infectious, granulomatous, or reactive processes. Pelvic malignancies, such as urologic cancers, lymphoma, or metastatic disease, cause obstruction of the lymphatic drainage system, as is also seen with filariasis where nematodes like *Wuchereria bancrofti*, *Brugia malayi*, or *Brugia timori* occlude the lymphatic channels. Other infectious agents like *Chlamydia trachomatis* (lymphogranuloma venereum), *Streptococcus pyogenes* (erysipelas), and *Mycobacterium tuberculosis* (tuberculosis) if left untreated can give rise to ulcerations, strictures, and fibrosis of the lymphatic channels. Granulomatous disease, including sarcoidosis, rheumatoid arthritis, and Crohn's disease, has been associated with cases of genital lymphedema [15]. Granuloma inguinale, a granulomatous, infectious disease caused by the gram-negative intracellular parasite *Calymmatobacterium granulomatis*, can lead to extensive ulceration where the entire genital area is mutilated, the scrotum denuded, and the penis unidentifiable [21]. Lymphedema can also be of reactive nature due to trauma, burns, radiation, venous thrombosis, or chronic venous insufficiency. It is also seen in patients suffering from systemic disease, including renal or cardiac insufficiency, leading to fluid overload and hypoproteinemia. If the lymphedema has not entered the chronic phase, it will most likely resolve spontaneously once the underlying disease is treated.

Initial Presentation/Diagnosis

Most patients who have trauma to the external genitalia with skin loss are seen in the emergency department or trauma bay. The degree of skin loss can vary from minor lacerations to complete skin loss, involving the penis, scrotum, perineum, and thighs. A thorough urologic examination is warranted, particularly if the skin loss was the result of penetrating trauma, due to risk of urethral and testicular injuries [2]. Up to 22 % of penile gunshot wounds have a concomitant urethral injury [17]. The extent of missing skin (as well as the viability of residual skin) must be assessed, as well as potential injury to the urethra or testicles. If the patient has gross or microscopic hematuria and is unable to void or blood is seen at the meatus, a retrograde urethrogram is indicated for evaluation of urethral injury. In addition, ultrasonography of the testicles is a valuable tool to assess their viability or integrity, especially if the suspicion for testicular injury is high. An assessment of wound contamination is important, since initial management steps and timing of reconstruction are different for clean versus contaminated wounds, with the latter requiring copious irrigation and possibly delayed closure or skin grafting. Furthermore, patients with self-inflicted injuries including skin loss due to self-mutilation should be evaluated for underlying psychiatric illness.

Burn patients are almost always seen in the emergency department or burn center. After initial resuscitation, the primary evaluation of any burn victim includes calculating the total body surface area (TBSA) affected by the burn. The genital area represents 1 % of the TBSA, and patients who suffer from perineal burns are estimated to have concomitant burn injuries of 20–50 % of their TBSA [22]. Secondarily, burned areas are assessed for their depth. First-degree burns are limited to the epidermis and are erythematous and painful. Second-degree burns, which involve the entire epidermis plus varying amounts of dermis, are classified as superficial or deep depending on the extent of dermal involvement. The affected area is erythematous, painful, and moist with characteristic-appearing blisters. Skin involved in third-degree burns is insensate and white or even brown/black if adipose tissue is involved. Electrical burns are more difficult to evaluate, since the extent of the injury is not immediately identifiable. Genital viability can be assessed using Doppler examination of the penis and testicles, which can help in surgical planning for possible penile amputation or orchiectomy. Associated trauma to the bladder, rectum, and pelvic organs should be explored via cystoscopy plus proctosigmoidoscopy in men and vaginal speculum examination in women [23]. Routine urinalysis should be performed to assess hemoglobinuria and myoglobinuria from tissue breakdown, which could lead to renal failure and must be treated aggressively with hydration and urine alkalinization [5].

Compared to avulsion injuries and burns, infectious processes leading to genital skin loss have a much more subtle presentation. For example, the initial presentation of Fournier's gangrene may only involve genital swelling and induration without any change in skin color. If not recognized early, the skin eventually becomes erythematous, weeping, crepitant, necrotic, and foul smelling. The patient initially develops significant pain in the affected area, which may become insensate with progressive ischemia and

Fig. 39.1 Fournier's gangrene involving anterior 50 % of scrotum. The skin and underlying scrotal tissue are frankly necrotic. Note significant erythema at periphery of necrotic region, indicating progressive necrosis deep to the skin

tissue destruction (Fig. 39.1). Within hours, the disease can advance to a fulminant, life-threatening skin necrosis with sepsis and organ failure. Imaging studies such as ultrasonography and computed tomography can help identify subcutaneous gas in the event of ambiguity in clinical diagnosis, but they should never delay surgical intervention if clinical suspicion is high. Unfortunately, the embarrassment patients experience when they suffer from conditions involving the external genitalia, especially when self-inflicted, may delay their presentation to hospital. This may result in progression of medically treatable conditions to surgical emergencies with major skin loss (Fig. 39.1).

Genital lymphedema is easily identified by a thorough history and physical exam. In the early stages, pitting edema of the skin can be demonstrated, which can evolve to tissue fibrosis and eventually lymphostatic elephantiasis. The skin of patients with chronic lymphedema has a "peau d' orange" (orange peel) appearance with warty outgrowths and generalized thickening. While the swelling itself does not cause pain or severe discomfort, the resulting disfigurement and impaired mobility can lead to significant physical and psychological morbidity (Fig. 39.2) [24].

For ambiguous clinical presentations, imaging studies including computed tomography, magnetic resonance imaging, and lymphoscintigraphy can be informative. The latter imaging technique, which involves venous injection of radiolabeled colloid, provides information about lymphatic anatomy as well as function [25].

Initial Management

Avulsion injuries of the external genitalia are rarely life-threatening. Prior to focusing on the patient's external genital injury, every attempt should be made to assess the patient's overall condition and begin any necessary resuscitation efforts without delay. For traumatic injuries to the genitalia (e.g., due to motor vehicle accidents or gunshot wounds), the patient should be evaluated as part of a routine trauma survey and any associated injuries identified and managed expeditiously. The genital wound should initially be irrigated with copious amounts of normal saline or sterile water. Until primary closure or more complex reconstruction can be performed, moist gauze dressing should be applied and changed two to three times daily to prevent tissue desicca-

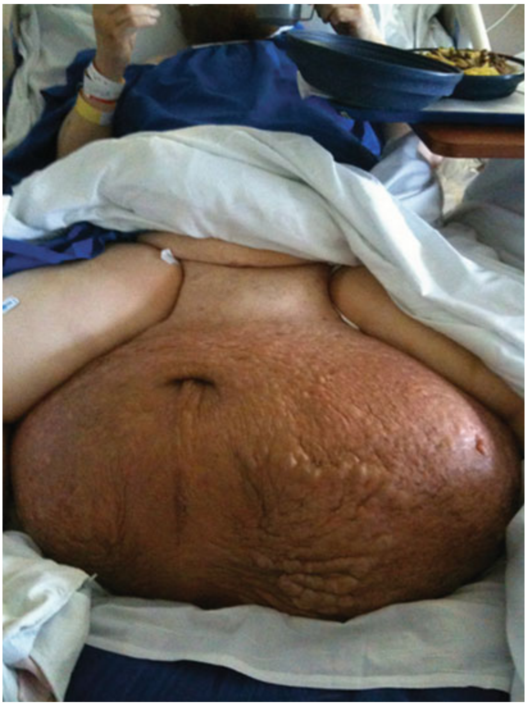


Fig. 39.2 A 55-year-old patient with massive idiopathic scrotal lymphedema. This patient's scrotum weighs approximately 35 kg and greatly impairs his mobility. Note the thickened, woody appearance of the skin with warty outgrowths and the dimple towards the superior aspect through which the patient voids

tion. If the patient is stable and the wound is clean and fresh, immediate repair and reconstruction are advised to prevent bacterial colonization and formation of a fibrous layer around the testicles that is not suitable for reconstruction [5, 26]. If immediate reconstruction of the scrotum is not feasible, the testicles can be placed into thigh pouches where they can remain until definitive reconstruction (Fig. 39.3). In patients for whom future fertility and cosmesis are not of concern, the testicles can remain in thigh pouches indefinitely [5].

Wounds that are contaminated, especially avulsion injuries caused by animal or human bites, should be irrigated and debrided, and empiric antibiotic therapy should be initiated with amoxicillin-clavulanic acid, a second-generation cephalosporin (e.g., cefoxitin, cefotetan), or clindamycin with a fluoroquinolone. Administration of tetanus and rabies prophylaxis is critical when clinically indicated [27].

For burn victims, initial management should also consist of resuscitation and stabilization of the patient with aggressive fluid and electrolyte replacement. A urethral catheter or suprapubic tube may be indicated for adequate assessment of the patient's volume status. Should a supra-

Fig. 39.3 A 62-year-old man with history of Fournier's gangrene of the scrotum. At the time of the initial scrotal debridement, the patient's testes were placed in thigh pouches bilaterally (marked by "X"). He is about to undergo testicular liberation and neoscrotal construction using split-thickness skin grafts (Image Courtesy of Steven Brandes)

pubic cystotomy be required, entry through an unburned area of the abdomen is preferable to prevent contamination and to facilitate reconstruction of the burned area [23]. For patients who are not critically ill and can void spontaneously without contaminating the burned area, some authors have recommended catheter-free management [28, 29]. For thermal burns, the affected area should be cooled down immediately with water to stop the burning process. For chemical burns, there may be a specific antidote that can be applied depending on the nature of the caustic agent (i.e., acidic versus alkaline). The overlying clothes that are contaminated should be removed immediately. If an antidote is not readily available, some authors recommend irrigation without delay using water or saline [17, 26].

Electrical burns require more complex management, since the burned area is not immediately visible and damage to other organ systems may be present. These patients must be closely monitored for cardiac arrhythmias and myoglobinuric renal failure. Regardless of underlying mechanism, following initial resuscitation, the degree/depth of any genital burn should be assessed and treated accordingly. Most first- and second-degree burns can be managed conservatively with application of topical antimicrobial agents, such as 1 % silver sulfadiazine cream. Some deep second-degree and all third-degree burns must be managed with immediate debridement, wound closure, and/or reconstruction.

Like trauma and burn victims, patients with Fournier's gangrene may be critically ill and require immediate resuscitation. Once the clinical diagnosis has been made, broad-spectrum intravenous antibiotics must be administered, with most literature recommending triple antibiotic coverage for aerobic, anaerobic, gram-positive, and gram-negative bacteria [9]. Even for nonsystemic infections, emergent surgical debridement is absolutely mandatory to minimize tissue loss and prevent life-threatening sepsis. The goal of surgical debridement is to remove all nonviable, infected tissue and to resect until bleeding margins are encountered. If penile tissue is involved and the shaft skin has been circumferentially excised, the resection margin should be carried up to the corona to prevent disfiguring lymphedema, which occurs due to the disruption of the lymphatic channels proximally. The tissue should be sent for culture so that antibiotic coverage can be revised appropriately. After initial debridement the patient should be monitored closely (possibly in an intensive care setting) for further spread of infection and may need to return to the operating room several more times for additional debridement. Moist saline-soaked gauze should be applied to areas where skin has been excised and must be changed two to three times a day.

There has been considerable experience using *vacuum-assisted closure* (*VAC*) to provide negative pressure wound therapy (NPWT) on the wound bed and potentially reduce number of dressing changes and expedite wound closure [30]. NPWT functions by removing potentially enhancing local vascularity, decreasing bacterial colonization, and increasing epithelialization. Many urologic conditions have been successfully treated using NPWT, including Fournier's gangrene defects (post debridement), partial- and full-thickness burns, and meshed skin grafts and flaps (Fig. 39.4).

In addition, urinary diversion with suprapubic cystotomy may be required in the event of extensive penile involvement. For patients with perirectal tissue loss, a diverting colostomy can help to prevent contamination of the wound after debridement. The initial management of patients presenting with genital strangulation due to constriction devices can pose a significant challenge for the urologic surgeon. The main goal is to emergently remove the object that is strangulating the genitalia to prevent skin necrosis or even complete amputation. This can be done in the emergency department under local anesthesia with a penile block or in the operating room with spinal or general anesthesia. Several methods for device removal have been

Fig. 39.4 A 58-year-old patient who has undergone (**a**) split-thickness skin graft resurfacing of penis, testes, and groins following extensive Fournier's gangrene. (**b**) The delicate grafts are further protected and adherent to the wound using the VAC (vacuum-assisted closure) device. (**c**) Excellent graft take noted at 1 month post-op (Images Courtesy of Steven Brandes)

described in the literature, including using tools like bolt cutters, an electrical rotating saw, or the string technique where a string is maneuvered beneath the constriction device and wrapped around the distal end of the phallus in order to squeeze out the edema. The constriction device is then pulled over the distal, wrapped penis until it is completely removed [14]. After relief of the constriction, most patients recover completely, but prolonged vascular compromise can lead to necrosis and gangrene; close monitoring and possible Doppler ultrasonography of the penis and testicles are therefore advised.

Patients who present with genital lymphedema usually do not require emergent treatment, since it is usually a chronic condition and the primary underlying disease process needs to be managed. Diuretics may be used in patients with fluid overload from congestive heart failure or renal failure. Lymphedema due to malignancy may require surgical resection or chemotherapy.

Fig. 39.4 (continued)

Reactive lymphedema caused by sarcoidosis has been successfully treated with steroids. Infections causing edema need to be treated with the appropriate antibiotic or antihelminthic drugs [31]. Hence, if the pathologic process in the lymphatic channels is reversible, the lymphedema can potentially be treated with conservative measures to decrease the swelling and prevent skin breakdown, including elevation, scrotal support, and skin hygiene. Once the edema becomes chronic and the lymphatics are permanently damaged, more aggressive therapy is needed.

Definitive Management

This part of the chapter will only focus on scrotal reconstruction; penile reconstruction is covered in detail elsewhere in this book. Prior to reconstruction, the wound needs to be scrubbed and irrigated thoroughly, nonviable skin debrided, hemostasis achieved, and any underlying infectious process systemically treated. Especially in patients with Fournier's gangrene who may undergo several debridements before the infectious process is under control, a delayed reconstruction following a minimum of 5–7 days of dressing changes is preferred [26]. In addition, wounds caused by human bites are contaminated and should not be closed primarily [32, 33]. Small scrotal wounds can usually be closed primarily due to the elasticity of the skin, especially if they are not contaminated and less than 60 % of skin is missing (Fig. 39.5) [22, 26]. The closure should be performed in two layers (dartos and skin) using 3-0 Vicryl and 4-0 chromic suture. A Penrose drain should be left in place to prevent transudate accumulation.

Once more than 60 % of the scrotal skin is lost, reconstruction is more complex, possibly requiring thigh pouches, thigh flaps, tissue expansion, and/or autologous skin grafts. If fertility and cosmesis are of no concern, thigh pouches are a reasonable long-term solution for some (elderly) patients. However, if the patient desires a reconstructive procedure and future optimal fertility, the testicles should only stay in the pouches temporarily. Initially, the testicles and spermatic cord are mobilized up to the external ring. The pouches are created with blunt finger dissection of the anterior medial thigh. The testicles are then placed into the pouches and do not need to be anchored with suture, but they should be placed at different levels to prevent collision during ambulation [34]. Ideally the testes should be seated posteriorly in the thigh pouches in order to decrease pressure during crossing of the thighs.

Rotational fasciocutaneous thigh flaps can be raised to create a neoscrotum (Fig. 39.6). Patients suitable for this reconstructive technique must have sufficient healthy thigh skin that can be mobilized and allow for primary donor site closure. The testicles are first sutured together in the middle to prevent a bifid appearance of the scrotum. The skin flaps are outlined and then incised, raising them superiorly and laterally to preserve the blood supply of the external pudendal, obturator, and medial circumflex arteries, in addition to the nerve

Fig. 39.5 A 28-year-old male with a small amount of scrotal skin avulsion related to a skateboarding accident (**a**). Because of the limited amount of tissue loss and inherent elasticity of the scrotal skin, a primary closure was performed (**b**)

supply from the ilioinguinal and genitofemoral nerves [26]. The flaps are brought together and sutures placed in the midline to give the appearance of a median raphe, after which the thigh wounds closed primarily. The testicles should be covered with the least possible amount of subcutaneous tissue to assure lower temperatures and maintain normal spermatogenesis [26, 35].

Another means of generating adequate donor flaps is with use of tissue expanders (Fig. 39.7). The expanders are placed under medial, anterior thigh flaps bilaterally and inflated several times for 5 min–300 cc, holding the thigh flaps in place with Allis clamps. The expanders are removed and the neoscrotum constructed as described above. The flap skin must be monitored closely

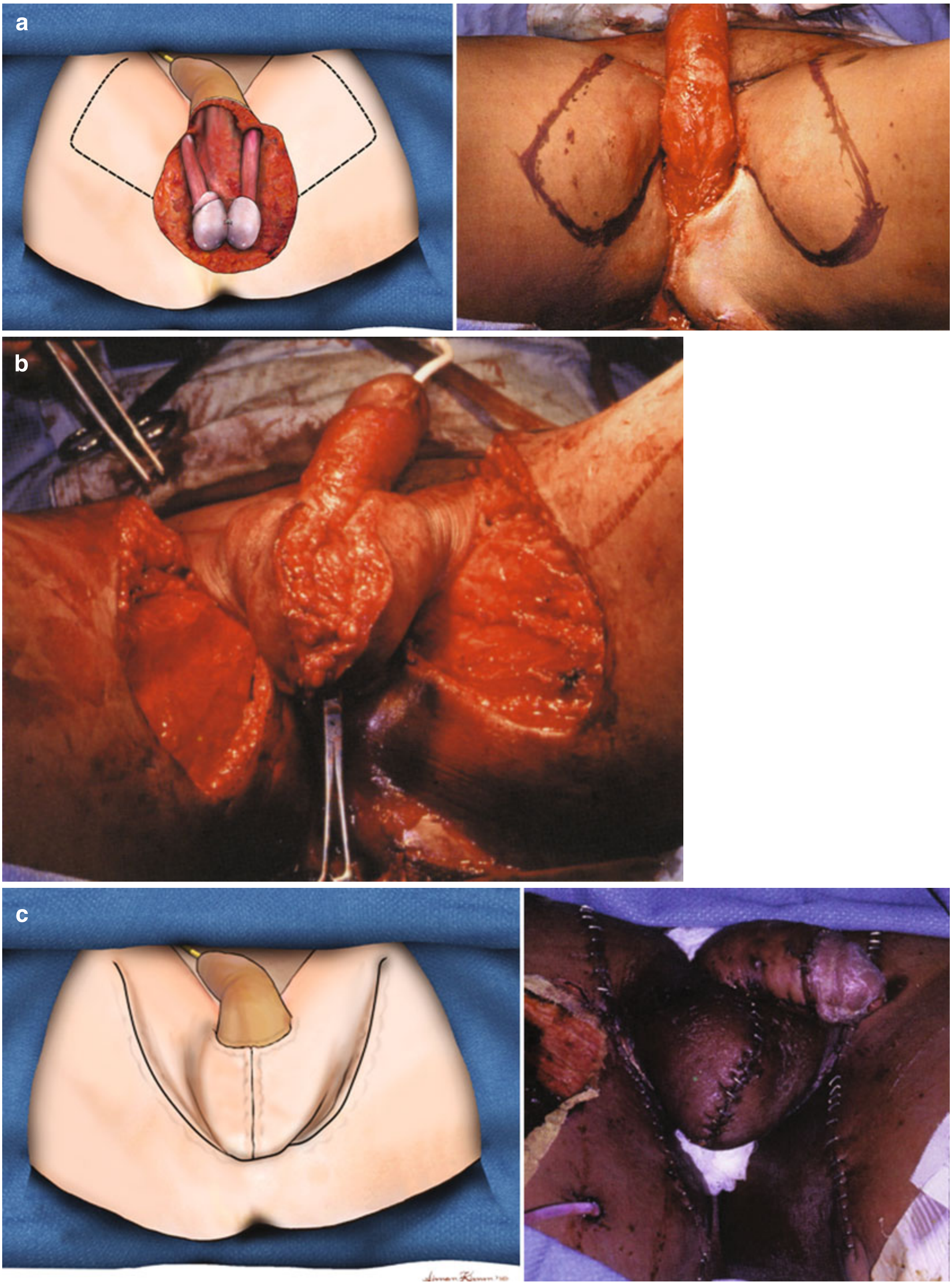


Fig. 39.6 Creation of neoscrotum using fasciocutaneous thigh flaps. Testes are sutured together in a dependent position and flaps are outlined based upon obturator and external pudendal arteries (**a**). Skin flaps are mobilized and sutured together in the midline in order to create a neoscrotum (**b**). Flap donor sites are closed primarily (**c**). There must be significant groin/thigh skin laxity for this approach to be successful (Images Courtesy of Steven Brandes, *Illustration by Simon Kimm, MD*)

during the expansion for color change that could indicate tissue ischemia [36].

The most commonly employed reconstructive modality is skin grafting. It is somewhat simpler than the previously mentioned procedures and yields good functional and cosmetic results. First, the testicles are brought into a dependent position with dissection of the spermatic cord up to the external ring and then sutured together in the midline with 3-0 Vicryl (absorbable, synthetic) suture to prevent a bifid appearance of the neoscrotum. A thick split-thickness skin graft with a graft thickness of 0.018–0.020 in. is then harvested from the anterior thigh, meshed at 1.5:1, and laid over the testicles to cover the wound. Of note, thicker skin grafts are less likely to contract [26]. Any excess graft skin can be trimmed prior to suturing the graft in place at the wound edges, using interrupted 4-0 chromic sutures. To ensure graft adherence, interrupted

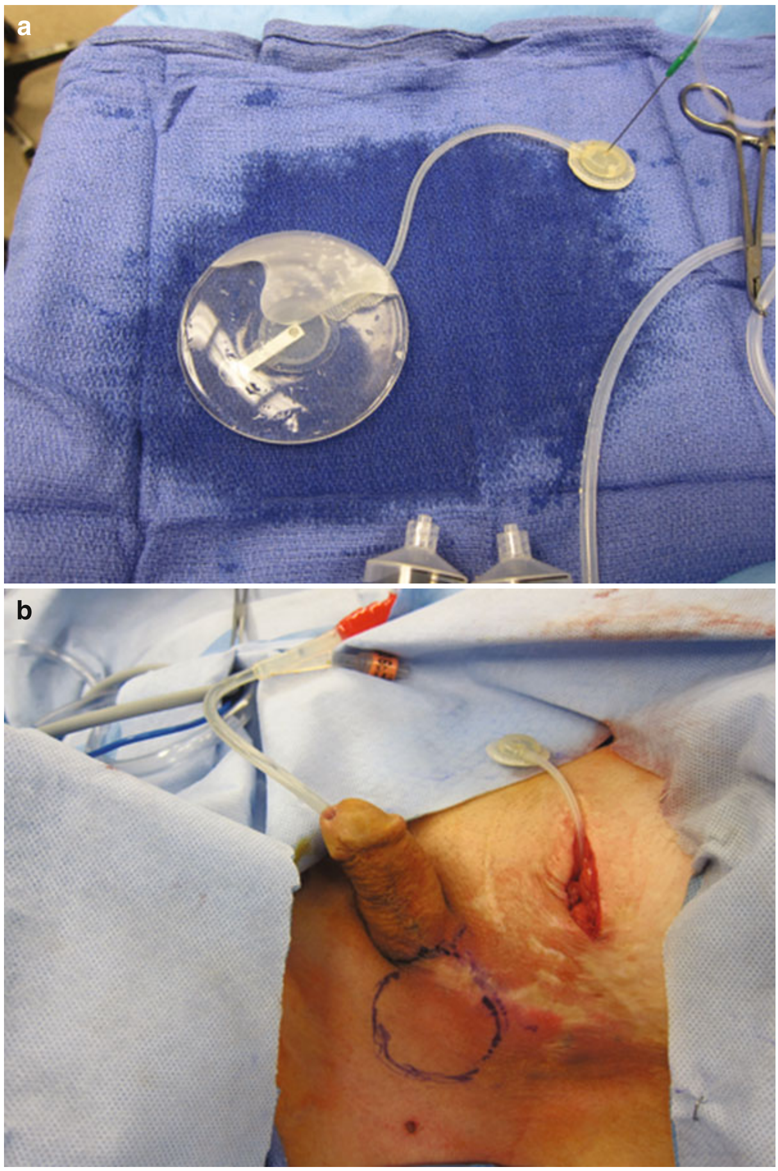


Fig. 39.7 The use of tissue expanders. An ex vivo tissue expander is tested prior to use (**a**). A tissue expander has been placed and inflated deep to a planned left groin flap (**b**). Schematic view of placement of bilateral tissue expanders prior to harvesting of thigh flaps (**c**) (Images Courtesy of Steven Brandes, *Illustration by Simon Kimm, MD*)

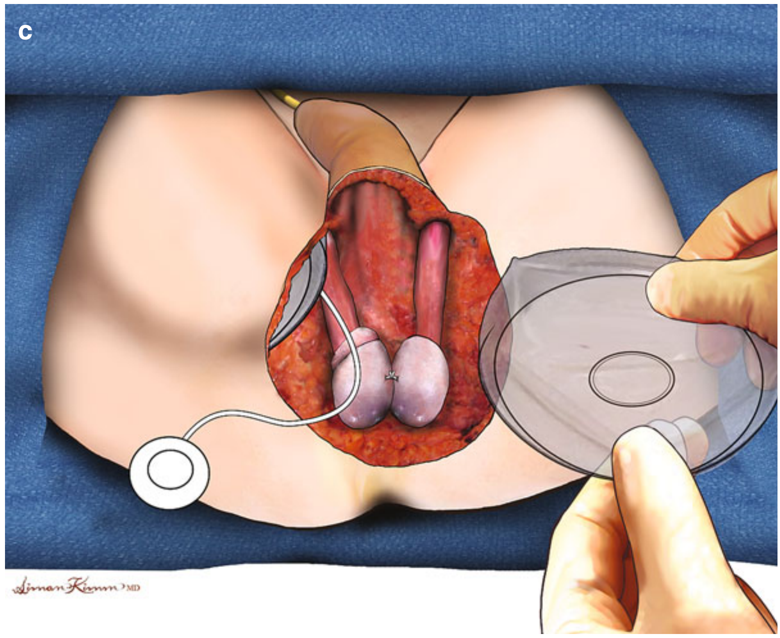


Fig. 39.7 (continued)

5-0 chromic sutures are placed throughout the meshed graft in a quilting fashion. The author also uses aerosolized fibrin sealant (Tisseal) in order to increase graft adherence. Thereafter, petroleum gauze is applied, followed by a layer of mineral-oil-soaked cotton, and finally fluffed gauze. This bolster dressing is stabilized with long 4-0 Vicryl "tie-over" sutures that are anchored at the graft periphery and tied together over the bolster. The patient remains on bed rest with the dressing in place for 5 days to allow initial plasmatic imbibition and subsequent capillary inosculation after approximately 36–48 h. Once the dressing is taken off, the patient is asked to take daily showers and dry the grafted area with a blow dryer on the cool setting. Harvesting of the skin graft is done with a dermatome that can be set to the desired graft thickness. The most common donor site is the anterior thigh, which is outlined and injected with 0.25 % Marcaine for local anesthesia prior to the skin harvest. Mineral oil is then distributed over the donor skin so that the dermatome can glide smoothly during the harvest. After the skin has been removed, epinephrine-soaked lap sponges can be applied to the donor site to minimize bleeding. The donor site is covered with beta-glucan mesh, followed by antimicrobial silver-impregnated dressing, and securely wrapped with gauze bandage. The gauze wrap can be removed in 3 days and the remaining dressing will eventually fall off; the loose edges can intermittently be trimmed. No additional care is needed once the beta-glucan dressing falls off (Fig. 39.8).

Scrotal reconstruction for patients with lymphedema encompasses several other techniques, including (1) physiologic procedures that aim to establish improved lymphatic outflow and (2) excisional procedures that aim to remove the indurated hyperplastic tissue. Techniques that can improve lymphatic outflow include lymphatic grafting, omental flap, mesenteric bridge, dermal bridge, and lymphovenous anastomoses. The latter technique is the most successful, resulting in a 50 % success rate if the cause is obstructive and 20 % if the cause is congenital [15]. In lymphovenous anastomoses, the lymphatics are identified using 0.25 % methylene blue that is injected into the distal scrotum, after which bilateral incisions are made from the lateral scrotum up along the inguinal ligament.

Larger, deeper lymphatic vessels are identified and sutured end to end to adjacent small veins of similar caliber using 11-0 nylon suture under a microscope (Fig. 39.9). Interestingly, the number of anastomoses does not correlate with success of the procedure [36].

Another option for patients in whom the skin has not undergone permanent changes, e.g., dermal fibrosis or warty outgrowths, is subcutaneous tissue removal with preservation and primary closure of the overlying skin. The scrotum is initially bisected and the testicles and

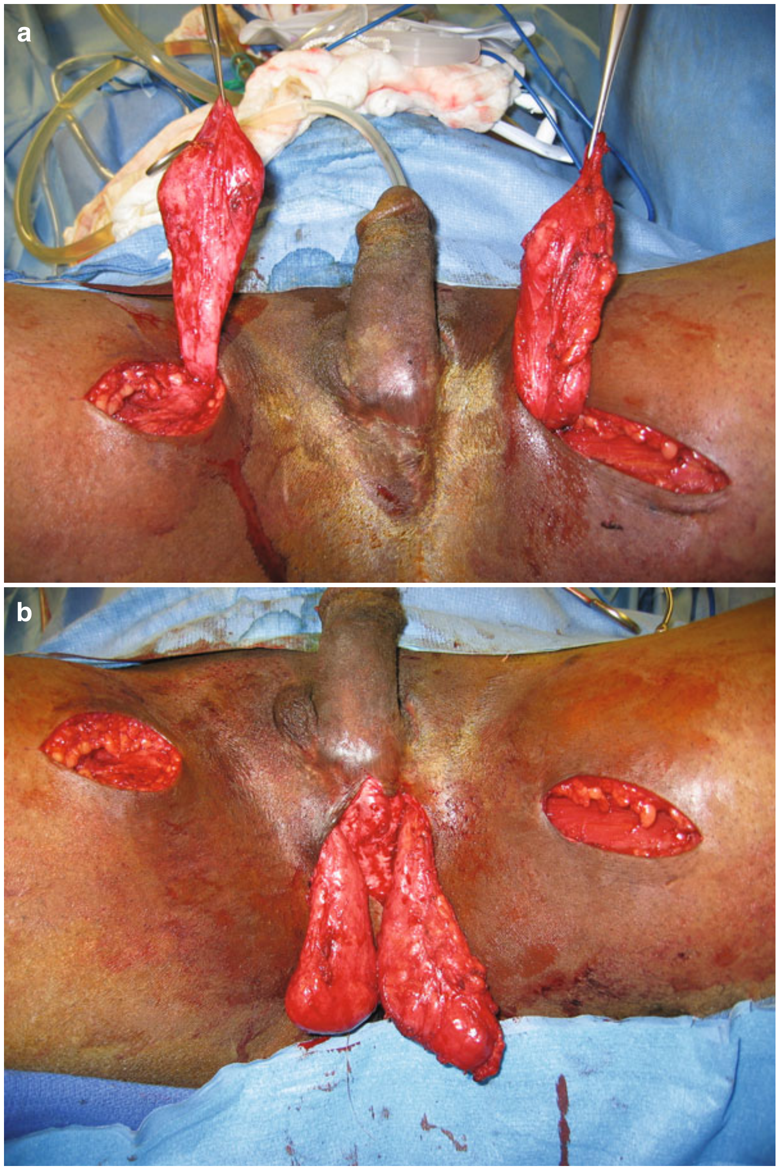
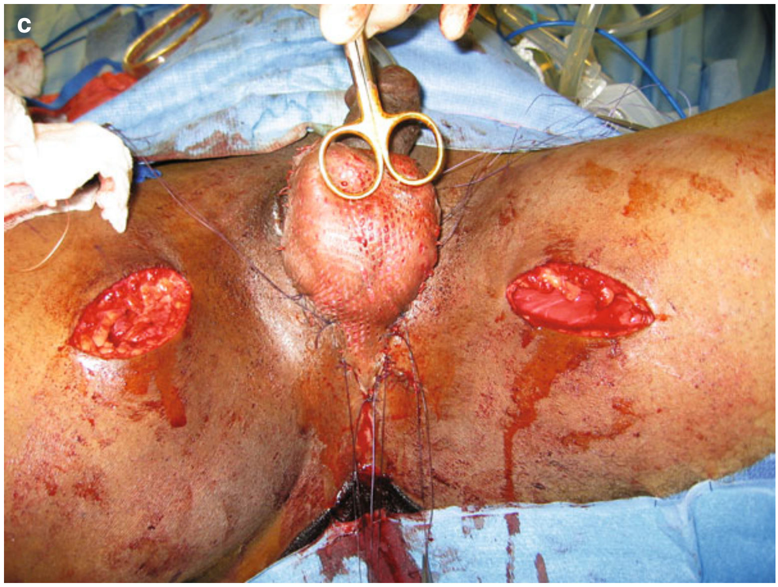


Fig. 39.8 Testicular liberation followed by creation of neoscrotum using meshed split-thickness skin graft. The testes are liberated from preexisting thigh pouches (**a**). The testes are tunneled back to their original location and sutured together in the midline (**b**). A meshed split-thickness skin graft is sutured over the testes to create a neoscrotum (**c**) (Images Courtesy of Steven Brandes)

Fig. 39.8 (continued)



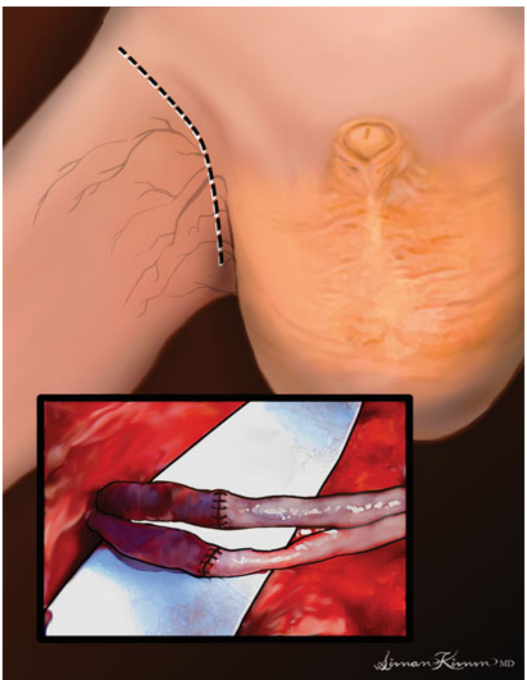


Fig. 39.9 Schematic drawing of lymphovenous anastomoses for treatment of lymphedema. Deep scrotal lymphatics are sutured end to end to adjacent veins of similar caliber (Illustration by Simon Kimm, MD)

cords are dissected and isolated, followed by complete subcutaneous scrotal tissue excision [15]. Excess skin is removed and the remaining skin primarily closed over the testicles. If the patient is suffering from chronic lymphedema, excision of the affected skin is warranted. The incisions are carried out bilaterally, starting at the base of the penis and extending laterally and posteriorly until healthy tissue is encountered. The entire skin and scrotal tissue are excised after isolation of the cords and testicles [37]. The reconstruction can be done with thigh flaps or skin grafting as described in detail above (Fig. 39.10).

Conclusion

Genital skin loss is an uncommonly encountered medical condition, which can have significant physical and psychological impact on the patient. The urologic surgeon needs to be aware of its various causes and distinct presentations. Depending on the etiology, some patients need emergent debridement, whereas others can be observed and undergo delayed

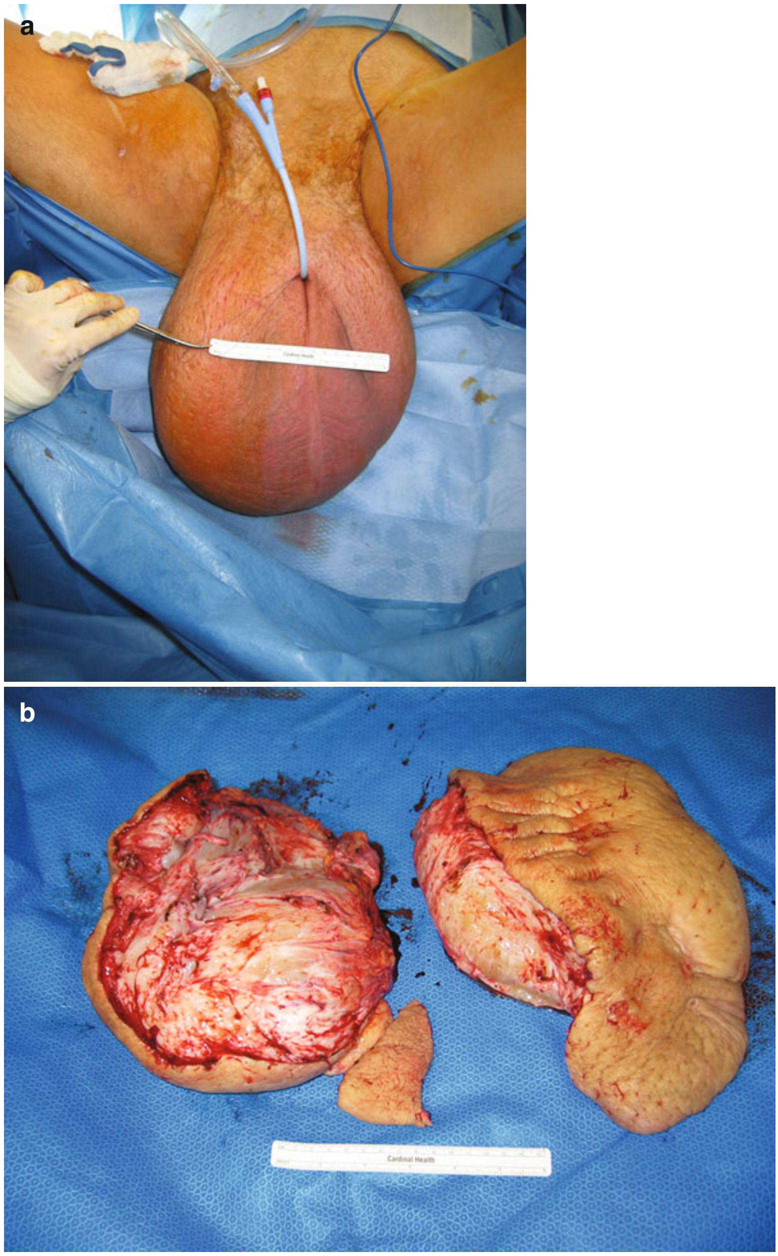
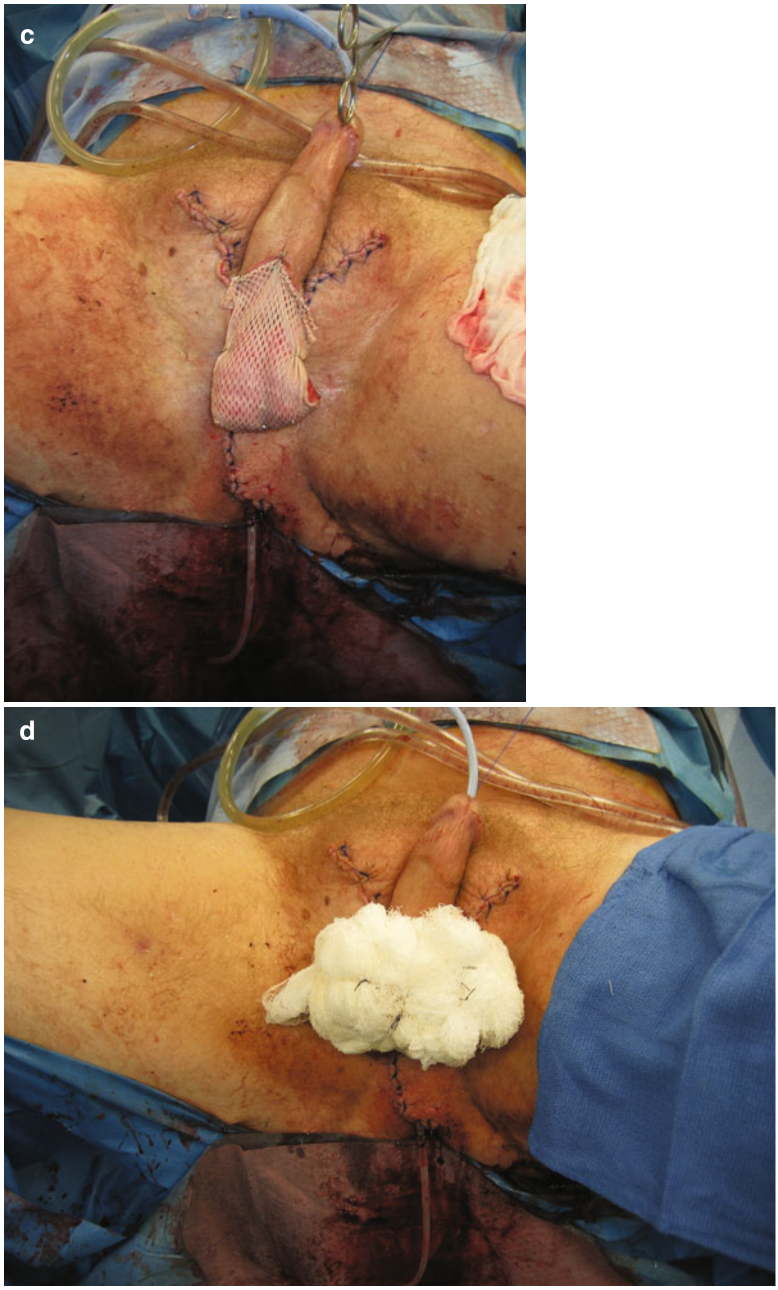


Fig. 39.10 A 52-year-old man with massive idiopathic scrotal lymphedema (**a**). Surgical specimen shows thickened hemiscrota with lymphedema extensively involving the subcutaneous tissues (**b**). Following total scrotal resection, a neoscrotum is created using a meshed split-thickness skin graft (**c**). The neoscrotum is protected with a bolster dressing for at least 5 days postoperatively (**d**) (Images Courtesy of Steven Brandes)

Fig. 39.10 (continued)



surgical treatment. Wound preparation is essential for successful reconstruction and several debridements may be necessary to create an optimal wound bed. Skin grafting has become the preferred technique for scrotal reconstruction, having good functional and cosmetic results. The reconstructive urologic surgeon should use a systematic approach for evaluation and initial management of the patient with genital skin loss and practice meticulous surgical technique for definitive reconstruction.

Surgical Pearls And Pitfalls

Key Intraoperative Surgical Points

Primary scrotal closure following partial avulsion:

Adequate debridement and tension-free mobilization of residual skin

Ensure testicular viability by direct inspection and/or Doppler ultrasonography

Approximate residual scrotal edges in two layers (3-0 Vicryl dartos layer, 4-0 chromic skin layer)

Place Penrose drain

Delayed neoscrotal construction with split-thickness skin grafts

Confirm that all infected/necrotic tissue has been debrided. ONLY graft to a healthy bed of granulation tissue

Harvest graft from anterior thigh at a thickness of 0.018 in. using a pneumatic dermatome

Graft is meshed at a 2:1 ratio

Potential Intraoperative Surgical Problems

Inadequate skin for primary closure: Consider alternative treatment options (skin excision with application of split-thickness skin grafts)

Inadequate graft harvest: Apply dermatome at steep (45°) angle; apply constant pressure with dermatome

Intraoperative Pearls

Tailor graft to create neoscrotum

Suture testes together in midline to avoid torsion

Suture graft to underlying testes and spermatic cords with 4-0 chromic

Tisseal improves graft adherence and minimizes suture use

Bolster dressing applied snugly over fresh graft

VAC (vacuum-assisted closure) Placement:

Debride wound bed in usual fashion

Insert sterile foam dressing into deepest aspect of wound defect

Cover with adhesive film to create airtight seal and connect to vacuum

Change dressing q48 h

Potential Intraoperative Problems

Unable to bring testes together in midline: Mobilize cords up to inguinal region for additional length

Favorite Surgical Instruments (For Skin Graft Harvest and Scrotal Reconstruction)

Pneumatic dermatome
Mineral oil
Adson-Brown forceps
Bishop Harmon forceps
2:1 meshing device
Epinephrine-soaked laparotomy sponges
Fine Metzenbaum scissors
Fibrin sealant (Tisseal)
Beta-glucan dressing (skin graft donor site)
4 in. Kerlix wrap

Bolster Dressing

Mineral-oil-soaked cotton
Xeroform gauze
Interface mesh
3 in. foam tape
Fluff gauze

Sutures

4-0 chromic gut on RB-1 needle
3-0 Vicryl SH needle (tie-over sutures)

Editorial Comment

For penile and scrotal skin loss, I have been greatly impressed how well a STSG takes. For penile coverage, I use a non-meshed graft that I fenestrate with a 15 blade. I wrap the graft so that the seam is on the ventral surface. When a patient looks at his own penis, he only looks at the dorsal surface – so a cosmetic and smooth dorsal surface is important – not the ventral aspect. To place the graft, staple the skin to the penis at the proximal, ventral, and distal ends. Once the graft is in place, suture the graft to the penis with 3-0 Vicryl at the 4 quadrants proximally and distally and at each staple place a 3-0 chromic – then remove all the staples. For coverage of the testis and cord, sew the two testes and cord together in the midline with absorbable suture and then cover with a 1.5–1 meshed graft. At first the testes and cord are fixed to the skin graft. However, after 6 months to a year, the testes start to separate from the overlying skin graft. Eventually, the testes freely float in the scrotal skin bag and the result is both functional and cosmetic (rugated in appearance from the meshing). It is just like when the open abdomen cannot be closed and the exposed bowel is covered with STSGs. At first the skin is adherent to the underlying bowel. After a year or so, the skin separates from the underlying bowel and becomes elastic. At this time delay, the abdomen can then be closed and the skin resected. The scrotal graft is the same – gradually becoming elastic and soft over time.

Depending on the extent of the grafting, I have gradually moved away from using a gauze bolster, to hold the grafts in place, and instead use a negative pressure wound therapy (NPWT), more commonly called a "VAC" or wound vacuum-assisted device. For patients who want to leave the hospital after 48 h, I place a bolster; however, for patients willing to stay in house for 5 days, a VAC is so much quicker to place and is versatile to cover nearly all wound sizes and location. Here, the skin graft is covered with Xeroform gauze, then covered with sheets of black polyurethane foam (which we staple in place), and then wrapped in adhesive plastic sheets. A small hole is cut in the plastic wrap and placed to suction – usually at negative 125 mmHg. The only place that seems to be a problem is the perineum, where the vacuum is difficult to seal. A properly working NPWT foam dressing looks like a prune or raisin, which is hard and wrinkled to palpation, and there is no audible whistling. As to postoperative bed rest, I think that 48 h is more than sufficient. To prevent complications from the immobilization, it is important to keep this patient on DVT prophylaxis with sequential compressive devices and subcutaneous heparin or Lovenox.

—Steven B. Brandes

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40 Surgery for Priapism

Arthur L. Burnett and Ifeanyichuku Anusionwu

Summary

Priapism is a persistent, uncontrolled erection without sexual purpose. Ischemic priapism, which is a compartment syndrome of the penis, requires immediate intervention. First-line treatment is aspiration with or without irrigation of the corpora cavernosa and intracavernous injection of sympathomimetic agents. For patients who have persistent priapism despite corporal aspiration and sympathomimetics, surgical shunting is recommended. Typically, distal shunts with or without intracorporal cannulation (Winter, Ebbehoj, Lue, El-Ghorab, and Burnett) are performed, and proximal shunts (Quackels, Grayhack, and Barry) are increasingly performed infrequently but are of historic interest. For patients who present after 48 h, corporal aspiration may be skipped as it is unlikely to be beneficial, and such patients may undergo an immediate attempt at shunting. For patients who present in an even more delayed fashion (>72 h), the probability of recovering erectile function is minimal and proceeding with penile prosthesis placement is acceptable. The rationale for not delaying prosthesis placement is that necrosis and fibrosis of the corpora cavernosa ensues after a protracted episode of priapism, making later prosthesis placement quite challenging. For patients with nonischemic priapism, initial management is usually observation, since a substantial number of cases will experience spontaneous resolution. If priapism persists after a period of observation, or upon patient request, angiography with selective embolization of a vascular fistula or aneurysm may be undertaken.

Introduction

Priapism is an uncontrollable prolonged penile erection without sexual purpose [1]. Etiologies for this may include, but are not limited to, sickle cell disease and other hematologic dyscrasias; psychotropic, antidepressant, and other medications; recreational drugs such as cocaine; vasoactive erectile agents; malignancies; neurologic disorders; trauma; and iatrogenic causes. Perhaps the best established at-risk group is patients with sickle cell disease who have a 29–42 % lifetime probability of having priapism [2–4]. Priapism is classified as ischemic or nonischemic. Ischemic priapism, also known as veno-occlusive or low-flow priapism, is characterized by minimal or absent cavernous blood flow and painful and rigid corpora cavernosa. Ischemic priapism is a compartment syndrome of the penis. Conversely, nonischemic priapism is characterized by partially erect, non-tender corpora cavernosa and normal to high blood flow velocities in cavernosal arteries on color Doppler ultrasound of the penis.

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An arteriolar-sinusoidal fistula or aneurysm, which usually results from trauma, may be seen on color Doppler ultrasound.

Initial evaluation includes history and physical exam to determine duration, etiology, presence of tenderness, degree of rigidity, and signs of perineal trauma or malignancy. While the diagnosis is typically made based on history and physical examination [5], routine laboratory testing in patients presenting with priapism includes complete blood count, white blood cell differential, reticulocyte count, and hemoglobin electrophoresis [6]. Urine toxicology and screening for psychoactive medications may also be helpful in determining etiology. Cavernous blood from corporal aspiration is usually sent for blood gas analysis. $Ph < 7.25$, $PO_2 < 30$ mmHg, and $PCO_2 > 60$ mmHg are consistent with ischemic priapism, while PH 7.40, $PO_2 > 90$ mmHg, and $PCO_2 < 40$ mmHg are consistent with nonischemic priapism and resembles normal arterial blood gas [7].

After 4 h of ischemic priapism, erectile tissue functional damage can occur. This may be due to acidosis, hypoxia, and glucopenia. Thus, intervention is immediately required for the management of ischemic priapism, while medical therapies (such as intravenous hydration, oxygenation, and blood transfusion for sickle cell disease) are considered adjunctive. Medical therapy in the form of daily oral or intracavernosal sympathomimetics, phosphodiesterase 5 inhibitors, or hormonal analogues is used in patients with stuttering or recurrent priapism aiming to prevent future episodes of priapism and thereby preserve erectile function [5].

First-line management involves corporal aspiration, with or without saline irrigation, to evacuate old blood from the corpora. This maneuver alone results in resolution of priapism in 30 % of cases, and if intracavernous injection of sympathomimetic agents is performed, the priapism resolution rate increases to 80 % [7]. For the 20 % of patients who are refractory to first-line therapy, surgical shunting is indicated. Shunting is also indicated in patients who present after 48 h of ischemic priapism, as it is generally accepted that these patients are unlikely to respond to intracavernous treatment.

The principle behind creating a penile shunt is to create a window in the tunica albuginea of the corpora cavernosa to allow egress of blood from the corpora cavernosa to the glans, corpus spongiosum, or a vein. Distal shunts, such as Winter [8], Ebbehoj [9], Lue [10], Al-Ghorab [11], and Burnett (Snake) shunts [12], are usually performed first, while the proximal shunts, such as Quackels [13], Grayhack [14], and Barry shunts [15], are performed secondarily or are mainly of historic interest. Because of the emergence of distal shunts with instrumentation/cannulation (Burnett and Lue procedures), the need for proximal shunts has decreased as the cannulated distal shunts create large channels with effective egress of stagnant blood, and the channels stay open long enough for priapism to resolve. The two cavernosa-venous shunts (Grayhack and Barry shunt) are rarely performed due to the technical difficulty of the procedures, as well as concerns about their low efficacy and high complication rates.

Ischemic priapism that presents in a significantly delayed fashion (e.g., >72 h) is unlikely to respond to shunt surgery. In such instances, it is acceptable to proceed to penile prosthesis placement because the probability of recovery of erectile function is minimal and delayed placement of penile prosthesis may be technically challenging after corporal necrosis and fibrosis has occurred.

In contrast to ischemic priapism which mandates immediate intervention, nonischemic priapism is managed initially with observation. This is because 62 % of untreated nonischemic priapism will resolve spontaneously [7]. Angiography and selective embolization are appropriate for patients who fail to resolve or desire treatment. If this fails, surgical ligation is a last resort.

Aspiration, Irrigation, and Injection of Sympathomimetic Agents

This is considered definitive first-line treatment of ischemic priapism. After a dorsal penile block is achieved, an 18 gauge needle is placed in the corpora cavernosa unilaterally or bilaterally, and old blood is aspirated until all the old blood has been removed. The initially aspirated blood is sent for blood gas analysis. The needle insertion site is frequently laterally placed at the mid shaft. However, more effective aspiration and irrigation may be accomplished by placing a 16 gauge angiocatheter transglanularly into the corpora cavernosa. This is similar to the Winter shunt described below. This allows blood egress through the channel after the angiocatheter is removed and has a lower risk of hematoma than laterally placed needles. Alternatively, the patient may be placed in lithotomy and needles placed in the proximal penile crura as well as distal corpora cavernosa bilaterally; in this manner, the corporal bodies can be maximally irrigated. Once irrigation is complete, a sympathomimetic agent is injected intracavernously. While phenylephrine, ephedrine, epinephrine, metaraminol, or etilefrine may be used [5], phenylephrine is the preferred agent. The dosing regimen for phenylephrine is 100–200 μg every 5–10 min until incurring detumescence or a maximum dose of 1,000 μg [6]. The patient is monitored during and shortly after these injections for adverse effects which may include headache, chest pain, hypertension, reflex bradycardia, tachycardia, and arrhythmia. If aspiration, irrigation, and intracavernous sympathomimetics fail, surgical shunting should be performed.

Penile Surgical Shunt

Percutaneous Distal Shunts

Winter

This is a distal corporoglanular shunt which can be performed under local or general anesthesia. The patient is positioned supine for the procedure. The tips of the corpora cavernosa are palpated through the glans. Several passes are made into the corpora using a large bore biopsy needle through a single puncture site in the glans in a direction parallel to the length of the corpora and staying away from the urethra. This maneuver is demonstrated in Fig. 40.1. The penis is squeezed from the base towards the glans to facilitate outflow of blood from the corpora to the glans. The procedure can be performed unilaterally or bilaterally. The glans puncture site is closed with figure-of-eight 3-0 chromic suture. If there is sustained detumescence and the glans is swollen, the result is considered adequate.

Ebbehoj

This is a distal corporoglanular shunt which can be performed under local or general anesthesia. The patient is positioned supine for the procedure. A no. 11 blade scalpel is passed percutaneously through the glans and repeatedly advanced into the corpora cavernosum. The direction is parallel to the length of the corporal bodies, taking care to avoid the urethra. The penis may be squeezed and closed as described for the Winter shunt.

Lue (T Shunt with "Tunneling")

This procedure can be performed in a clinic or emergency room setting under local anesthesia. The patient is prepped in the usual sterile manner, and after a penile block, a no. 10 blade scalpel is placed vertically through the glans to the corporal body [10]. The insertion point of the blade should be at least 4 mm away from the meatus to avoid urethral injury. Once the blade is fully inside the cavernosum, it is rotated 90° away from the urethra and then removed. Stagnant blood is evacuated through the shunt. If detumescence is achieved, the glans incision is closed with an absorbable suture, only taking superficial bites to avoid obliterating the shunt. The patient is observed for 15 min after closure of the incision. If detumescence is not sustained, a similar shunt procedure is performed on the other cavernosum. For patients who have had priapism for a long duration (e.g., 3 days or longer), bilateral shunts are created and a 20 French sound or dilator is inserted into the shunt to create an intracavernous "tunnel."

Open Distal Shunt

El-Ghorab

This procedure is usually performed under general anesthesia or sedation. A penile-glans block is typically performed additionally. The patient is

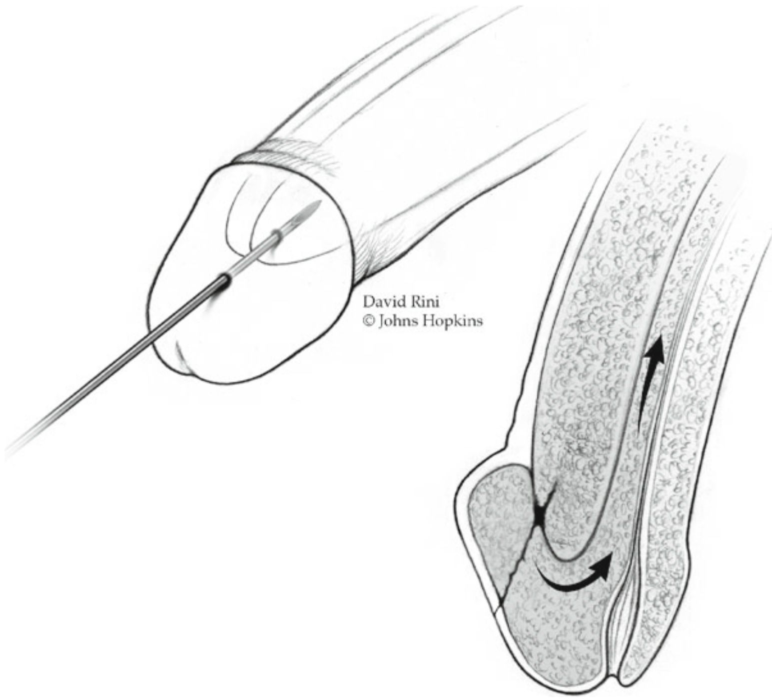

Fig. 40.1 Winter (percutaneous distal corporoglanular) shunt, showing insertion of the needle into the corpus cavernosum through the glans (Copyright Johns Hopkins, Baltimore, MD)

positioned supine for the procedure. A tourniquet is placed around the base of the penis to control incisional bleeding. A roughly 2 cm transverse incision is made at the dorsum of the glans, 1 cm distal to the coronal sulcus. If this incision is made instead in the distal aspect of the shaft, injury to the nerves in this area may result. The rigid tips of the corpora cavernosa are palpated and separated from the glans. The tips of the corpora cavernosa are then grasped with a Kocher clamp or a 2-0 Vicryl suture on a snap. A 5 by 5 mm circular segment of the tunica albuginea is excised from the tip of each corpora cavernosum using either a scalpel or a pair of scissors as shown in Fig. 40.2. Once satisfactory detumescence is achieved, the glans incision is closed with 3-0 chromic suture with care taken not to obliterate the vascular space of the glans. Remember to remove the tourniquet at the end of the case.

Burnett/Snake Maneuver (El-Ghorab with Cannulation)

This procedure is performed initially like the standard El-Ghorab procedure. However, once the circular piece of tunica albuginea is excised from the tips of the corpora cavernosa, a size 7/8 Hegar dilator is inserted retrograde into each corpora cavernosum through the window in the distal corpora. The Hegar dilator is advanced several centimeters proximally while applying a boring motion. This creates a sizeable surgical channel in the corporal bodies, and once the Hegar dilator is removed, blood can be evacuated from the penis by squeezing from the base towards the glans. This modification of the El-Ghorab procedure may allow a more complete evacuation of stagnant blood, thus allowing the shunt to stay patent. As with the standard El-Ghorab procedure, the glans incision is closed with 3-0 chromic suture. A light compression dressing is applied to the penis at the conclusion of the case.

Open Proximal Shunts

Quackels

This is a corporospongiosal shunt performed under general anesthesia. The patient is placed in lithotomy position, and an 18 Fr urethral catheter is placed to allow palpation of the urethra.

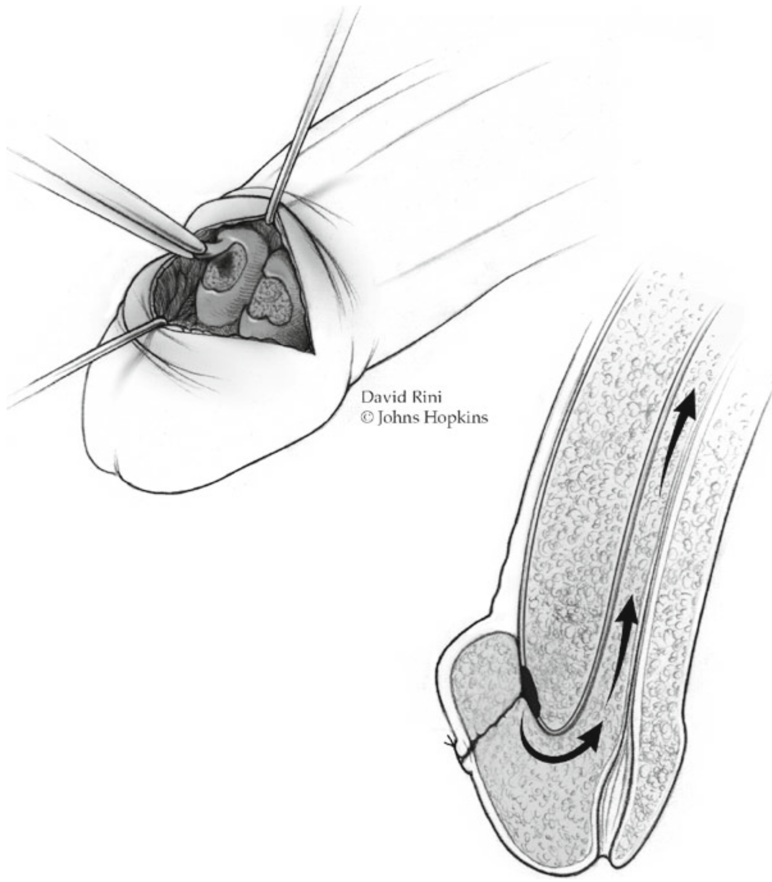

Fig. 40.2 El-Ghorab (open distal corporoglanular) shunt depicted, with a circular segment of tunica albuginea excised from the tip of each corpus cavernosum (Copyright Johns Hopkins, Baltimore, MD)

A roughly 4 cm incision is made in the midline perineum between the scrotum and anus using a no. 15 blade scalpel. The incision is carried to the level of the bulbocavernosus muscle using electrocautery. A Lone Star retractor is used for exposure. The bulbocavernosus muscle is dissected off the corpus spongiosum. One centimeter-long ellipses of tissue are excised from the spongiosum and cavernosum, with care taken to avoid urethral injury. Alternatively, simple incisions can be made without excision of any tissue. The defects are staggered connecting the spongiosum with the corpora cavernosa bilaterally as seen in Fig. 40.3; this staggering reduces risk of forming a urethral fistula. The walls of the opening between a cavernosum and the spongiosum are sutured together with a running 5-0 polydioxanone suture. Hemostasis is obtained. Urethral integrity may be confirmed at the conclusion of the procedure with urethroscopy. The perineum is closed in two layers of 2-0 Vicryl suture. The skin is closed with interrupted 3-0 chromic suture.

Vein Anastomosis

Grayhack Shunt

This is a corpora-saphenous vein shunt. This is performed under general anesthesia with the patient supine. The first incision is vertical and at the base of the penis, with exposure of the tunica albuginea of the corpus cavernosum. The second incision is made at the saphenous-femoral junction, 3 cm below the inguinal ligament. The saphenous vein is dissected for about 10 cm distal to the fossa ovalis. The vein is ligated at this point, and tunneled below the skin and subcutaneous tissue, until it is brought out through the incision at the base of the penis. A 1.5 by 0.5 cm ellipse of tunica albuginea is excised from the ipsilateral corpora

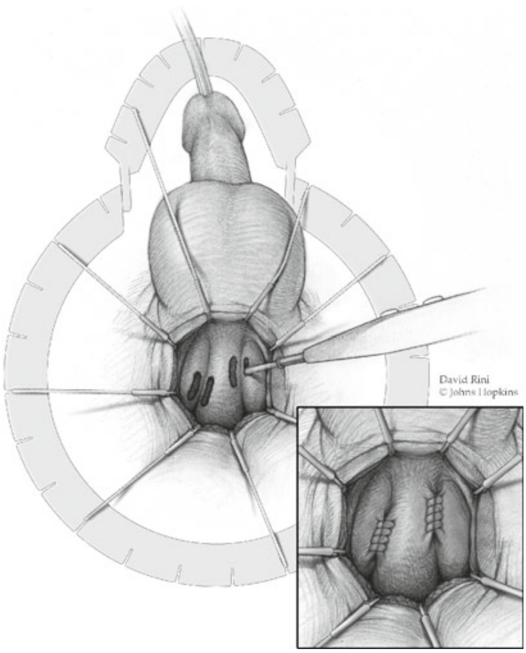

Fig. 40.3 Quackels (open proximal corporospongiosal) shunt with staggered openings connecting each corpus cavernosum to the corpus spongiosum (Copyright Johns Hopkins, Baltimore, MD)

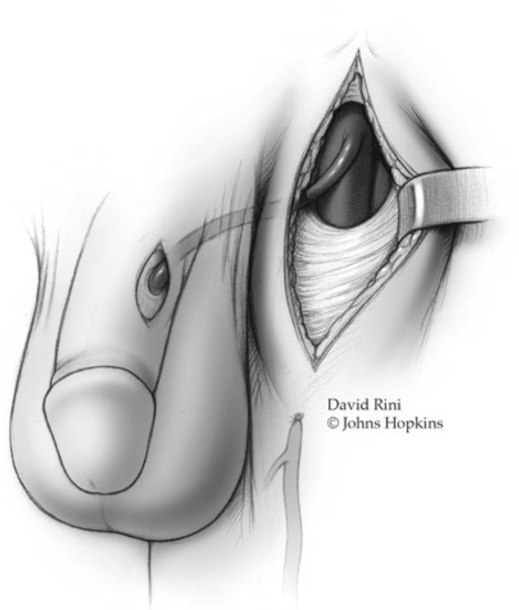

Fig. 40.4 Grayhack (corpora-saphenous vein) shunt showing the saphenous vein anastomosed to the corpus cavernosum (Copyright Johns Hopkins, Baltimore, MD)

cavernosum, with care taken not to injure the neurovascular structures of the penis. The saphenous vein is spatulated and anastomosed to the opening in the tunica albuginea using 5-0 polydioxanone suture. Figure 40.4 illustrates this technique. The penis is squeezed and dry dressing is applied.

Barry Shunt

This is a corpora-deep dorsal vein shunt performed under general anesthesia with the patient positioned supine. A 4 cm skin incision is made at the base of the penis. Dissection is carried out to the deep dorsal vein, taking care not to damage the dorsal artery or nerves. The vein is dissected distally, then ligated and divided. The ventral side of the vein is widely spatulated. A small elliptical incision of a similar caliber is made in one corpora cavernosa. The vein is then anastomosed to the corpus cavernosal opening in a tension-free end-to-side fashion. The anastomosis should be tension-free. The skin incision is then closed with 3-0 chromic suture.

Postoperative Care

Antibiotics should be administered perioperatively and postoperatively. Patients may be instructed to squeeze the penis every few minutes for up to 12 h in order to keep the shunt patent. Due to postischemic hyperemia, the penis may still appear tumescent after shunting. It is critical to rule out recurrent priapism. If this cannot be done based on physical exam, cavernous blood gas testing should be repeated and color duplex ultrasound should be performed to determine if there is penile arterial blood flow. Rarely, intracavernosal pressure monitoring may also be performed in this setting.

Complications

The complications of shunt procedures include urethral injury, urethral fistulas, purulent cavernositis, abscess, skin necrosis, bleeding, and pulmonary embolism (particularly after the Grayhack procedure). Veno-occlusive erectile dysfunction can develop if the shunt fails to close over time; fortunately most shunts close spontaneously, but venous shunts have a lower probability of closure. Moreover, erectile dysfunction after shunting may also be due to the priapism episode with attendant smooth muscle dysfunction and/or fibrosis.

Penile Reconstructive Surgery to Correct Deformities and Erectile Dysfunction

According to the International Society for Sexual Medicine Standards Committee, penile shunting has limited utility after priapism has lasted >72 h [16, 17]. In such circumstances, cavernous thrombosis makes it unlikely that the corpora can be cleared of stagnant blood, and the shunt will remain patent.

These delayed presentations can be managed with penile prosthesis placement in the acute setting, since the probability of erectile dysfunction is extremely high, and delayed prosthesis placement may be fraught with difficulties from corporal fibrosis and penile shortening. Some authors place a malleable penile prosthesis initially, while others place a three-piece inflatable penile prosthesis. If a malleable prosthesis is placed, it can later be exchanged for an inflatable three-piece penile prosthesis.

Alternatively, in patients who present after 72 h, penile prosthesis placement can be deferred until there is development of significant erectile dysfunction in the post-acute phase. The procedure, however, may be more challenging, requiring corporal tissue excision rather than dilation. Cavernotomes have also been designed for use in creating corporal cavities for challenging penile prosthesis placements. Described below in further detail are two strategies [18, 19] for corporal tissue excision. The goal of these techniques is to create a channel for cylinder placement in patients with advanced corporal fibrosis in whom dilation is unsuccessful or deemed risky. Also a prosthesis may be placed initially in a fibrotic foreshortened penis to function as a tissue expander, and 1 year later, the cylinders can be upsized to a larger size. If tunical perforations are noted (e.g., from a prior shunt procedure), the cylinders can be secured to the tunica albuginea with nonabsorbable suture to avoid migration and erosion. However, even if one overcomes the technical challenges associated with placement of penile prostheses in these severely scarred corpora cavernosa, there remains the concern for complications such as urethral injury, tunica erosion, and infection. In instances where there is significant loss of corporal tissue from necrosis, a flap such as a free forearm flap may be used for penile reconstruction or creation of a neophallus; a penile prosthesis can then be implanted in the reconstructed phallus [16]. Figure 40.5 shows the algorithm for management of ischemic priapism.

Open Corporal Excavation

This procedure is performed under general anesthesia with the patient positioned supine. A penoscrotal incision is made and then carried distally up to the frenulum. A ring retractor is used for retraction. Long corporotomies are made bilaterally. Horizontal mattress sutures with 2-0 polydioxanone are placed at 1 cm intervals on the tunica albuginea throughout the length of the corporotomy. Metzenbaum scissors is used to dissect the plane between the tunica albuginea and the fibrotic corporal tissue. Once the fibrotic corpora are dissected circumferentially, a Penrose drain is placed around it and used for retraction while the rest of the corpora is dissected proximally and distally. The dissected corporal tissue is then transected distally under the glans and proximally at the crura. After measurements are made, a cylinder of appropriate size is placed, and the rest of the penile prosthesis placement proceeds routinely. The corporotomies are closed by tying the pre-placed horizontal mattress sutures together.

Corporoscopic Excavation

The procedure is performed under general anesthesia with the patient positioned supine or in lithotomy. A urethral catheter and a glans stay suture are placed. An incision is made penoscrotally. Stay sutures are placed on either side of a 1.5 cm corporotomy. At this point, passage of a 7 Hegar dilator is attempted. If this cannot be achieved without undue force, then optical corporotomy is performed. The corporotomy set, which

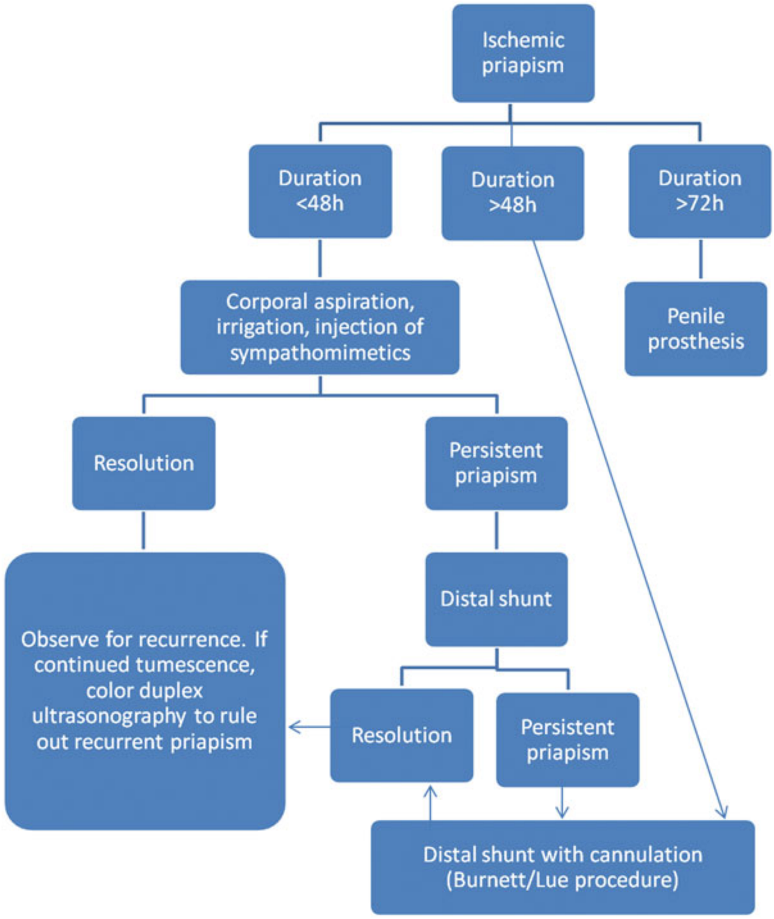

Fig. 40.5 Algorithm for management of ischemic priapism. The above algorithm is a rough guideline with the best recommended intervention that can be expected to relieve the priapism and preserve sexual activity based on time intervals. It is not an exclusive management direction, and each case should be considered individually

is the same as a urethrotomy set, includes a 21 French sheath, a 0 or 30° lens, and a blade mounted on a working element. The corporotomy set is introduced into the 1.5 cm corporotomy. With one hand, the assistant holds the penis on tension using the glans stay suture. With the other hand, the assistant applies manual compression at the base of the penis to minimize blood flow and improve visibility. The blade is directed laterally, and away from the urethra, and the fibrous tissue is cut. The corporotomy set is advanced further and more corpora cut. This is repeated until a suitable channel is created throughout the length of the corpora. If the fibrous tissue does not cut appropriately, a cutting current may be used on an appropriate tip instead of the cold knife. The tract is then dilated with Hegar dilators up to size 12/13. Transcorporal resection is performed to further enlarge and smooth out the channel. A 26 French resectoscope with a loop is advanced as far as possible into the corporotomy. Using the cutting current, the fibrous corpora are resected mostly on its lateral side. The chips are removed by dragging them out with the loop of the resectoscope. Once a suitable channel is created and chips are removed, placement of the penile prosthesis proceeds routinely.

Surgery for Nonischemic Priapism

The initial management of nonischemic priapism is observation since almost two-thirds of cases will resolve spontaneously [7], and complications of treatment may include abscess formation, erectile dysfunction, and neurologic injury. Initial conservative management may include ice packs and pressure packing to induce vasospasm/thrombosis of the ruptured artery. Definitive therapy can be delayed for several months without significant sequelae. If the fistula fails to close after a suitable observation period and the patient requests intervention, angiography and embolization of the fistula can be performed by interventional radiology. Embolization may be performed using nonpermanent material such as autologous blood clot or absorbable gels. This is preferred to permanent materials like coils, ethanol, and acrylic glue because the former is associated with lower risk of erectile dysfunction (5 % versus 39 %); both permanent and nonpermanent materials have a resolution rate of roughly 75 % [7]. If embolization fails, surgical ligation may be performed with the aid of intraoperative color duplex ultrasonography. Risks of intervention include erectile dysfunction in up to 50 % of cases, gluteal ischemia, purulent cavernositis, penile gangrene, and perineal abscess [20].

Preferred Surgical Instruments

- Kocher clamp.
- No. 10, 11, and 15 blade scalpels.
- 7/8 Hegar dilator.
- Large bore biopsy needle.
- Penrose drain for tourniquet.
- Lone Star retractor.
- Metzenbaum scissors

Surgical Pearls and Pitfalls

Key Points

- For percutaneous shunt procedures (Winter and Ebbehoj), make multiple subcutaneous passes to increase the chance that the shunt will remain patent; the needle or blade should be directed parallel to, but lateral to, the urethra to avoid urethral injury.
- For El-Ghorab procedure, grasp tip of corpora cavernosum with Kocher clamp or a 2-0 suture on a tag so that the corpora will not retract during detumescence.
- During cannulation for Burnett or Lue procedure, the dilator should be gently passed through the entire length of the corporal body.
- For patients who present in a delayed fashion, distal shunts with cannulation (Burnett procedure and Lue procedure) are the shunts of choice and have essentially eliminated the need for proximal shunting. They create a sizeable channel in the corpora cavernosa allowing a more complete evacuation of stagnant blood.

Potential Problems

- *Needle clots off during corporal aspiration*: Attempt irrigation through the needle. If still not patent, place a new needle for continued aspiration.
- *Urethra is injured during shunt creation*: If distal shunt and injury pinpoint/small, leave indwelling urethral catheter at completion of shunt. If larger perforation, repair urethrotomy using 4-0 Maxon suture then place indwelling urethral catheter.
- *Penis still appears engorged after shunt procedure*: Repeat blood gas testing and perform color duplex ultrasound to evaluate for penile arterial blood flow which differentiates recurrent priapism from postischemic hyperemia.
- *If corporal dilation is challenging during placement of inflatable penile prosthesis*: Consider corporal excavation or placement of a malleable penile prosthesis.

Editorial Comment

Surgery for priapism as suggested here is usually effective in restoring normal blood flow to the penis. For those that continue to have recurrent painful erections after shunting procedures, we have found the acute insertion of a malleable penile prosthesis to achieve remarkable results. Upon deeply dilating proximally into the corporotomies, the prompt return of bright red blood is a welcome sign which correlates well to symptomatic resolution. We have noted that the ischemic priapistic pain disappears virtually immediately after implantation, thus enabling prompt discharge from the hospital and symptomatic relief (with restoration of sexual function). Care must be taken not to oversize the malleable implant given the ischemic surgical field and the presence of previous distal shunt maneuvers—best results are achieved by subtracting 1 cm from the total measured corporal length, fitting it only to the coronal sulcus. We prefer insertion of malleable devices due to cost constraints and technical simplicity, and we have found that nearly all patients are quite satisfied without requesting exchange for an inflatable device.

—Allen F. Morey

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41 Penile Skin Grafting and Resurfacing of the Glans

Giulio Garaffa, Salvatore Sansalome, and David John Ralph

Summary

Skin grafts still represent the solution of choice for genital reconstruction in patients who have lost genital skin or mucosa as a consequence of excision of benign and malignant conditions, trauma and infection as they guarantee superior results in terms of cosmesis and function recovery than local flaps.

Introduction

The aim of genital reconstructive surgery is a complete restoration of sexual and urinary function with an acceptable cosmetic result in order to allow the patient to resume penetrative intercourse with confidence. Due to the unique anatomy and texture of the male genitalia, reconstruction still remains a challenge for the surgeon.

Ideally, in patients with genital skin loss due to trauma, avulsion and partial or complete excision, surgical repair should be immediate with preservation of as much viable tissue as possible. When primary repair with genital tissue is not feasible, skin grafts and a variety of pedicled and free flaps are available for genital reconstruction.

This chapter will concentrate on the techniques of glans resurfacing and penile skin grafting, and a nonstructured PubMed-based review of the literature on the topic has been carried out.

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Glans Resurfacing

Glans resurfacing involves the complete excision of the glans mucosa, which is literally peeled off the underlying spongiosum, followed by repair with a nongenital split-thickness skin graft (STSG). Although no other epithelium presents characteristics in terms of colour and texture to match adequately the glans mucosa, genital skin should not be used for repair in patients with lichen sclerosus (LS) and carcinoma in situ (CIS) because the remaining genital skin may potentially be affected or in the future develop the same conditions.

The skin is usually harvested from the inner thigh as this area can be easily included in the surgical field due to the vicinity to the genitals and because the donor site scar can be easily hidden.

This procedure is indicated in patients with diffuse LS of the glans penis who have failed to respond adequately to medical treatment or in case of widespread CIS [1–4] (Fig. 41.1).

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Fig. 41.1 Diffuse lichen sclerosus of the glans penis

Specific Equipment

- Penile tourniquet (12 French Foley catheter)
- Size 15 bladed scalpel or sharp-tipped tenotomy scissors
- Adson's toothed forceps
- 5/0 Vicryl® rapide
- Air dermatome
- Jelonet® and gauze for the glans dressing
- Kaltostat® and Tegaderm® dressing for the donor site

Patient Preparation and Surgical Technique

Broad-spectrum antibiotics are administered at the induction of the anaesthetic and the shave of the surgical field is carried out in theatre. The patient lies in a supine position with the legs gently abducted on a vein board.

Skin is prepared in the standard fashion and the field is draped leaving the genitals and right thigh exposed, as a right-handed surgeon would be positioned on the right side of the patient. For left-handed surgeons, the left thigh is prepared instead.

Ideally, the graft should be harvested first and the donor site infiltrated with bupivacaine-adrenalin solution and dressed with Kaltostat, gauze and Tegaderm before proceeding with the glans resurfacing in order to prevent contamination of the donor site from the genitalia. In our experience, best results are achieved with 0.008–0.016 in. thick STSG.

The glans epithelium is initially marked in quadrants from the meatus to the coronal sulcus, and under tourniquet compression, a perimeatal and circumcoronal incision is performed (Fig. 41.2). The glans epithelium and subepithelial tissue are then completely dissected off the underlying spongiosum, starting from the meatus to the coronal sulcus for each quadrant, and sent separately for histological evaluation (Fig. 41.3). This procedure can be carried out either with a 15 bladed scalpel or with sharp tenotomy scissors according to the surgeon preference and availability of instruments in theatre.

During the dissection of the affected mucosa, it is paramount for the surgeon not to loose the fine plane between the thickened mucosa and the underlying spongy tissue. In fact, no affected mucosa should be left on the glans; otherwise, the oncological outcome of the procedure will be compromised. Also a "deep" dissection down in the healthy spongy tissue should be avoided to prevent profuse bleeding and a poor final cosmetic result.

Once the dissection is complete, the tourniquet compression is removed and the major

Fig. 41.2 The glans is marked into quadrants

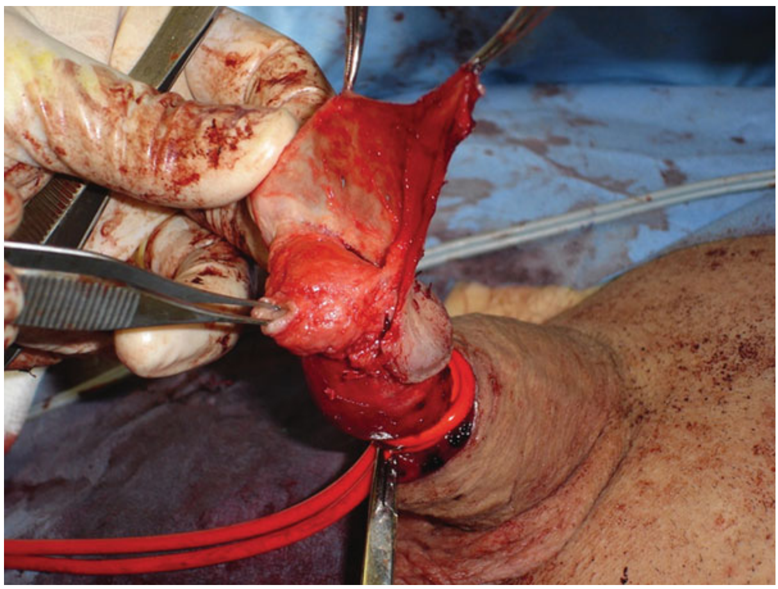

Fig. 41.3 The dissection is carried out between the thickened glans mucosa and the underlying spongy tissue

bleeding points are diathermed. It is paramount at this stage not to be too aggressive with the diathermy as many of the minor bleeding points are likely to settle once the graft is positioned on the spongy tissue and because the formation of necrotic tissue interferes with the graft take.

The distal end of the penile skin is then sutured 1 cm proximal to the coronal sulcus with 5/0 Vicryl rapide and the graft is applied on the denuded spongy tissue (Fig. 41.4).

Accurate immobilisation of the graft to the recipient site and prevention of extravasation of urine are always necessary to prevent graft loss. The graft is therefore quilted to the recipient area using multiple 5-0 interrupted Vicryl rapide sutures. The initial sutures are placed between the STSG and the initial perimeatal incision and quilting sutures are then placed proximally in order to keep the graft in contact with the underlying spongy tissue and prevent formation of

Fig. 41.4 The distal edge of the penile skin is sutured onto the underlying shaft 1 cm proximal to the corona

haematomas, as applying a compressive dressing over the glans is practically impossible. In order to achieve superior cosmetic results, the seam of the graft should be located on the less visible ventral aspect of the glans. As an alternative to quilting, various authors have successfully used fibrin sealant glue, as it appears to reduce the operating time and improve graft take [5, 6]. Once the graft is adequately fitting on the spongy tissue, 5/0 Vicryl sutures are placed proximally in order to recreate the coronal groove and the proximal end of the inner layer of the prepuce. Finally, the proximal end of the graft is sutured to the distal shaft skin to recreate the appearance of a circumcised penis (Fig. 41.5).

A 16 French Foley catheter is then inserted to prevent extravasation of urine on the graft; a suprapubic urinary diversion is usually not required.

A simple non-adherent dressing with Jelonet and gauzes is applied on the glans penis. Usually the recipient site dressing and urethral catheter are removed after 5 days, when the graft is likely to have taken. Donor and recipient area should then be protected from friction for a further 3 weeks and patients should refrain from engaging in penetrative sexual intercourse for 5–6 weeks.

Patients with only a small portion of the mucosa of the glans affected by LS or CIS can be offered a partial glans resurfacing. The surgical steps of this procedure are the same described for full glans resurfacing, but in these patients only the affected mucosa is excised while the healthy remaining aspect of the glans is not resurfaced; repair is achieved with a STSG (Fig. 41.6).

Outcome of the Procedure

Graft take tends to be complete in all patients and excellent cosmetic and functional results have been reported in almost all cases and it may take up to 1 year before sensation returns to the grafted area [2] (Fig. 41.7).

In patients with LS, if all the affected mucosa has been excised, glans resurfacing represents a definitive treatment, while in case of CIS, patients must be warned that further surgery will be required in up to 28 % of cases due to the presence of positive margins or recurrence of the disease [3, 4].

Penile Shaft Grafting

Genital skin loss is usually consequence of trauma, necrotizing fasciitis, excision of benign and malignant lesions, excessive cir-

Fig. 41.5 The STSG is applied on the denuded spongy tissue and quilted with 5/0 Vicryl rapide sutures

Fig. 41.6 Partial glans resurfacing. Only the portion of the glans affected by LS has been resurfaced

cumcision, previous hypospadias or epispadia surgery, buried penis, animal bites and burns [7–15].

Since the use of local flaps for penile skin defect cover is associated with poor cosmetic results due to the different skin texture and colour and the presence of hair, skin grafts still represent the solution of choice.

Although various authors use meshed and non-meshed STSG for penile shaft cover due to their ease of harvesting and superior take rate, full-thickness skin grafts (FTSG) tend to heal with less contracture and maintain a more significant degree of elasticity [12–15] (Figs. 41.8 and 41.9). Therefore, FTSG harvested from non-hair-bearing areas of the body

Fig. 41.7 The final outcome at 6 months postoperative follow-up

Fig. 41.8 Full-thickness skin grafts are ideal for repair of defects on the penile shaft as they heal with less contracture and guarantee the elasticity necessary for the physiological girth and length expansion during erections

should be the solution of choice for shaft skin defects repair in patients who have good quality erection, are concerned with cosmetic outcome and wish to resume penetrative sexual activity. For skin defects at the level of the corona, better results are instead achieved with STSG using the same technique previously described for glans resurfacing.

Specific Equipment

The equipment required is the same previously described for glans resurfacing and pseudoglans formation. Various other instruments might be required at the surgeon's request, according to the underlying aetiology, during the initial phase of excision or debridement of the affected penile tissue.

Fig. 41.9 Split-thickness skin grafts tend to heal with a significant degree of contracture and therefore are indicated only in patients in which cosmesis and sexual function are not an issue

Patient's Preparation and Surgical Technique

In elective settings, patient's preparation is similar to the one described for glans resurfacing. If a FTSG needs to be harvested, the donor site, usually the abdomen, axilla or inner arm, is prepped in the usual fashion. Grafts are usually harvested first to prevent contamination from the genital area. Split-thickness skin grafts are usually harvested from the inner thigh with an air dermatome; the donor site is then dressed in the same fashion described in the previous sections of this chapter.

If a FTSG is required, it is paramount to choose a non-hair-bearing donor site as the hair follicles will eventually be transferred with the graft to the recipient site; usually, the donor site has an hexagonal shape with the major axis along Langer's lines to render primary closure of the defect relatively easier (Fig. 41.10).

Adequate preparation of the FTSG is necessary to optimise its take; in particular, all subcutaneous adipose tissue must be carefully dissected to leave the dermis exposed. Excessive dissection of the dermis should be also carefully avoided, as an excessively thin dermis will transform the FTSG into a STSG.

The recipient site must be also adequately prepared prior to grafting; all pathologic tissue must be carefully excised in order to leave the underlying healthy penile tunicas exposed.

In patients with LS or SCC, it is paramount to excise all the affected tissue in order to prevent delayed recurrence at the surgical margins.

In patients with lymphoedema, excision of the lymphoedematous tissue should be complete and particular attention must be paid not to undermine the skin edges in the attempt to excise the underlying oedematous dartos as this will compromise the skin blood supply; therefore, it is always advised to excise the affected dermis with all the overlying skin.

In our experience, the inner layer of the prepuce is never involved by lymphoedema, as it does not share the same lymphatic drainage of the rest of the penis. Therefore, in uncircumcised patients, the inner layer of the foreskin should be always preserved and used as a flap for proximal shaft cover; this will significantly reduce the amount of shaft requiring grafting.

Unless the excision and grafting are carried out on the distal aspect of the shaft, tourniquet compression is not indicated, as it is likely to interfere with the surgical dissection at the base of the penis.

Once all the affected tissue has been excised, the proximal healthy edge of the penile skin is fixed on the shaft with interrupted 5/0 Vicryl rapide sutures and the skin graft is applied on the dorsal aspect of the shaft (Figs. 41.11, 41.12 and 41.13). The graft is then sutured to the healthy proximal and distal skin edges and quilted to the underlying penile fascias using interrupted 5/0 Vicryl rapide sutures.

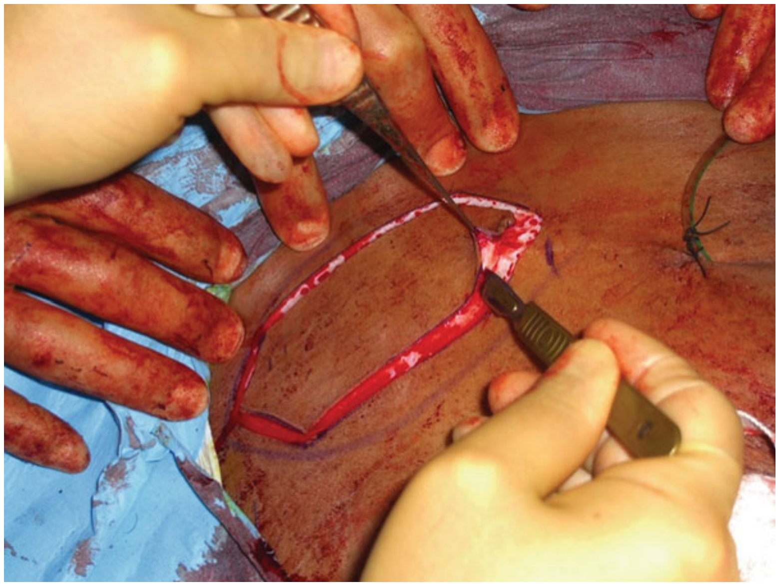

Fig. 41.10 Full-thickness skin grafts are harvested from non-hair-bearing areas of the body. In this patient, the right iliac fossa represented the donor area

Fig. 41.11 Concealed penis as a consequence of excessive circumcision

The two edges of the graft are then joined on the ventral aspect of the penis above the urethra.

After a 16 French catheter is inserted in the urethra, a non-adherent dressing with Jelonet and gauzes is applied on the shaft and postoperative instructions are identical to the one previously described for glans resurfacing (Figs. 41.14 and 41.15).

In patients sexually active, prevention of contracture following penile skin grafting is paramount to prevent shortening and to guarantee the elasticity necessary to preserve physiological length and girth expansion during erection. Therefore, penile stretching is encouraged from postoperative week 3 either with the use of a stretching device or with the regular administration of phosphodiesterase type 5 inhibitors (PDE5i), which promote a quick recovery of the spontaneous nocturnal erections.

Fig. 41.12 The circumcision scar is excised and the edges of the penile skin are quilted to the underlying dartos fascia

Fig. 41.13 The full-thickness skin graft is applied and quilted on the denuded dartos

Outcome of the Procedure

The use of skin grafts for penile shaft repair is a simple and reproducible technique as reported in Table 41.1. The most common complications are poor graft take and poor cosmetic and functional outcome due to contracture, dyschromia and keloid formation. In case of poor graft take, patients are better managed with regrafting to prevent the formation of the contracture typical of the process of healing by second intention.

Fig. 41.14 A 16 French catheter is inserted in the urethra and a non-adherent dressing with Jelonet and gauzes is applied on the shaft to prevent movement of the graft

Fig. 41.15 The final result at 6 months follow-up visit

Conclusion

Skin grafting represents an excellent technique for genital skin defects repair and provides superior cosmetic and functional results than local flaps.

The technique is reasonably simple and reproducible; however, the surgeon must be familiar with grafting techniques and able to recognise and deal with the potential intraoperative surgical problems, as summarised in Table 41.2.

Editorial Comment

The use of split-thickness skin grafting to reconstruct and cover glans resurfacing and penile skin resection defects is remarkably successful, with excellent functional and cosmetic results. For skin graft harvesting, we prefer to use either a Padgett or Zimmer pneumatic dermatome, at a depth of 15–18 thousandths of an inch. At this depth, the graft is superficial to the hair follicles and thus always non-hair bearing. The skin is typically

Table 41.1 Outcome of penile shaft skin grafting

Author	Year	Condition	Number of patients	Graft	Follow-up	Graft take	Complication
Gillett [16]	2005	Buried penis	4	STSG	13 months	/	0
Weinfeld [17]	2005	a	4	STSG	-	100 %	0
Stokes [18]	2006	Lymphoedema	8	STSG	-	100 %	0
Morris [6]	2006	Fournier's	6	STSG	-	100 %	0
Tahmaz [19]	2006	Fournier's	6	STSG	-	/	/
Wang [20]	2008	Paget's	18	STSG	3.2 years	80 %	15 (83 %)[b]
Garaffa [14]	2008	Lymphoedema	7	FTSG	27 months	80–100 %	1 (14 %)[b]
Tang [5]	2008	Buried penis	5	STSG	-	80–100 %	0

[a]Fournier's gangrene in three patients, excision of tumour in the remainder
[b]Small-scale skin necrosis of the graft healed by second intention

Table 41.2 Surgical Pearls and Pitfalls

Key intraoperative surgical points	
Graft should be harvested first	
STSG are the solution of choice for glans and corona	
FTSG are the solution of choice for the shaft	
Complete excision of the affected genital tissue	
Adequate preparation of the surgical field for grafting	
Exposure of well-vascularised recipient site	
Graft initially applied on the dorsal aspect of glans/shaft and trimmed ventrally on the midline to improve cosmesis	
Accurate quilting of the graft to prevent movement as compressive dressing is not feasible	
Urine drainage with catheter	
Dressing on recipient area removed after 5 days, protection from friction for 5–6 weeks	
Potential intraoperative surgical problems	**Management**
Loss of plane during dissection	Start dissection in different place
Perforation of the tunica albuginea	Repair the defect with desorbable 5/0 sutures
Tear in the graft	Repair of the defect with 5/0 desorbable suture
Proximal positive frozen section	Repair small tears with 5/0 desorbable sutures
Penile urethra injury	In case of large tears consider harvesting new graft
Neurovascular bundle injury	Continue proximally the excision till the margins are clear
Persistence of infected tissue after debridement for Fournier's gangrene	Repair the injury with separate 4/0 Vicryl rapide stitches and leave a 16 French urethral catheter for 10 days

harvested from the anterior thigh and covered with a Tegaderm(3M) dressing for 5 days (as wounds heal well in a moist environment). We always use a non-meshed graft on the penis and glans and sparingly fenestrate it with a 15 blade. Fenestration is performed to prevent blood or serous fluid from collecting under the graft and thus promote apposition with the host bed. To hold the graft in place, we typically place either a "penis house" or a negative pressure wound therapy device. As the years have gone on, I have more commonly used the VAC device rather than the bolster dressing – as it is quick and easy to place and the results excellent – particularly when the skin defects are large. However, the bolster has some advantages to the VAC – for the bolster, the patient can be discharged to home after a day or two, while for the VAC, the patient needs to stay in house for 5 days, until the dressing is all removed. For the bolster (penis house) dressing, we place a sheet of Xeroform, followed by a wrap of cotton batting soaked in mineral oil, followed by fluff gauze and then wrap it all in a cotton/polyester stretch roll bandage (Conform, Kendall). The base of the wrap (penis house) is then sutured to the skin at 4 quadrants. A Foley is maintained till the dressing is removed after 5 days.

—Steven B. Brandes

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Peyronie's Disease Reconstruction: Simple and Complex

42

Laurence A. Levine and Stephen M. Larsen

Summary

Peyronie's disease (PD) is often a physically and psychologically devastating condition for the affected man. Though conservative treatments have come a long way since PD was first described, surgical correction remains the most reliable and durable treatment for this condition. This chapter describes the surgical management of PD from indications, patient selection, patient counseling, surgical approaches, instruments, graft materials, postoperative management, and rehabilitation strategies. Both simple and complex reconstructive techniques are detailed with step-by-step intraoperative photography and expert instruction.

Surgical Reconstruction

Preoperative Evaluation

The preoperative evaluation of Peyronie's disease is critical for differentiating simple from complex disease, which will in turn dictate what type of surgical approach will be most beneficial to the patient. Levine et al. suggested a standardized evaluation addressing history, physical examination, diagnostic imaging, and nonvalidated questionnaires [1]. The history should specifically address time of onset, pain, deformity, palpable lump, any trauma that may have preceded the onset of symptoms by days to weeks, and any previous treatments the patient may have undergone. It is useful to ask the patient to estimate the degree and direction of erect penile curvature, presence of indentation, hinging/buckling with axial forces, and amount of shortening. Though curvature is the hallmark symptom of disease, shortening can be the most psychologically devastating, occurring in 70 % of patients and ranging from 1 to 10 cm [2]. Determining whether there is a family history of Peyronie's disease or other fibrotic disorders such as Dupuytren's is also useful as it does appear to occur more frequently among males in the same family and through generations.

Questions regarding pre-Peyronie's erectile status are important and guide surgical planning. Though diminished rigidity may be associated with several underlying medical conditions such as diabetes, smoking, and peripheral vascular disease, it may also be psychogenic in nature given the devastating psychological effects that Peyronie's has on the affected individual [3, 4]. Questions regarding sexual dysfunction should include ejaculation, orgasm, and change in sensation.

The critical part of the physical examination is of the phallus. A stretched penile length must be obtained because of the concern for further shortening that may occur with this scarring disorder

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and/or as a result of surgery. The technique described by Wessels et al. is recommended. With the patient in the supine position, the glans is grasped and pulled to full stretch at 90° from the plane of the body [5]. A rigid ruler is used by pressing down on the suprapubic fat pad to the pubic bone, and the penis is measured dorsally to the corona or meatus depending on physician preference.

Preoperative penile sensitivity can be assessed with light touch and biothesiometry, though no standard evaluation of this parameter has been established. Biothesiometry has been suggested to be an indirect measure of penile sexual sensation, as vibratory nerves travel with penile sexual sensory nerves. Intact vibratory sensation should correlate with sexual sensation.

The most important part of the clinical diagnosis and preoperative evaluation is to visually evaluate the penis in the erect state so that objective measures can be made of the deformity. Pharmacologically induced erection via injection of vasoactive agent such as papaverine alone, Tri-Mix (papaverine, phentolamine, and prostaglandin E1), or prostaglandin alone is the most reliable method when compared to vacuum induced or photograph of office or home erection [6]. This is also useful as it is an indicator of vascular integrity and erectile response to the injected vasoactive drug. If a full erection does not occur, redosing is recommended to try to obtain an erection which is equal to or better than that which can be obtained at home with sexual stimulation. Pressure can also be applied to the base of the penis if needed as psychogenic inhibition during direct observation can be significant. Curvature is then measured in the erect state with a goniometer or protractor, while a simple string can be used to measure girth at the base, subcoronal area, and any area of indentation/hourglass narrowing. Duplex ultrasound can also be incorporated in the flaccid condition looking for corporal fibrosis and plaque calcification [7, 8]. Recent reports have suggested that up to 30 % of men will have plaque calcification, and contrary to previous reports, this can occur early after initial onset of the plaque formation and therefore may not be an indicator of mature disease [9].

Table 42.1 Indications for surgical correction of Peyronie's disease

Stable disease (6 months with no pain and stable deformity)
Compromised or inability to engage in coitus
Extensive plaque calcification
Failed conservative treatment
Wants the most rapid and reliable result

Indications

Indications for surgical reconstruction for men with Peyronie's disease (PD) include (1) stable disease, defined as at least 1 year from onset and at least 6 months of stable deformity, (2) compromised ability to engage in coital activity due to deformity and/or inadequate rigidity, (3) failure of conservative therapy, (4) extensive plaque calcification, and (5) patient desires most rapid and reliable correction once disease is stable. Penile pain is a relative contraindication except when it may be due to a strong erection imparting torque-like pressure on the penis (Table 42.1) [10].

Obtaining Preoperative Consent

This is a critical aspect of PD management mainly because most patients with PD are distressed and emotionally devastated. It is important to have a frank discussion so that he understands the possible limitations of the operation, and set appropriate expectations regarding outcomes to optimize patient satisfaction [10, 11].One must address the possibility of persistent or recurrent curvature, change in penile erect length, diminished rigidity, and decreased sexual sensation (Table 42.2).

Persistent or recurrent curvature is unusual but has been shown in 6–10 % of men [10, 12]. The patient should understand that the goal is to make him "functionally straight," which expert opinion defines as a residual deformity of 20° or less. Change in penile erect length is more likely in plication vs. grafting though all surgical correction procedures have been associated with some length loss. This is extremely important for the patient to understand preoperatively as

Table 42.2 Preoperative surgical consent issues

Set expectations regarding outcome
Persistent/recurrent curvature
Goal – "functionally straight" – <20°
Change in length
More likely shorter with plication vs. grafting
Diminished rigidity
≥5 % in all studies – especially with grafting
Dependent upon pre-op erectile quality
Decreased sexual sensation
Common but infrequently reported to compromise orgasm/ejaculation

Table 42.3 Peyronie's disease surgical algorithm

I. When rigidity is adequate preoperatively with or without oral pharmacotherapy
A. Tunica plication when:
(i) Curvature <60–70°
(ii) No destabilizing hourglass or hinge
(iii) Predicted loss of length <20 % erect length
B. Plaque incision/partial excision and grafting when:
(i) Curvature >60–70°
(ii) Destabilizing hinge
II. When rigidity is suboptimal
A. Penile prosthesis implantation

Table 42.4 Indications for surgical correction with grafting

No significant loss of erectile capacity
Curvature >60–70°
Severe indentation causing unstable erection (hinge effect)
Extensive calcification
Understands increased risk of postoperative erectile dysfunction

70–80 % of PD patients initially present with loss of length due to the fibrotic disease process [10, 11]. Diminished rigidity has long been reported, and studies over the last 10–15 years state that up to 30 % of men may have some degree of postoperative loss of rigidity, which usually responds to PDE5 inhibitors. Rigidity will not likely be made better by the procedure, and therefore, consideration for penile prosthesis should be discussed if the patient already has significant erectile dysfunction (ED) preoperatively [10, 12]. Decreased sexual sensation has been examined and reported upon infrequently, but it does appear that around 20 % of men will describe some reduction in penile sensitivity, rarely interfering with orgasm or ejaculation. Sensory change whether it is hypesthesia or hypoesthesia may occur in the acute postoperative period but tends to resolve over the ensuing months [13].

Surgical Algorithm for the Management of PD

Several surgical algorithms have been published and are summarized in Table 42.3 [14–16].

In men who have rigidity which is adequate for coital activity with or without pharmacotherapy, then tunica plication techniques vs. plaque incision or partial excision and grafting techniques may be employed. Tunica plication techniques are recommended for those who have a simple curve of less than 60–70°, absence of hourglass or hinge effect, and when the anticipated loss of length would be less than 20 % of the total erect or stretched length. Plaque incision or partial excision and grafting is recommended for those men with more complex curves of greater than 60–70° and/or have a destabilizing hourglass or hinge effect. These men should have strong sexually induced rigidity to reduce the likelihood of postoperative ED [17, 18]. See Table 42.4.

In the man with PD who also has ED that does not respond to medical therapy, published surgical algorithms have indicated that penile prosthesis placement is the procedure of choice [14, 16, 19]. This allows for correcting the deformity while addressing the erectile dysfunction as well. If curvature is not satisfactorily corrected after the prosthesis is inflated at the time of placement, additional straightening maneuvers may be performed. The recommended first step is manual modeling, as initially reported by Wilson et al. [20]. If after modeling there is residual curvature in excess of 30°, then an incision in the tunica albuginea overlying the area of maximum curvature can be made. It is recommended that

Table 42.5 Algorithm for prosthesis placement

Placement of inflatable prosthesis
Manual modeling
Tunica incision
Grafting of incision defect if >2 cm with biograft

if the incisional defect is greater than 2 cm in any dimension, then a biograft should be placed over the defect to prevent cicatrix contracture of the incision or herniation of the prosthesis (Table 42.5) [19].

Surgical Plication Techniques

Multiple surgical plication techniques have been offered for PD, beginning with the Nesbit procedure, which is a form of excision of tunica on the contralateral side of the curvature [21]. In the setting of a ventral curvature, once Buck's fascia has been elevated, small wedges of the tunica albuginea are excised and then the defect is closed, typically with permanent suture. Variations on this procedure have evolved, including the Yachia technique, which utilizes the Heineke-Mikulicz technique [22]. In the setting of a dorsal curvature, a short full-thickness vertical incision is made on the ventral shaft tunic opposite the area of maximum curvature, which is then closed transversely to shorten the ventral aspect and correct the curvature.

The 16-dot procedure has also been presented where there is no incision but the tunica albuginea is plicated with permanent suture using an extended Lembert-type suture technique [23, 24]. Another variation is a modification of the Duckett-Baskin tunica albuginea plication (TAP) which was originally used for children with chordee and has been modified for PD. A partial thickness incision is made transversely on the contralateral side to the point of maximum curvature [25, 26]. A pair of transverse parallel incisions is made from 1 to 1.5 cm in length down through the longitudinal fibers but does not violate the inner circular fibers of the tunic. These incisions are separated by 0.5–1.0 cm and the longitudinal fibers between the two transverse incisions are removed so as to reduce the bulk of the plication. This procedure can be done with a combination of permanent and absorbable sutures.

The key is that all plication procedures shorten the long side of the penis and therefore can result in loss of length on that aspect. Studies have examined the loss of penile length using the TAP technique where the factors which predicted loss of length were the direction of curvature and degree of curvature [27]. Therefore, those men who have a ventral curvature of greater than 60° tend to have the greatest potential loss of penile length.

The drawbacks of any tunica plication procedure for PD are that it does not correct shortening and potentially may enhance loss of penile shaft length. It does not address hinge or hourglass effect and may exacerbate it, resulting in an unstable penis. In addition, there can be pain associated with the knots and, as noted, a potential for tactile and sexual sensitivity changes [10, 13]. Literature over the past 10 years indicates that surgical straightening with a variety of plication procedures can be expected in 85–100 % of patients, risk of new ED ranges from 0 to 13 %, and diminished sensation is reported in 4–21 %, with follow-up of up to 89 months. See Figs. 42.1, 42.2, 42.3, 42.4, 42.5, 42.6, 42.7, 42.8, 42.9, 42.10, 42.11, 42.12, 42.13, and 42.14 for a detailed depiction of performing this operation.

The International Consultation of Sexual Medicine (ICSM) published their recommendations regarding plication procedures and reported that there was "no evidence that one surgical approach provides better outcomes over another, but curvature correction can be expected with less risk of new ED" compared to grafting procedures [10].

Incision or Partial Excision and Grafting

Indications

Indications for incision or partial excision and grafting for surgical correction of PD include greater complexity of disease with several or all

Fig. 42.1 This view shows the measurement of the penis on stretch dorsally from pubis to corona. The subcoronal markings identify the site for the circumcising incision to allow degloving of the penis

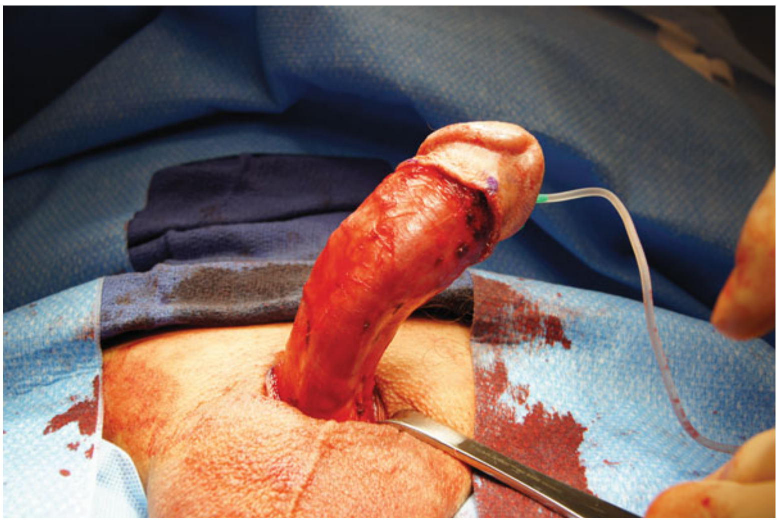


Fig. 42.2 The penis has been degloved and artificial erection established with 60 mg of papaverine and an infusion of saline. In this view we can see that there is proximal shaft indentation on the left side with left lateral curvature

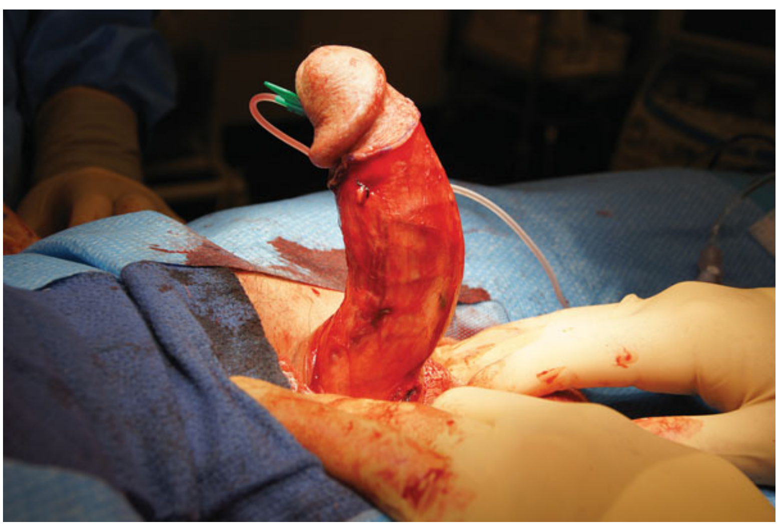


Fig. 42.3 In this view we can see that there is also a dorsal curvature with mild indentation

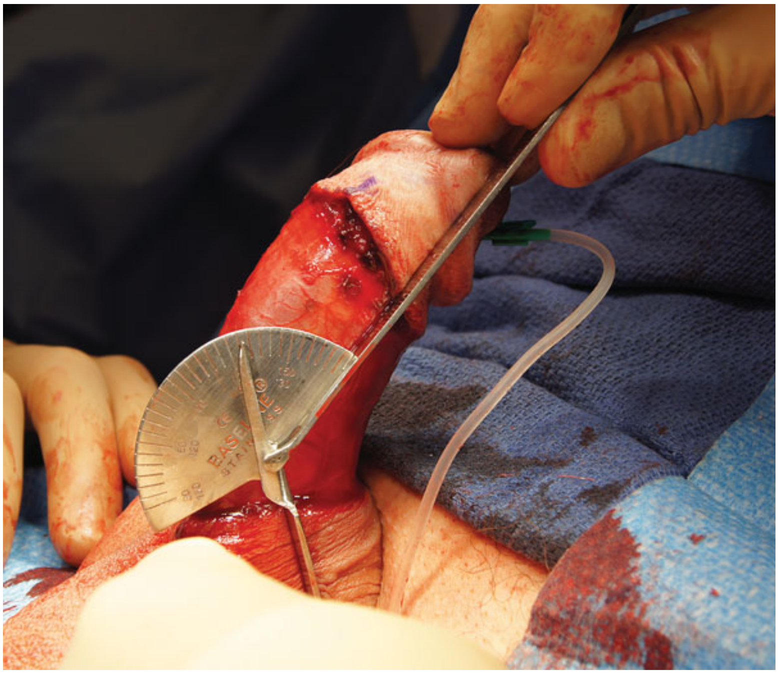


Fig. 42.4 With the phallus fully erect, the goniometer is brought to the field and demonstrates a 45° dorsal left lateral curve

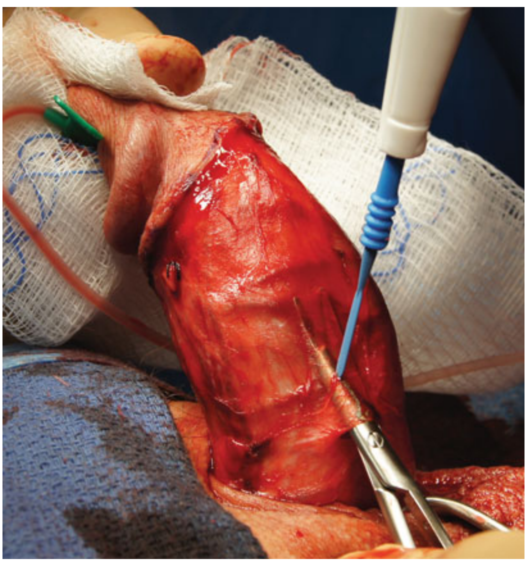


Fig. 42.5 The ventral lateral aspect of Buck's fascia is entered on the right side of the shaft approximately 1 cm lateral to the urethral ridge. Buck's fascia is opened with cautery

of the following: curvature greater than 60–70°, shaft narrowing, hinging, and extensive plaque calcification. Most importantly, for a patient to be a candidate for incision or partial excision and grafting, they must have good preoperative erections [17]. This can be determined during the patient interview, where he is asked directly: "if your penis was straight, would the quality of rigidity that you currently have allow intercourse?" Should the patient hesitate, the incision and grafting procedure should not be performed, unless they fully understand the risk of more advanced postoperative erectile dysfunction and the possible need for subsequent prosthesis placement to attain adequate rigidity.

Other factors have emerged in the literature as possible predictors of postoperative ED, including age >55 years, evidence of corporal veno-occlusive dysfunction on duplex ultrasound analysis, with a resistance index of less than 0.80, ventral curvature, and possibly the severity of the curvature [18, 28, 29]. These predictors have been suggested as a result of single-center studies with a limited number of patients in each cohort. Larger-scale studies indicate that the most critical criterion for any grafting procedure appears to be the quality of their preoperative erections [17, 18, 29].

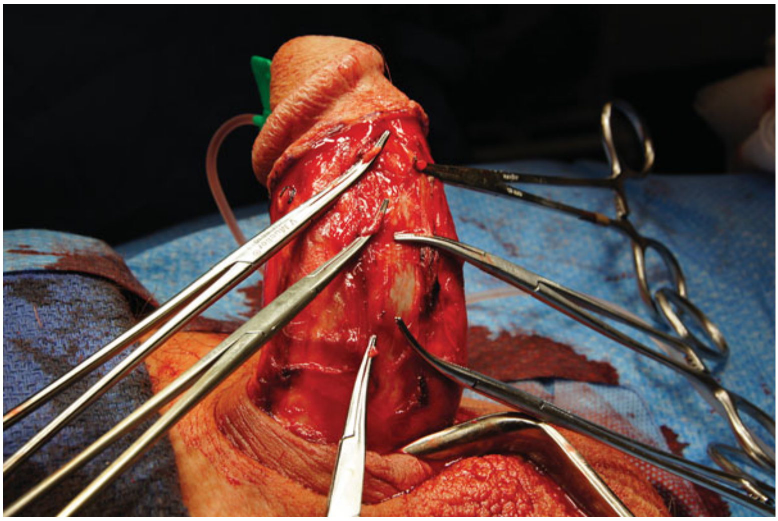
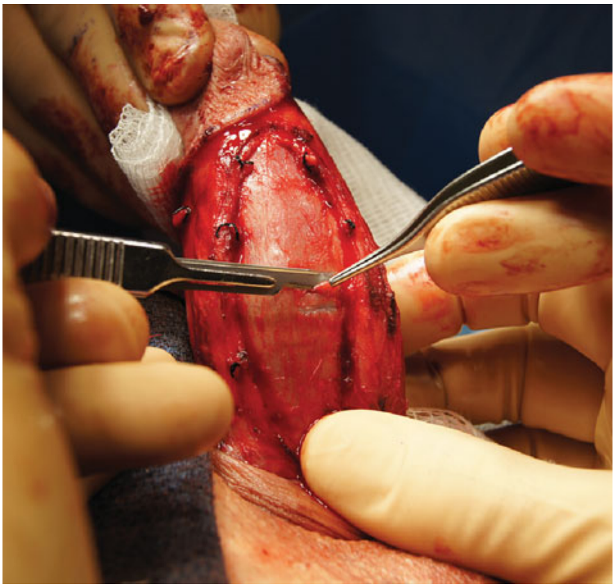
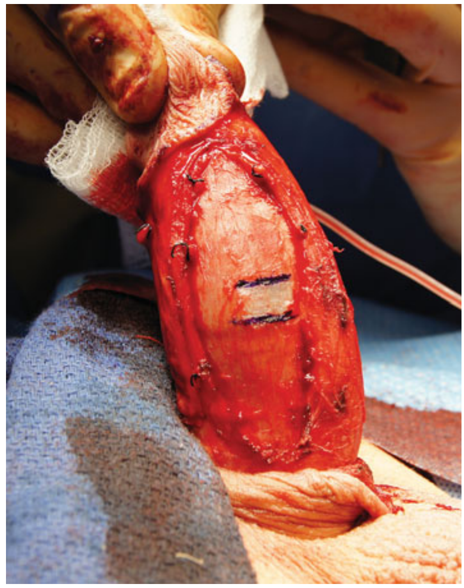


Fig. 42.6 Circumflex vessels encountered during elevation of Buck's fascia are divided and then ligated using the curved Jacobsen fine-tipped hemostats

Fig. 42.7 Buck's fascia has now been mobilized both laterally and towards the urethral ridge to expose the area of tunica to undergo plication

Fig. 42.8 The first pair of transverse parallel tunica incisions is made. These are made down through the longitudinal but not to violate the circular fibers, so as to not injure the underlying cavernosal tissue. Typically incisions are made from 0.5 to 1.5 cm in length and separated by 0.3–1.0 cm. Wider separation may encourage excessive indentation with dog ears that might encourage hinging if there is contralateral narrowing





Figs. 42.9 and 42.10 The longitudinal fibers between the two parallel incisions are elevated and excised to reduce the bulk of the plicated tissue

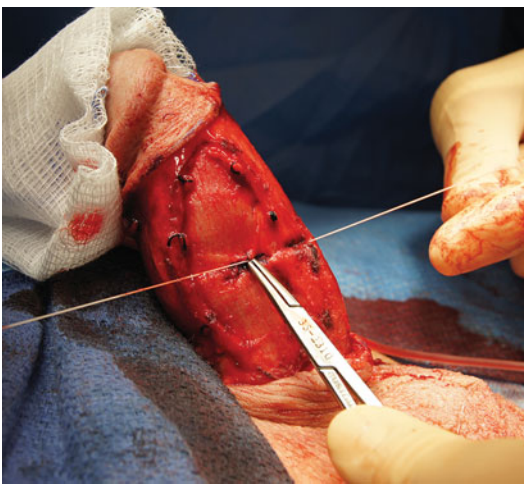


Fig. 42.11 The first central 2-0 Tevdek® (Teleflex Medical OEM, Kenosha, WI) is placed in an inverting mattress fashion so as to bury the knot. To ensure that the tie remains in place, a specially designed smooth hemostat is applied to grasp the suture and prevent loosening

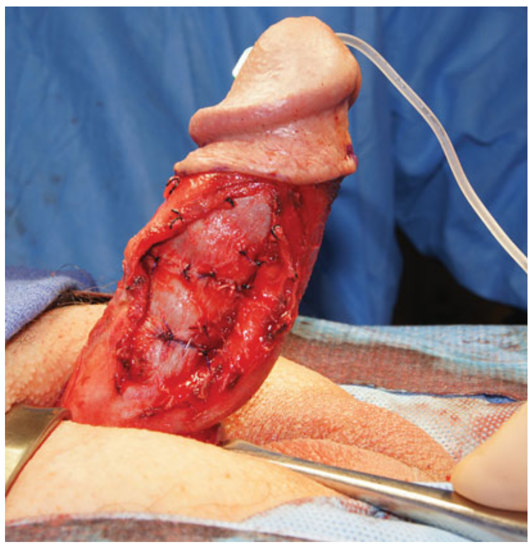


Fig. 42.12 Following the initial Tevdek permanent suture, a pair of 3-0 PDS sutures is placed in a Lembert fashion to ensure that the permanent knot remains buried and to reinforce the plication. In this view, we can see three plications of varying lengths, which have corrected the dorsal lateral curvature, with exposure of the tunic only on the patient's right side. Typically, a simple dorsal curvature would require elevation of Buck's fascia on both sides of the urethra so that paired ventral plications would be made to correct the dorsal curvature

Fig. 42.13 The Buck's fascia is reapproximated with a running 4-0 chromic with the penis on stretch after residual tumescence is brought down by injection of dilute phenylephrine solution at 100 mcg/cc

Fig. 42.14 At the conclusion of the procedure, the shaft skin is reapproximated to subcoronal skin with interrupted horizontal mattress 4-0 chromic, and stretched length is measured and found to be virtually unchanged, as the plications were made on the ventral lateral aspect of the shaft, which does not affect the dorsal length of the penis

Grafting Techniques

Surgical grafting techniques include plaque incision or partial plaque excision. Historically, total excision of the plaque was practiced to "cut out the disease," resulting in onlays of large grafts with an unacceptably high rate of ED [30]. Therefore, plaque incision was introduced, where a modified H-incision is made in the area of maximum curvature [31]. This allows the tunic to be expanded in this area, thereby correcting the curvature and shaft caliber. Occasionally multiple incisions with grafting are needed to obtain satisfactory straightening, or plication may be used for optimal correction of deformity.

Partial plaque excision has also been suggested, where the area of maximum deformity is excised particularly if it is associated with severe indentation. The corners of the defect are darted in a radial fashion to enhance correction of narrowing in that area [32]. Geometrical principles have been applied to the grafting technique in an effort to obtain a reliably sized graft, but there have been reports of a higher rate of ED when this technique is used [18, 33]. Regardless, it is recommended that the defect should be expanded so as to allow correction of curvature and indentation. The key to these operations is to limit the trauma to the cavernosal tissue to maintain the veno-occlusive relationship between the cavernosal tissue and the overlying tunic and graft. See Figs. 42.15, 42.16, 42.17, 42.18, 42.19, 42.20, 42.21, 42.22, 42.23, 42.24, and 42.25 for a detailed depiction on how to perform the partial plaque excision and grafting procedure.

Graft Materials

The concept of the ideal graft has been debated. At this time, no graft has been identified as perfect. Multiple grafts have been used historically, including fat, dermis, tunica vaginalis, dura mater, temporalis fascia, saphenous vein, crura, and buc-

Fig. 42.15 Once appropriate anesthesia is obtained and the patient is prepped and draped, the penis is placed on stretch so as to measure the length by pressing down with a firm ruler dorsally from the pubis to the corona. This measurement will be useful to include in one's operative report and for postoperative follow-up

Fig. 42.16 An artificial erection is created with the aid of a vasodilating agent such as alprostadil, papaverine, or Tri-Mix. Infusion of saline can augment the effect of these drugs as needed to recreate an erection throughout the operation. It should be noted that the preferred technique is to place a 21 gauge butterfly needle through the glans into the corpus cavernosum. In this way, the needle is less likely to get in the way during surgery. No tourniquet is required or recommended with this technique, as this can cause further distortion of the penis

cal mucosa, which are harvested from the patient [34–41]. These have fallen out of favor because of a need for extended surgery to harvest the graft as well as a second incision to close, which has potential complications of healing, scarring, and possible lymphedema. Synthetic Dacron and PTFE grafts have been used historically and are not recommended now as there is a potential risk of infection, localized inflammatory response, and fibrosis [42]. Finally, "off-the-shelf" allografts and xenografts have emerged, including processed pericardium from a bovine or human source, porcine intestinal submucosa, and porcine skin. The two most common grafts currently used

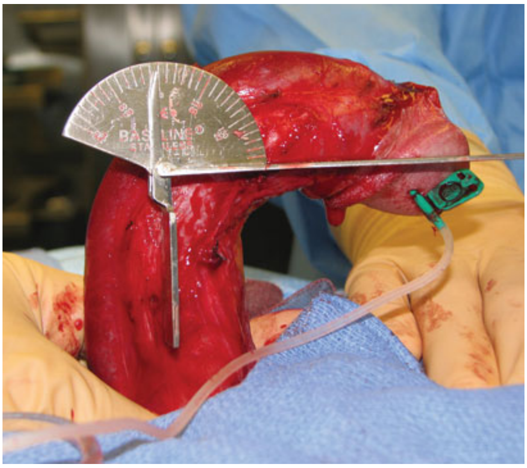


Fig. 42.17 With the penis now fully erect and the shaft skin degloved with a circumcising incision, a goniometer is used to measure the curvature

are Tutoplast™ (Coloplast US, Minneapolis, MN) processed human and bovine pericardium, and small intestinal submucosa (SIS) grafts (Surgisis ES, Cook Urological, Spencer, IN) [43, 44]. The pericardial grafts are thin, strong, do not contract, and have virtually absent reported infection or rejection rate. The SIS grafts have similar advantages to pericardium, except there have been reports of graft contraction of up to 25 % with associated recurrent curvature [13, 45–48].

Postoperative Management

The postoperative period is critical. Typically a patient is seen 2 weeks after surgery, at which point massage and stretch therapy is initiated [49]. The patient is instructed to grasp the penis by the glans and gently stretch it and then with his other hand massage the shaft of the penis for 5 min twice per day for 2–4 weeks. The massage and stretch can be performed by the patient's

Fig. 42.18 Buck's fascia is elevated with the neurovascular bundle over the area of maximum curvature. A pair of parallel longitudinal incisions is made approximately 1 cm lateral to the urethral ridge and then elevation of Buck's fascia is made with meticulous sharp dissection with care to limit injury to the neurovascular structures contained within Buck's fascia. Elevation of Buck's fascia is performed to provide appropriate exposure for reconstruction and does not need to extend the full length of the shaft. In this picture there is a marking on the tunic in the area of maximum curvature, which will be excised. As this defect expands, there is correction of the length and girth deformity

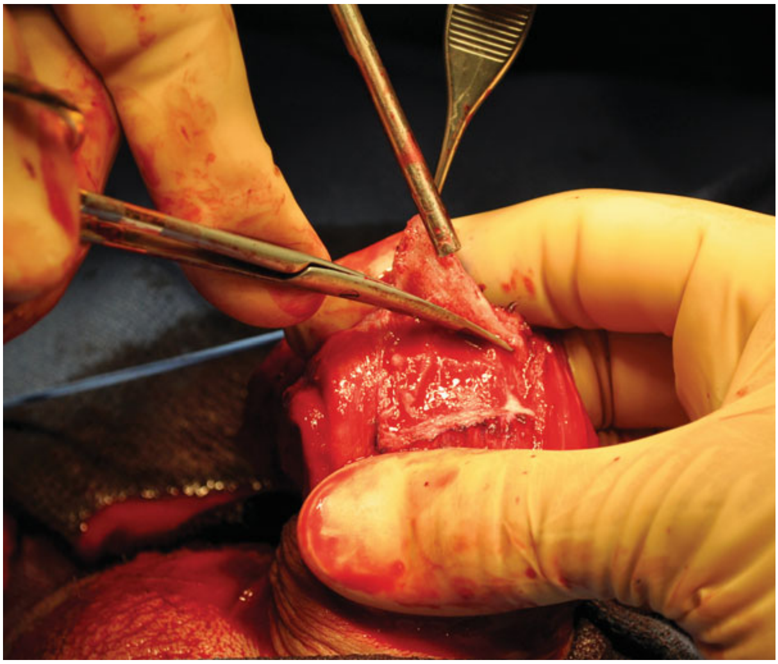


Fig. 42.19 Once the marked area of plaque is incised, very careful dissection should be made to elevate the attached tunica to limit the injury to the underlying cavernosal tissue

Fig. 42.20 This picture shows the rectangular piece of tunic excised. The dimension of the excised tunic varies with the severity of curve and indentation

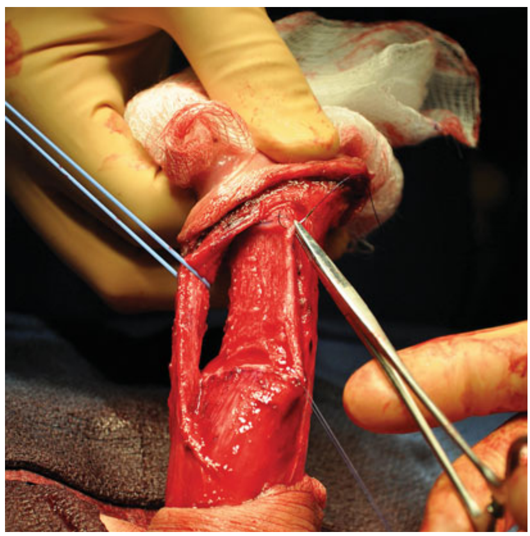


Fig. 42.21 The corners of the defect are darted in a radial fashion. This expansion of the defect will reduce the likelihood of graft contracture and will correct indentation so as to obtain a more uniform shaft caliber. 4-0 PDS stay sutures are applied in the four corners of the defect and also at the midpoint, essentially the septum, on the proximal and distal transverse aspects as well

partner for the second 2 weeks if possible. This will reinitiate the sexual experience for the couple and hopefully diminish the fear of reinjuring the penis, for which the partner may feel responsible. Investigators have recommended the use of nocturnal PDE5 inhibitors to enhance postoperative vasodilation, which may help support graft take as well as reduce cicatrix contraction [29]. Finally, external penile stretching devices have been encouraged and have been recently shown to reduce length loss postoperatively and can even enhance the likelihood of further length gain with both grafting and plication procedures [50, 51].

In a review of the published reports on grafting for PD over the past 12 years, satisfactory

Fig. 42.22 Once the stay sutures are applied, the penis can be placed on stretch for measurement of total stretched length to the corona. The defect is carefully measured as well. The goal in virtually all cases regardless of direction of curvature (dorsal or dorsal lateral) is to make the lateral longitudinal aspects equal on both sides. In this case the stretched length of defect on the lateral aspect is 4 cm bilaterally. Establishing equal measurements for the longitudinal aspects is critical for correction of the deformity. In addition, should the curvature be purely a lateral one, it must be remembered to always traverse to the contralateral side of the septum, as these fibers must be taken down to correct the curvature. If there is no significant indentation on the contralateral side, then simply excising or incising tunic to the contralateral aspect (2 or 10 o'clock position) of the septum will be satisfactory

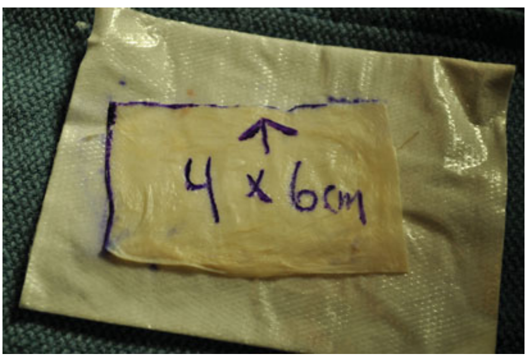


Fig. 42.23 In this case, the defect was measured 4 cm on the longitudinal aspect and 6 cm transversely. Our preferred graft material is processed human pericardium Tutoplast™ (Coloplast US, Minneapolis, MN) which is known to be thin, strong, has appropriate elasticity, and virtually no postoperative contraction. Therefore, the size of graft should be measured to be just several millimeters longer in length and width, unlike other grafts which may be more apt to contract 10–25 % of their volume. The graft is then secured to the edge of the tunica defect in a running fashion with the previously placed 4-0 PDS stay sutures. The penis should be maintained on stretch so as to prevent "reefing" of the graft and defect

Fig. 42.24 Buck's fascia is reapproximated in a running fashion bilaterally with a 4-0 chromic suture. This picture demonstrates the postoperative artificial erection with correction of curvature and narrowing

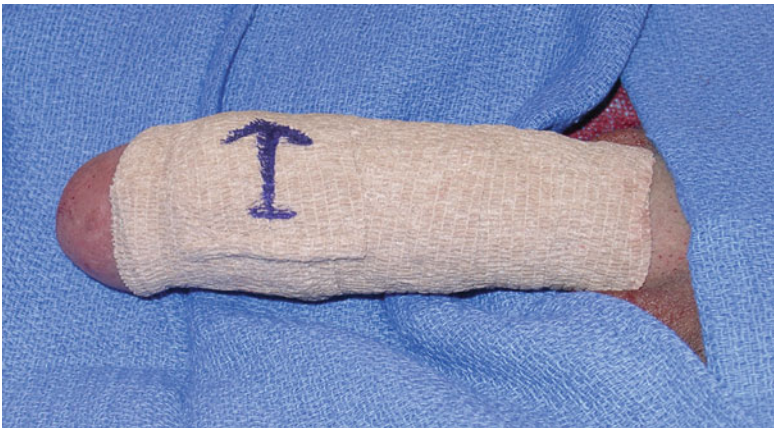


Fig. 42.25 A variety of dressings may be used but it is felt that a light compression dressing will reduce bleeding and edema. Note that no Foley catheter was used throughout this procedure. The dressing applied over the incision is Xeroform™ (Covidien, Mansfield, MA), a petroleum jelly antibiotic impregnated gauze, and followed with a COBAN™ (3M, St. Paul, MN) elastic wrap is lightly applied to the shaft so as not to cause significant compression, which could result in postoperative ischemia

straightening was found in 74–100 % of patients, but postoperative ED, which does not have a uniform definition in the literature, has been reported in 5–53 % of patients. Diminished sensation after grafting has been reported in a few series with a follow-up of less than 5 years [12]. In the few single-center surgical outcome reviews with 5 or more years of follow-up, ED has been reported in up to 22–24 %, with recurrent or persistent curvature in the 8–12 % range [48, 52, 53].

Penile Prosthesis for Men with Peyronie's Disease

Indications

As described above, in men with PD and concurrent ED refractory to PDE5 inhibitors, penile prosthesis placement is the procedure of choice [14, 16, 19]. Manual modeling may then be performed if necessary as only patients with mild curvature or presence of hinging without curvature will be fully corrected with prosthesis placement. Incising the tunica albuginea is then indicated if residual curvature is in excess of 30°. Grafting of this incisional defect is recommended if it is greater than 2 cm in any dimension.

Techniques for Straightening When Placing Penile Prosthesis for PD

An inflatable penile prosthesis appears to be the preferred surgical implant, as the pressure within the cylinders allows for superior correction of curvature with manual modeling, as well as improved girth enhancement. Malleable prostheses when used for PD historically were associated with narrow, cool, less than natural erections [54].

Manual modeling via the penoscrotal approach is recommended with a high pressure inflatable cylinder, but all available three-piece and two-piece devices have been used successfully to correct deformity. The prosthesis cylinders should be placed first, and then the corporotomies are closed. Using a surrogate reservoir attached to the pump tubing, the prosthesis can be filled to full rigidity, which will allow visualization of the deformity. To protect the pump from the high pressures that may occur during manual modeling, shodded hemostat clamps can be applied to the tubing between the pump and the cylinders. The penis is then bent in the contralateral direction to the curvature. It is recommended to try to hold the penis in this position for 60–90 s, but experience has suggested that around 30 s may be all that is possible. Regardless, once the modeling is performed, the penis can be reassessed by inflating more fluid, reapplying the hemostats, and then performing the modeling procedure repeatedly until satisfactory curvature correction is attained. The modeling technique should be a gradual bending rather than a violent maneuver, as this will reduce the likelihood of inadvertent tearing of the tunic or injury to the overlying neurovascular bundle. Urethral injuries while performing this technique by distal extrusion of the prosthetic cylinders at the fossa navicularis has been reported by Wilson [20, 55]. To reduce the likelihood of this occurring, the bending hand should be placed on the shaft of the penis rather than the glans, to avoid downward pressure on the tips of the cylinders. The other hand should be grasping the base of the penis with pressure over the corporotomies, which will provide support to this area and reduce the likelihood of disruption of the suture line. See Figs. 42.26, 42.27, 42.28, 42.29, 42.30, 42.31, 42.32, 42.33, 42.34, 42.35, 42.36, 42.37, 42.38, 42.39, 42.40, 42.41, and 42.42 for a detailed depiction of how to perform penile prosthesis placement and manual modeling.

Published reports on the use of modeling have indicated that sensory deficits after manual modeling are rare but are a potential complication that should be discussed with the patient preoperatively [56]. Although it would appear that for more severe curvature the more advanced techniques will be necessary, published experience has suggested that curvature correction may be used as first-line therapy for correction of curva-

Fig. 42.26 Once the patient has undergone the appropriate prepping and draping under anesthesia, the penis is measured on stretch dorsally from pubis to corona

Fig. 42.27 In this individual, a significant ventral penoscrotal web was identified, which will be addressed at the end of the procedure as part of the closure

Fig. 42.28 The author's choice in the patient with Peyronie's disease is to make a transverse upper scrotal incision approximately 5 cm in length. Dartos is entered and divided with cautery

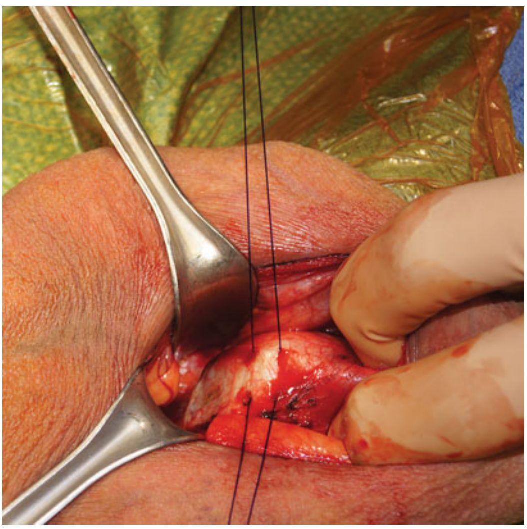


Fig. 42.29 Exposure is made by sweeping the tissues off the proximal ventrolateral corpora bilaterally. Buck's fascia over this area is elevated and 2-0 PDS sutures are applied as stay sutures

ture after prosthesis implantation. An alternative to this would be to perform a tunic plication such as the 16-dot suture technique contralateral to the curvature before placement of the prosthesis so as to correct curvature [57].

When there is residual curve of greater than 30° or residual indentation causing the inflated cylinder to buckle, tunical incision is recommended after elevating Buck's fascia in that area. The transverse penoscrotal skin incision will allow access to virtually the entire shaft, except when the curvature is quite distal on the shaft, so degloving the penis is rarely necessary. The tunical incision is made with the cylinders deflated, using the cautery to release the tunic with an effort to preserve the cavernosal tissue over the implant. When Coloplast™ Titan (Coloplast US, Minneapolis, MN) cylinders are used, the energy should be less than 30 W to reduce potential cylinder injury [58]. Once the incision is made, the cylinders are reinflated and further modeling can be performed to optimize deformity correction. Although there is not a clearly accepted approach, grafting over the defect is recommended when the defect measures greater than 2 cm in any dimension. This is to reduce the likelihood of cicatrix contraction or cylinder herniation [19]. Historically, synthetic grafts were used, but currently biografts of pericardium or porcine small intestinal submucosa (SIS) are recommended. Use of locally harvested dermal grafts is not recommended, as there is risk of transferring bacteria to the prosthesis. See Figs. 42.43, 42.44, 42.45, 42.46, 42.47, 42.48, 42.49, 42.50, and 42.51 for a detailed depiction on how to perform plaque incision and pericardial grafting after prosthesis placement.

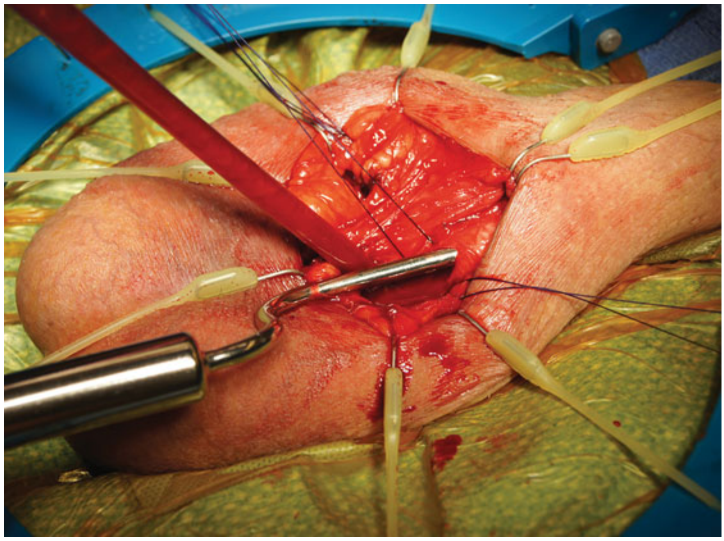


Fig. 42.30 A self-retaining retractor is positioned, providing exposure, and when using an inflatable prosthesis, typically a 2 ½–3 cm corporotomy is all that is necessary to gain access to the intracorporeal space. In this photo, the Brook's dilator has been passed distally through the corporotomy. This dilator is preferred over the Hagar sound, as it seems to have a lower likelihood to crossover or cause urethral trauma

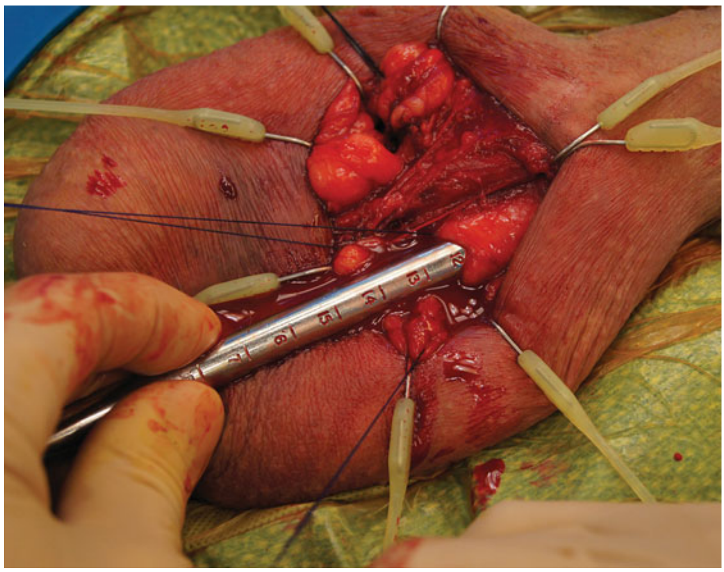


Fig. 42.31 The measuring sound is positioned within the cavernosal space with the penis on full stretch to the distal and proximal ends of the corpora cavernosa. Using the stay sutures, appropriate intracorporal measurements can be obtained

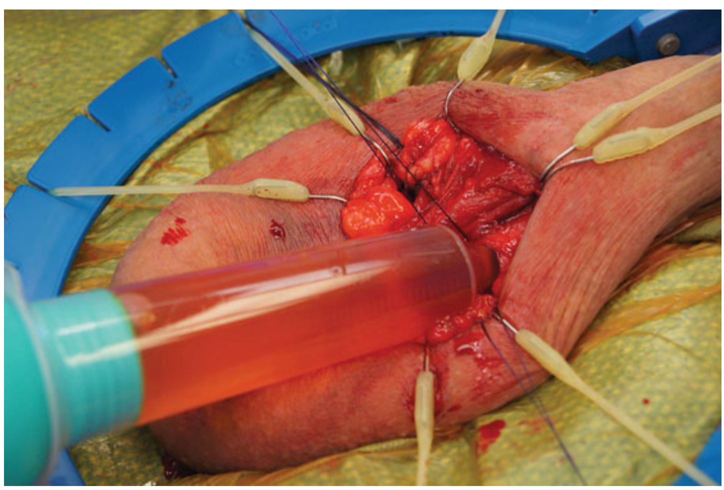


Fig. 42.32 Throughout this operation, copious antibiotic irrigation is used. Multiple approaches have been described. Our preferred regime includes rifampin (600 mg/1 L water) and bacitracin (50,000 units/1 L saline). In those men who have diabetes, amphotericin (50 mg/1 L water) irrigation is used

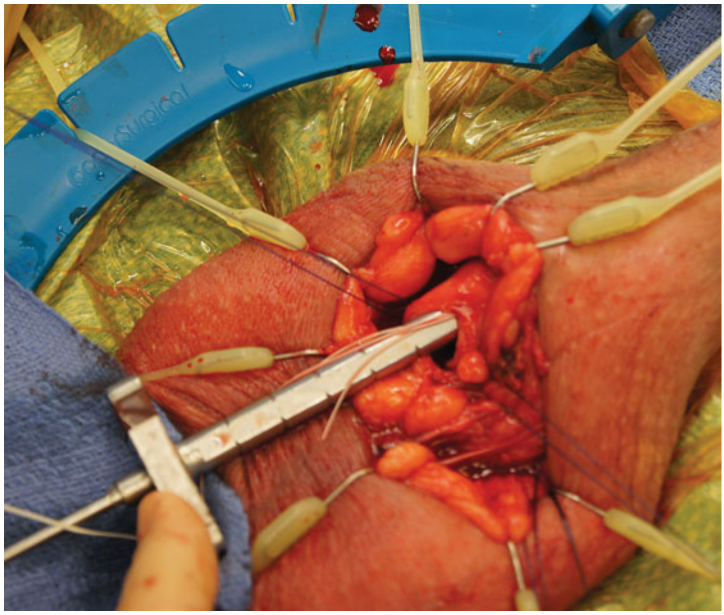


Fig. 42.33 Here the left prosthetic cylinder has been placed within the corporal space with the aid of the Furlow inserter. The right cylinder is being prepared to be inserted. The corporotomies are closed, preferentially with running 2-0 PDS suture, which provides better hemostasis than pre-placing stay sutures only. The previously placed stay sutures can be used to reinforce the closure

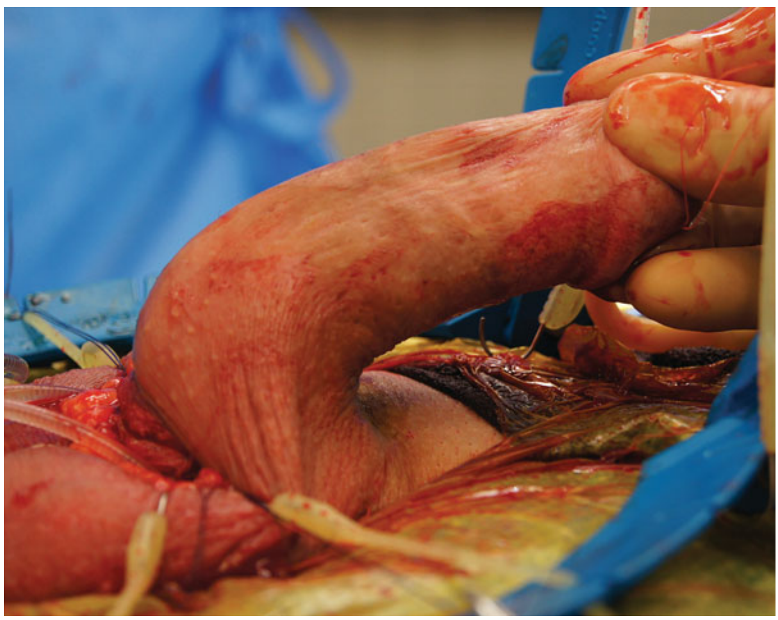


Fig. 42.34 With the prosthesis fully inflated, severe dorsal curvature is visualized

There have been limited publications looking at the long-term results with regard to outcomes and satisfaction with inflatable penile prostheses in men with PD and ED refractory to PDE5 inhibitors. Recently Levine and associates reported on 90 consecutive men undergoing placement of an inflatable penile prosthesis, with 4 % having satisfactory straightening with prosthesis placement alone, 79 % having satisfactory curvature correction with prosthesis and modeling, 4 % required tunical incision, and 12 % had incision and grafting for correction of curvature [56]. It did not appear that the additional maneuvers

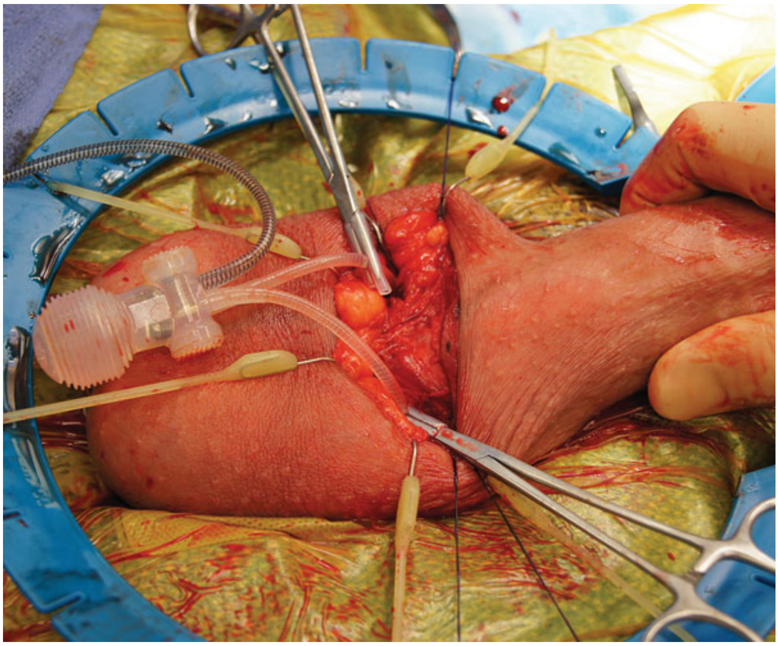


Fig. 42.35 Rubber-shod hemostats are applied to the tubing between the cylinder and the pump once the prosthesis is fully inflated, demonstrating the deformity

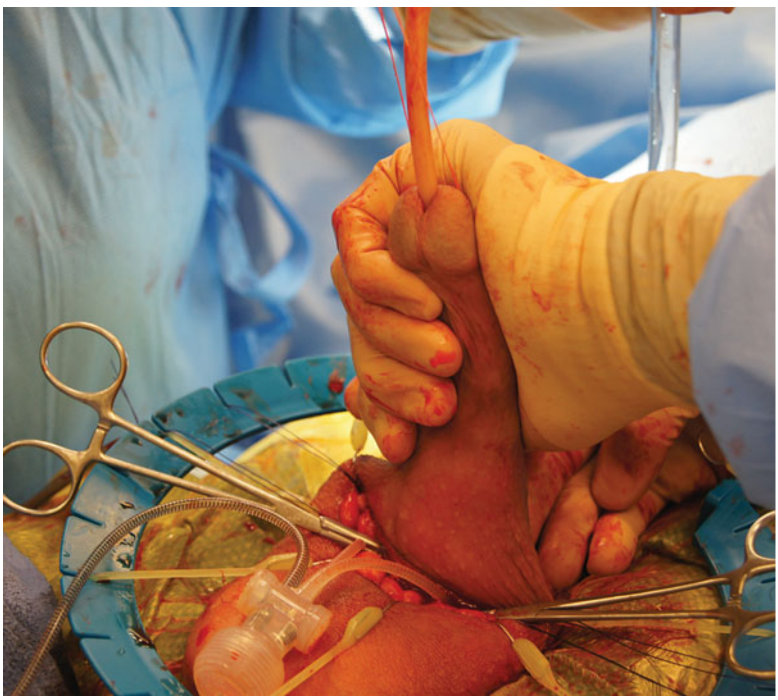


Fig. 42.36 The penis is grasped with one hand so as to bend it in a direction contralateral (ventral) to the curvature but so as to keep the tips of the prosthesis exposed and thereby reduce the likelihood of distal urethral trauma

increased the rate of mechanical failure or infection. In the nonvalidated questionnaire used in this study, overall satisfaction was 84 %, whereas only 73 % were satisfied with curvature correction. This may indicate a flaw in the design of the questionnaire but may also reflect the general disappointment and frustration of patients with PD. Thus, preoperative counseling and setting appropriate expectations as with any prosthesis placement is critical [59]. It is recommended that discussion is also focused on the goal of obtaining "functional straightness," in which a residual curvature of 20° or less in any direction would likely not compromise sexual activity.

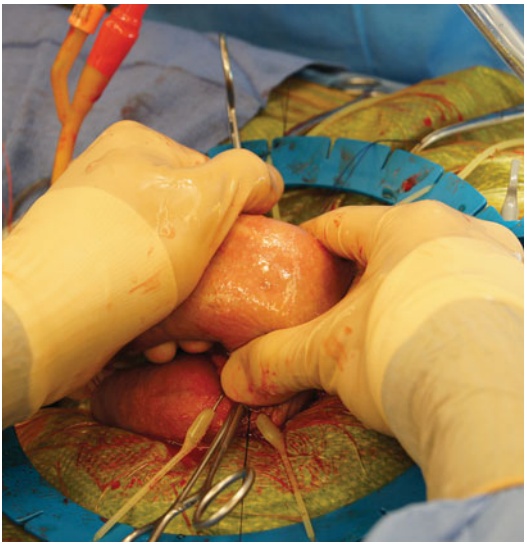


Fig. 42.37 This demonstrates the left hand creating the bending in the contralateral direction with the right hand's index finger and thumb over the corporotomies, reducing the likelihood of incisional blowout

By far the most common postoperative complaint heard in men who undergo penile prosthesis placement is length loss [60]. This is of particular concern in the PD population, the majority of whom report length loss at initial presentation. Any additional length loss due to the implant may be distressing to the patient and should be addressed preoperatively. For those men who cannot tolerate any further length loss, a recent small pilot study using traction therapy before penile prosthesis placement in men with PD as well as other disorders causing penile shortening (e.g., prosthesis explants, radical prostatectomy) did demonstrate that after 3–4 months of daily traction for an average of 3 h or more per day, there was no further loss of length after prosthesis placement, and the majority had gained some length (0.5–2.0 cm) compared to their pre-traction stretched length [61].

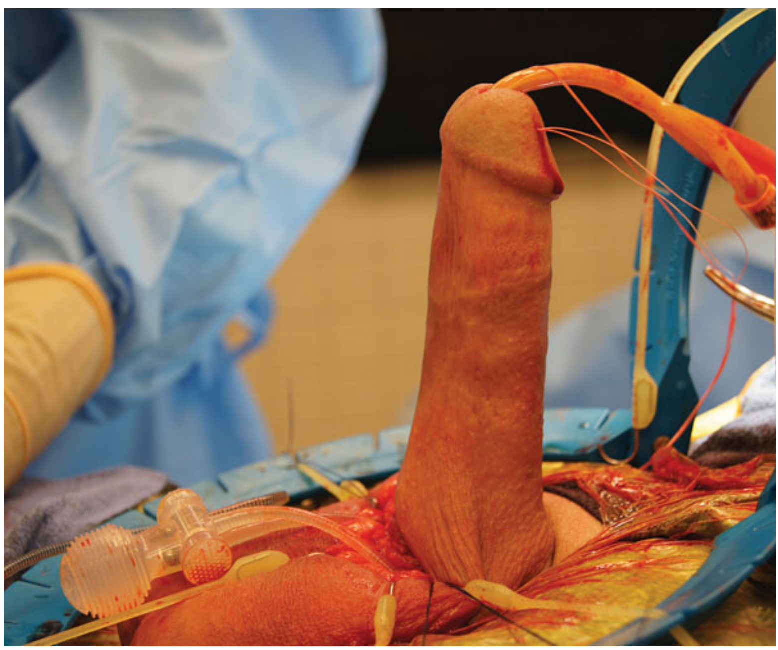


Fig. 42.38 The penis is now straight with the prosthesis inflated. The rest of the procedure follows standard approaches for placement of the pump in the scrotum as well as the reservoir within the space of Retzius

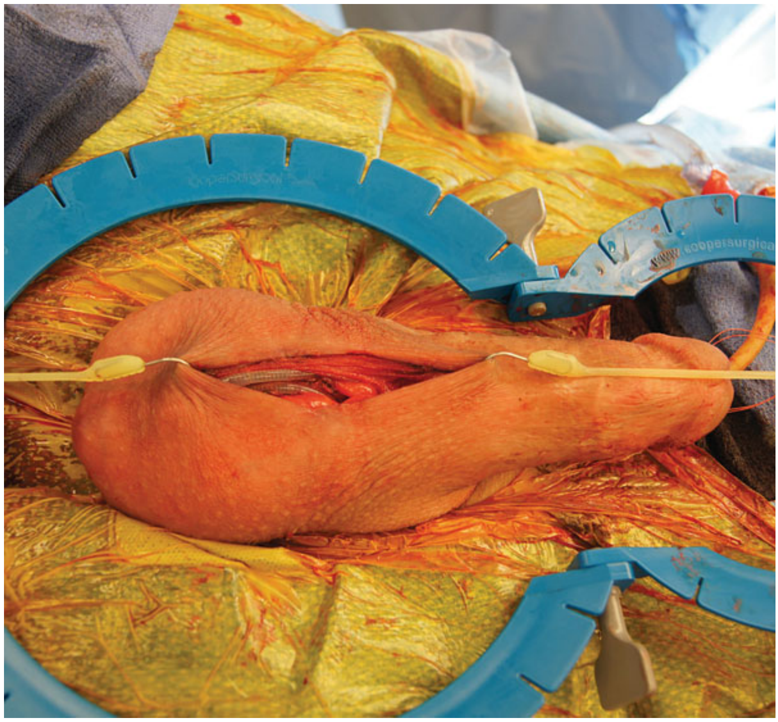


Fig. 42.39 This individual had a significant penoscrotal web. A ventral scrotoplasty was performed by closing the original transverse incision in a longitudinal fashion with the aid of the self-retaining retractor. Once hemostasis is obtained, the dartos is approximated in two running layers with 3-0 PDS. If it is noted that there is persistent oozing of the scrotal tissues or from the corporotomy site, then a closed drainage tube should be placed through a separate stab wound

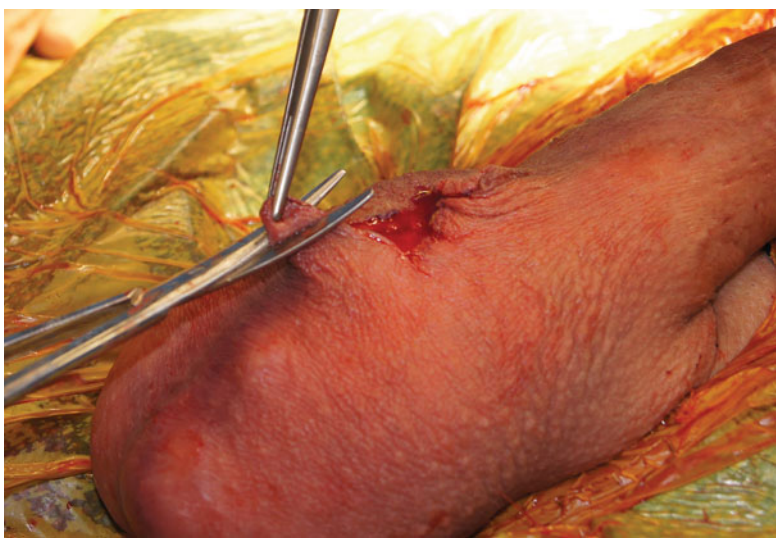


Fig. 42.40 This technique does tend to result in significant dog ears at the proximal distal aspect of the closure. These should be excised before closing the skin

Fig. 42.41 The scrotal wound is now fully approximated with a running subcuticular 4-0 Monocryl™ (Ethicon, Blue Ash, OH)

Fig. 42.42 The prosthesis is now inflated, demonstrating the correction of the ventral scrotal web and satisfactory straightening

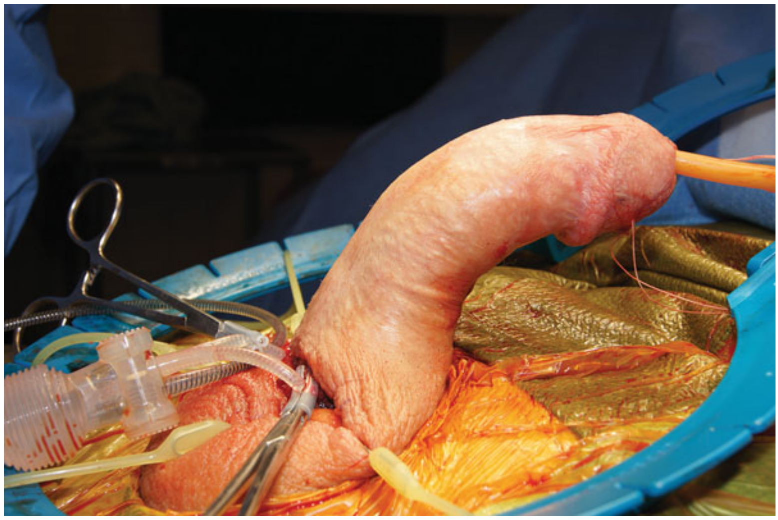


Fig. 42.43 In this picture we can see that the penile prosthesis has been placed, the corporotomies have been closed, and a surrogate reservoir is used to allow full prosthesis inflation to demonstrate the deformity. The rubber-shod hemostats are applied to the tubing between the cylinders and the pump on both sides prior to modeling

Fig. 42.44 After performing modeling repeatedly with at least 30 s maintained in the ventral position to correct curvature in this dorsally curved penis, there is still substantial residual curvature. It is our practice that if there is an excess of 30° of residual curvature after manual modeling, additional straightening maneuvers are indicated

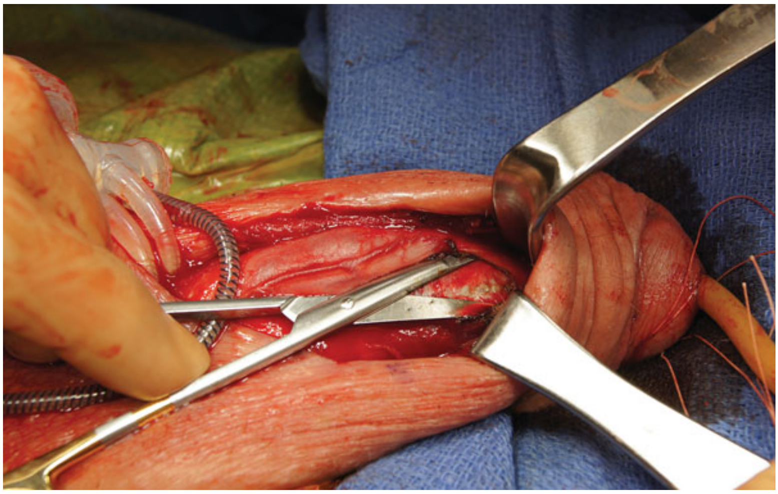


Fig. 42.45 Typically the transverse penoscrotal incision allows mobilization of the shaft and dartos tissue to allow exposure of the area of curvature where Buck's fascia will be elevated to expose the tunica to be incised with cautery. In this view, mobilization of skin and dartos is noted with elevation of Buck's fascia over the tunic to be incised

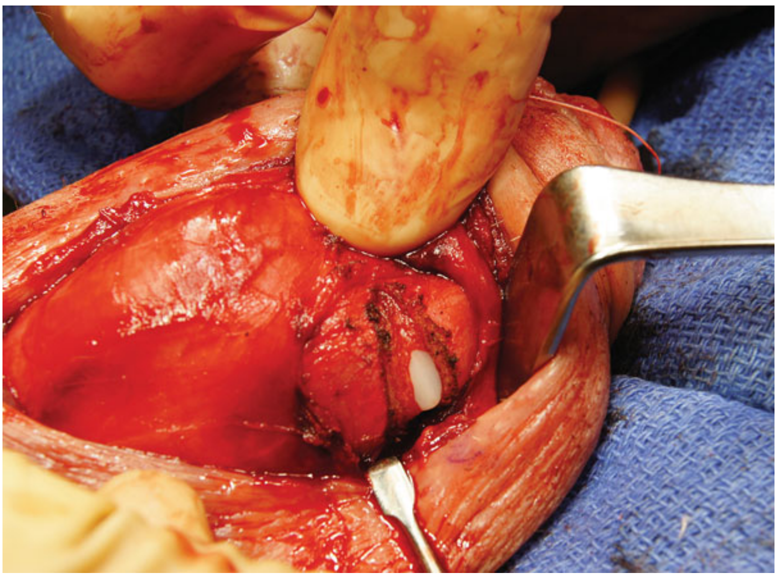


Fig. 42.46 This view demonstrates the incision through the tunica revealing the underlying prosthesis. Incision is made so as to release the tethering scar tissue, but with the rather distal position of the curvature in this individual, adequate elevation of Buck's fascia could not be accomplished on the more dorsal aspect of the shaft. It should be noted that cautery mode is used to incise the tunica. During this maneuver, the prosthesis should be deflated and no more than 30 W of energy should be used to prevent injury to the corporal cylinders. The prosthesis can then be refilled and further modeling performed

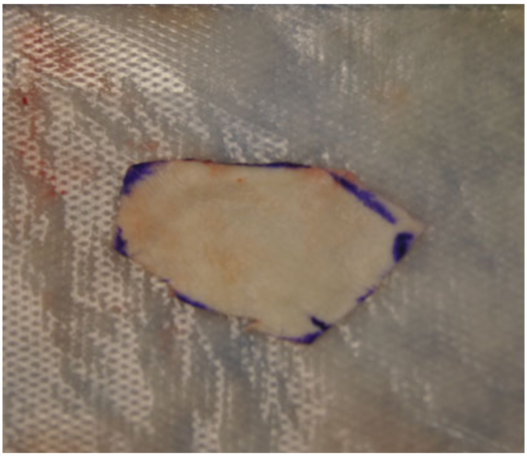


Fig. 42.47 The resulting defect from the tunica incision and modeling was in excess of 2 cm; it was elected to secure a piece of Tutoplast processed human pericardium graft over the defect so as to prevent prosthesis herniation or cicatrix contracture. The graft is measured in situ

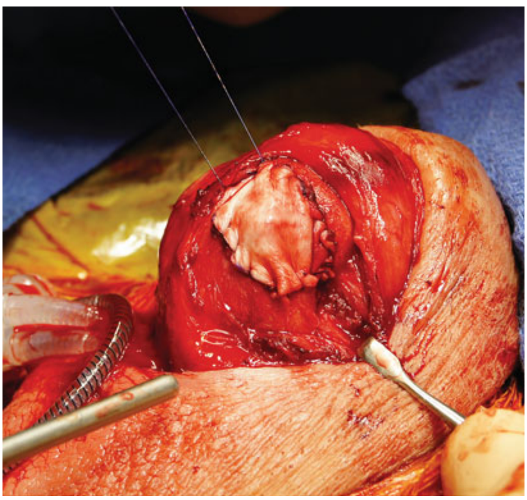


Fig. 42.48 This demonstrates the Tutoplast graft secured to the tunic defect with a pair of running 4-0 PDS sutures

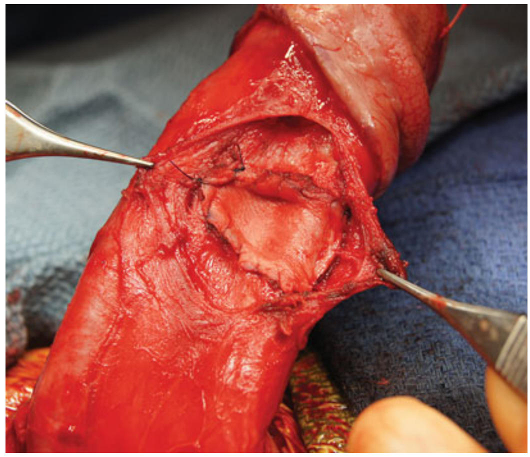


Fig. 42.49 As this patient was unable to be satisfactorily straightened through the penoscrotal incision due to the distal nature of the curvature, a degloving procedure was performed, exposing the open Buck's fascia and previously placed graft. With the benefits of this exposure, adequate, safe mobilization of the neurovascular bundle could be obtained over the dorsal area of the septum which then was incised with cautery, releasing the residual tethering scar

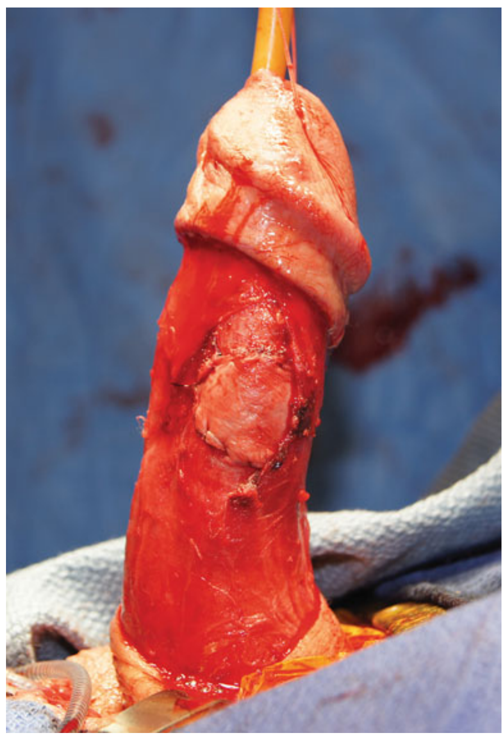


Fig. 42.50 This demonstrates the satisfactory correction of curvature, now with the combination of plaque incision and grafting. Buck's fascia is approximated over the Tutoplast graft with running 4-0 chromic

Fig. 42.51 This shows the prosthesis inflated with shaft skin reapproximated with interrupted horizontal mattress 4-0 chromic and the scrotal wound also closed after positioning the prosthesis reservoir and pump

Conclusion

In conclusion, surgical correction of PD with or without penile prosthesis placement remains the gold standard to correct deformity. These men need to undergo a detailed and comprehensive consent process so that the patient will be more understanding of the potential limitations of the surgery in order to set appropriate expectations thus improving postoperative satisfaction. For the man with satisfactory preoperative rigidity with curvature less than 60–70° without significant indentation, then some form of tunica plication is indicated. There does not appear to be any one plication technique which has been demonstrated to be superior to others, as no head-to-head comparative trial has been published. In addition, for those men who have more severe, complex deformity but who have strong preoperative erectile function and no evidence of venous insufficiency on duplex ultrasound image analysis, these men should be considered candidates for straightening with plaque incision or partial excision and grafting. The complications associated with these operations include incomplete straightening, recurrent curvature, shaft shortening, diminished penile sexual sensation, and erectile dysfunction. Finally, for those men who have inadequate rigidity and PD, penile prosthesis placement with straightening maneuvers as necessary should be considered first-line surgery.

Surgical Pearls and Pitfalls

Tunica Albuginea Plication

- Buck's fascia is incised exposing the area of the tunica albuginea opposite the point of maximum deformity.
- A pair of partial thickness incisions approximately 1–1.5 cm in length is made.
- Incisions are separated by 0.5–1.0 cm.
- Longitudinal fibers between the two transverse incisions are removed.
- A single 2-0 Tevdek is used to approximate the edges of the newly created defect.
- It is essential to maintain tension on the suture, sometimes with the help of an assistant, to adequately approximate the edges of the incisions.
- Several incisions and plications will likely be necessary to obtain the desired result.

Partial Plaque Excision and Grafting

- The extent of the disease is seen maximally via artificial erection with intracavernosal

injection of vasoactive agent (papaverine, prostaglandin E1, or Trimix).
- An infusion pump may also be beneficial.
- The penis is degloved via a circumcising incision.
- Buck's fascia is elevated via a pair of longitudinal incisions at the 5 and 7 o'clock positions 1 cm lateral to the urethral ridge taking care to leave the neurovascular bundle intact.
- A modified H-incision or partial plaque excision is made to create a rectangular or square defect.
- The tunica is then separated from the underlying cavernosal tissue sharply.
- Care must be taken not to damage the cavernosal tissue so as not to interfere with the veno-occlusive mechanism, which is important for postoperative rigidity.
- Corners of the defect are darted radially to optimize correction of any girth defects.
- The edges of the defect are then measured on stretch by applying 4-0 PDS stay sutures at the corners and at the midpoint of the transverse aspects.
- The graft is secured in place with running absorbable suture.
- An artificial erection can then be used to determine if there is any residual curvature or leaks which may require correction.
- Buck's fascia is reapproximated to provide support to the graft as well as tamponade any residual bleeding.

Manual Modeling After Penile Prosthesis Placement

- Performed after prosthesis cylinders are in place and corporotomies are closed.
- Utilize a surrogate reservoir to fill the prosthesis and visualize curvature.
- Pump is protected by placing rubber-shod hemostat clamps on cylinder tubing.
- Care is taken to exert bending force on the penile shaft and not the glans to help minimize cylinder trauma on the urethra.
- Modeling technique is a gradual bending rather than a violent maneuver.
- The maneuver is repeated until the desired result.

Tunica Albuginea Incision After Penile Prosthesis Placement

- Performed for residual curvature of 30° or more after manual modeling.
- Incision is made with cylinders deflated using cautery.
- Energy should be reduced to 30 W.
- Cylinders are reinflated after incision is made.
- It is recommended to place a graft in a tunica defect measuring 2 cm in any dimension.

Potential Problems

Tunica Albuginea Plication

- Suture continues to loosen while tying: have an assistant place a smooth hemostat on the knot to secure to tissue while making the next throw.
- May exacerbate hinge or hourglass effect resulting in an unstable penis: consider grafting instead of TAP.
- May not fully straighten penis: perform further plications.
- During elevation of the dorsal neurovascular bundle and deep dorsal vein for correction of ventral curvature, injury may occur to the nerves, resulting in sensory deficit.

Manual Modeling After Penile Prosthesis

- Curvature remains after modeling: perform tunica albuginea incision.
- Cylinder extrusion: repair defect and copious irrigation:
  - Via urethra: remove prosthesis, consider leaving malleable rod on contralateral side, and place catheter for 7–10 days.
  - Via corporotomy: repair corporotomy.

Tunical Incision After Penile Prosthesis Placement

- Poor visualization of distal deformity via penoscrotal incision: perform circumcising incision and deglove.
- Cylinder herniation through defect: place graft over defect.

Preferred Surgical Instruments of LA Levine

- Scalloped-tipped Horton-Devine scissors by Snowden-Pencer® (Tucker, GA)

- Bipolar cautery
- “Special snap” (mosquito clamp with serrations ground smooth)
- Long-nosed nasal speculum
- Cavro pump
- Multiple curved Jacobsen hemostats
- Rigid ruler
- Loupe magnification (2.5 × 3.5×)
- Jorgensen scissors for reservoir placement
- Brook’s cavernosal dilators

Editorial Comment

We have found that penile plication procedures yield a consistently high degree of straightening and patient satisfaction without objective loss of penile length. Using a 2 cm longitudinal proximal shaft incision, we have found that even complex deformities can be corrected without penile degloving [1]. The procedure takes less than 1 h to perform and the recovery is extremely rapid, thus constituting a safe, simple, minimally invasive treatment strategy. For complex multiplanar or severe deformities (>60°), additional stitches are usually necessary for adequate reconstruction, and we have noted that each stitch provides roughly 6° of correction [2].

We have been unimpressed with the results of manual modeling for correction of angulation after penile implant insertion and have therefore abandoned these maneuvers at our center. On the other hand, we have had excellent results with preliminary plication followed by IPP insertion as described by the UCSF group in reference 57 below. The penoscrotal incision may be displaced distally to the subcoronal area as needed using a Senn retractor. The technique spares the patient (and surgeon) a second incision and avoids the potential complications of modeling and grafting maneuvers.

—Allen F. Morey

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The Buried Penis in Adults

43

Richard A. Santucci and Mang L. Chen

Summary

Adulthood buried penis is becoming an increasingly prevalent problem due to the rise in obesity. Weight loss and exercise may help overall health, but reconstructive surgery, especially in patients with scrotal lymphedema, cellulitis, abscess, or gangrene, is the primary treatment. We present a detailed description of our widely applicable surgical approach for management of these patients.

Introduction

The buried penis is a descriptive term for a phallus encompassed by fat, subcutaneous tissue, and skin such that normal voiding and sexual function are impossible. In adulthood, the buried penis is usually an acquired disease strongly associated with obesity and other more local diseases such as penoscrotal lymphedema. In childhood, this condition is congenital and is often due to the maldevelopment of penile shaft skin or micropenis. The childhood disease must be understood to be different than the adult disease; most surgical techniques used in pediatric cases are not applicable to the obese adult patient. The most common iatrogenic etiology for childhood buried penis is overzealous circumcision [1], and we believe that overzealous or repetitive circumcision may worsen adult buried penis. Because of these different etiologies, specific therapeutic approaches are required for various causes of the buried penis, although the basic approaches can be widely applied. In adults, buried penis is surgically managed with four general steps: (1) unburying, (2) excess tissue and diseased tissue resection (escutcheonectomy, scrotectomy, suprapubic defatting), (3) scrotoplasty, and (4) split-thickness skin graft (STSG) coverage of the unburied penis.

The buried penis was notably described by Campbell in 1951 and expounded upon by Crawford in 1977 [2]. However, these initial papers focused on childhood buried penis. In fact, there is ample pediatric literature on the subject and its surgical management. The adulthood variant of this disease is less often described, but it has become an increasingly prevalent problem with the rise in obesity. This has spawned a handful of clinical reviews and descriptions of surgical approaches over the past few decades. In this chapter, we will describe this disease entity in adults and focus on reconstructive surgical principles for successful management of the buried penis.

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Fig. 43.1 Clinical presentation: Escutcheon creates pseudocavity of invaginated skin where urine can accumulate and lead to skin irritation, poor hygiene, and infection. There is no scrotal disease in this patient

Clinical Presentation

An adult with a buried penis is most often morbidly obese with comorbidities like hypertension, diabetes, and depression. Others may have primary penoscrotal lymphedema or iatrogenic causes for their condition. Regardless of the etiology, the primary unifying complaints are an inability to void normally, expose the penis for cleaning, and perform sexually.

On physical exam, most patients have an overhanging collection of suprapubic tissue we have called the "escutcheon" that sometimes encompasses and conceals the penis. The escutcheon is the tissue just above the penis corresponding to the mons pubis in females and is usually distinctly different from the abdominal pannus. The penis is usually not visible and the glans can only sometimes be digitally palpated thru a pseudocavity created by invagination of the escutcheon (Fig. 43.1). Patients can have erythema and denudation of perineal skin from urinary pooling in these pseudocavities. Unexpected lichen sclerosis can sometimes be found after unburying, and discovery of severe urethral stricture disease after unburying is not uncommon. Some patients also have associated primary genital lymphedema, with lymphedematous scrotal and perigenital skin. Occasionally, cellulitis, abscess, and Fournier's gangrene may complicate the case and should prompt antimicrobial (cellulitis) or surgical (abscess/gangrene) intervention (Fig. 43.2).

Obstructive urinary symptoms from lichen sclerosis involving the meatus and urethra can be indistinguishable from urinary symptoms due to the buried penis itself. Patients are therefore counseled preoperatively concerning the need for possible surgical intervention for urethral stricture (often due to unappreciated lichen sclerosis) if found concomitantly during surgery. This may take the form of urethrotomy, delayed urethroplasty, or significant surgery to release dense glans-to-shaft adhesions. Patients are also warned

Fig. 43.2 Preoperative photo: Escutcheon creates pseudocavity of invaginated skin. In addition, the scrotum is enlarged, edematous, and erythematous consistent with scrotal lymphedema and cellulitis

that obesity, chronic local skin infection, and associated diseases such as diabetes increase their risk of wound healing difficulties [3] and infection [4].

Indications for Surgery

Buried penis is a surgical disease. Weight loss and weight management may be an option in some obese patients, but weight loss thru exercise and dieting may be futile in this massively obese patient population, and weight loss usually does not cure the buried penis. Furthermore, such transformation—if successful—is slow, and overhanging prepubic tissue may still be present even after weight loss, necessitating reconstructive surgery. Early surgery may be indicated for those with repeat episodes of cellulitis and bothersome urinary symptoms. Immediate incision and drainage followed by staged surgery may be necessary in those with abscess or gangrene.

Preoperative Preparation

Most patients have multiple medical comorbidities and will require preoperative cardiac and anesthesia clearance as well as medical optimization prior to surgery. Electrocardiograms, chest x-rays, routine blood work, urinalysis, and urine culture are necessary. Weight loss is encouraged but not enforced before surgery. Excellent pre- and postoperative glucose control may decrease the incidence of surgical infection.

Surgical Options

There are multiple techniques described in the literature by plastic surgeons and urologists for the management of the buried penis in adults. Donatucci et al. described a treatment algorithm that starts first with penis release followed by panniculectomy and suspensory ligament release if necessary [5]. Grafts and flaps are used if primary closure is not achievable. Other authors describe placing tacking sutures that secure the penopubic junction subdermis to the rectus fascia and the penoscrotal junction subdermis to the tunica albuginea with combined dermolipectomy [6]. Adham et al. endorsed a similar technique, but instead of dermatolipectomy, liposuction and abdominoplasty were performed [7]. The nature and degree of burying seen in our population of often morbidly obese adults would not, in our opinion, respond to minimal interventions such as tacking sutures. Shaeer et al. described local flap coverage for penile reconstruction after adhesiolysis, dermatolipectomy, and penile fixation [8].

Patients with buried penis can also have scrotal lymphedema that will require subtotal scrotal resection, partial scrotal resection, or scrotoplasty. Tang et al. described a method that involves penile adhesiolysis and removal of inflamed shaft skin, dermatolipectomy of the prepubic fat pad (termed escutcheonectomy by these authors), scrotoplasty as needed, and split-thickness skin grafting (STSG) for penile skin coverage [9]. This is the technique we have adopted and will subsequently describe in detail.

Operative Technique

All of the previously described techniques are effective for specific cases, but in the morbidly obese, we prefer a surgical approach that includes the following primary components: (1) penile release from surrounding tissue, (2) tissue resection (includes escutcheonectomy and lipectomy with or without partial or total scrotectomy) and penile fixation to neighboring subdermis, (3) scrotoplasty, and (4) penile coverage with STSG.

Prophylactic first-generation cephalosporins with an aminoglycoside are given prior to anesthetic induction. Sequential compression devices are applied and we position the patient in dorsal lithotomy or in frog-legged supine position depending on the degree of scrotal involvement. In cases of massive scrotal enlargement, the patient is placed in lithotomy position and a sterile Mayo surgical instrument tray is placed in between the legs to support the scrotum and escutcheon. We position the left leg to facilitate split-thickness skin graft harvesting from the left anterior thigh later in the procedure. After standard prepping and draping, we identify the penis first to avoid glans injury.

Penile Release

The penis is delivered forcefully from the pseudocavity, and if possible, the phimotic ring is identified and carefully incised, avoiding damage to the penis itself. A 2-0 monofilament suture is placed thru the glans to provide traction. If the glans cannot be seen, a careful dorsal slit is made until the penis is visible. Adequacy of shaft skin is assessed; in rare cases, the penile skin is adequate to avoid STSG. A circumcising incision is made about 3 mm from the corona. Using the monofilament suture to pull the penis out will generally show that only a fraction of the shaft skin required is present (Fig. 43.3). In some cases, lichen sclerosis creates dense scar adhesions of the penile skin tissue to glans, and dissecting the glans apart from the shaft can be time consuming and difficult.

After circumcision, the penis is degloved down to the superficial suspensory ligament, which is not transected. Occasional lichen sclerosis with associated meatal stenosis or urethral stricture will be discovered, necessitating dilation and/or urethrotomy. Delayed urethral reconstruction may ultimately be required.

Tissue Resection, Penile Fixation, and Scrotoplasty

Escutcheonectomy is performed concomitantly. We make a curved horizontal incision above the proximal penis and continue this distally around the escutcheon and sometimes the diseased scrotum (Fig. 43.4). The remaining prepubic

Fig. 43.3 Penis unburying: After dorsal slit, 2-0 monofilament suture is placed thru dorsal aspect of glans as a holding suture to retract the penis outward. The penile shaft is then freed from surround tissue to unbury it. Oftentimes, there is little to no usable native penile shaft skin

Fig. 43.4 Escutcheonectomy: Large horizontal incision is made above the proximal penile shaft and diseased scrotal skin is completely removed. In addition, we estimated where the penis will exit the skin and made a circular incision

tissue undergoes partial lipectomy to create a quarter-inch flap. The distal end of this flap is brought caudad and secured to the base of the penis with interrupted 2-0 Vicryl sutures placed in the subdermis of the flap. Alternatively, a circular hole can be made in the flap to accommodate the penis (Fig. 43.4). This may give a more satisfactory cosmetic result, but caution is required as this approach may result in both inferior loss of the flap and dehiscence, though this happens rarely. The remainder of the escutcheonectomy wound is closed in multiple layers using neighboring scrotal and pubic tissue with care taken to minimize potential tissue spaces and resultant seroma formation. We sew the subdermis 2 cm away from the penile base to the superficial suspensory ligament and peripubic tissue. We try to bring the skin up onto the shaft to create a "turtleneck" effect (Fig. 43.5) to avoid scar contracture at the base of the penis, which can be unsatisfactory from a cosmetic and hygienic standpoint. We place closed suction drains under the flap to enhance seroma prevention.

Fig. 43.5 Affixing dermis to penile shaft: This “turtleneck” reconstruction helps keep the penis from retracting into a deep cleft

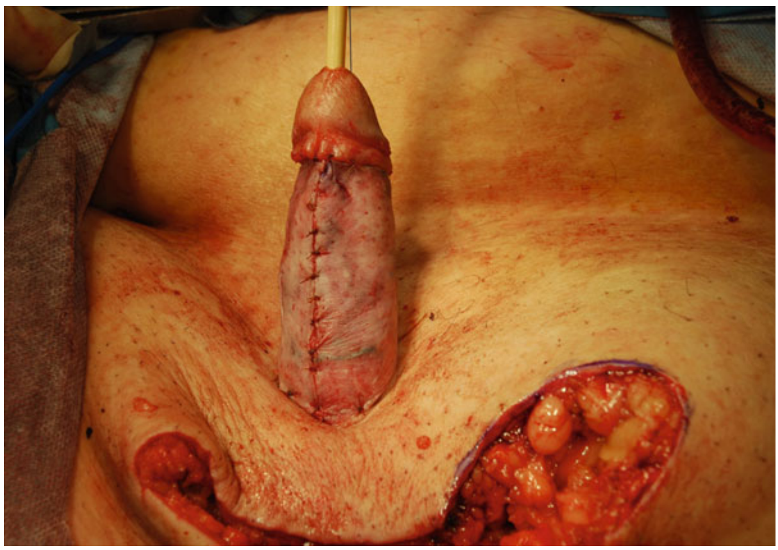

Fig. 43.6 STSG placement on penile shaft: Interrupted 3-0 chromic sutures are placed to secure the STSG onto the penile shaft dartos fascia as well as the coronal and escutcheon skin. Note that the suture line is ventrally located

Penile Reconstruction

The remainder of the exposed penile shaft is covered with non-meshed STSG from the left anterior thigh or the escutcheon specimen itself, which is harvested at a thickness of 0.015 in. with an electric dermatome (Dermatome, Zimmer, Warsaw, IN). The thigh is placed on stretch with towel clips and stabilized to facilitate graft harvest. The graft edges are secured to dartos fascia and coronal penile skin with interrupted 3-0 chromic sutures (Fig. 43.6), and the central portion of the graft is secured with dilute fibrin sealant (Tisseel VH, Baxter, Deerfield, IL) that is sprayed underneath the graft [10]. Dilution of fibrin glue increases hardening time from seconds to minutes to improve proper graft placement.

The penis is then dressed with a lubricant-impregnated gauze pad and covered with a normal gauze pad. The remainder of the wound is covered with antibiotic ointment and dry dressings. We cover the STSG donor site with a large, clear, adherent dressing (Opsite, Smith & Nephew, London, UK) with a small suction tube

Fig. 43.7 Dressing the STSG donor site: TLS drain is placed under a large clear adherent dressing

underneath (TLS, Porex Surgical, Newnan, GA) to prevent fluid accumulation under the dressing and to enhance adherence (Fig. 43.7). Ideally, the donor site dressing is left on as long as possible, and if left long enough may result in painless healing. If it falls off or must be removed prematurely, Vaseline-impregnated gauze can be placed on the wound until full healing occurs. After full healing, the donor site skin will be dry (because of the removal of apocrine sweat glands) and may need to be treated with emollients to avoid xeroderma.

Postoperative Care

The use of fibrin glue allows very reliable penile skin graft take. This allows earlier patient mobilization because the risk of graft dislodgement is minimal. We keep postoperative patients on bed rest with bathroom privileges for 24 h. The catheter is removed the next morning and the penile and wound dressings are changed. The patient is encouraged to move around as tolerated. Occasionally, there will be a (generally small) collection of fluid behind the penile STSG, which will require bedside needle aspiration or scalpel release to improve graft survival. After 48 h, the patient is allowed to shower and change his own dressing. By 72 h, many patients can be discharged, and by 4 days, most patients can be discharged.

Patients are seen every week in clinic for 2–4 weeks after discharge and every 2–4 months thereafter if wound healing progressively improves.

Results

Blood loss varies due to varied fat vascularization. Most STSG donor sites and the escutcheonectomy wound heal well within several weeks, though escutcheonectomy wound dehiscence is occasionally observed and managed with dry dressings, daily cleansing, and time. For patients with diseased and enlarged scrotums, scrotectomy and scrotoplasty immediately improve ambulation. Scrotoplasty wounds require minimal care and often heal without incident. Penile skin graft take is usually 100 %; areas with unsuccessful graft take undergo healing by secondary intention. Patients notice immediate improvement in voiding symptoms and later improvement in sexual function. An infrequent delayed complaint is scar contracture of the peri-penile suture line that is sometimes visually displeasing and difficult to clean. Fully healed patients are encouraged to transform their lives with a personalized diet and exercise program. Those who fail are referred to a bariatric surgeon.

Conclusion

We detailed a comprehensive and systematic approach for surgical management of acquired buried penis in adults that can achieve excellent results. Drastic intervention is often the only effective means to assist with this disease, especially when soft tissue infection of the scrotum or escutcheon is also evident. Radical resection and penile reconstruction combined with a postoperative weight loss plan can dramatically improve psychological, emotional, and medical well-being. Patients are most pleased with the ability to void from a standing position and the return of sexual function.

Surgical Pearls and Pitfalls

Key Intraoperative Surgical Points

- Put large glans stitch for retraction to help with penile eversion.
- Inflamed penile shaft skin must be removed and replaced with STSG.
- When securing local skin to proximal penile shaft of the degloved penis, make sure to place deep dermal interrupted sutures followed by another layer of dermal interrupted sutures (2-0 absorbable braided suture) to "turtleneck" the skin onto the penile shaft. Failure to do so will lead to a deep cleft that is difficult to clean once healed.
- Dilute fibrin sealant is required for proper placement of the STSG to the penile shaft.
- Prepubic skin remaining after escutcheonectomy must be defatted aggressively to avoid reburying the penis.
- If escutcheonectomy is performed, consider taking STSG from specimen instead of thigh.
- Place suction drain.

Potential Intraoperative Surgical Problems

- Penile injury: may occur if glans is not identified and tagged prior to performing escutcheonectomy.
- Testicular and spermatic cord injury: may occur if not isolated prior to escutcheonectomy.
- Skin necrosis: may occur from overzealous thinning of the remaining prepubic skin and underlying tissue.
- Wound dehiscence: may occasionally occur and is prevented with perioperative glucose control, wound hygiene, and multiple layers of absorbable suture during wound closure and scrotoplasty.

Preferred Instruments and Suture of Authors

- Monopolar cautery
- Forceps
  - DeBakey forceps
- Suture
  - 3-0 chromic on RB-1 needle (securing STSG to penile shaft)
  - 2-0 Vicryl on SH needle (closing subcutaneous, deep dermal, and dermal-epidermal layers)
  - 2-0 Prolene (glans-holding stitch)

Editorial Comment

Buried penis is no longer uncommon at most reconstructive centers. Most cases are related to sequelae of morbid obesity, but many others are due to lichen sclerosus. The first move at the time of surgery is to expose the glans enough to place a deep traction suture. Then the penile shaft can then be projected out of its fibrotic constraints and examined with the shaft fully elongated.

We have noted a spectrum of cutaneous involvement in buried penis cases. Younger patients may present earlier, with less pronounced inflammatory changes on the penile shaft; for these we have utilized a ventral slit/scrotal flap maneuver which enables reconstitution of the penoscrotal angle with anchoring sutures, full reduction of the phimotic skin, and ventral skin coverage with a rotational scrotal skin flap. An advantage of this maneuver is that patients are spared the tedious wound care issues related to skin grafting. These patients are then restored to sexual activity and standing voiding in a minimally invasive manner.

For more extensive cases, complete penile skin removal with skin grafting is usually required. We like to use negative pressure dressings to stabilize the grafts. Concomitant abdominoplasty is often helpful, but insurance coverage for this is spotty and many patients will not want to pay for that maneuver themselves. We work closely with our plastic surgeons on these cases and alternate follow-up in the postoperative period. Harvesting the skin graft from the redundant abdominal tissue to be excised is sensible and effective. Deep prepubic anchoring sutures are critical to stabilize the bulky abdominal tissues in their proper location above the penile shaft.

—Allen F. Morey

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44 Penile Fracture

Jack H. Mydlo and Leo R. Doumanian

Summary

Penile fracture is defined as the rupture of the tunica albuginea of the corpus cavernosum caused by blunt trauma to the erect penis. The overwhelming majority of tunical tears are sexual in nature. There is significant geographical variation in the cause and incidence of penile fractures. Considered an uncommon injury by many, penile fracture rates may be increasing.

The presenting features associated with true penile fractures are relatively consistent and typically straightforward. The simple clinical diagnosis usually renders adjunct imaging unnecessary, unless concomitant urethral injury is suspected. Historically, penile fracture management included mostly conservative, nonsurgical measures. In the 1980s, operative intervention became favorable after several studies demonstrated a decrease in long-term morbidity.

The principles of penile fracture repair are dependable despite the many differing opinions about the timing of surgical exploration, the need for urethral catheterization, the type of incision and fashion of suture material utilized, and the requirement for prophylactic antibiotics. With adequate exposure and hematoma evacuation, the fracture site is identified and repaired. Most patients are discharged within 24 h with some men engaging in sexual activity 2 weeks after surgery.

Today, urgent surgical exploration is the standard of care given fewer complications, shorter hospital stays, improved outcomes, and better patient satisfaction. Current observations note a rising trend of published reports in the world literature, despite low public awareness. Does the data reflect a greater world interest or an actual increase in traumatic penile ruptures? Regardless, penile fractures produce devastating physical, functional, and psychological consequences unless properly repaired.

Introduction

Penile fracture is defined as the rupture of the tunica albuginea of the corpus cavernosum caused by blunt trauma to the erect penis [1]. Immediate attention is required for tunical disruptions, the most common cause of an acute penis [1]. Concomitant injuries include partial or complete transection of urethral or spongiosal tissue and avulsion of dorsal nerves and vessels [2]. Historically, the first documented penile fracture was credited to the Arab physician Abul Kasem over 1,000 years ago [3].

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True penile fracture incidence is largely unknown [4, 5]. Cohorts of men avoid proper medical attention due to embarrassment, fear, and aversion to surgery [5–7]. The worldwide literature demonstrates considerable geographic variation in both incidence and etiology of penile fractures. Interestingly, the greatest number of penile fractures is provided by the Middle Eastern and North African experience [8].

Considered an uncommon injury by many, penile fracture rates may be increasing. Over a 16-year period in Saudi Arabia, Ekwere and Al Rashid noted a 58 % increase in tunical disruptions [9]. Additionally, the National Inpatient Sample recorded 1,043 US hospital admissions carrying the diagnosis of penile fractures from 2006 to 2007 [10]. Current observations note a rising trend of published reports in the world literature, despite low public awareness [9, 10]. Does the data reflect a greater world interest or an actual increase in traumatic penile ruptures [9, 10]? Regardless, penile fractures produce devastating physical, functional, and psychological consequences [4, 5]. Unfortunately, abstinence is the only proven prevention strategy, however unrealistic [4, 5].

Anatomy and Pathophysiology

Understanding fracture mechanics requires anatomic review of penile structure and function. A tough, fibroelastic sheath, the tunica albuginea, envelopes the ventral corpus spongiosum and dorsally paired corpora cavernosa [11]. With erection, the corpora cavernosa is filled with blood and the tunica albuginea thins from 2 to 0.25–0.5 mm [12]. The rigid penis now loses elasticity. With abrupt loading, intracavernosal pressures can exceed penile tensile strength, fracturing the inner circular and outer longitudinal fibers of the tunica albuginea [13]. Normal erectile studies reveal intracavernosal mean arterial pressures at approximately 100 mmHg, whereas intracorporeal pressures approaching 1,500 mmHg are required to rupture the tunica [14]. Preexisting pathological states, such as tunical fibrosclerosis, inflammation, and perivascular lymphocytic infiltration, can predispose rupture at lower pressures [14–16]. Supporting evidence includes a significantly higher frequency of penile trauma seen in patients with Peyronie's disease [17].

External to the tunica albuginea run the deep dorsal arteries and veins. During erection, blunt traumatic soft tissue injuries can occur without damaging the tunica albuginea [18, 19]. Furthermore, Buck's fascia, the deep perineal tissue plane that surrounds both the cavernosa and penile vessels, fuses proximally with the deep urogenital region [20]. Characteristic injury patterns associated with penile fractures depend on the integrity of this tissue plane. Upon tunical disruption, cavernosal bleeding leaks into surrounding tissues and remains contained to the penis by an intact Buck's fascia [21]. If Buck's fascia is violated, hemorrhage may spread to perineal, scrotal, and lower abdominal wall structures [9].

Tunical ruptures are usually unilateral, located proximally near the base of the penis with a predilection for right cavernosal injury [22, 23]. In a series of 300 Tunisian men, 60 % noted right corporeal tears [24]. Additionally, the penile fracture sites were located in the proximal, middle, and distal cavernosa in 54, 20, and 26 %, respectively [24]. Most tunical tears have a transverse orientation with occasional longitudinal extension [8]. True longitudinal tears are a rarity with few case reports in the literature [8]. However, bilateral corporeal injuries account for 4–10 % of all penile fractures and must always raise suspicion for concomitant spongiosal and urethral disruption [25, 26].

Combined spongiosal and urethral injuries may complicate penile fracture, with a variable incidence ranging from 14 to 38 % in the United States and Europe to almost nonexistent (0–3 %) in Asia and the Middle East [27–29]. This discrepancy reflects the different injury mechanisms of the world, with coital fractures more prevalent in Westernized countries [8]. Zargooshi's well-known Iranian series discovered 5 urethral tears in conjunction with a total of 352 tunical lacerations [30]. The North African experience demonstrated a 3.2 % combined injury rate among 312 Tunisian men [15]. Penile manipulation accounted for about 75 % of all fractures from the two preceding series [15, 30]. On the other hand, a recent Brazilian study of 125 men noted a 16 % combined urethral and penile fracture injury rate [26]. Additionally, 20.5 % of US men with penile fractures from 2006 to 2007 were identified as having concomitant urethral disruption [10]. Coital injuries were almost exclusively responsible for fracture in these large, Western data sets [10, 26].

Pathophysiologic states that render the urethra more rigid, such as spongiofibrosis or stricture disease, may predispose the urethra to concomitant injury [31]. Also, ventral tunical tears, often resulting from sexual mishaps, pose an increased risk of urethral laceration [21, 22]. Most combined urethral disruptions are partial in nature and occur mainly with bilateral cavernosal tears. Sporadic reports of complete urethral laceration do exist [22, 32]. Surgical exploration of a 17-year-old boy that fell on his erect penis discovered a left tunical fracture and complete transection of his adjacent penile urethra [33]. Additionally, 1 case report details an isolated corpus spongiosal injury with intact tunical integrity [34].

Etiology and Demographics

The overwhelming majority of penile fractures are sexual in nature, accounting for one in every 175,000 hospital care emergencies [35–37]. A combined 23 series with 613 aggregate cases revealed sexual intercourse and masturbation as responsible for 43 and 46 % of penile fractures, respectively [24]. Although most penile fractures occur during erection, 3 % of 208 tunical tears resulted from a direct blow to a flaccid penis in one study [21, 29]. However, our current discussion focuses on cavernosal erectile injuries.

There is significant geographical variation in the cause and incidence of penile fractures, with the highest reported rates from the Middle East and North Africa [8]. A thorough review discovered that 54 % of 1,642 cases in the world literature originated in the Mediterranean Moslem region, including Turkey [35]. To date, the two largest series include an 18-year follow-up of 352 Iranian patients and the 30-year Tunisian experience of 300 penile fractures [24, 30]. As a comparison, 150 fractures accrued over a 12-year period from Brazil comprise the largest data set from more westernized countries [26].

Masturbation injuries and penile manipulations account for most fractures from North Africa and the Middle East [5, 26, 38–53]. This includes the widespread practice of *taqaandan* in the Kermanshah Province of western Iran. *Taqaandan* has been described as an intentional, forceful bending of the erect penile shaft as cultural habit to provide relaxation and release tension [30]. With a population of two million, there is no region in the world with a greater incidence and prevalence than Kermanshah. Zargooshi's 18-year review of 352 men revealed *taqaandan* was responsible for 76.4 % of injuries in his data set [30].

Accounting for 33–58 % of all injuries, vaginal intercourse is the most common cause of penile fracture with the majority of cases from North America [35]. During vigorous sexual activity, the penis may slip out of the vagina and be thrust against the female perineum or symphysis pubis. This direct, blunt force precipitates penile buckling and potential tunical disruption. Certain sexual practices, namely, the female superior position, may increase fracture risk due to severe, abnormal angulation [54]. Tunical laceration has also been reported during intercourse in the standing position, when the woman suddenly collapsed and fell, acutely bending the penis [55]. There are no fracture accounts resulting from fellatio with very few injuries sustained during anal intercourse [46].

With an annual incidence of 0.29–1.36 cases per 100,000 people, some additional etiologies in the literature include impaling a penis in a mattress, slamming the penis in a door, placing an erect penis into tight pants, striking a toilet seat, hitting a bedpost, falling from a tree, and masturbating into a cocktail shaker [27, 35–37, 56–58]. The list continues, and any additional patient accounts, both real and fabricated, will never cease to amaze the authors.

Clinical Features and Physical Exam Findings

History and physical exam findings associated with true penile fractures are relatively consistent. The simple diagnosis usually renders adjunct imaging unnecessary, unless concomitant urethral injury is suspected. Although false penile fractures with intact tunical integrity represent 5 % of surgical explorations, the evaluation of the acute penis is usually straightforward [19].

Most authors agree that the diagnosis of penile fractures is largely clinical [38, 59]. Stereotypical presentation includes a pop or cracking sound followed by immediate detumescence [15, 58]. The noise has been described as resembling "the breaking of a corn stalk" or "breaking of a glass rod" [60, 61]. Combined date review from 6 recent studies totaling 1,028 patients noted a cracking or popping sound in 48–100 % [13, 26, 30, 62–64]. Abrupt detumescence and penile swelling is observed in almost 100 % of coital injuries, although Zargooshi reports 22 % of his subjects denied immediate flaccidity after *taqaandan* [13, 64]. Pain, acute swelling, purple ecchymosis, and penile deformity give rise to the "eggplant" or "aubergine" sign if Buck's fascia remains intact [49, 65, 66]. With violation of Buck's fascia, hemorrhage may spread around Colles' fascia to perineal, scrotal, and lower abdominal wall structures and represent a "butterfly" injury pattern [22, 67]. Pain may vary from mild to critical without any direct correlation to injury severity [5]. Surprisingly, some penile fracture patients practicing *taqaandan* reported no pain at all [13, 30]. Additionally, the penis is often deviated towards the side opposite the tear secondary to mass effect of the hematoma [12, 22].

On occasion, the "rolling sign" can help identify the tunical fracture, although pain and edema may preclude proper physical examination. As the penile skin is gently rolled over the injury site, a firm, immobile, and tender swelling can be appreciated as a palpable clot within the torn tunica [68]. At times, an actual gap or depression in the penile shaft may be revealed. In our experience, we find this particularly difficult to ascertain; however, Beysel et al. successfully identified tunical defects in 55 % of men in their series [56, 69, 70].

Complex Penile Fractures

Concomitant injury to the corpus spongiosum and urethra may occur in 1 to 38 % of all penile fractures [5, 71] (Fig. 44.1). Sexual intercourse, considered high-energy trauma in some instances, leads to the majority of complex penile fractures [72]. Although most urethral tears are partial in nature, complete transection has been reported in the literature [73]. There is an increased association between bilateral corporeal ruptures, with an incidence of 4–10 %, and complex penile fractures (Fig. 44.2). Whenever confronted with this particular injury pattern, suspicion for urethral involvement must arise [25, 26, 62, 74].

The diagnosis can be difficult and all complex injuries must be repaired. Meatal bleeding, hematuria, and urinary retention are suggestive, but not specific for urethral injury [25, 40, 75, 76]. Physical findings alone can be misleading. Microscopic hematuria demonstrates a 50 % positive predictive value for urethral laceration [75]. Additionally,

Fig. 44.1 Transverse penile fracture of the corpora cavernosa and concomitant near transection of the corpus spongiosum and urethra (Image courtesy of SB Brandes)

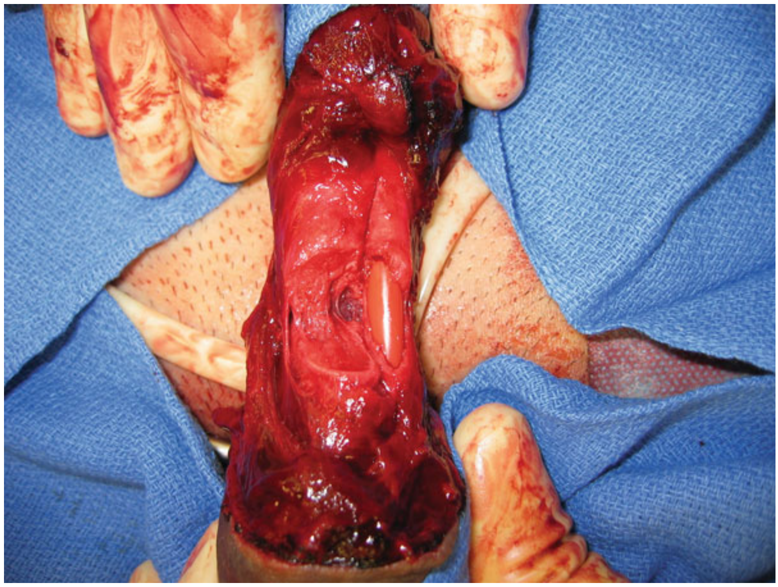

Fig. 44.2 Near-complete transection of the urethra and spongiosum. Note the associated bilateral corporeal rupture (Image courtesy of SB Brandes)

meatal bleeding without urethral injury has been reported [76]. Regardless of preoperative imaging and clinical exam findings, direct urethral inspection during surgical exploration is mandatory.

False Penile Fracture

Approximately 5 % of all "clinically" diagnosed penile fractures result from soft tissue bleeding without tunical violation [19]. In Zargooshi's large series, 10 out of 362 fractures explored demonstrated intact cavernosal bodies and isolated penile venous damage [30]. These injuries usually reflect nonspecific dartos bleeding, rupture of the superficial dorsal vein, deep dorsal vein, or dorsal artery [19] (Fig. 44.3). In extremely rare instances, a ruptured suspensory ligament or penile Mondor's disease, an unusual inflammatory condition of the superficial penile veins, can also produce false penile fractures [77, 78].

Clinically, the two entities can be indistinguishable. Like true penile fractures, these injuries often present with the sudden onset of pain, swelling, and ecchymosis [79, 80]. Certain nonspecific findings, such as an absent audible snap, gradual post-injury detumescence, and the ability to have an erection at a time removed

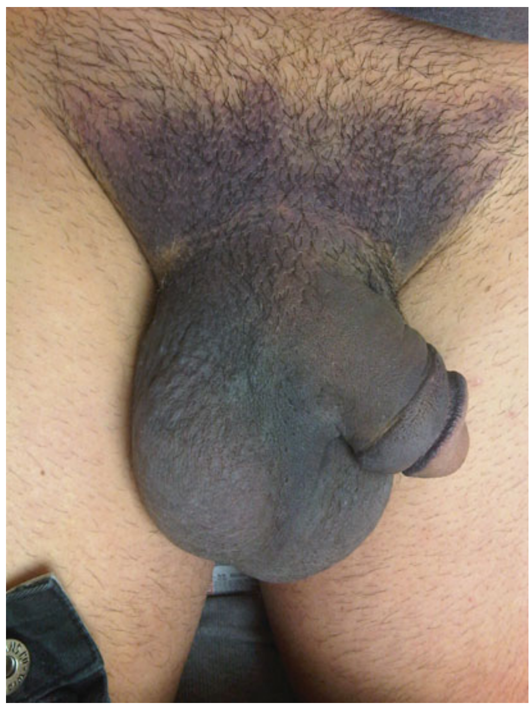

Fig. 44.3 Dorsal vein injury resulting in diffuse penile and scrotal ecchymosis after traumatic intercourse. Note the ecchymosis is symmetrical and does not cause an eggplant or lopsided appearance, as with penile fracture. The patient had pain and swelling but did not hear a classic "pop" nor did he lose his erection (Image courtesy of SB Brandes)

from the insult, suggest false penile fracture [79, 80].

A closer look at two large series by Feki et al. and El-Assmy et al. discovered a 10.5 and 5 % rate of false penile fractures in 159 and 316 patients, respectively [19, 81]. By combining the data sets, false penile fracture etiology included nonspecific dartos bleeding and dorsal vein laceration in 63 and 37 %, respectively [19, 81]. Bar-Yosef and colleagues, with their considerable experience, have proposed circumcision as a contributing risk factor to penile vascular injury during intercourse due to tauter penile skin [18]. However, the evidence is limited [18]. Additionally, dorsal artery ligation can be performed to control bleeding without any negative long-term effects on penile and erectile functioning [79].

The Role of Imaging

The clinical features associated with true penile fractures are relatively consistent. The diagnosis is typically straightforward and ancillary imaging examinations are usually unnecessary, unless concomitant urethral injury is suspected. However, atypical presentations and false penile fractures can lead to diagnostic uncertainty. As a result, some authors continue to utilize cavernosography, ultrasonography, urethrography, magnetic resonance imaging, color Doppler duplex scanning, and angiography for the evaluation of suspected penile fractures [82]. Despite technological advances, we still believe that history, physical examination, and clinical judgment are the most valuable tools for assessment of penile fractures.

Cavernosography

Dever and colleagues first reported diagnostic cavernosography for penile fractures in 1983 [83]. In several early reports, routine cavernosography was recommended for all suspected fracture injuries [46, 70]. As time progressed, cavernosography was reserved for atypical cases [75]. Today, cavernosography is discouraged due to the invasive nature, possibility of infection, risk of tissue reactions, potential for corporeal fibrosis, and high incidence of false-negative results [75, 82, 84]. Additionally, there are reports of priapism resulting from cavernosography in the literature [1]. In our opinion, cavernosography has little to no clinical utility.

Ultrasonography

Also in 1983, Dierks and Hawkins published *Sonography and Penile Trauma* depicting preoperative visualization of a tunical disruption with associated hematoma [85]. Since then, the application of penile ultrasonography in the acute setting has been well described [82]. With large tunical fractures and hematomas, ultrasonography has been shown to have an 86–93 % detection rate at high-volume centers [19, 86, 87]. Despite the increased use of ultrasonography in emergency departments for both diagnostic and therapeutic interventions, the utilization of US for penile fractures has not grown in parallel [88, 89].

Penile ultrasonography is widely available, inexpensive, and operator dependent, requiring specific expertise [90]. The tunica albuginea is easily identified as a hyperechoic linear structure [90]. Ultrasound characteristics of penile fracture include disruption of the hyperechoic tunica in the presence of hematoma. In real time, penile compression with color Doppler can produce a flush of blood, helping to confirm the diagnosis [91].

The rarity of penile fractures limits worldwide experience. The accurate diagnosis can be difficult, especially with small tunical tears and a clot obscuring the fracture line [37, 92]. Ateyah and colleagues visualized 20 out of 30 tunical tears by ultrasound. Despite their 66.7 % detection rate, they still conclude that history and physical exam may be superior to ultrasonography because interpretation is too heavily dependent on operator use and experience [13]. The findings from ultrasonography do not necessarily influence the decision to explore, even in the setting of false fractures. Thus, with ultrasonographic false negatives being common, such as a

50 % rate from El-Assmy et al., this imaging modality has limited clinical use as well [81, 82].

Concomitant Urethral Injury

Combined spongiosal and urethral disruption may complicate penile fracture in 1 to 38 % of patients [5, 71]. The diagnosis of urethral injury can be difficult because classic findings of blood at the meatus, hematuria, and an inability to void are nonspecific [25, 40, 75, 76]. Additionally, false-negative results have been well documented [25]. Mydlo et al. demonstrated 2 out of 7 false negatives during retrograde urethrography for complex penile fracture [25].

Previously, Miller and McAninch advocated routine urethrography as a standard practice for most penile fractures [93]. Many experts now forgo urethrography because intraoperative recognition of urethral disruption is quite straightforward [71, 82, 94]. Other, more practical options include careful urethroscopy under anesthesia [25]. Additionally, simple retrograde instillation of indigo carmine and saline can facilitate identification of urethral damage during repair. Regardless of investigation, direct urethral inspection during surgical exploration is mandatory. All urethral injuries must be fixed because damaged penile structures exposed to urinary leakage demonstrate increased fibrotic collagen deposition and other potentially devastating sequelae including strictures, fistulas, and infection [40, 49]. The pendulum has swung and we believe the clinical utility of retrograde urethrography must now be questioned [82].

Magnetic Resonance Imaging

Magnetic resonance imaging has been utilized in several small series. False penile fractures are easily identified due to MRIs multiplanar capabilities and good spatial and tissue contrast resolution [78, 95–97]. When MRI was performed in 4 patients with suspected false fractures, diagnostic accuracy was 75 % and allowed for nonoperative management [81]. Disruption of the low-signal-intensity tunica albuginea is well seen on both T1- and T2-weighted images [20]. Additionally, MRI may help confirm urethral disruption, although current data is limited [97]. Practically speaking, magnetic resonance imaging is expensive, impractical, and not widely available and performing MR imaging should not delay treatment [95].

Treatment and Management

Operative repair was first described by Fetter and Gartman in 1936 [98]. Historically, penile fractures were subject to conservative, nonoperative management. In the 1980s, the superiority of surgical intervention was demonstrated by a decrease in long-term morbidity from 30 % (nonoperative approach) to 4 % [53, 99]. Today, immediate repair is the standard of care given fewer complications, shorter hospital stays, improved outcomes, and better patient satisfaction [22, 40].

Immediate Surgical Repair Versus Conservative Nonoperative Management

Conservative management, intentional or otherwise, included pressure dressings, cold compress, Foley catheterization, anti-inflammatory drugs, fibrinolytics, antibiotics, and sedatives [5, 35, 100, 101]. Without intervention, large tunical defects would naturally heal. Unfortunately, 30–53 % of these patients would then suffer from delayed chordee and fibrous plaque formation, producing pain and erectile dysfunction [25, 102].

Without question, several studies have consistently demonstrated surgical superiority over conservative management. Muentener et al., in their 22-year experience, found a significantly higher complication rate in the nonoperative group [103]. Nicolaisen and colleagues urged early surgical treatment based on a 29 % complication rate with an average hospital stay of

14 days for those conservatively managed [51]. Zargooshi's 98.6 % potency rate in 214 men can be compared to 8/10 nonoperated men who developed ED [30]. Specific long-term complication rates of 30 and 40.7 % were also demonstrated by Jack et al. and Bennani et al., respectively [75, 104]. Additional penile morbidity included penile pain, organized hematoma formation, cavernous fibrositis, infection, penile nodules, severe penile angulation, and arterial-venous fistulas [27, 50, 53].

Additionally, a recent retrospective review includes a direct comparison between the nonoperative group refusing intervention and those who underwent simple surgical repair. Not only was the hospital stay considerably longer (average of 3.0 vs. 8.6 days), but an 80 % complication rate included wound infection, painful erection, penile curvature, and erectile dysfunction for the conservative cohort [64]. This was compared to 10.8 % morbidity for immediate surgical repair [64]. The data is compelling and indisputable. Conservative management has no role in the management of true penile fracture. In this day and age, there should be no controversy regarding surgical versus nonoperative management.

Delayed Surgical Repair

Most contemporary studies continue to favor immediate surgical repair given excellent functional and cosmetic results with minimal complications and decreased hospital stay [26, 35, 41, 56, 71, 105]. However, some authors advocate delaying surgical repair for 7–12 days after the initial insult, provided the corpus spongiosum and urethra are intact [103, 106–108]. Concomitant urethral injuries are an absolute contraindication to delayed surgical management and must be emergently explored.

In the acute traumatic setting, accurate localization of the corporeal fracture site can be much more difficult given diffuse penile edema and hematoma formation. Adequate exposure of both corpora will likely require penile degloving and extensive tissue mobilization during urgent exploration [67]. The involved dissection injures more vasculature and nerves, traumatizes the tissue, increases operative time, and leads to a higher incidence of wound infection and skin necrosis [23]. By 7–12 days after injury, penile swelling resolves, the hematoma reabsorbs, and the clot overlying the tunical fracture is more easily palpable [103, 107, 108]. Since the majority of corporeal fractures are small, unilateral tears, penile degloving is now unnecessary. By delaying operative exploration, a transverse incision can be utilized, thus minimizing tissue disturbance.

Several series support delayed surgical management and demonstrate comparable results with immediate surgical repair. Nasser and Mostafa described 24 patients who underwent conservative treatment for 7–12 days with subsequent surgical repair under local anesthesia. No intraoperative or postoperative complications were encountered, and all patients regained sexual function 4–6 weeks after injury [107]. Naraynsingh et al. demonstrated similar success with a simple, direct repair several days after initial injury. There were no complications at an 18-month follow-up [103].

A Final Word

We believe nonoperative, conservative management must be discouraged. Complication rates are unacceptable given most patients with penile fractures are relatively healthy and tolerate the operation well [51]. Additionally, despite worldwide experience and an extensive review of the literature, the urological community continues to consider penile fractures as operative emergencies. Although true in the setting of combined urethral injury and penile fracture, the data clearly demonstrates that delaying immediate exploration until reasonably convenient, rather than the middle of the night, should not be viewed as careless or negligent.

Surgical Technique and Decision Making

Despite many differing opinions about the timing of surgical exploration, the need for urethral catheterization, the requirement for prophylactic antibiotics, the type of incision, and the fashion of suture material utilized, the principles of surgical repair remain consistent [16, 22, 35, 37]:

- Adequate exposure
- Evacuation of the hematoma
- Identification and repair of the fracture site
- Hemostasis and ligation of bleeding vessels
- Irrigation of wound and debridement of devitalized tissues
- Confirmation of urethral integrity and repair if necessary

Although surgical repair with local and spinal blocks has been reported, general anesthesia is most commonly employed [22, 35, 107]. Informed consent is always required and most patients with penile fractures are relatively healthy and tolerate the operation without difficulty [51]. Before exploration, patients should be warned that future erectile dysfunction is more likely related to injury severity rather than the surgery itself [37].

Prophylactic Antibiotics

Most published series predictably demonstrate the empiric use of antibiotics, although uncomplicated penile fractures likely do not require antimicrobials [50, 109, 110]. In complex penile fractures with urethral disruption, antibiotics are indicated due to urinary extravasation. Despite appropriate antimicrobial coverage in this setting, wound infection may still occur [42].

Intraoperative Urethral Catheterization

The need for intraoperative catheterization is debatable. After flexible cystoscopy confirms urethral integrity, most experts routinely place a Foley catheter [25, 67]. The catheter aids in orienting the penis and allows identification of the urethra, preventing inadvertent injury during cavernosal dissection [25, 67]. If present, associated urethral repair requires a catheter for scaffolding [67]. McAninch and Mydlo routinely catheterize their patients overnight, whereas Zargooshi advocates Foley catheterization only when the tunical fracture is close to the urethra [25, 50, 111]. The decision to catheterize must weigh the risks of infection and further trauma to the urethra with the benefits outlined above [109].

Urethral Disruption

There are many variable opinions regarding management of associated urethral injuries in the literature. Complete urethral transection requires an anastomotic urethroplasty with absorbable, interrupted suture (Fig. 44.4). A suprapubic tube may be necessary depending on the complexity of repair [16, 112]. Management options for partial urethral tears, including urethral catheterization, primary closure, or suprapubic cystotomy tube placement, demonstrate equal success rates in different series [5, 25, 50, 75, 76, 111]. Depending on the complexity of urethral injury, a catheter can be left in place for 7–14 days for partial lacerations or up to 6 weeks for complete transection [67, 72, 113].

Incision

The many access options for penile fracture repair prove that none is ideal for all situations [35]. Multiple approaches have been used, including a circumcising degloving, midline penoscrotal, inguinoscrotal, lateral longitudinal, and suprapubic incision [67]. The type and location are operator dependent, although we use and recommend a degloving approach as encouraged by McAninch and others [71, 93, 114]. Additionally, some advocate selective use of each incision based on clinical presentation and severity of injury [45, 115].

The degloving incision readily allows exposure to all three corpora, facilitating identification and repair of coexisting urethral and contralateral injuries [52, 93, 116]. This approach may be associated with increased neurovascular injury and complicated by abscess and skin necrosis [23, 68, 115, 117]. Midline

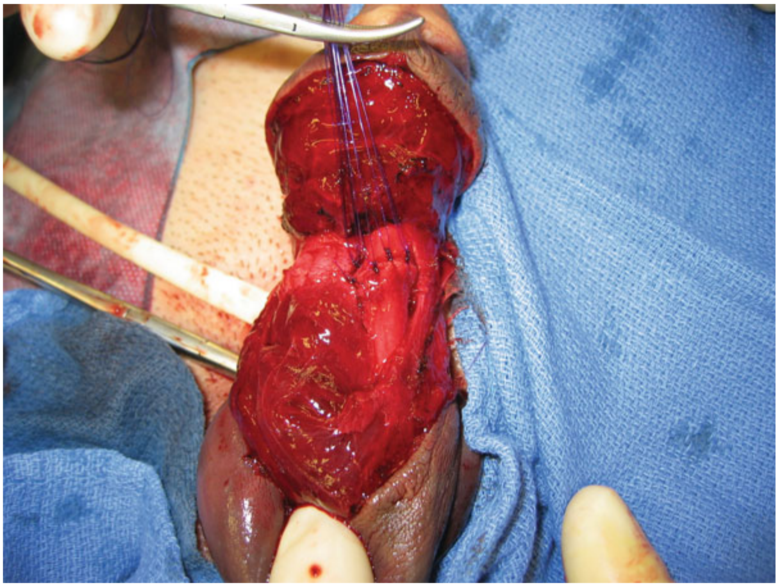

Fig. 44.4 Complete urethral transection repaired by anastomotic urethroplasty with absorbable, interrupted suture (4-0 Vicryl) (Image courtesy of SB Brandes)

penoscrotal access avoids the excessive dissection of a degloving approach with good cosmesis [118]. Inguinoscrotal incisions can facilitate proximal fracture repair in those instances when penile edema is marked enough to threaten skin viability, although this approach may result in difficulty in urethral repair, penile angulation, wound infection, and unsatisfactory cosmesis [119]. A simple, lateral longitudinal incision over the fracture site, often utilized in delayed surgical repair, may produce poor cosmesis, although less invasive [116, 120]. A suprapubic incision gives access to all three corpora and is useful if penile vascular surgery is required [121]. Regardless of the incision site, proper dissection must be carried down until the hematoma within Buck's fascia is exposed and evacuated [75].

Suture Material and Technique

The underlying laceration in the tunica albuginea usually runs transverse in direction and lies ventral in the corpora, with a right-sided incidence as high as 75 % [35, 45, 52]. If the corporeal disruption is not readily evident, Shaeer found saline- or methylene blue-guided repair as a reliable method for identifying tunical or urethral tears [122]. Closure of the tunical violation is best managed with running or interrupted absorbable sutures [123] (Fig. 44.5). Similar results have been reported with nonabsorbable suture with inverted knots [7, 71]. As reported by Punekar and Kinne, nonabsorbable sutures are preferred for closing tunical defects in recurrent fractures [124]. Disadvantages associated with nonabsorbable suture include palpable knots, stitch sinus, foreign body granulation at suture site, and discomfort for patient and partner during coitus [21, 125]. By appropriately inverting the suture ties, palpable knots may be averted as discussed by Prasanna and colleagues [7].

If possible, we advise closure in the same axis as the laceration. If a significant amount of tunica requires debridement and excision, the tear may be closed in a different orientation [51]. Most authors recommend longitudinal closure along the axis of the shaft with a transverse orientation if narrowing will result from a longitudinal closure [46, 51]. After surgical repair, intracorporeal saline injection and artificial erection, known as the Gittes test, can confirm tunical integrity [25, 67, 126]. Some authors prefer injecting saline mixed with indigo carmine to verify adequacy of repair [67].

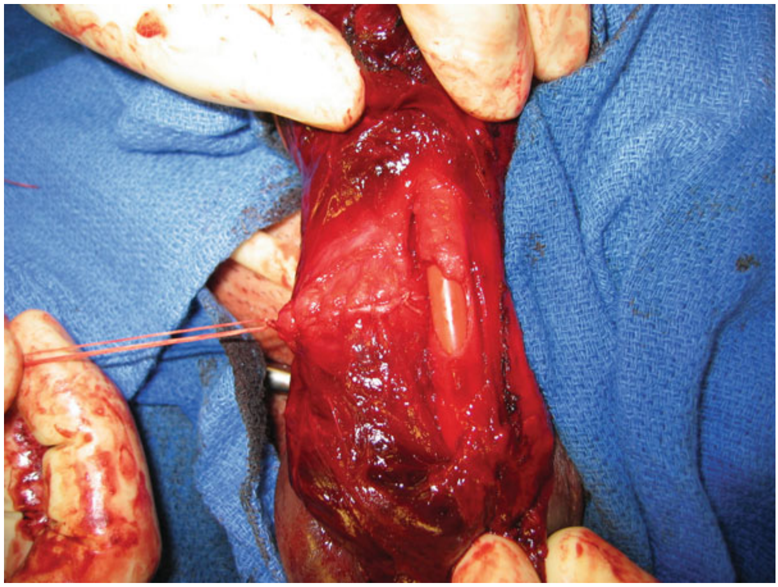

Fig. 44.5 Closure of the right tunical injury with running absorbable sutures (2-0 Vicryl). Note partially transected urethra with Foley in place bridging the defect (Image courtesy of SB Brandes)

Postoperative Management

In our experience, most patients are discharged within 24 h of repair. We usually continue perioperative antibiotics for two to three doses after exploration and remove the Foley catheter the next morning. Compressive sterile bandages are applied and oral, nonnarcotic analgesics are encouraged.

We view postoperative erectile suppressive medications as unnecessary. Although some authors discuss the theoretical concern for re-rupture due to early post-repair tumescence, painful stimuli are usually sufficient to prevent extremely rigid erections [15, 22, 50]. The arbitrarily advised 4–6-week period of sexual abstinence following blunt penile injury is not evidence based in the literature [30]. Muentener et al. noted that sexual intercourse can safely be resumed 2 weeks after surgery [49]. Additionally, a 13-year follow-up study of 32 patients, some of whom resumed sexual activity as early as 2 weeks postoperatively, reported no fracture recurrence [107].

Long-Term Outcomes and Complications

Although immediate surgical intervention has been shown to reduce morbidity, 6 to 25 % of patients still experience long-term sequelae [5, 25, 40, 46, 127, 128]. Reported long-term complaints following fracture repair include painful erection, painful intercourse, skin necrosis, sensory loss, penile nodules, penile deviation, erectile dysfunction, pseudodiverticula, arteriovenous fistula, urethrocavernous fistula, urethral stricture, and priapism [5, 35, 49].

Penile curvature remains the most common long-term complaint present in 5–14 % of patients. Corrective surgery is rarely required and the curvature is usually mild [8, 46, 75]. The incidence of erectile dysfunction is low (0–5 %) and, if present, can be attributed to traumatic corporeal veno-occlusive dysfunction, persistent venous leakage, arterial insufficiency, neurogenic factors, and psychosexual sequelae [8, 46, 75]. Overall, given the force of trauma required to produce such an injury, excellent outcomes with satisfied patients can be expected with immediate or delayed surgical repair.

Conclusion

Since the dawn of civilization, men have sustained traumatic, blunt trauma to the erect penis resulting in fracture of the tunica albuginea. The clinical features associated with true penile fractures are relatively consistent and the diagnosis is typically straightforward. Historically, penile fracture management included mostly conservative, nonoperative measures. In the 1980s, operative intervention became favorable after several studies demonstrated a decrease in long-term morbidity from 30 to 4 % [53, 99]. Today, urgent surgical repair is the standard of care given fewer complications, shorter hospital stays, improved outcomes, and better patient satisfaction [22, 40].

Preferred Surgical Instruments

- Scissor Jameson 7 curved Potts tenotomy
- Scissor 7 black handle Metz
- Gerald forceps
- Mosquito clamps

Suture

- 5-0 PDS (RB-1 and RB-2)
- 4-0 PDS (RB-1)
- 2-0 Vicryl

Surgical Pearls and Pitfalls

Key Intraoperative Surgical Points

- Ancillary imaging examinations are misleading, and the decision to surgically explore should be based on history and physical examination.
- A circumferential degloving incision readily allows excellent exposure to all three corpora, facilitating identification and repair of coexisting urethral and contralateral injuries.
- During surgical exploration, direct urethral inspection with urethroscopy or simple retrograde instillation of saline or indigo carmine is mandatory to rule out concomitant urethral or spongiosal injury.
- Foley catheterization aids in orienting the penis and allows identification of the urethra, preventing inadvertent injury during cavernosal dissection.
- Extensive tissue mobilization may be required given diffuse penile edema and hematoma formation.
- Proper dissection must be carried down until the hematoma within Buck's fascia is exposed and evacuated.
- Closure of the tunical violation is best managed with running or interrupted absorbable suture in the same axis as the laceration.
- After surgical repair, intracorporeal saline injection and artificial erection confirm tunical integrity.

Potential Intraoperative Surgical Problems

- *Penile Curvature after corporeal closure*: perform penile plication with braided polyester sutures
- *Corporeal closure resulting in penile narrowing*: reconstruction of the corporeal gap by free graft patch (saphenous vein, bovine pericardium, buccal mucosa)
- *Tunical fracture not identified on artificial erection*: patient with false penile fracture from soft tissue bleeding without tunical violation

Editorial Comment

Penile fracture is a diagnosis based on physical examination and symptoms. Typically, the penile shaft looks deformed and swollen, lopsided, or like an eggplant. At times the defect can be palpated in the corpora, as long as the swelling is not too extensive. Penile swelling does not correlate well to the degree of corporal tear. I have seen many patients with minimal swelling and ecchymoses but with long transverse corporal tears. I have never used any imaging like MRI or US to make the diagnosis. As to symptoms, the patients usually have sudden severe pain during intercourse, immediate swelling, and loss of erection and often hear a "pop" or cracking sound. When the physical exam and the symptoms are equivocal, I suspect a dorsal vein injury rather than a penile fracture. Despite most textbooks stating penile fracture is a surgical emergency, I have never really treated it this way. Patients who present in the middle of the night, I always explore the following day or afternoon in an elective and scheduled fashion. I do not think there is any harm in delaying repair by 12–24 h (if not longer).

As to surgical exploration and repair, I explore all patients through a subcoronal degloving incision. While I admit that this exposure is aggressive, it gives me full exposure of the corporal bodies, especially when the swelling is massive and it is difficult to tell where the injury is on the penis. In my experience, the corporal tears are always transverse and close to the midline and close to the urethra. I usually place a Penrose tourniquet at the base of the penis to keep the field as bloodless as possible. I think the tourniquet helps facilitate exposure and repair of the corpora and any associated urethral injury. If no corporal injury is noted on exploration, I will do a Gittes test and inject saline into the corpora to look for a leak. Oftentimes, injecting the saline unmasks a clot that was covering a small corporal tear. If no corporal injury can be found at all, despite the Gittes test, the diagnosis then is dorsal vein injury. When there is an associated urethral injury, there is often blood at the meatus or spotting in the underwear. For urethral injuries the corporal injury usually crosses the midline and involves both corpora. Here the urethra needs to be mobilized like an anastomotic urethroplasty of the corpora. The tunica is repaired first by a running 2-0 Vicryl suture. The urethra and spongiosum are then repaired in one or two layers with interrupted 4-0 Vicryl. Postoperatively, I typically get a pericatheter retrograde urethrogram at 7–14 days to look for any anastomotic leak, before removing the catheter.

—Steven B. Brandes

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45 Vascular Surgery for Erectile Dysfunction

Jacqueline D. Villalta and Tom F. Lue

Summary

The incidence of erectile dysfunction (ED) after blunt pelvic trauma is between 11 and 30 % and increases greatly with concomitant urethral injury and/or bilateral pubic rami. Most patients with ED after pelvic trauma respond to intracavernosal injection therapy, suggesting that there is a neurogenic component. Only a very select group of patients are candidates for a revascularization procedure. Potential candidates are young (usually less than 55 years old), have a focal occlusive disease of the penile or cavernosal artery on arteriography, no vascular risk factors, no evidence of neurologic erectile dysfunction, and a history of acute or chronic perineal or pelvic trauma. Specifics as to the penile revascularization surgical technique of inferior epigastric artery to dorsal artery of the penis anastomosis and as an alternative to the dorsal vein are detailed within. Overall reported success rates are from 50 to 60 %.

Venous leak erectile dysfunction typically results from atrophy of the intracorporal muscles or of the tunica albuginea. These patients are not amenable to penile venous surgery as they have an uncorrectable physiology. A minority of patients have either congenital or acquired isolated proximal penile venous anomalies. Congenital venous leakage results in large ectopic, superficial dorsal veins or large crural veins. Blunt perineal trauma may result in structural changes in crural erectile tissue resulting in isolated crural venous leak. Although initial published series with 1-year follow-up demonstrated poor outcomes, highly select patients with isolated crural venous leak treated by crural ligation may have significant improvement in erectile function. The Report on the Treatment of Organic Erectile Dysfunction, however, does not recommend venous leak surgery and considers it experimental.

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Introduction

Atherosclerotic or traumatic arterial occlusive disease can decrease perfusion to the corpora cavernosa, resulting in increase in the time to maximal erection and decreasing rigidity of the erect penis. Arteriogenic erectile dysfunction is most commonly a part of systemic atherosclerosis, and its onset is similar to coronary arterial disease [1]. Risk factors for arteriogenic ED include smoking, hypertension, hyperlipidemia, diabetes, and perineal or pelvic trauma [2]. In patients with atherosclerosis and erectile dysfunction, arteriography demonstrates bilateral diffuse disease affecting the internal pudendal, common penile, and cavernous arteries.

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Levine et al. described focal occlusion of the common penile or cavernous artery, which was found in young men who had sustained blunt pelvic or perineal trauma [3]. The incidence of erectile dysfunction after blunt pelvic trauma is between 11 and 30 % and increases up to 62 % when there is a concomitant urethral injury [4–6]. Bilateral pubic rami fractures with urethral injury are highly associated with concomitant erectile dysfunction [6]. Up to 89 % of patients with erectile dysfunction after pelvic trauma respond to intracavernosal injection therapy, suggesting that there is a neurogenic component [6].

Venogenic erectile dysfunction is thought to result from failure of sufficient venous occlusion [7]. Degenerative changes or traumatic injury to the tunica albuginea may result in impaired compression of the subtunical and emissary veins [8, 9]. Acquired venous leak may result from perineal trauma, surgical treatment of priapism, or congenital anomalous penile venous drainage [10–12].

Penile Revascularization Surgery

Patient Selection and Indications

Penile revascularization is the only surgical procedure to date that is capable of restoring natural penile erections without the need for vasoactive medication, external mechanical devices, or surgical placement of a prosthetic device. Michal et al. first described penile arterial revascularization surgery for erectile dysfunction in 1973 with direct arterial anastomosis of the inferior epigastric artery to the corpus cavernosa (Michal I). This group reported excellent flow rates of greater than 100 ml/s, however with also about 100 % stenosis rates [13]. The technique was later modified and the inferior epigastric artery was anastomosed end to side with the dorsal penile artery (Michal II). The modification was reported to have a 56 % success rate [14].

Further modifications were employed by Virag et al. with anastomosing of the inferior epigastric artery to the deep dorsal vein to allow for retrograde penile perfusion [15]. Improvements in the arterialization of the dorsal vein were achieved by ligating the deep dorsal vein distal to anastomosis and its circumflex branches to avoid hyperemia of the glans [16]. Other variations in the surgical technique have included anastomosing the penile artery and vein and then subsequently anastomosing the inferior epigastric artery [17].

Lack of standardization in patient selection, hemodynamic evaluation, surgical technique, and limited long-term outcome data using validated instruments have resulted in this surgery being considered experimental. The Erectile Dysfunction Clinical Guideline Panel published in the Report on the Treatment of Organic Erectile Dysfunction in 1996, is an evidence-based guideline for the diagnosis and treatment of erectile dysfunction [18]. The original report was updated in 2005, and the current guidelines for penile revascularization are based on this report [19]. The panel recommendations were based on an Index Patient that represents the most common presentation of erectile dysfunction. The Arterial Occlusive Disease Index Patient was defined as an otherwise healthy man, 55 years old or younger with recently acquired erectile dysfunction due to focal arterial occlusive disease, who is the most likely patient to benefit from vascular reconstruction. These strict inclusion criteria eliminated other risk factors associated with diffuse vascular disease or chronic ischemia such as smoking, diabetes, and coronary arterial disease. This definition was used to evaluate the efficacy of the treatment of arterial occlusive disease. Of 31 papers initially identified in the world literature on vascular reconstruction, only 4 studies were included in the outcomes evaluation as the other 27 papers did not meet criteria for the Arterial Occlusive Disease Index Patient or for lack of objective outcome data. The four studies included a total of 50 patients of which 42 had inferior epigastric artery to dorsal penile artery and 8 had inferior epigastric artery to dorsal penile vein anastomosis with a range of 36–91 % satisfactory outcome [20–23]. Due to the small patient population who met criteria, the Panel's recommendation could not objectively confirm satisfactory outcome and stated that *Arterial* *reconstructive surgery is a treatment option only in healthy individuals with recently acquired erectile dysfunction secondary to a focal arterial occlusion and in the absence of any evidence of generalized vascular disease*. Based on the Panel's recommendations, only a very select group of patients are considered to be candidates for a revascularization procedure. A patient is a potential candidate for arterial revascularization if they are young (usually less than 55 years old), have a focal occlusive disease of the penile or cavernosal artery on arteriography, no vascular risk factors, no evidence of neurologic erectile dysfunction, and report of acute or chronic perineal or pelvic trauma [24].

The association of erectile dysfunction with pelvic fracture urethral injuries is well documented with multiple etiologies, including multiple sites of proximal venous leak in 62 % of patients as well as multiple sites of arterial occlusion, most commonly in the penile and cavernosal arteries. Isolated arterial occlusion was only noted in about 30 % of patients [25]. This select subset of patients with purely arterial occlusion resulting in erectile dysfunction may be good candidates for arterial revascularization.

Evaluation

Initial evaluation requires a thorough medical, sexual, and psychosocial history. The goal is to determine any underlying medical conditions that may predispose to arteriogenic erectile dysfunction such as cardiovascular disease, diabetes mellitus, smoking, or history of pelvic/perineal trauma. A history includes assessment of sexual interest, performance, and satisfaction, which can be done with a variety of patient self-administered questionnaires. The International Index of Erectile Function (IIEF) is the most commonly used questionnaire, which has been validated across various cultures and languages [26]. These questionnaires do not only provide information about sexual function and quality of life, but they also serve as baseline metrics by which the patient can be followed with longitudinally for assessment of outcome after treatment. A focused physical exam is performed aimed at evaluating for signs of hypogonadism, sensory abnormality, and Peyronie's plaque.

Diagnostic Evaluation

There are no specific guidelines for the diagnostic recommendation prior to proceeding with any penile revascularization procedure. However, noninvasive evaluation with penile color Doppler ultrasound in combination with pharmacologic stimulation with intracavernosal injection of a vasodilating agent is used for initial assessment. Peak systolic velocity (PSV) <25 cm/s is considered suggestive of arterial insufficiency erectile dysfunction and has been shown to correspond with 100 % sensitivity and 95 % specificity with abnormal internal pudendal arteriography (Fig. 45.1) [27]. Velocities between 25 and 30 cm/s are considered indeterminate although there are age-related changes to PSV that should be taken into account [28]. Changes in the diameter of the cavernous artery of less than 75 % and less than 0.7 mm after vasodilator injection are found in patients with severe vascular disease [29]. However, changes in cavernous arterial vasodilation have not been found to correlate with abnormalities in arteriography [30]. One must also be aware that variations in the penile arterial anatomy may result in alterations in the measurement of PSV and interpretation of the study is dependent on the expertise of the ultrasonographer [30]. Additionally one must rule exclude coexisting veno-occlusive dysfunction with a normal resistive index of less than 0.9 [31].

Some advocate routine dynamic infusion or pharmacologic cavernosometry and cavernosography or as an additional step if Doppler ultrasound findings are indeterminate in excluding veno-occlusive disease [32]. With complete smooth muscle relaxation after infusion of a vasodilator with possible redosing, findings should be consistent with normal veno-occlusive function. Specifically, infusion flow of <5 cc/min to maintain an intracavernosal erection pressure of >100 mmHg and pressure decrease of less than <45 mmHg over 30 s should be present [33]. Cavernosography identifies any abnormal drain-

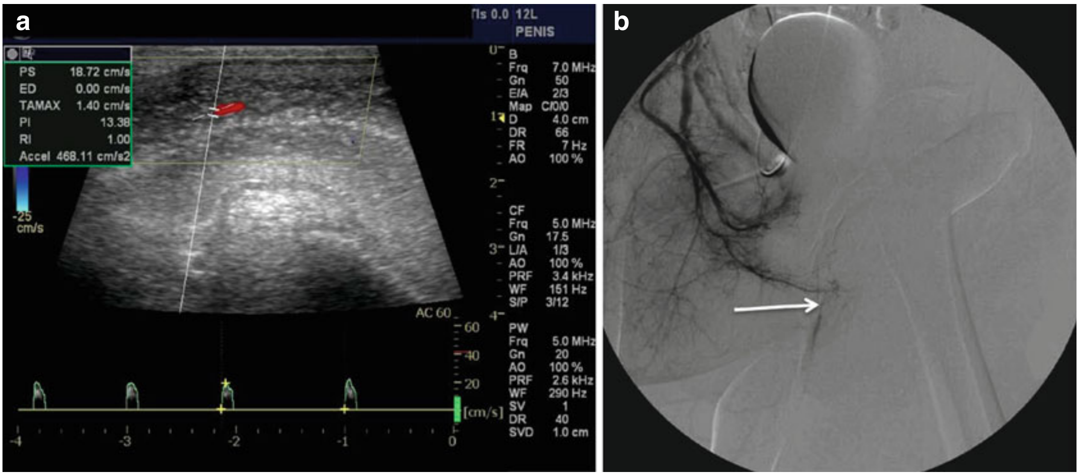

Fig. 45.1 Doppler ultrasound and pharmacologic pudendal angiogram of patient presenting with erectile dysfunction after a pelvic fracture. (**a**) Doppler ultrasound with low peak systolic flow velocity (<25 cm/s). (**b**) Right pelvic angiogram with occlusion of right internal pudendal artery (note arrow)

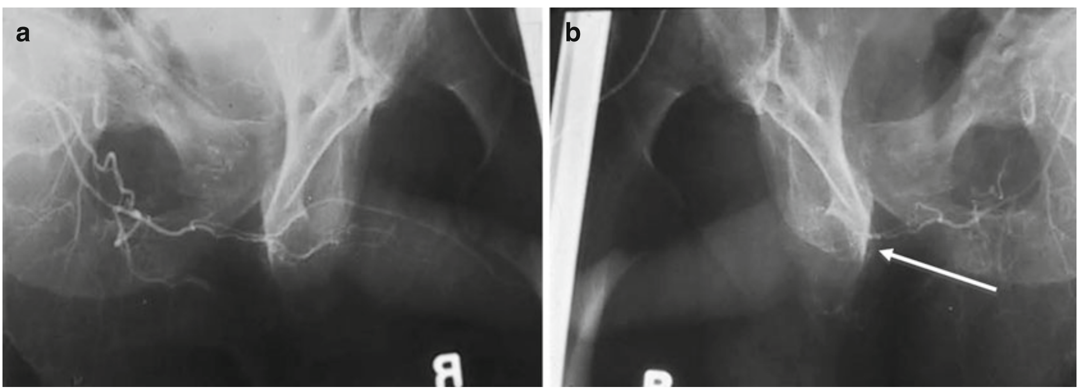

Fig. 45.2 Pharmacologic arteriography. (**a**) Pharmacologic (after intracavernosal injection of papaverine) right pudendal arteriogram shows normal dorsal and cavernous arteries. (**b**) Pudendal arteriogram showing occlusion of penile artery (note arrow)

age to the glans, corpus spongiosum, superficial dorsal veins, cavernous veins, and crural veins [7, 34, 35].

Lastly, selective internal pudendal artery angiography is used to evaluate the penile vascular system and document the location of the focal arterial occlusion. Simultaneous intracavernosal injection of a vasodilating agent is given to achieve maximal vasodilation. Additionally, the angiogram will provide information about patency and anatomy of the donor and recipient vessels for surgical planning (Fig. 45.2).

Surgical Technique

Preparation

After induction of general anesthesia, the patient is placed supine on the operating room table. Pressure points of the upper and lower extremity are padded. The patient's abdomen and genitalia are shaved. Once the patient is draped, a 16 French Foley catheter is placed with sterile technique. One weight-based dose of a first-generation cephalosporin (e.g., cefazolin) or vancomycin is given if the patient is penicillin allergic.

Harvesting of Inferior Epigastric Artery

The senior author of this chapter prefers to harvest the donor inferior epigastric artery through a laparoscopic approach for improved cosmesis and faster recovery time. An infraumbilical incision is made, and the subcutaneous tissue is dissected down to the level of the anterior rectus sheath off one side of midline. After an incision is made in the anterior rectus sheath and a window is created through the rectus muscle, a 10 mm balloon trocar is placed and preperitoneal insufflation is achieved. Two 5 mm trocars are placed on the contralateral side of the donor inferior epigastric artery, lateral to the artery. The inferior epigastric artery is identified at its origin from the external iliac artery, and the dissection is carried caudal to cephalic, to the point of bifurcation near the umbilicus. The artery and accompanying vein are dissected together to avoid injury to the artery. Once the inferior epigastric bundle is clipped and divided, a small longitudinal incision is made at the base of the penis. A 10 mm dilating trocar is placed through the Hesselbach's triangle through this incision, and the epigastric bundle is pulled through the trocar sheath under direct visualization to prevent torsion. Transperitoneal laparoscopic- or robotic-assisted technique can also be employed as a minimally invasive approach [36, 37].

Alternatively, a lower midline, transverse, or paramedian abdominal incision is made and carried down to the level of the rectus fascia. The fascia is divided longitudinally and the rectus muscle is mobilized medially or laterally. The inferior epigastric artery is identified in the preperitoneal space and dissected from its origin from the external iliac artery distally to the level of the umbilicus with its surrounding fat and veins. It should be of sufficient length to have a tension-free anastomosis. Bipolar cautery or small titanium clips are used to control and divide any arterial branches. Topical papaverine is applied to the artery during the dissection to prevent vasospasm.

Microvascular Anastomosis

Various penile or peri-penile incisions can be used for the vascular anastomosis including a curvilinear anterior scrotal peri-penile incision two fingerbreadths inferior to the base of the penis on the opposite side of where the inferior epigastric artery will be harvested [38]. If a lower midline incision is used to harvest the inferior epigastric artery, it can be extended to the proximal penile shaft. A longitudinal incision over the dorsal aspect of the penis or a transverse incision at the base of the penis can be used for laparoscopic- or robotic-assisted harvesting of the inferior epigastric artery.

After making the penile skin incision and carrying it down through dartos fascia, the tunica albuginea is bluntly dissected as proximally as possible and the paired dorsal arteries and dorsal vein are identified. If a laparoscopic- or robotic-assisted technique is used to harvest the donor artery, the trocar used to deliver the inferior epigastric artery is placed in Hesselbach's triangle. If the inferior epigastric artery was harvested in an open fashion, a window is made in the fundiform ligament and extended to the external inguinal ring. A Schnidt clamp is placed through this window to transfer the artery to the dorsal aspect of the penis.

An operating microscope is brought into the surgical field. The chosen dorsal artery is circumferentially dissected from its attachment to the tunica albuginea, taking care to avoid injury to any branches of the cavernosal artery. The adventitia of the dorsal artery and inferior epigastric artery are excised to prevent thrombosis of the anastomosis, and the distal end of the inferior epigastric artery is spatulated. Vascular clamps such as bulldogs or aneurysm clips are placed on the donor and recipient vessels for hemostasis during the anastomosis. A 9-0 Prolene suture is placed through a 1 mm segment of the anterior surface of the dorsal artery and excised after tension is placed on the suture to make an arteriotomy. An end-to-side anastomosis is performed with interrupted 9-0 Prolene sutures after a suture is placed at each apex (Fig. 45.3). The vascular clamps are removed and the donor and recipient artery are inspected for good pulsatile flow as well as good hemostasis. Doppler ultrasound can also be used to document arterial patency. The subcutaneous tissues are close in two layers with

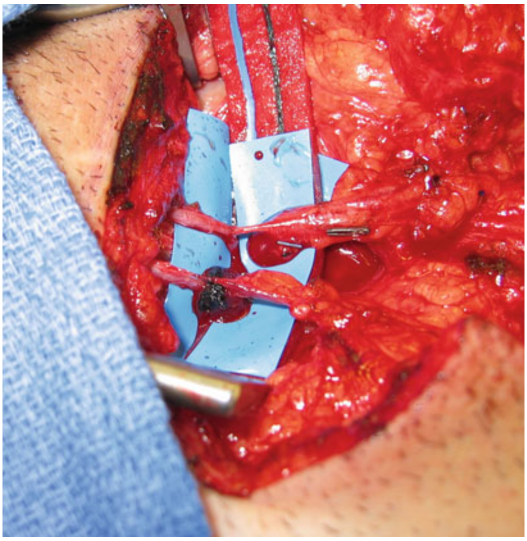

Fig. 45.3 Microvascular end-to-side arterial anastomosis between bilateral inferior epigastric arteries and dorsal arteries of the penis (Image courtesy of SB Brandes)

5-0 Vicryl and the skin in closed with 5-0 interrupted horizontal mattress sutures. Xeroform and Coban dressing are placed on the penis for hemostasis and the urethral catheter is left overnight.

Alternative anastomoses include end-to-end arterial revascularization where the proximal dorsal artery is ligated and divided. Dividing the proximal aspect of the artery is thought to decrease turbulence. Dorsal vein arterialization can be achieved with either side-to-end or end-to-end anastomosis. A valvulotome or Fogarty balloon is used to disrupt the valves. The branches of the deep dorsal vein near the glans are ligated with absorbable suture to prevent glans hyperemia.

Complications

The most common complications after penile revascularization surgery are penile edema and ecchymosis. A Coban dressing applied to the penile shaft can help control postoperative edema and ecchymosis. Rates of decreased penile sensation and penile shortening are reported as high as 25 and 28 %, respectively, in one series [32]. Preservation of the suspensory and fundiform ligaments during the penile dissection is thought to help preserve penile length; nevertheless scar formation may still result in penile shortening. Glans hyperemia may occur in dorsal vein arterialization if communicating veins to the glans have not been ligated. Disruption of the anastomosis may occur weeks after the operation due to blunt trauma from intercourse, masturbation, or accidents [33].

Outcomes

Many retrospective studies have reported outcome data for penile revascularization surgery for patients with any cause of arteriogenic erectile dysfunction. These studies are limited by variable inclusion and exclusion criteria, short length of follow-up, and lack of objective follow-up data. Young men who have sustained traumatic arterial lesions appear to have better outcomes compared to elderly patients. No comparative prospective, randomized studies have assessed the outcome of penile revascularization surgery for arteriogenic erectile dysfunction.

Historically, long-term success rates have ranged from 50 to 60 %. As the patient population in these series has been heterogeneous and has not met the current patient criteria of the Arterial Occlusive Disease Index Patient, outcomes are not applicable, nor generalizable.

In 2005, the Erectile Dysfunction Clinical Guideline Panel based their recommendations for revascularization surgery on four studies that had been published to date. Grasso et al. published their outcomes of 22 patients in who underwent inferior epigastric artery to dorsal vein arterialization procedures in 1992 [23]. They reported that 55 % of patients were able to have erections sufficient for intercourse at one-year follow-up. Another published series by De Palma and colleagues reported 60 % success rate of spontaneous erections or with the aid of intracavernosal vasodilating medication or a vacuum constriction device in 11 patients undergoing inferior epigastric to dorsal artery anastomosis [21]. The series with the longest follow-up is that of Jarow and DeFranzo [22]. Of 11 men who underwent penile revascularization, 9 had inferior epigastric artery to dorsal artery anastomosis and 2 had dorsal vein procedures. At an average of 50-month follow-up, 91 % of patients had improved erections from their preoperative baseline with 27 % requiring intracavernosal injections as an adjunct. Ang et al. described the outcomes of six patients with pure arteriogenic or mixed arteriogenic-vasculogenic erectile dysfunction who underwent dorsal vein arterialization [20]. At a follow-up of 20 months, they reported an overall 66 % success, where half of those patients required intracavernosal vasodilator medication.

Since the Erectile Dysfunction Clinical Guideline Panel published their recommendation report in 2005, Munarriz et al. has published the largest series of vascular reconstruction using validated outcomes in 2009 [24]. In this series, inferior epigastric artery to dorsal artery microarterial bypass surgery was performed. Their patient selection criteria include the following: (1) age 55 years or younger, (2) absence of vascular risk factors, (3) no evidence of neurologic ED, (4) no hormonal abnormalities, (5) no evidence of active psychiatric disorders, (6) no evidence of Peyronie's disease, (7) absence of premature ejaculation, (8) report of acute or chronic perineal/pelvic trauma, (9) no evidence of corporo-occlusive dysfunction by duplex Doppler ultrasound and cavernosometry, and (10) focal occlusive disease of the common penile or cavernosal arteries documented by selective internal pudendal arteriography. This study included 71 men, with an average age of 30.5 years old with a mean follow-up of 34.5 months.

The main outcome measured was preoperative total International Index of Erectile Function (IIEF) score, EF domain of the IIEF, and questions 3 and 4. The preoperative and postoperative outcomes were 35.5, 13.7, 2.2, and 2.1 compared to 56.2, 16.6, and 23.8, respectively. Fifty-five percent of patients had an IIEF-EF domain score of 26, and overall, 73 % of patients had an IIEF-EF score of equal to or greater than 21.

Penile Venous Surgery

Patient Selection Indications

Venous leak erectile dysfunction typically results from atrophy of the intracorporal muscles or of the tunica albuginea. These patients are not amenable to penile venous surgery as they have an uncorrectable physiology. A minority of patients have either congenital or acquired isolated proximal penile venous anomalies. Congenital venous leakage results in large ectopic, superficial dorsal veins or large crural veins [12]. Blunt perineal trauma may result in structural changes in crural erectile tissue resulting in isolated crural venous leak [39].

Typically, these patients report primary erectile dysfunction dating back to the first sexual encounter with the inability to penetrate or with an erection that subsides in seconds. Additionally, patient may report partial rigidity with nocturnal erections or masturbation [40]. In the case of venous leak from perineal trauma, patients typically report normal erectile function prior to the traumatic event with erectile dysfunction similar to the individuals with congenital venous leakage after the trauma.

Although some patients have erectile dysfunction from focal congenital venous anomalies or from perineal trauma, in most patients it is difficult to distinguish functional abnormalities of the corporal smooth muscle from anatomical defects such as tunical abnormalities [41]. It is also difficult to differentiate and diagnose what percentage of erectile dysfunction is due to veno-occlusive disease or general arterial hypoperfusion. Additionally, there is no standardized approach to diagnosis nor evidence from randomized clinical trials indicating the efficacy of surgical management for veno-occlusive disease. As a result, the Erectile Dysfunction Clinical Guideline Panel published in the Report on the Treatment of Organic Erectile Dysfunction in 1996 with a revision in 2005 concluded that *surgeries performed with the intent to limit the venous outflow of the penis are not recommended* [18, 19]. However, as indicated above, there are a few selected patients with failure of medical management with PDE5 inhibitors or intracavernosal injection with a vasoactive agent, normal cavernous arteries, and

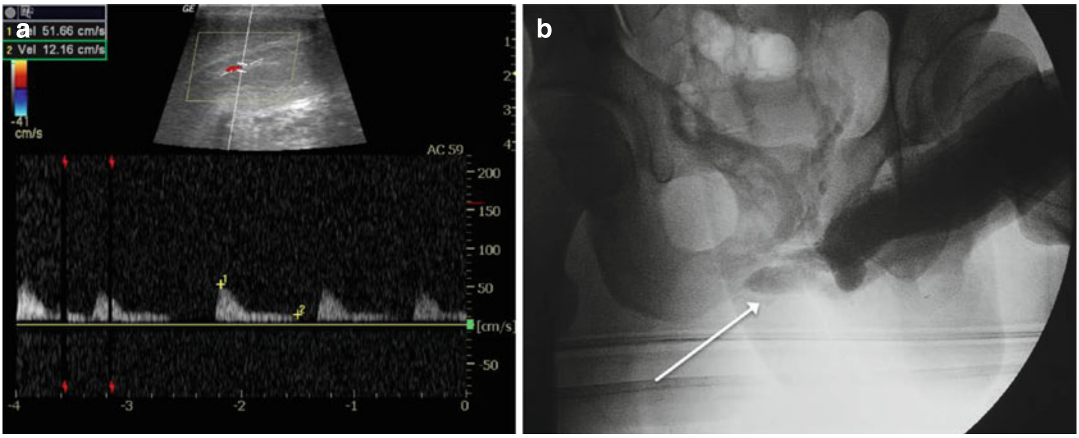

Fig. 45.4 Patient with lifelong history of erectile dysfunction. (**a**) Doppler penile ultrasound shows high peak systolic flow velocity (normal arterial flow) of the cavernosal arteries after injection of 0.5 ml of Trimix solution and self-stimulation. High end-diastolic flow velocity of >10 cm/s is indicative of venous leak. (**b**) Pharmacologic cavernosogram after injection of 0.5 ml of Trimix solution (shows crural leakage *arrow*)

with a clearly identifiable location of posterior venous leak that might benefit from penile venous surgery [42].

Evaluation

As stated in the previous section on penile arterial revascularization, the initial evaluation includes thorough medical, sexual, and psychosocial history. Sexual history includes one or self-administered questionnaires such as the IIEF [26]. If a trial of PDE5 inhibitors or intracavernosal injection with a vasoactive agent does not produce any results, the patient can then be further evaluated with color duplex ultrasound, cavernosometry, and cavernosography.

In a patient with a history suggestive of venous leak erectile dysfunction and who has failed medical management, one can proceed with color duplex ultrasound with intracavernosal injection of a vasodilating agent. Duplex ultrasound demonstrates peak flow velocity greater than 35 cm/s, ruling out arteriogenic cause of erectile dysfunction. In addition, there is persistent end-diastolic velocity of greater than 10 cm/s in the cavernous arteries (Fig. 45.4, panel a) [43].

If the color Doppler ultrasound is suggestive of a venous leak, we proceed with further penile hemodynamic evaluation with a pharmacologic cavernosometry and cavernosography with 0.5 ml of Trimix (papaverine 30 mg/ml, phentolamine 1 mg/ml, prostaglandin E1 10 mcg/ml) with redosing if necessary to achieve smooth muscle relaxation [42]. Infusion flow to maintain intracorporal pressure greater than 100 mmHg at greater 5 ml/s and a decrease in intracorporal pressure of greater than 45 mmHg over 30 s is suggestive of venous leak on cavernosometry [44]. Cavernosography with diluted iodinated contrast is done with intracavernosal pressure of less than 100 mmHg to visualize abnormal venous channels while images are taken with fluoroscopy to monitor the drainage of the corpora cavernosa [42]. Abnormal venous channels can be seen draining to the glans, corpus spongiosum, superficial dorsal veins, cavernous veins, and crural veins (Fig. 45.4, panel b) [7, 34, 35].

Surgical Technique

Preparation

After induction of general anesthesia, the patient is placed supine on the operating room table. Alternatively, if crural ligation is being performed, the patient is placed in the dorsal lithotomy position. Pressure points of the upper and lower

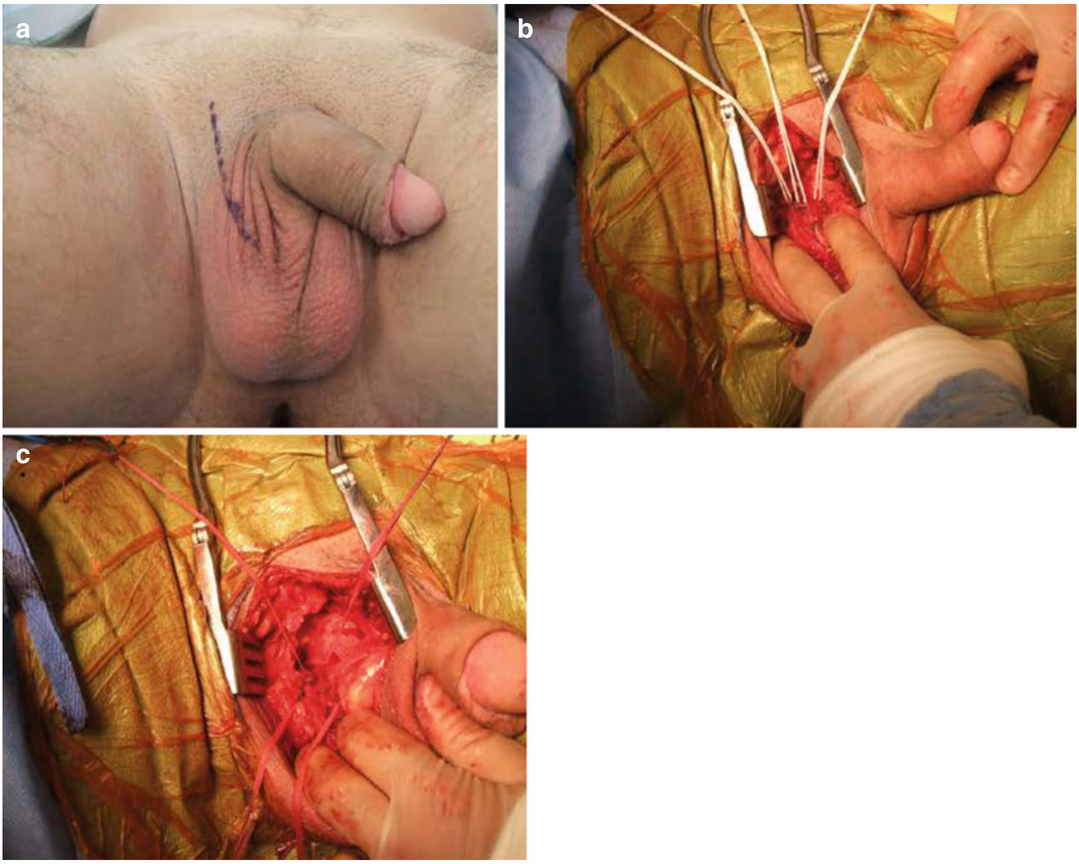

Fig. 45.5 Crural ligation surgery. (**a**) One-sided inguinoscrotal incision is used to perform bilateral crural ligation and ligation/excision of deep dorsal veins. (**b**) After the deep dorsal vein was resected, the hilum was entered to isolate the neurovascular structures. The three vessel loops go around the patient's right dorsal nerve and artery, the right and left cavernous arteries, and the left dorsal nerve and artery, respectively. (**c**) The polyester umbilical tapes were passed between the corpus spongiosum and the corpora cavernosa and were placed under the neurovascular bundles mentioned in (**b**) before they were tied

extremity are padded. The patient's genitalia are shaved. Once the patient is draped, a 16 French Foley catheter is placed with sterile technique. One weight-based dose of a first-generation cephalosporin (e.g., cefazolin) or vancomycin is given if the patient is penicillin allergic.

Crural Ligation

A 6 cm inguinoscrotal incision 2 cm lateral to the root of the penis is made and carried down to the base of the penis without entering the tunica vaginalis (Fig. 45.5, panel a). Sharp and blunt dissection is used to free the dorsum of the penis from the subcutaneous tissue. The fundiform and suspensory ligaments of the penis are incised which detaches the base of the penis from the pubic bone. After incising Buck's fascia and identifying the deep dorsal vein, branches are ligated, followed by dissection of the dorsal vein from the tunica. The deep dorsal vein is suture ligated proximally with a 2-0 nonabsorbable suture such as silk or TiCron (braided polyester). A 4 cm segment of the deep dorsal vein is excised from just under the pubic bone to the midshaft of the penis.

The dorsal artery and nerve are carefully reflected off of the tunica albuginea bilaterally. The cavernous artery and nerves are also dissected to identify the entrance of the artery into the corpus cavernosum (Fig. 45.5, panel b).

A 16 Fr Foley catheter is passed into the bladder to help locate the bulbar urethra (if not already placed at the beginning of the operation). The crus is then dissected off the bulbar portion of the corpus spongiosum. A right-angle clamp is passed between the crus and bulbar spongiosum. The tip of the clamp is passed dorsally proximal to the entrance of the cavernous artery into the corpus cavernosum. Four umbilical tapes are passed between the spongiosum and crus (Fig. 45.5, panel c). The other ends of the two tapes are passed under the dorsal and cavernous arteries and the nerves on the dorsolateral aspect of the crus and then tied. The same procedure is performed on the opposite crus. The tunica albuginea is reattached to the periosteum of the pubis with a zero silk suture. Careful skin closure is performed in layers to prevent postoperative penile shortening. A compression dressing is applied to the penis and scrotum after surgery. The Foley catheter is removed the following day.

Flores et al. [45] describe a variation to crural ligation, which does not include ligation of the deep dorsal vein or dissection of the dorsal arteries and veins. A transverse scrotal incision is made and subcutaneous tissues are dissected until the crura are exposed. The crura are carefully separated from the corpus spongiosum, and the plane between the two structures is developed. A right-angle clamp was used to pass two umbilical tapes around the crus from medial to lateral. The umbilical tapes are tied around each crus starting 1 cm from the posterior crural end and separated by 1 cm from each other. The same procedure is performed on the opposite crura. A drain is not placed and the patient goes home the same day.

Complications

Common immediate complications include penile and scrotal ecchymosis, hematoma, penile edema, pain from nocturnal erections, and rarely infection. Long-term complications are penile shortening and decreased penile sensation. Penile shortening can occur in as many as 20–30 % of patients; however, it is rarely clinically significant [45, 46]. The use of a vacuum erection device starting 1 month postoperatively for 3 months can help with penile shortening [40]. Numbness of the glans or penile shaft is common and occasionally can affect the ability to achieve orgasm [51]. Typically, loss of penile sensation is temporary and completely returns in 7–9 months [51]. Penile numbness can be minimized by not degloving the penis [40]. Rarely, a patient can experience scar contraction that leads to penile tethering and curvature that requires subsequent release of scar tissue and scar revision [47]. Austoni et al. have reported rare occurrences of priapism after venous leak surgery [48].

Outcomes

Similar to outcomes data for penile arterial revascularization, retrospective studies include a heterogeneous population with variable inclusion and exclusion criteria and lack of objective measures and short follow-up. Immediately postoperatively, multiple series in the 1980s–1990s reported initial success rates up to 85 %; however, with longer than 12-month follow-up, success rates decrease to as low as 25 % [47, 49, 50].

More contemporary series with highly selective groups of younger patients and with greater than a year follow-up report between 45 and 66 % success of achieving excellent unassisted erections with crural ligation surgery. Rahman et al. reported outcomes data on a select cohort of men with congenital crural venous leak erectile dysfunction who underwent crural ligation with ligation of the dorsal vein as described above [42]. This study included 11 men younger than 40 years with a history of lifelong erectile dysfunction and venous leakage from abnormal crural veins on cavernosography. Men with psychogenic or mixed vasculogenic erectile dysfunction were excluded as well as Doppler ultrasound demonstrating peak flow velocity less than 25 cm/s or negative end-diastolic pressure and diffuse venous leakage on cavernosography. With a mean age of 28 years, overall 82 % of patient had improvement in their erectile function. Of those men, 45 % reported improved unassisted erectile function with 36 %

requiring intermittent PDE5 inhibitor treatment at a mean follow-up of 34 months. Mean IIEF scores increased from 8.9 to 17.5 postoperatively and 64 % had IIEF score greater than 19.

In a similar selected cohort of men with isolated crural venous leak on dynamic infusion cavernosometry and cavernosography, in 2011, Flores et al. reported 66 % success rate of achieving unassisted erections at a mean follow-up of 16 months in 15 patients with crural ligation alone using a scrotal incision [44]. Overall, 93 % of patients had improved erections with or without PDE5 inhibitor treatment. There was an increase in IIEF score from 18 to 24 postoperatively.

Although initial series publishing longer than 12-month outcomes have demonstrated poor outcomes, highly selected patients with isolated crural venous leak can have significant improvement in erectile function. Even though the Report on the Treatment of Organic Erectile Dysfunction does not recommend venous leak surgery and considers it experimental, improvement in erectile function, even with the assistance of PDE5 inhibitors, greatly improves the quality of life, especially when erectile dysfunction was refractory to medical management prior to crural ligation surgery.

Surgical Pearls and Pitfalls

Arterial Surgery

- Either laparoscopic or open approach can be used to harvest the donor artery, the inferior epigastric artery.
- The epigastric vascular bundle is passed via the external ring to the base of the penis.
- The recipient vessel, the dorsal artery, or the deep dorsal vein is isolated.
- The adventitia of the donor and recipient vessels is carefully stripped off the vessel to prevent thrombosis of the anastomosis.
- End-to-side or end-to-end anastomosis is made with fine sutures under operative microscope.

Potential Problems

- Inadequate length of the donor artery: The anatomy and branching pattern of the epigastric artery on the angiogram must be studied before surgery and appropriate length determined.
- Glans hyperemia: The deep dorsal vein and its branches distal to the epigastric artery-dorsal vein anastomosis need to be carefully ligated to prevent the problem.
- Inadequate size of dorsal artery: Change to epigastric artery-dorsal vein anastomosis.
- Early thrombosis of anastomosis: Mini-heparin at the conclusion of anastomosis and baby aspirin for 3 months.
- Penile shortening: Avoid dissection of the fundiform ligament.

Venous Surgery (Crural Ligation)

Dorsal Approach

- An inguinoscrotal incision is made to approach the crura from above.
- The fundiform and suspensory ligaments are cut to allow detachment of the penile base from the pubic bone.
- Buck’s fascia is opened to isolate and resect the proximal portion of the deep dorsal vein.
- The dorsal artery and dorsal nerve are dissected off the tunica.
- The cavernous arteries are traced to the entrance to the corpora cavernosa.
- The urethral bulb is separated from the crura to allow passage of umbilical tapes.
- The crural ligation should be performed proximal to the entrance of the cavernous arteries with at least two separate polyester (not cotton) umbilical tapes.

Ventral Approach

- A vertical perineal incision is made to identify the urethral bulb and both crura.
- The ischiocavernosus muscle overlying the crura is dissected to expose the tunica of the crura.
- At least two umbilical tapes are passed between the crura and the pubic bone and separated tied to secure closure of the crura.

Potential Problems

- Ligation of the cavernous artery: Intraoperative Doppler ultrasound must be used to positively identify the entrance of the cavernous artery to the corpora to avoid ligation of the cavernous artery.

- Injury to the urethra: A Foley catheter must be inserted before passing of the umbilical tape to avoid injury.
- Foreign body reaction/infection of the umbilical tapes: Use polyester, not cotton umbilical tapes.
- Penile shortening: The dorsal tunica should be sutured to the periosteum of the pubic bone to substitute the severed suspensory ligament, and the layers of tissue in the infrapubic region should be carefully closed to avoid excessive scar and penile shortening.

Editorial Comment

Most of my experience with vascular surgery for erectile dysfunction is with penile revascularization for pelvic fracture patients with erectile dysfunction. Venous leak surgery never really worked in my hands, because with time, alternative drainage channels developed and the venous leak impotence uniformly recurred. At one time early in my career, I was performing many dorsal vein ligations as well as sending patients to interventional radiology for transvenous embolizations of the dorsal vein and branches. Success rates were very poor at 1-year follow-up (<20 %) and thus we stopped performing such surgeries. Lue seems to have had reasonable success with crural ligation for highly select congenital venous leak patients that are refractory to oral and intracavernosal injection therapies. However, the reported study populations are very small and complications rates are not trivial. Clearly a well-performed cavernosography is the key to getting a proper road map, so to properly select the best surgical candidate.

As to penile revascularization, it is key to limit such surgeries to young patients who are impotent after pelvic fracture and have no associated comorbidities, in particular, hypertension smoking, diabetes, etc. The other key is to do a properly performed arteriogram and to speak with your interventional radiologist. Key aspects are to first obtain a penile Doppler with cavernosal injection (Trimix) that demonstrates arteriogenic impotence. Once this is demonstrated, the key technical aspects of the arteriogram are to inject the cavernosa with vasoactive substances 10–15 min before the onset of the study. We prefer 0.2 ml of Trimix. It is important that each pudendal artery is cannulated and intravascular nitroglycerin injected to help dilate the vessels. We would like to see distal reconstitution of the dorsal artery of the penis to confirm its patency, as the potential recipient of an end-to-side inferior epigastric artery anastomosis. I ask the radiologist to also squirt the epigastric arteries at the same time, in order to demonstrate presence and patency on each side. I have always harvested the epigastric arteries via a midline abdominal incision, but after reading this chapter, I will change my practice to a laparoscopic extraperitoneal dissection method. Unless you have extensive microvascular surgical skills and experience, I would suggest you have your plastic surgical colleague who has good microsurgical skills to assist you with the surgery. I would not tackle such surgery alone. My overall success rates with such surgery improving erectile function have been similar to published series, at roughly 50 %. Of those who responded, about half needed to use oral PDE5 meds and the other half use intracavernosal injection therapy. My best success comes with patients who complained of cold glans penis syndrome. Typically, such patients state that after revascularization the cold feeling is gone and the glans and penis feel warm immediately postoperatively – stating this in the recovery room. I send patients home on just aspirin. Early in my career I would send patients home fully anticoagulated on Coumadin, but I had one patient who got into a fight 1 month after surgery and was struck in the suprapubic region with a cue stick. He bled profusely and required ligation of the epigastrics. Aspirin is sufficient to help prevent epigastric artery thrombosis.

Lastly, it has been suggested that caution is warranted in patients who fail posterior urethroplasty for urethral injury from pelvic fracture, concomitant hypospadias, or penile stricture. As anastomotic urethroplasty is urethral advancement surgery, based on bipedal blood supply through the penis, it makes intuitive sense that ED, hypospadias, and synchronous penile stricture patients have compromised urethral retrograde blood supply. Thus, for posterior urethroplasty patients, I would suggest that you evaluate the penile vascular flow in these patients who suffer from ED and penile numbness or prior failed posterior urethroplasty. Those with arteriogenic impotence and distal reconstitution of the vessels would be reasonable candidates for revascularization before the urethroplasty, in order to prevent proximal urethral ischemia.

—Steven B. Brandes

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Penile and Inguinal Reconstruction and Tissue Preservation for Penile Cancer

46

Steven B. Brandes and Jairam R. Eswara

Summary

Penile cancer is a rare disease in North America, but it has considerable psychosocial and health consequences. Patients often present after a significant delay and, consequently, with advanced disease that typically requires ablative and amputative surgery. To minimize the disfiguring effects of such radical surgery, penile-sparing therapies have been employed for ≤T2 stage disease. Herein, we detail a number of tissue-preserving treatments that are available for penile cancer. For CIS and T1 disease, topical 5-FU and imiquimod, Mohs surgery, laser ablation, radiation (external beam or interstitial), or simple surgical excision is an effective option. For T2 disease, radiation, partial or total glansectomy, or partial penectomy is a means to reduce disfigurement. While these treatments have a higher rate of local tumor recurrence than partial or total penectomy, they are not associated with worse survival. Reconstruction after a subtotal penectomy can be performed by penile advancement and skin grafting or replacement surgery with a sensate free flap. Sartorius muscle, rotational, and thigh flaps anatomy and mobilization techniques are also detailed. Penile-sparing therapies offer good cosmetic results and reasonable phallic length (to allow for urination while standing and the potential for sexual activity) without compromising oncologic control.

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Introduction

While partial or total penectomy typically achieves excellent local cancer control, they can result in considerable aesthetic, physical, urinary voiding and psychosexual postoperative morbidity and disability [1]. Such amputative surgeries are typically relegated to stage T4, high grade T3, or proximal stage T2 disease (see Table 46.1 for TNM staging). There are numerous reconstructive procedures described for preserving or regaining the ability to void standing and the ability to perform vaginal penetration intercourse after definitive invasive penile cancer therapy. Herein, we focus on reconstruction after extensive glans resection for Tis to T1 tumors, partial penectomy (including glansectomy), and total penectomy. Often the simplest and easiest method to reconstruct the penis after surgical resection is to use tissue-preserving techniques that maximize penile tissue and functional preservation without compromising oncological control.

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Table 46.1 TNM clinical classification of penile carcinoma (2009)

Tx	Primary tumor cannot be assessed
T0	No evidence of primary tumor
Tis	Carcinoma in situ
Ta	Noninvasive verrucous carcinoma with no direct invasion
T1	Tumor invades the subepithelial connective tissue T1a Tumor invades the subepithelial connective tissue without lymphovascular invasion and is not poorly differentiated or undifferentiated T1b Tumor invades the subepithelial connective tissue with lymphovascular invasion or is poorly differentiated or undifferentiated
T2	Tumor invades corpus spongiosum or corpora cavernosa
T3	Tumor invades urethra
T4	Tumor invades other adjacent structures
Nx	Regional lymph nodes cannot be assessed
N0	No palpable or visibly enlarged inguinal lymph node
N1	Palpable mobile unilateral inguinal lymph node
N2	Palpable mobile multiple or bilateral inguinal lymph nodes
N3	Fixed inguinal nodal mass or pelvic lymphadenopathy, unilateral or bilateral
M0	No distant metastasis
M1	Distant metastasis

Ta/Tis/T1 Tumors

Topical Therapies

Carcinoma in situ of the penis may be treated with topical therapies such as imiquimod and 5-FU. There have been several case reports documenting successful treatment of CIS with imiquimod with no recurrence (follow-up 4–18 months) [2–4]. Similarly favorable results were found with topical 5-FU. Several smaller series have shown no recurrence (median follow-up 24–40 months) [5, 6]. The largest series examining the efficacy of topical therapy was carried out by the Penile Cancer Centre at St. George's Hospital in London [7]. Of 42 patients with CIS that received topical therapy with 5-FU, 69 % had a complete or partial response. Imiquimod was used in 9 patients, 4 of whom (44 %) had a complete response. Notably, 12 % of patients had an adverse event with 5-FU, while 11 % had an adverse event with imiquimod.

Laser Ablation

Laser ablation of penile lesions is an alternative to glans resurfacing and is most commonly carried out with either a Nd:YAG laser or a CO_2 laser. Laser ablation is most commonly used for CIS. There are reports, however, of treating select T1 and T2 lesions successfully with laser, with good oncological and cosmetic results [8–10]. For such tumors, it has been our practice to use laser ablation only for CIS disease and prefer to use Mohs or glansectomy surgery for T1/T2 tumors. The main disadvantage of laser therapy is the lack of a surgical pathological margin and thus theoretically a higher potential for residual disease and subsequent local recurrence. Small noninvasive recurrences may be retreated by laser; however, invasive recurrences will require surgical excision or partial penectomy.

Mohs Microsurgery

Mohs micrographic surgery (MMS) is based on sequential tissue excision under repeat microscopic control. The major advantages of MMS are as follows: identification of tumor outgrowths, removal of the tumor with no positive margins, and maximal preservation of tissue for an improved functional and cosmetic result.

Mohs developed the technique in the 1930s as a microscopically controlled chemosurgery, where zinc chloride fixed, preserved tissue was excised [11]. Contemporary MMS utilizes a fresh unfixed tissue technique, as first detailed by Tromovitch and Stegman in 1974 [12]. The first case series of MMS for penile cancer was reported in 1985 by Mohs et al. in 29 patients, using a fixed tissue technique [13]. However, the first case series of MMS using the fresh tissue technique for penile cancer was not reported till 1987 [14].

Technique

The technical details of MMS processing have been extensively reviewed elsewhere, and we refer the reader to the manuscripts we have referenced [12, 15, 16]. Briefly, MMS entails immediate horizontal frozen sectioning of the entire margin of excised tissue with mapping and microscopic identification of remaining tumor. The excised layers of tissue are spatially oriented and microscopically reviewed by the same surgeon. This is followed by repeat excisions based on tumor mapping and examination until a tumor-free plane is noted throughout. The surgeon performing the resection of the tumor is typically the same person who performs the sectioning and microscopic examination for residual tumor. MMS is thus a time-consuming procedure, often taking hours. For this reason, MMS is performed in an outpatient setting under penile block and conscious sedation.

Inclusion criteria for performing penile MMS are typically (1) carcinoma in situ or verrucous carcinoma, (2) squamous cell carcinoma (SCCA) of the distal penis or glans penis that is otherwise amenable to partial penectomy, and (3) patient desire to maintain tissue preservation and function. Exclusion criteria to MMS are SCCA not amenable to partial penectomy, tumor size, or a proximal shaft location not allowing a functional residual phallus for voiding (typically <4 cm stretched length) or advanced stage (III–IV).

We have had extensive clinical experience with MMS and recently reported our results with 33 patients who underwent a total of 41 Mohs procedures with a mean of 58-month follow-up [17]. Disease recurred in 32 % of patients, but this did not result in an increase in mortality (disease-specific mortality 3 %). Local recurrences were managed by repeat MMS in seven patients and by penectomy in one. Size of resected tumors was fairly large, averaging 509 mm^2. To resect such tumors, an average of 2.6 resection stages were needed. See Figs. 46.1, 46.2, 46.3, and 46.4 for illustrations of typical penile cancer MMS procedures and reconstructions.

Of our 41 procedures, 5 were terminated for positive margins, including 3 due to urethral involvement and 2 due to extensive defect size. Of the remaining tumors, 26 were stage Tis, 4 were T1, 7 were T2, and 4 were T3. A total of 13 defects were reconstructed by primary repair or granulation, 4 were reconstructed by skin grafts, and 9 were reconstructed by local tissue flaps and urethroplasty. There were two cases of tumor progression; however, cancer-specific mortality was unaffected.

In conclusion, MMS for low stage penile cancer can result in a relatively high local recurrence rate; however, with repeat procedures and vigilant follow-up, survival rates are excellent and progression rates low.

Glans Penis Reconstruction by Resurfacing

Extensive carcinoma in situ or noninvasive verrucous carcinoma of the glans penis can be effectively reconstructed with total glans resurfacing [18, 19]. First described for lichen sclerosus of the glans, the technique involves sharp dissection of the glans epithelium and subepithelium ("glans skinning") in quadrants from the meatus to the coronal sulcus or 1 cm proximal of the coronal sulcus (Fig. 46.5). Once frozen sections of the margins are negative, the denuded glans is covered by an unmeshed split-thickness skin graft (harvested from the thigh or flank) and sutured in place using a standard quilting technique. Using an unmeshed split-thickness skin graft yields superior cosmetic results compared to a meshed graft. Graft take, cosmetic appearance and functional outcomes, and local cancer control have been excellent. Reconstruction using the mucosal layer of the prepuce has also been described [20].

T2/T3 Tumors

Reconstruction by Limiting Amputation Margins

The gold standard for invasive lesions has been a partial penectomy with 20 mm margins. The dogma of 20 mm margins has recently come into question, however. The optimal surgical

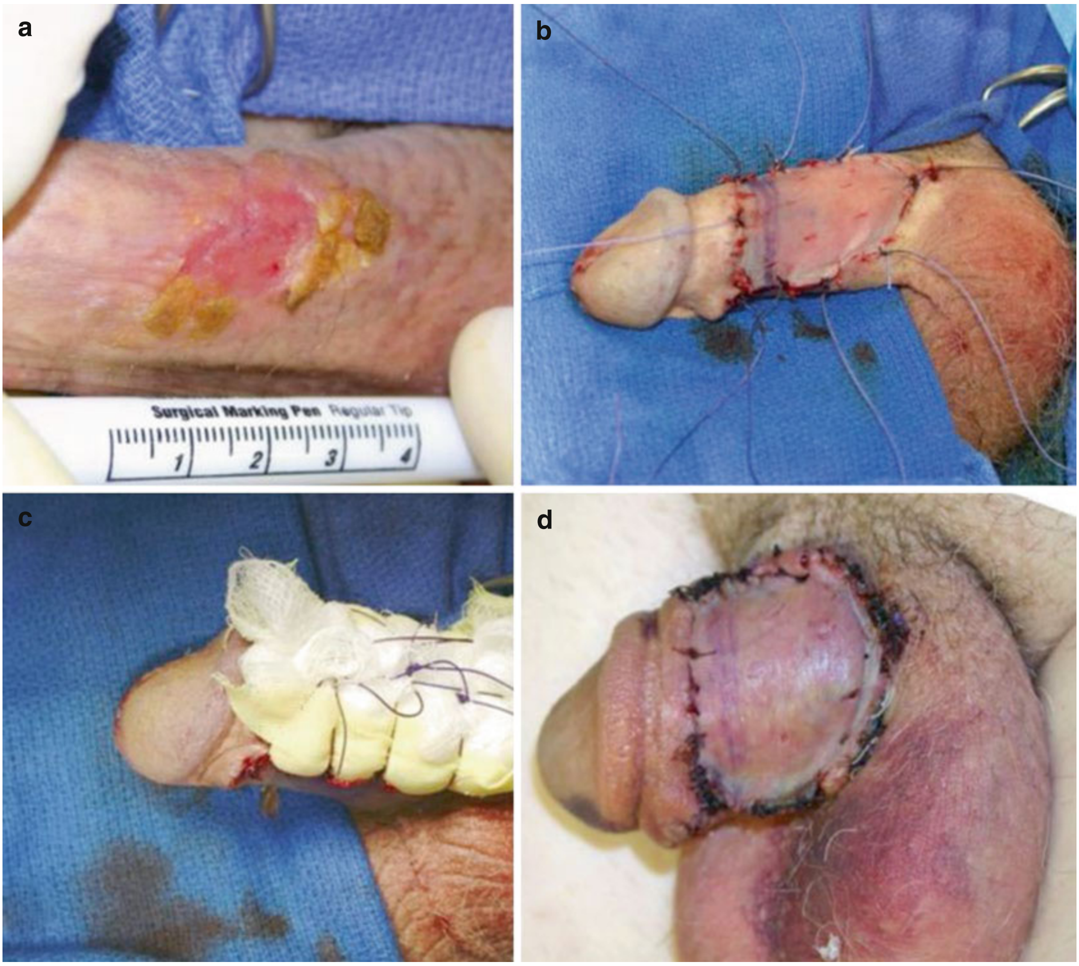

Fig. 46.1 Mohs microsurgical excision for penile shaft SCCA (**a**) initial penile shaft tumor. (**b**) After lesion excision, defect repaired by split-thickness skin graft. (**c**) Bolster dressing (**d**) grafted penis at 5 days post op

margin length has been challenged as overly aggressive and difuguring. Current practice seeks to achieve a negative surgical margin (<20 mm) while still maximizing penile tissue and function. Hoffman et al. had no local recurrences in 14 patients who underwent partial or total penectomy, with seven having resection margins ≤10 mm [21]. The mean follow-up was 33 and 40 months, respectively. In 61 partial and total penectomy specimens, Agrawal et al. noted 7 of 52 patients with grade 1 and 2 tumors had negative margins <5 mm away from the macroscopic lesion, while 3 of 12 patients with grade 3 tumors had negative margins <10 mm away from the gross lesion [22]. In 51 patients (102 surgical margins) treated with a multiple techniques, Minhas et al. found a local recurrence rate of 4 % after a median follow-up of 26 months [23]. Therefore, resection margins of 20 mm are *not* required and appear that even a few millimeters may be sufficient to offer adequate oncological control [21–23]. Since the majority of penile cancers are distal (located on the prepuce, glans, or coronal sulcus), they are potentially amenable to a more limited resection. Moreover, maximizing penile length can have a profound impact on subsequent reconstruction and make the difference between the ability to void standing or sitting and to have penetrative intercourse.

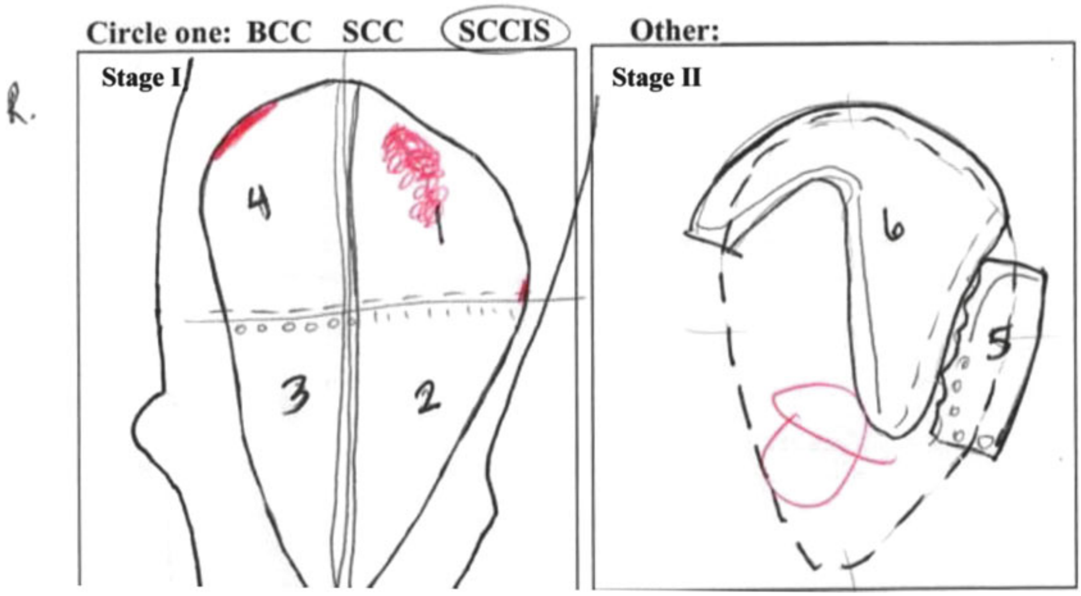

Fig. 46.2 Stage map for the MMS resection of Fig. 46.1. Note six sections and two stages in order to get to a tumor-free state. Note the *red hash marks*, which indicate areas of positive margins in stage I, requiring additional excision

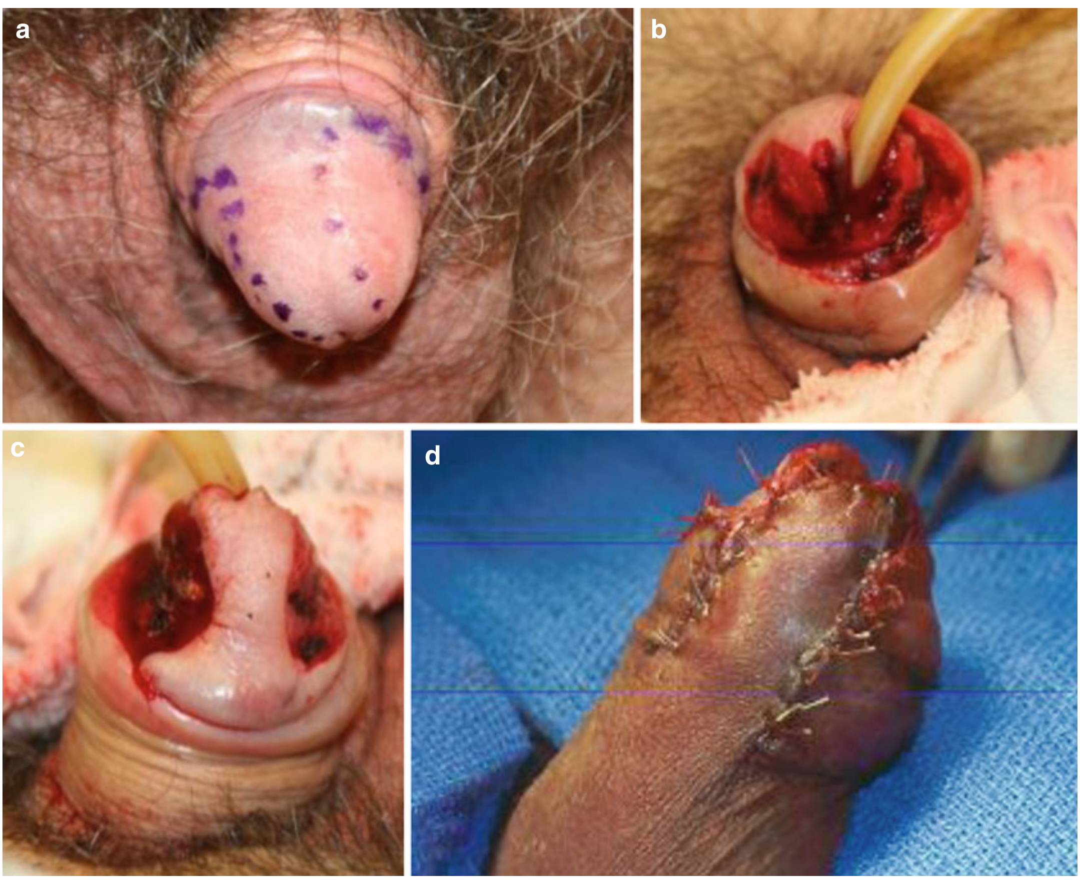

Fig. 46.3 Mohs microsurgical excision for glans penile SCCA (**a**–**c**). Subsequent reconstruction with a local penile skin advancement flap (**d**)

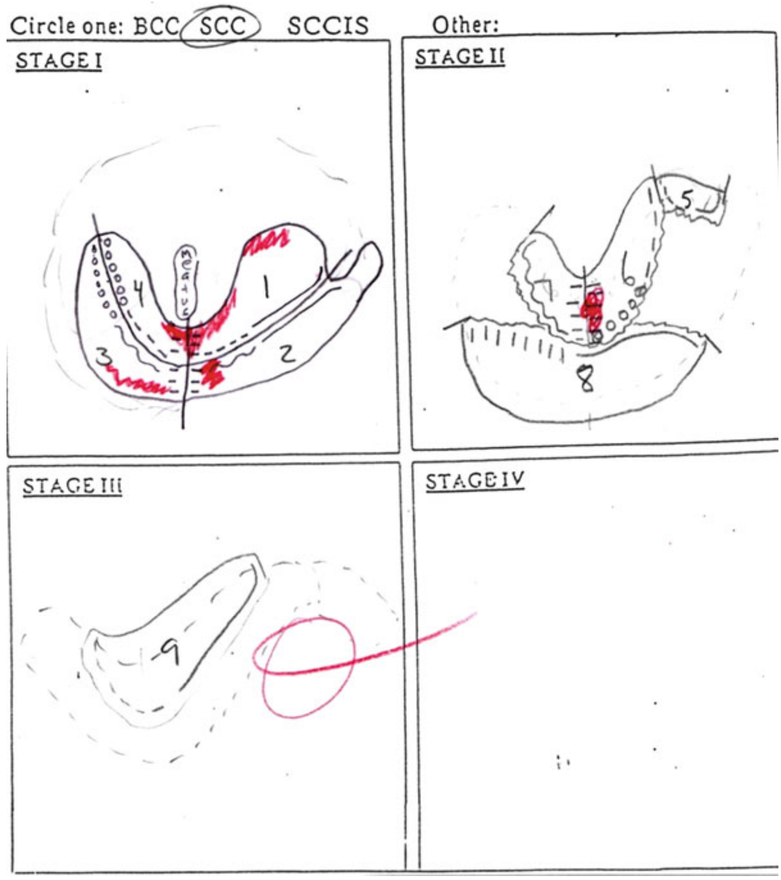

Fig. 46.4 Stage map for the MMS resection of the patient in Fig. 46.3. Note nine slides/sections and three stages in order to get to a tumor-free state. Again, note the *red hash marks*, which indicate areas of positive margins requiring additional excision

Penile Reconstruction After Glansectomy or Distal Partial Penectomy

The goals of partial penectomy are to allow appropriate resection of the tumor (negative intraoperative frozen section and/or postoperative pathology) while preserving enough penile length to allow upright voiding (≥4 cm) and penetrative sexual intercourse (roughly ≥7.5 cm). The loss of either may lead to severe physical and psychological disability. Most patients are reluctant to undergo amputative penile surgery, and this has prompted the development of penile-sparing and reconstructive techniques.

Glansectomy and Glans Reconstruction

A glansectomy is performed by separating the glans from the corporal heads, transecting the urethra, and spatulating it distally. For T1 and T2 lesions confined to the glans, this has been shown to be an effective technique with good aesthetic and functional results. A frozen section of the proximal margin is essential to the oncologic success of glansectomy. If the frozen sections are positive, a distal corporectomy is performed and the distal corpora are progressively excised proximally until the margins are clear from malignancy. Once a distal corporectomy is performed, the corpora are sutured together in order to recreate a round shape and are covered with a STSG to fashion a pseudoglans using the same technique described below after simple glansectomy. Recurrence rates after distal corporectomy are up to 6 %.

Austoni was among the first to propose glansectomy by utilizing the anatomical division between the corpora cavernosa and corpus spon-

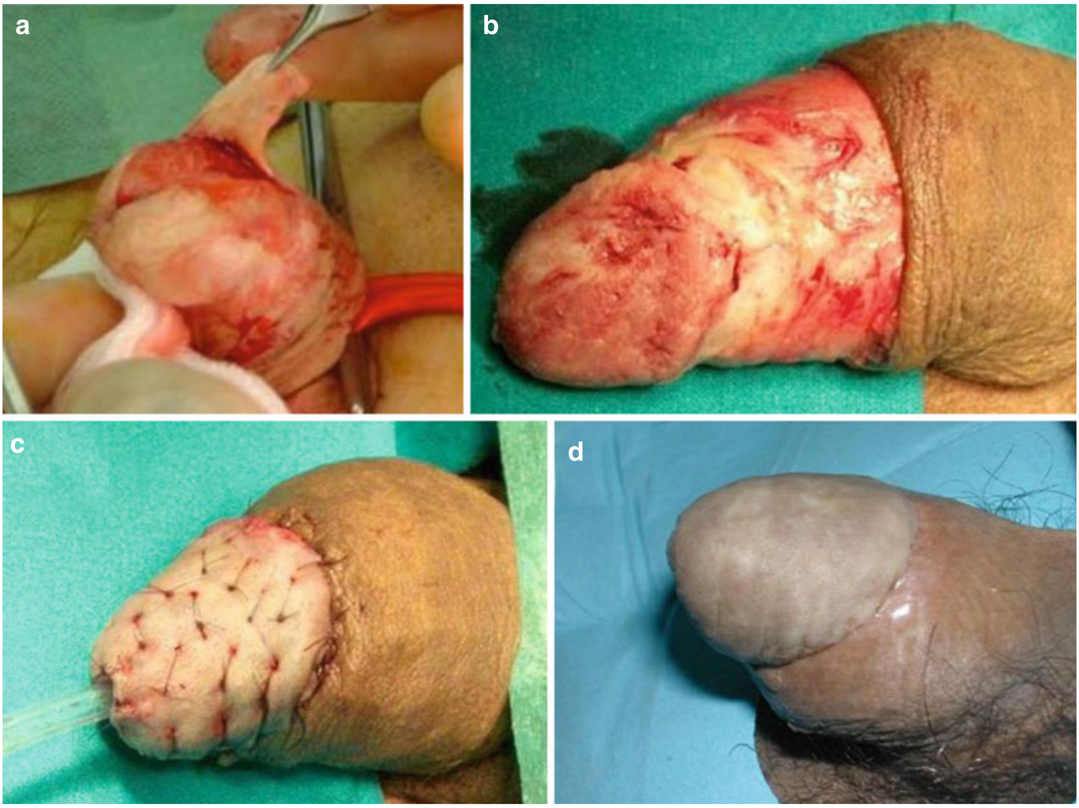

Fig. 46.5 Glans resurfacing by glans skinning in quadrants technique (**a**, **b**). Reconstruction by split-thickness skin graft (note quilting sutures) (**c**). Postoperative appearance months after grafting (**d**) (Images courtesy of E. Palminteri)

giosum [24]. In order to prevent meatal stenosis, the urethral stump is spatulated on the ventral aspect and its edges everted with interrupted sutures. A pseudoglans is then created by suturing the distal end of the penile skin to the underlying fascias approximately 2 cm proximal to the corporeal heads and then by applying a STSG onto the denuded corporeal heads.. The graft is initially sutured to the urethral edge and the quilting is progressively continued proximally till the margin of the penile skin. Oncologic control and local recurrence rates appear to closely mirror partial penectomy rates. Smith et al., from St. George's Hospital in London, reported that of 72 patients who underwent glansectomy and reconstruction with a split-thickness skin graft [25] (Figs. 46.6 and 46.7), the local recurrence rate was only 4 %, at a median follow-up of 27 months, as long as the proximal resection margins were clear. Palminteri noted similar results with respect to both cancer control and cosmetic results in his series of five glansectomies and subsequent neoglans creation with split-thickness skin graft (32-month follow-up) [18]. All patients maintained erectile function. Penile-sparing therapies, therefore, with histologically confirmed negative margins are oncologically safe and effective for most glans-confined cancers. Subsequent penile reconstruction can be both functional and cosmetic. Another method for coverage is to just advance the shaft skin distally and sew it directly to the urethral meatus or residual glans (Fig. 46.8). This method can also be used for partial glansectomy coverage (Fig. 46.9).

An alternative method for glans reconstruction after glansectomy is extensive mobilization of the penile urethra as an advancement flap, widely spatulated distally to act as a cover of the distal corpora. Interestingly, at a mean follow-up of 13 months, cancer control and preservation of

Fig. 46.6 Glansectomy. Initial glans tumor (**a**). Glans dissection (**b, c**). Split-thickness skin graft of the penile shaft (**d**). Post operative appearance, simulating a glans penis (**e**) (Courtesy N. Watkins)

preoperative erection, orgasm, and libido were excellent [26]. Glansectomy without skin graft reconstruction has also been successfully utilized for the treatment of verrucous carcinoma of the glans, Buschke-Löwenstein tumors, and malignant melanoma [27]. Hatzichristou et al. found that local recurrence rates were low with acceptable aesthetic and functional results [28].

Glanuloplasty

In select cases of small discrete T1 tumors of the glans, glanuloplasty has been successfully performed (Fig. 46.10). The technique involves partial glans excision with wide local excision of the tumor and preservation of the urethral meatus, along with concomitant reconstruction with full- or split-thickness skin grafts [29,

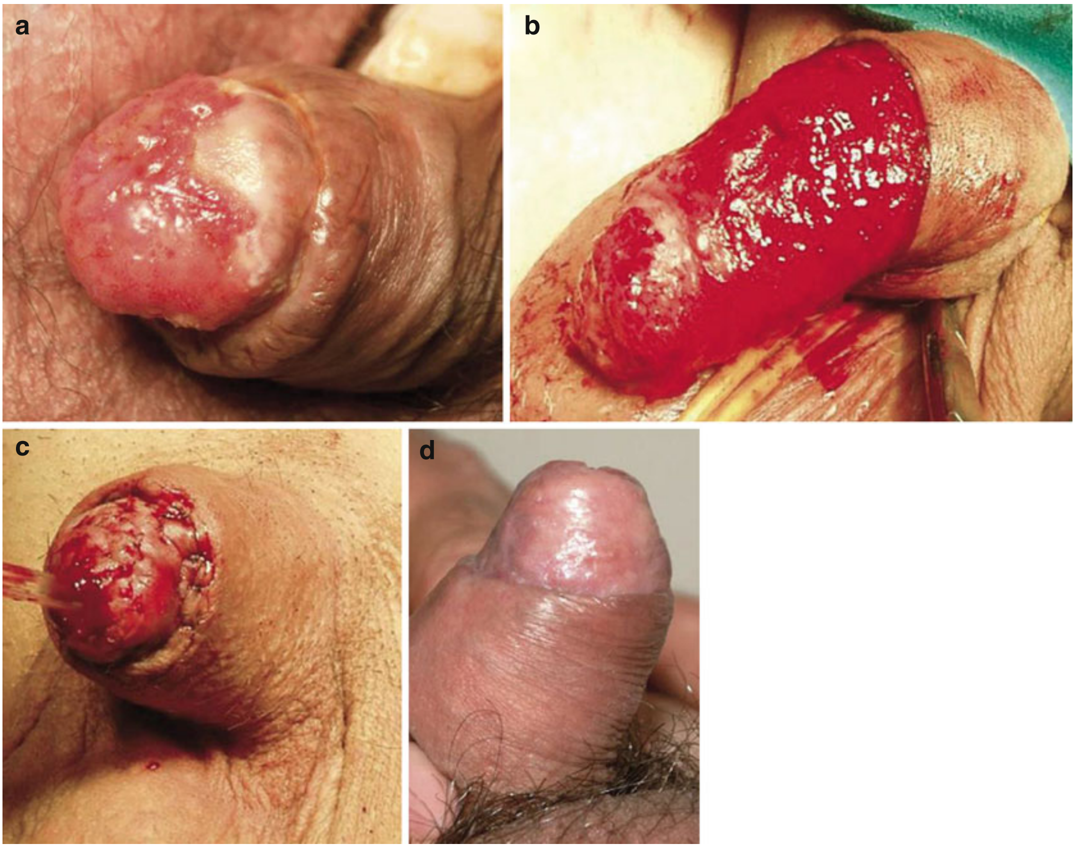

Fig. 46.7 Reconstruction after Glansectomy. (**a**) Glans penis with SCCA. (**b**) Penile shaft after glansectomy resection. (**c**) Reconstruction with penile shaft skin advancement and split-thickness skin graft to the distal shaft. (**d**) Post operative pseudoglans appearance (Images courtesy E. Palminteri)

30]. Glanuloplasty is associated with acceptable cosmetic and oncological results. Close follow-up is required as local recurrence rates can be high, and these require subsequent salvage surgery. Salvage surgery has a high success rate and does not seem to affect overall disease-specific survival [31].

The urethra is released from distal to proximal up to the penoscrotal junction, allowing a 2 cm urethral advancement over the distal end of the cavernous bodies. The urethra is widely spatulated 2.5 cm ventrally allowing coverage of the distal ends of the cavernous bodies, and it is then fixed to the tunica albuginea with 4-0 polyfilament absorbable suture. After the neo-glans is covered with the urethra, the penile skin is sutured to the tunica albuginea proximal to the previously placed suture (Fig. 46.11) [30].

After Partial Penectomy (Amputation)

In patients where the cancer extends into the corporal bodies (T2) or the urethra (T3), more extensive resection, including partial penectomy with a negative margin, is required. The remaining penile stump is then assessed for functionality and possible reconstruction. The length of the residual penile stump will dictate the method of subsequent reconstruction. The question bears, what is the minimum length of penis needed to have satisfactory vaginal penetration intercourse. In general, we use the cutoff of 4 cm flaccid or 7.5 cm stretched lengths. Such lengths are 2 standard deviations off the mean for penile lengths – which are 8.8 cm flaccid and 12.4 cm stretched. Thus, the maximum amount of penis that can be amputated distally and still have a penis of sufficient length is 4.8 cm (8.8–4 cm = 4.8) [32].

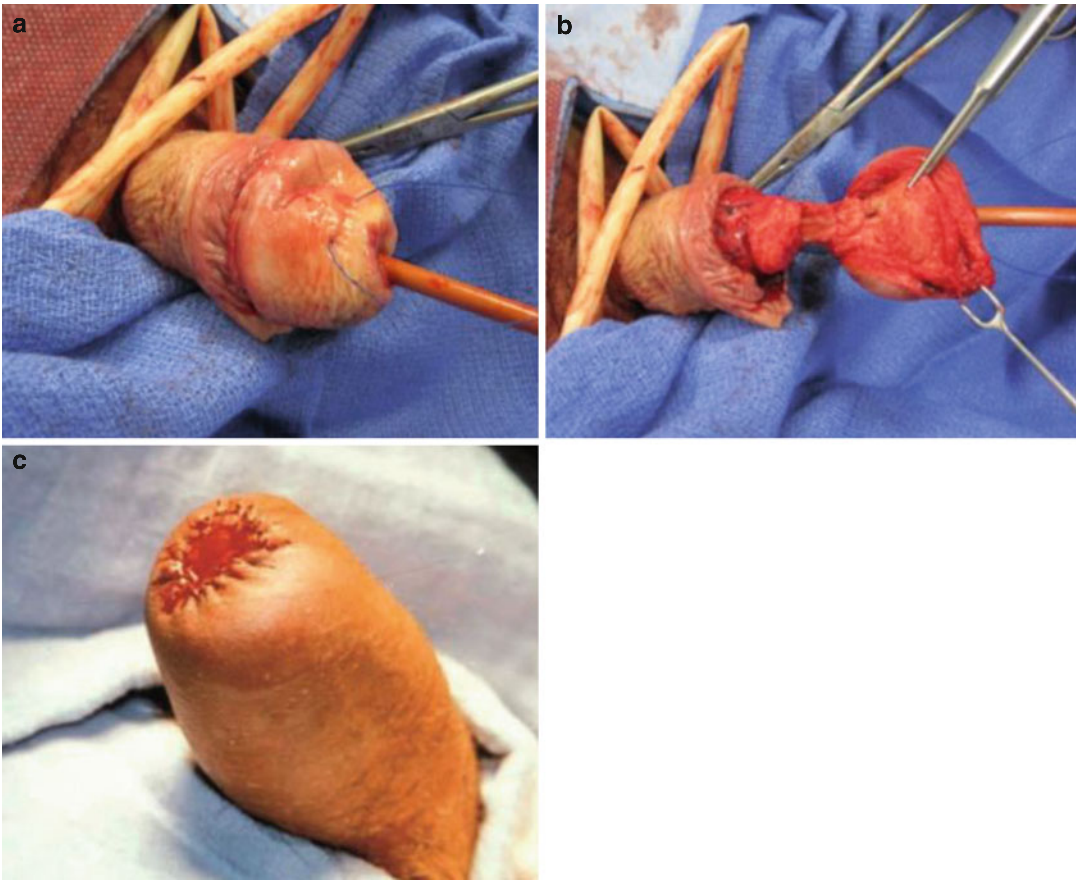

Fig. 46.8 Glansectomy with reconstruction by skin advancement. (**a**) Penis with SCCA within the glans tissue. (**b**) Glans removal off the corporal bodies. (**c**) Skin advancement to cover

Sufficient Penile Stump

When the penile stump is of sufficient length, the penis can be cosmetically reconstructed by creating a neo-glans. Here, the denuded corpora are covered with a split-thickness skin graft, from the tip of the neo-glans to the mobilized shaft skin and the distal urethra spatulated. Tethering of the penis by the shaft skin is avoided by its releasing it proximally. Palminteri et al. showed excellent outcomes with seven patients who underwent partial penectomy and subsequent neo-glans creation with split-thickness skin grafts sutured to the distal corpora [18].

The other key feature to this surgery is that they amputated each penis with a hemispherical incision (rather than straight guillotine), resulting in a more cosmetic dome-shaped reconstructed stump, to which the skin graft can be applied. At a mean follow-up of 32 months, there were no recurrences, and all patients were satisfied with the appearance of the neo-glans and their ability to maintain erections. Long-term follow-up results are still needed, however. Another method for constructing a neo-glans after partial penectomy is a two-stage scrotal advancement flap onto the corporal stump and neomeatus, with delayed scrotal flap pedicle division. Mazza reported acceptable results in 34 patients with 73 months follow-up, yet 6 % of patients experienced flap necrosis and 18 % needed depilation [33]. Even when a large scrotal flap is used, elasticity of the scrotal skin typically allows for primary closure of the donor site. The major disadvantage of scro-

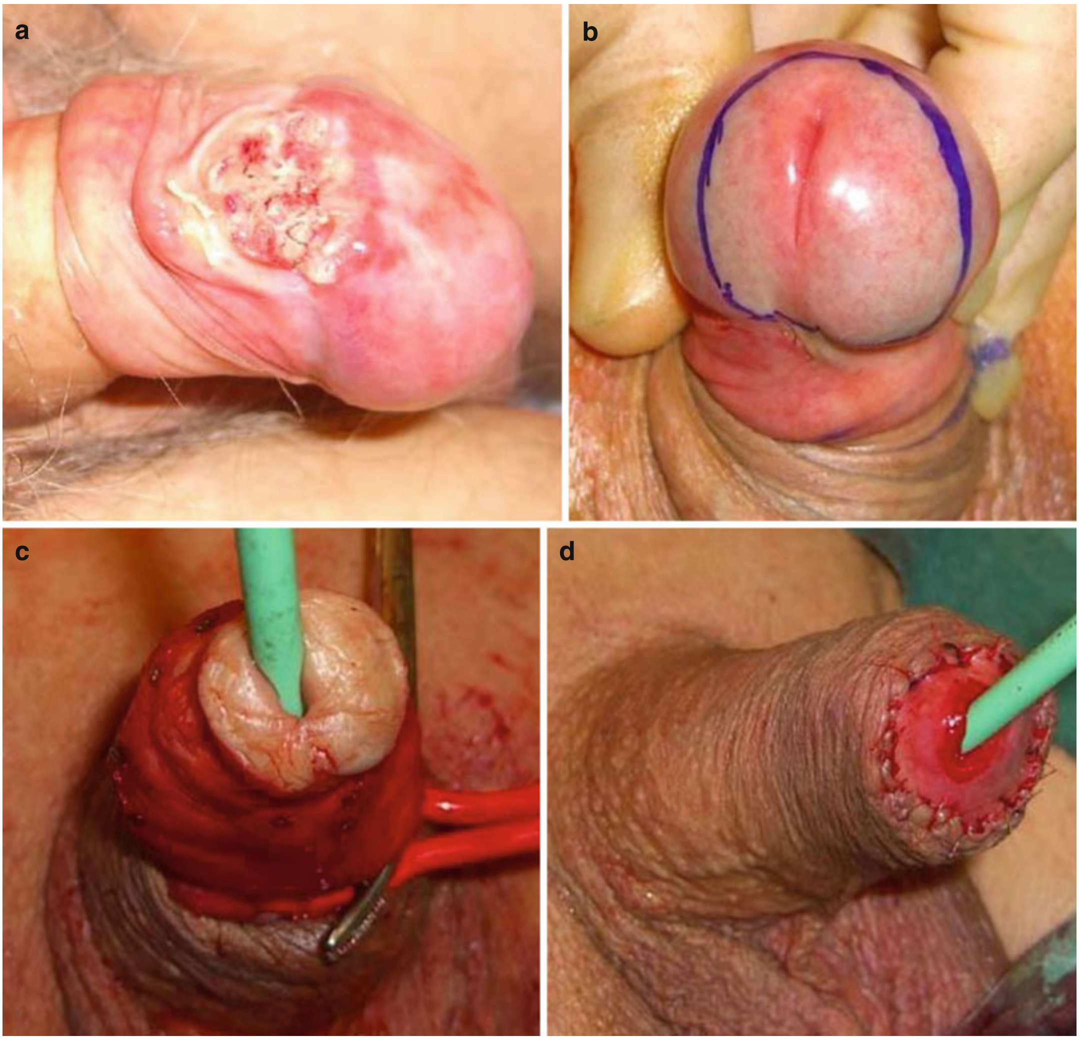

Fig. 46.9 Partial glansectomy. (**a**) Initial tumor. (**b**) Blue resection line. (**c**) Tumor excised. (**d**) Reconstruction by skin advancement (Courtesy of N. Watkins)

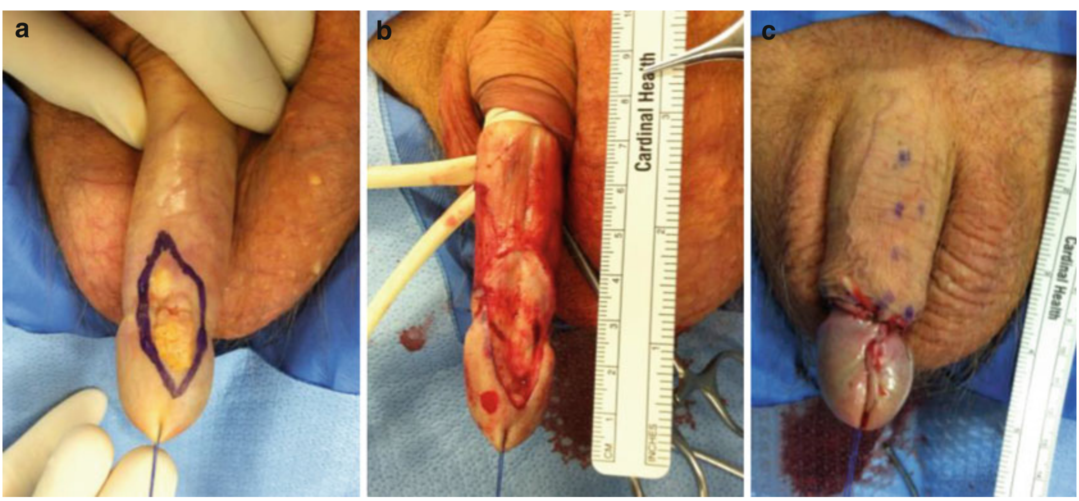

Fig. 46.10 Partial glansectomy. (**a**) Initial tumor. (**b**) Tumor excised. Note Penrose tourniquet for vascular control. Primary closure of glans wings and shaft skin advancement (**c**)

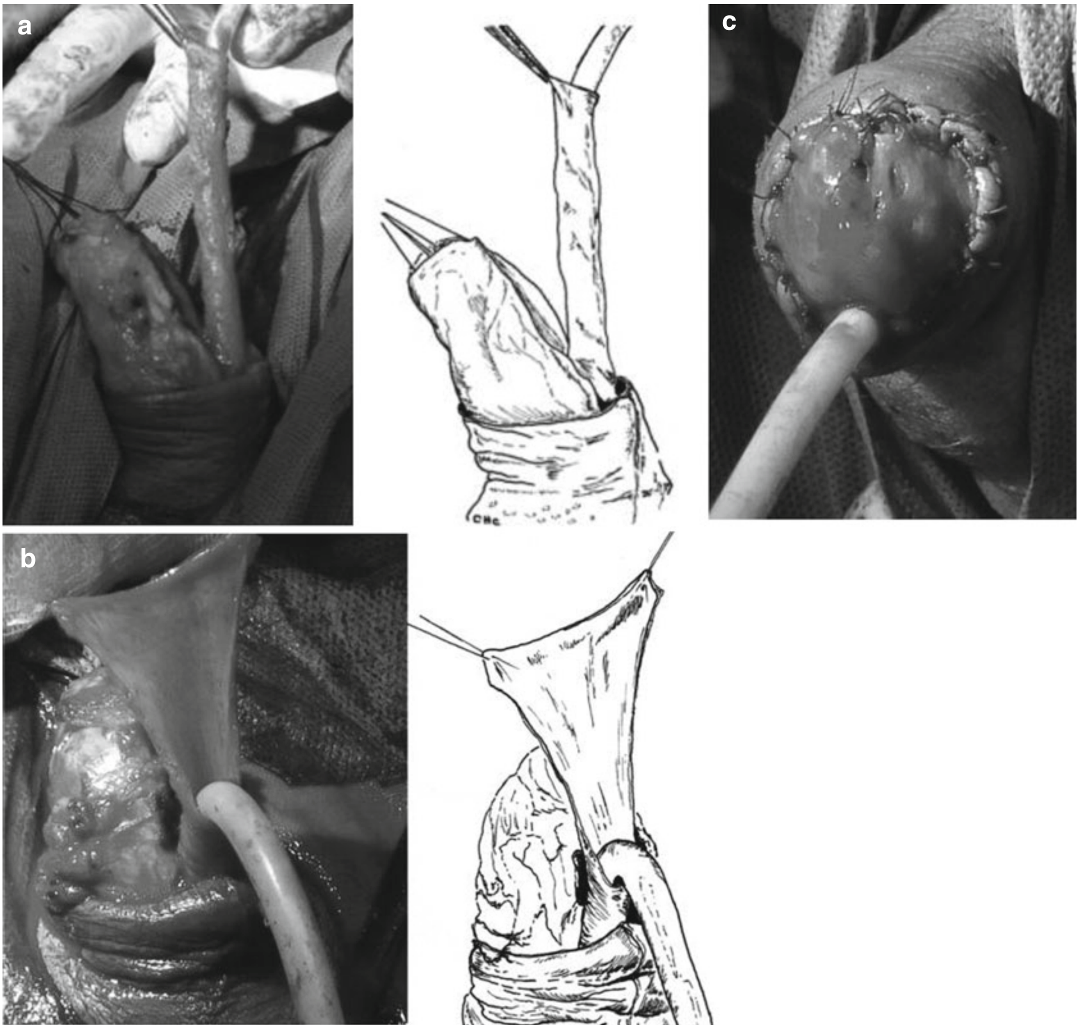

Fig. 46.11 Partial penectomy with glanuloplasty by urethral advancement flap. (**a**) Urethral mobilization to the penoscrotal junction. (**b**) Urethral ventral spatulation. (**c**) Urethra sutured to the distal end of the corporal bodies, in order to act as a cover (Images courtesy JJ Belinky)

tal skin on the penis is its hair-bearing nature and its less then natural rugged appearance. While cosmesis with skin grafting may prove to be a better long-term choice, skin grafts are typically insensate, while scrotal rotational flaps based on the superior lateral scrotum remain sensate.

Short Penile Stump

Depending on tumor location and initial penile length, the resulting stump may be short (<4 cm) after partial penectomy. To avoid converting such patients to a total penectomy and perineal urethrostomy, the suspensory ligament can be divided to help improve penile length by up to 2–3 cm [34]. The mobilized penis is then resutured to the pubic bone, with nonabsorbable braided suture (e.g., Ethibond or Tevdek). If the shaft skin tethers the stump, the skin can be sutured to the proximal shaft, and the distal denuded corpora covered with a split-thickness skin graft. This technique creates a neo-glans appearance with a better cosmetic outcome than conventional amputative surgery (Fig. 46.12). An

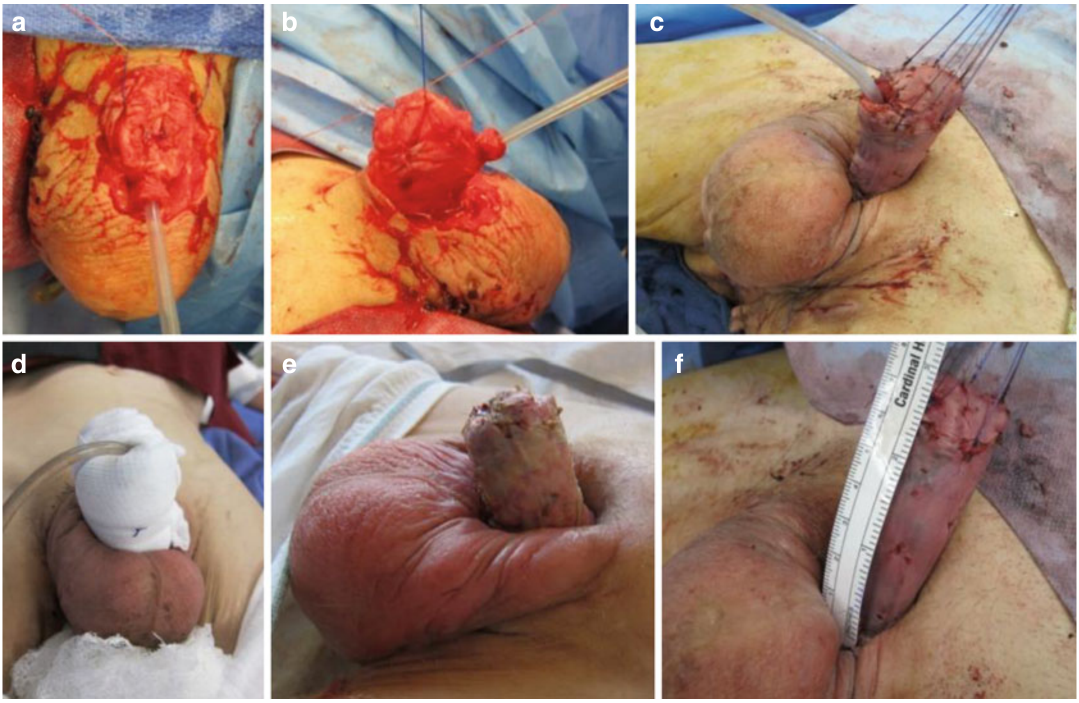

Fig. 46.12 Short stump after partial penectomy. Reconstruction by penile advancement (**a**, **b**) and split-thickness skin grafting (**c**). Bolster dressing, colloquially known as a "penis house." (**d**) Penis after bolster removed. Note excellent graft take and excellent 7 cm penile length (**e**, **f**)

alternative method for skin coverage is the transfer of superior lateral scrotal myocutaneous flaps [34, 35]. In general, scrotal flaps are hair bearing and the skin often thick and redundant and in our hands have resulted in relatively poor cosmetic results. We, therefore, do not use scrotal flaps and prefer skin grafting.

Often the shaft length looks reasonable at the time of the partial penectomy, but postoperatively while standing the length can appear much shorter and often times hidden. A phalloplasty reconstruction can be performed in a delayed/staged fashion to improve body image and voiding and sexual function. Patients with a reasonable residual penile stump can achieve further penile lengthening by a suspensory ligament release. A dorsal V-Y skin advancement or a ventral V-Y-plasty to lower the insertion of the scrotal skin can also give the appearance of a longer phallus [36]. We have little experience with scrotal flaps, but as they continue to have hair with systematic.

Penile Reconstruction After Total Penectomy

Total penectomy with perineal urethrostomy, the so-called toilet penectomy, is typically performed for stage T3 or T4 proximal penile cancers. In patients with no evidence of cancer recurrence, total phallic reconstruction may be considered in order to improve body image and psychosexual identity, particularly in younger men. Reports of phallic reconstruction after total penectomy for cancer are rare and typically employ a radial forearm free flap [37]. See Chap. 35 herein by Djordjevic for surgical details as to neophallus reconstruction. The technical aspects of creating a neophallus after penectomy are very similar to that for a female-to-male gender reassignment operation [37]. Chang and Hwang first described a forearm free flap based on the radial artery for phallic reconstruction [38]. The major advantages of this flap are it is reliable and sensate and has a predictable anatomy, reliable vascular supply, and pliable skin [38, 39]. Major disadvantages are the donor site scar and deformity of the nondominant arm, complexity of the surgery, and the high complication rates, particularly urethral stricture. Modifications to the original Chang and Hwang technique include varying designs of the skin island (such as cricket bat shape) and the relative position of the neourethral paddle in relation to the shaft coverage skin. The Biemer modification centers the urethra portion of the flap over the artery [40]. Modifications of the Biemer design also include the glans reconstruction method of Puckett and Montie, which when combined may offer the best cosmetic results [39, 41]. Ideally, the procedure would be performed in a staged manner after a subtotal penectomy, where the corporal body ends are preserved, and adequate urethral length is maintained with the creation of an infrapubic urethrostomy (instead of the traditional perineal urethrostomy). In carefully selected young patients, penectomy can be successfully combined with an immediate penile reconstruction [37]. In a delayed fashion, an inflatable penile prosthesis can be successfully placed for sexual function with acceptable complication rates [42].

Reconstruction for Radical Inguinal Lymph Node Dissection

For an inguinal lymph node dissection, the patient is placed on spreader bars or in the frog-leg position. The borders of a standard inguinal lymph node dissection (after Daeseler) are the fascia lata, the inguinal ligament superiorly, the adductor longus medially, the sartorius laterally, and 5–8 cm caudal to the inguinal ligament inferiorly (Fig. 46.14). Usually this corresponds to an area drawn out on the skin, starting with the lateral border, being from the anterior superior iliac spine (ASIS) to 20 cm inferiorly, the medial border – pubic tubercle to 15 cm inferiorly, and then a transverse line roughly 12 cm in length, connecting the two vertical lines. To prevent seroma formation, we utilize a liberal use of LigaSure and surgical clips for lymphatic control of the LN packets.

While well beyond the scope of this chapter, the borders of a modified inguinal lymph node dissection (after Catalona) were a major advance in reducing morbidity while not increasing the false negative rate. While the dissection margins here are smaller, the key features are preservation of the saphenous vein, thicker skin flaps deep to Scarpa's fascia and no need for transposition of the sartorius muscle or groin reconstruction. Other methods to reducing morbidity from an inguinal lymph node dissection are use of a dynamic dual sulfan sentinel lymph node biopsy as described by Horenblas, or using a video endoscopic inguinal lymphadenectomy (VEIL procedure) [43, 44]. The most common complications of a standard inguinal lymph node dissection are flap necrosis (2–64 %), wound breakdown (38–61 %), wound infection (3–70 %), lymphocele (2.5–87 %), and lymphedema (5–100 %).

Sartorius Muscle Flap

Transposition of the sartorius muscle was originally described to cover the femoral vessels after inguinal lymphadenectomy in 1948 by Baronofsky [45]. Inguinal lymphadenectomy is associated with significant morbidity, particularly when large amounts of inguinal skin are resected, and either the opening is too large to close primarily or the skin edges of the flaps necrose – leaving the femoral vessels exposed [46]. The sartorius muscle is ideal to cover this defect, as it is located just lateral to the femoral vessels (Fig. 46.13). A sartorius flap typically leaves no functional deficit and rarely results in cosmetic deformity.

Anatomy

The sartorius muscle originates on the anterior superior iliac spine (ASIS), inserts onto the anteromedial surface of the proximal tibia below the condyle, and shares a common tendinous insertion with the gracilis and semitendinosus muscle (see Table 46.2). It forms the lateral border of the femoral triangle. It contains on average 6–7 equally sized vascular pedicles that originate from the superficial femoral artery entering into

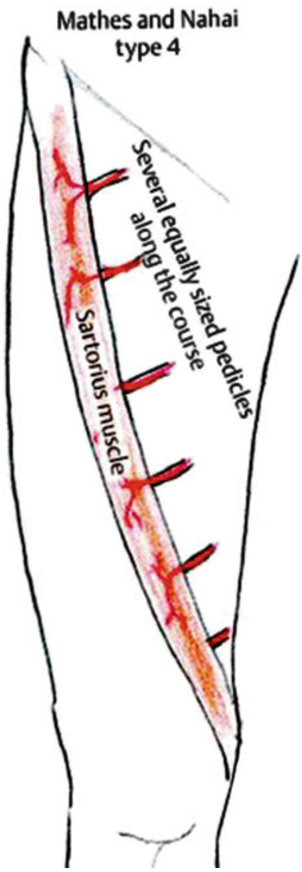

Fig. 46.13 Sartorius muscle flap cartoon detailing its segmental vascular supply (From Krishnan [48])

Table 46.2 Sartorius muscle characteristics

Function	Flex, abduct, laterally rotate thigh at hip; flex leg at knee
Origin	Anterior superior iliac spine
Insertion	Anteromedial surface of the tibia just below the condyle
Innervation	Branch of femoral nerve (L2,3)
Blood supply	Six to seven segmental pedicles of superficial femoral vessels
Length	45 cm
Width	6 cm proximally

the deep posterior and medial aspects of the muscle (Fig. 46.15). The vascular territories are nonoverlapping, so ligation of any pedicle will lead to segmental muscle necrosis. The most proximal pedicle is located 6 cm distal to the ASIS, and the nerve (a branch of the femoral nerve) enters at the proximal end. The sartorius is approximately 45 cm long by 3 cm wide, but only the proximal 10–12 cm of the muscle is used to cover the femoral vessels. The rotational arc of the muscle flap is limited by the multiple pedicles entering into the medial surface of the muscle belly.

Mobilization

As the lateral margin of dissection for an inguinal lymph node dissection, the sartorius is typically already exposed. If necessary, the groin incision may be extended up to the ASIS to facilitate exposure. The lateral border of the muscle is sharply released from surrounding tissues, and its tendinous insertion detached from the ASIS with electrocautery to maximize rotational freedom. As the blood supply is segmental, the muscle can be circumferentially mobilized only until the first segmental pedicle, which is consistently 6 cm distal to the ASIS. The perforating segmental branches enter the posteromedial edge of the muscle, so only the lateral edge can be safely dissected free. The muscle can then be flipped 180° on the medial edge of its longitudinal axis (*like a door on a hinge*) (Fig. 46.14). Excessive medial dissection (>6 cm distal from the muscle origin) risks injuring the proximal pedicle and necrosis of the proximal end. The main complications associated with a sartorius flap are hematoma formation and distal necrosis.

Rotational Skin Flaps

If the inguinal tumor mass is large and anterior, then the defect postresection can typically be fairly large. Tension on the edges of the already thin skin flap edges promotes ischemia and delayed necrosis. To perform a tension-free closure of the inguinal defects, we have usually employed a large semicircular rotational flap or advancement flap of the anterior abdominal wall skin and subcutaneous tissue [47]. Here, the skin is separated from the anterior rectus sheath and the external oblique fascia with electrocautery, in the same manner as is done for a panniculectomy, and then a curvilinear incision is made 30–45 cm in length. See Fig. 46.15, for example, of abdominal skin wall flap rotated on an arc. For

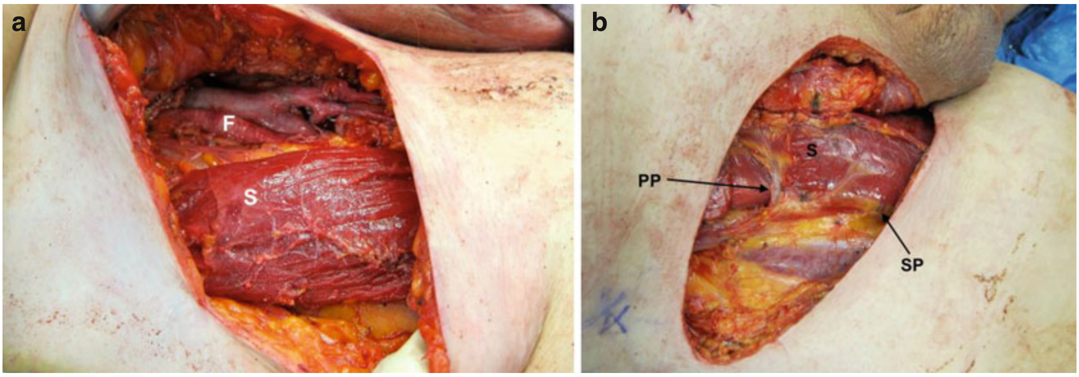

Fig. 46.14 (**a**) Close-up of inguinal anatomy noting anatomical position of the sartorius muscle and exposed femoral vessels (**a**). *S* Sartorius muscle, *F* Femoral vessels. (**b**) Sartorius muscle mobilized on its lateral surface and rotated on its medial border ("like a book") to cover the femoral vessels. Note the primary pedicle (*PP*) and the secondary vascular pedicle (4 cm caudal) (*SP*). *PP* Proximal pedicle, *SP* Segmental

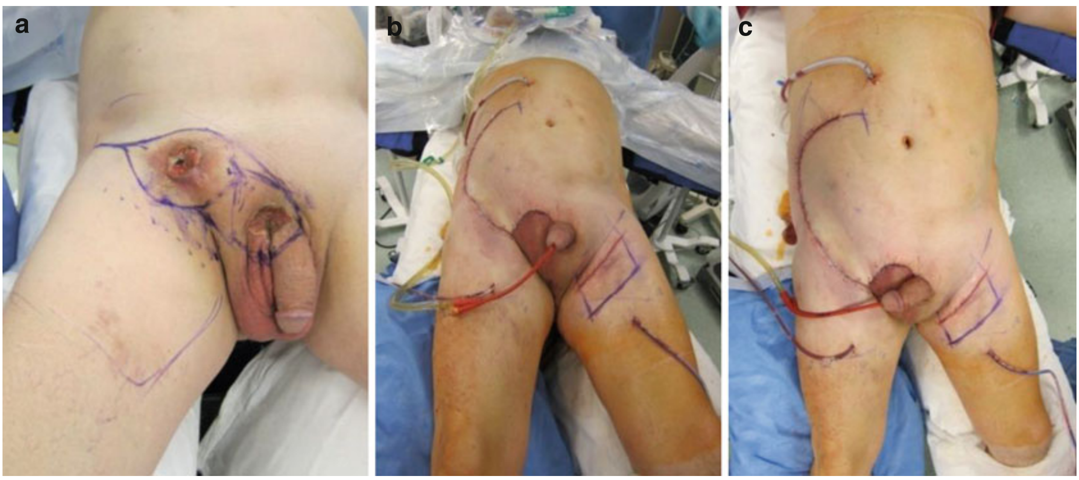

Fig. 46.15 (**a**) Initial tumor with cavitary right inguinal metastasis. (**b**, **c**) Inguinal reconstruction with rotational right abdominal wall flap and scrotal advancement flap

medial groin defects not covered by the rotational skin flap, the scrotum, mainly because of its elastic nature and good blood supply, makes it an excellent choice for coverage and defect closure.

Anterior Lateral Thigh Flap

In the supine position, draw a line from the anterior superior iliac spine to the superolateral border of the patella. The midpoint on this line is typically the location of the ALT flap perforator, within a 3 cm radius from this midpoint (Fig. 46.16a). The medial border of the flap corresponds to a line drawn from the ASIS to the superior aspect of the patella (Fig. 46.16b). The lateral border of the flap extends to the midlateral thigh. The lateral circumflex femoral artery, which arises from the lateral side of the profunda femoris artery, passes laterally and deep to the femoral nerve branches and the sartorius and rectus femoris muscles. It then divides into ascending, transverse, and descending branches. The descending branch is the main blood supply to the ALT flap. The length of the vascular pedicle

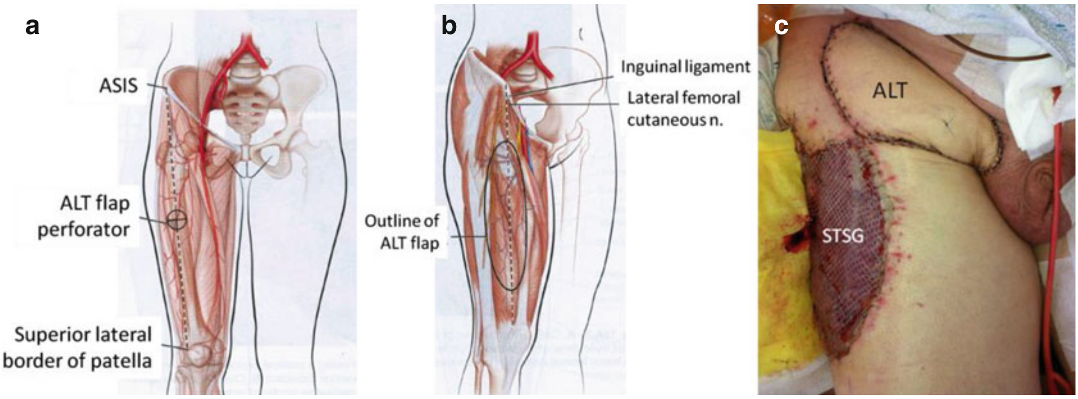

Fig. 46.16 Key anatomical landmarks for harvest of an anterior lateral thigh flap (*ALT*). (**a**) Note the ALT flap perforator is at the midpoint of the line from the ASIS to the lateral border of the patella, within a 3 cm radius. (**b**) Note the large size of the potential ALT flap (Images courtesy Michael Zenn, Duke University). (**c**) ALT mobilized to groin and harvest site skin grafted. *ASIS* anterior superior iliac spine, *STSG* split-thickness skin graft

is typically 8–12 cm. Sixty percent of the time the vessels course through the muscle, and thus a portion of the vastus lateralis muscle may be harvested or intramuscular dissection required. Nerve innervation of the flap is from the lateral femoral cutaneous, which passes under the lateral end of the inguinal ligament and into the thigh. The main advantages of the flap is that the flap is thin and pliable and can be rapidly harvested and the perforator arborization is extensive so that skin flaps as large as 12 × 36 cm can be harvested. If the flap is >9 cm wide, the donor site will need to be skin grafted, rather than closed primarily (Fig. 46.16c). The main disadvantage of the flap is that it can be hair bearing and the donor site conspicuous.

Conclusions

Penile cancer is a rare disease in the West, but it has an enormous psychosocial and health impact. A number of penile-sparing modalities are available to treat superficial disease and disease involving the corpora, and these have significantly decreased morbidity. Reconstruction of the defect has led to improved function and appearance and increased quality of life. While penile-sparing therapies have resulted in higher rates of local recurrence, recurrence does not seem to affect survival.

Surgical Pearls and Pitfalls

Key intraoperative surgical points	Potential intraoperative surgical problems
Obtain intraoperative frozen section of the proximal margin at the time of partial penectomy or glansectomy	
Surgical margins for good local control can safely be much shorter than 2 cm	Short penis stump – Release suspensory ligament to give extra length Deficient penile shaft skin after partial: be prepared to do a STSG for shaft coverage
For planned neophallus reconstruction after penectomy, leave the urethral meatus at the pubis and do not perform a perineal urethrostomy	
For Ta/T1 tumors confined to the glans – highly consider Mohs microsurgery or glansectomy	Large penile skin defects after resection – STSG Glans defects – usually treat by primary closure or secondary intention
Perform partial penectomy by hemispherical incision rather than by straight guillotine	
Sartorius muscle blood supply is segmental so it cannot be rotated on an arc but rather flipped like a door on a hinge	

Editorial Comment

Penile cancer is a psychologically devastating diagnosis. Reconstructive procedures for preservation of appearance and function can mitigate some of the debilitating psychological effects. Fortunately, the historical dogma that penile cancer requires a minimum 2 cm margin is being superseded by the practice of minimizing cancer resection to achieve negative margins while emphasizing organ preservation to minimize psychological and physical disability.

The emerging evidence is that penile skin grafting and glans reconstruction provide excellent cosmetic and functional outcomes. For cancers confined to the glans, Mohs microsurgery followed by advancement of the edges of the glans defect and local rotation of flexible penile skin flaps can produce an appearance that is quite natural. For patients that require partial penectomy or glansectomy, glans resurfacing can be reliably achieved by skin grafts applied to the corporal bodies, which create a strikingly natural appearance of the neo-glans.

Lee C. Zhao, MD
Allen F. Morey, MD

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47 New Advances in Penile Implant Surgery

Steven K. Wilson and John D. Terrell

Summary

Although the penile prosthesis has remained the preferred treatment for end-stage erectile dysfunction over the past 40 years, significant technical advances have recently been described. The transverse scrotal incision is most often used for implantation, but a rebirth in interest in the infrapubic incision has recently occurred. Prosthesis infection has been dramatically reduced by the use of infection retardant coated devices. New techniques of ectopic reservoir placement avoiding placement in the retroperitoneal space have been developed. Newly designed flat reservoirs have promoted insertion in the abdominal wall out of harm's way.

New surgical techniques are available to facilitate insertion of cylinders into scarred corporal bodies resulting from previously removed cylinders, priapism, vascular insufficiency, or Peyronie's disease. New surgical instruments are available to facilitate the insertion without the necessity of extensive resection of the fibrotic tissue. Capsule formation around the device is a tough fibrous membrane which must be influenced in the post-operative period for optimal penile size to result. It is also useful as a natural tissue repair in repairs of impending cylinder erosion and reservoir hernia.

Introduction

Penile implants have been available for 40 years in the United States. Coincidentally, the senior author of this chapter started practice in 1973, as the inflatable implant became popularized. While virtually every surgical procedure he learned in residency training is now obsolete and despite popular oral and injection therapies for mild to moderate erectile dysfunction, penile prosthesis implantation remains the only therapy existent for end organ failure.

The initial 3-piece inflatable penile prosthesis (IPP) was called the Scott prosthesis after its inventor F. Brantley Scott, a Professor of Urology at Baylor University in Houston. The implant was placed through an infrapubic incision. The figure shows the infrapubic placement illustration from Dr. Scott's first publication in 1974 [1]. Since the tubing was not kink proof, it was necessary to traverse both inguinal canals. Today there are only two inflatable penile prosthesis manufacturers in the world: American Medical Systems (Division of Endo Pharmaceuticals, Minnetonka, MN) and Coloplast Corporation (Minneapolis, MN).

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While implant adverse events have become significantly reduced, the major causes for reoperation of IPP are mechanical malfunction and device infection. Since the devices have been available for more than 40 years, they have undergone multiple enhancements designed to improve longevity and physician/patient satisfaction. In 2007, a published single-surgeon study of over 2000 implants showed the 5-year survival rate from revision for mechanical failure for both manufacturers' IPPs was 95 % and the 15-year rate was 70 % [2]. Of all medical devices placed in humans, these survival rates make the IPP one of the least likely to require revision for mechanical failure.

Early in this century, the manufacturers began to coat their devices with proprietary infection-retardant coatings. These coating technologies allow absorption/elution of drugs into the implant spaces and account for an approximate 50 % reduction in penile implant infection rates. Current literature tracking device infection shows first-time implant risk of infection to be reduced from 3–5 to 1–2 % [3, 4]. Revision infection risk has also been reduced dramatically [5].

Most patients undergoing this surgical treatment for end-stage erectile dysfunction are extremely happy with their outcomes [6]. A recent validated questionnaire completed by patients who had successfully tried oral and injection therapies indicated the IPP to be more satisfactory than these more conservative, less-invasive therapies [7].

Thus, prosthetic urology boasts inflatable devices with a 40-year history of escalating reliability and patient/partner satisfaction while (as of late) significantly limiting mechanical/bacterial adverse events. One may consider that such a 40-year old arena could be viewed as mature and sedate. To the contrary, this chapter will review the exciting new developments in the field of penile implant surgery that have occurred in the last decade.

Current Surgical Approaches

Upper Transverse Scrotal Incision

The possibility of dorsal nerve injury and the increased morbidity of a large abdominal incision were most responsible for the decline in popularity of the infrapubic incision. In the mid-1980s, interest in the penoscrotal incision blossomed with both vertical and transverse incisions promoted. Montague's textbook chapter in 1993 [8] was a driving force, and by 2000, implant companies reported 70–80 % of models sold were for penoscrotal approach. After a 2003 publication described a new technique whereby both the penile implant and artificial urinary sphincter (AUS) could be consistently conducted through the same, single upper transverse scrotal incision [9], this surgical approach became the dominantly utilized approach. This advancement provides improved access to the proximal corporal bodies, allows dual implantation of an IPP/urinary sphincter with only one incision, and, when necessary, facilitates scrotoplasty (Fig. 47.1).

Recently there has been a resurgence of interest in the infrapubic incision for first-time implants. Perito enhanced Scott's originally described approach. His technique altered the former extensive abdominal operation to be quick and minimally invasive through a small 3 cm opening [10]. The resulting lack of trauma to the scrotum allows earlier cycling with 82 % of Dr. Perito's patients sexually active within 4 weeks of surgery. Utilizing his tiny incision, Dr. Perito has also been one of the pioneers of ectopic reservoir placement (see below). Currently, the infrapubic approach is escalating, as many surgeons have found the benefit of reduced use of rear tip extenders (RTE) to help maximize cylinder-based axial rigidity.

Scrotoplasty or Ventral Phalloplasty

In the United States, the majority of male children undergo a circumcision soon after birth. A pediatrician usually performs the removal of the foreskin with a Gomco clamp apparatus. This may result in an excessive amount of skin removed, and in adulthood the attachment of scrotal skin on the penis may be high on the shaft of the penis. This webbing of genital skin gives the appearance of decreased penile length (Fig. 47.2). Scrotoplasty or ventral phalloplasty

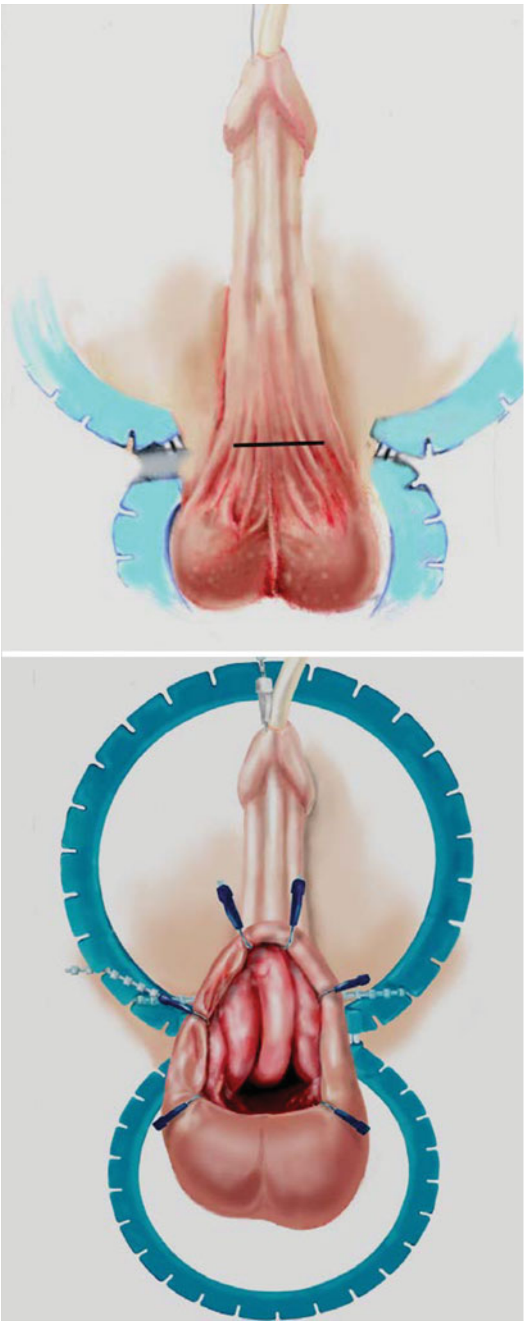


Fig. 47.1 Exposure of proximal corpora and urethra facilitated with transverse scrotal incision and self-retaining retractor

alters the attachment of scrotal skin to allow more of the ventral surface of the penis to be outside the body. First described in the urologic literature for the pediatric buried penis [11] and subsequently used for shortened penile length resulting from corporal fibrosis [12], this enhancement surgery has been popularized by Carrion and the University of South Florida group who use it routinely as an adjunctive procedure during IPPs on circumcised men [13]. The procedure adds very little increase of operative time, and 86 % of their patients perceive a longer penis than prior to surgery.

Scrotoplasty is particularly easy to perform if the upper transverse scrotal incision is used for IPP. Following completion of the implantation, the surgeon merely converts the transverse incision to a vertical one and excises the redundant scrotal web in the process (Fig. 47.3).

Ectopic or Submuscular Placement of IPP Reservoirs

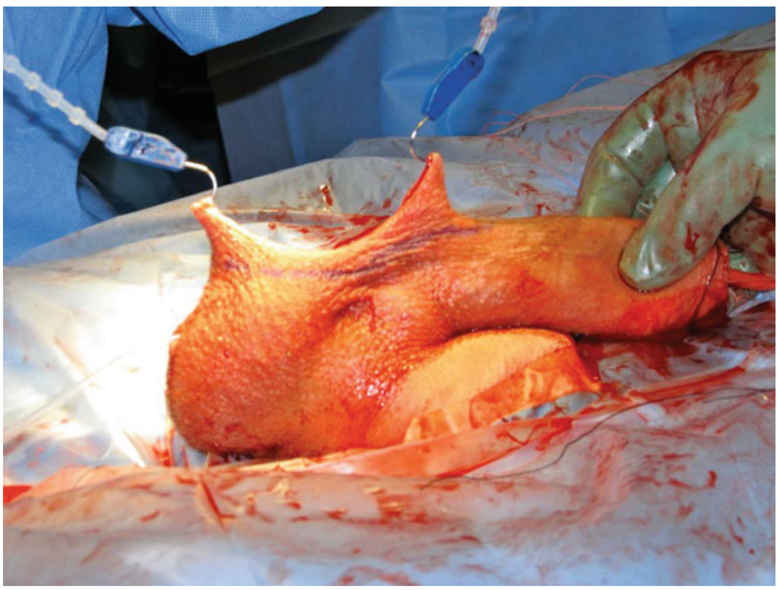
The exponential popularity of robotic prostatectomy has necessitated further review of IPP reservoir placement in the retroperitoneum. During the robotic prostatectomy, the surgeon dissects down the peritoneal veil to achieve access to the prostate gland. After removal of the gland and anastomosis of the bladder to the urethral stump, the robotic surgeon has no rationale to reestablish the continuity of the peritoneum. This creates an anatomical situation where the retroperitoneal space of Retzius may no longer exist. This alteration of anatomy may result in intraperitoneal placement of the reservoir during subsequent IPP placement via the traditional method of piercing the transversalis fascia [14].

The term *ectopic* was coined to describe any alternative IPP reservoir or sphincter balloon placement outside the traditional space of Retzius [15]. Synonyms for this alternative location would be transabdominal wall and submuscular or intrafascial placement. All terms refer to the practice of placing the reservoir in the abdominal wall anterior to the transversalis fascia but posterior to the muscle layers of the abdomen (Fig. 47.4).

Ectopic placement of reservoirs is advisable in patients who have altered surgical planes in

Fig. 47.2 Before and after scrotoplasty

Fig. 47.3 Convert transverse incision to vertical and excise skin tags (web)



the prevesical area. This may be secondary to previous bladder, colon, or prostate surgery. Ectopic reservoir placement may also facilitate reservoir placement in the very obese or in patients having a past history of hernia repair with mesh [16]. Bowel, bladder, or pelvic blood vessel injury is basically not possible with submuscular abdominal wall placement of reservoirs. The potential shortcoming is that the reservoir may be palpable in patients with minimal body fat.

The two inflatable penile prosthesis manufacturers have facilitated this new and safer method of placement by developing reservoirs that have

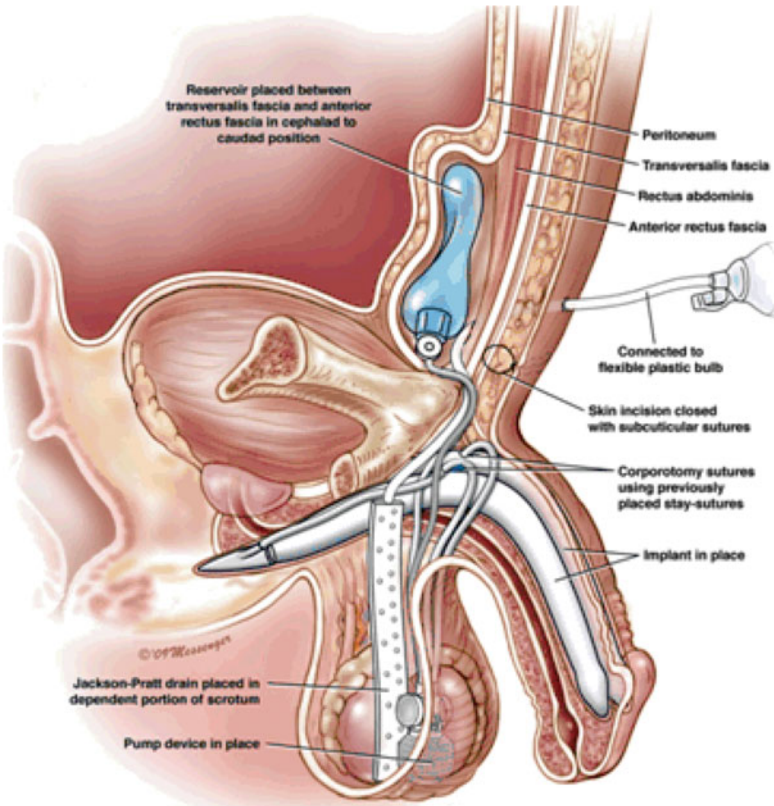


Fig. 47.4 Ectopic or submuscular placement of reservoir

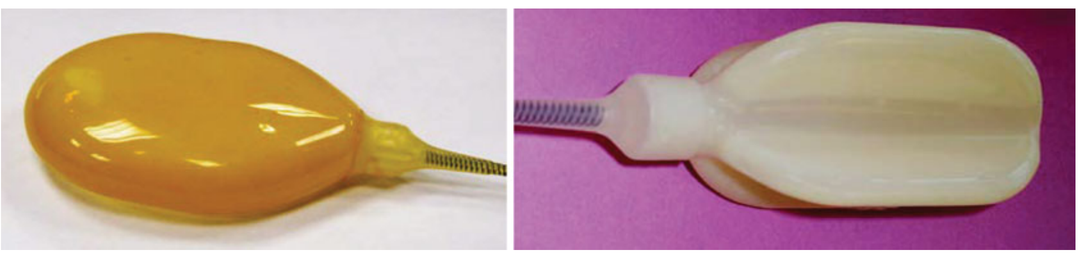


Fig. 47.5 AMS Conceal® Reservoir on the left and Coloplast Cloverleaf® Reservoir on the right

a flat or pancake configuration rather than the traditional spherical (AMS) or cylindrical (Coloplast) reservoirs (Fig. 47.5). The AMS flat reservoir, Conceal®, notes a 2–4 cm thickness when filled to capacity of 80 cc. The Coloplast reservoir, Cloverleaf®, boasts a similar configuration when the 125 cc model is half filled with approximately 70 cc. A cadaver dissection illustrates the Conceal®, in an ectopic placement anterior to the transversalis fascia (Fig. 47.6). Also evident in this picture is the hole in the transversalis fascia that illustrates where piercing the fascia would have been performed to place the reservoir in a traditional prevesical location.

When ectopic placement of reservoirs was first described, a finger was used to rupture the back wall of the inguinal canal allowing access to the submuscular space [15] (Fig. 47.7). Perito et al. subsequently described using a 3.5″ nasal speculum that allowed more cephalad placement of the reservoir [17]. Morey et al. have expanded

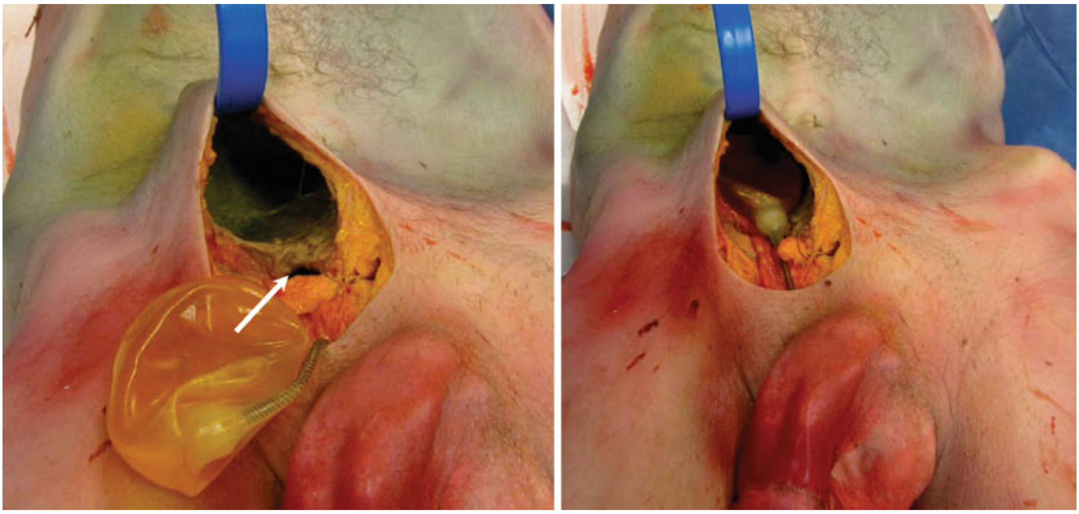


Fig. 47.6 Cadaver study showing ectopic location and also where transversalis is pierced (see *white arrow*) in traditional prevesical space reservoir placement

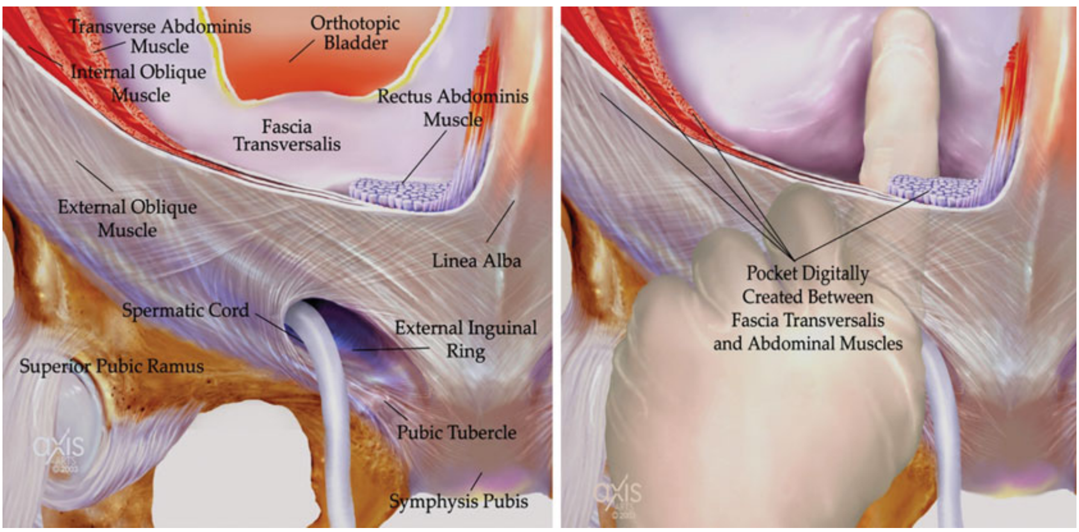


Fig. 47.7 Original description of ectopic placement of reservoirs by forcibly passing finger through back wall of inguinal canal

on this technique using a long Foerster lung grasping clamp to create a tunnel beneath the abdominal wall up to 25 cm long. This allows even higher placement of the reservoir beneath the sturdy rectus muscle, and most patients report inability to palpate the mass in their abdominal wall. In practice, the authors have found it difficult to secure this specialized tool and have substituted the ubiquitous sponge stick or ring forceps to facilitate similar results (Fig. 47.8).

Peyronie's Disease

Peyronie's disease is present in 12–18 % of all patients with a penile prosthesis [3]. Very often unsuspected curvature or hourglass deformity is

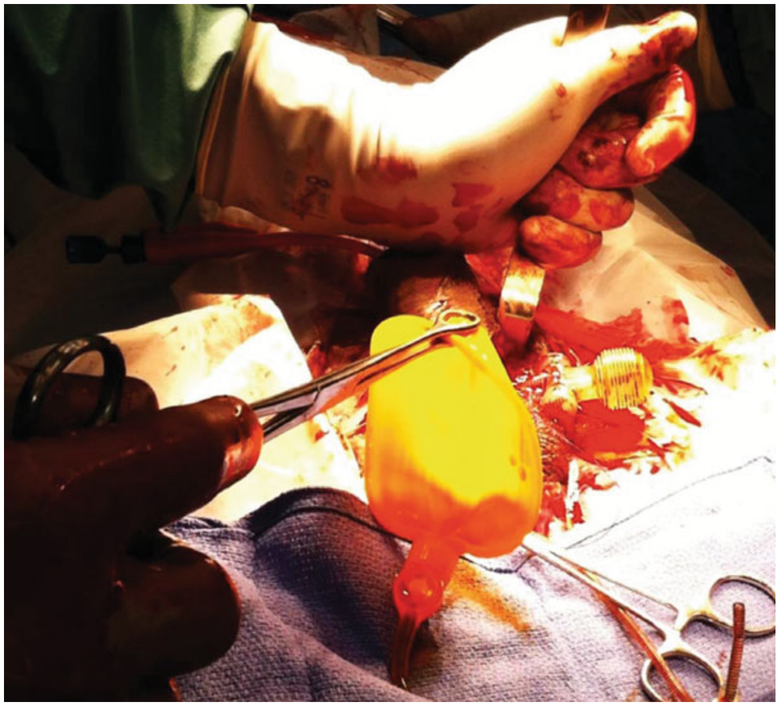


Fig. 47.8 Passing reservoir into ectopic location with ring forceps

evident upon inflating the device in the operating room. Even if Peyronie's disease is suspected and the curve is severe, approximately 50 % of patients require nothing more than an inflatable device to decrease the curvature to <30º. Curves <30º may become completely straight with usage of the device within 8–12 months of implantation [18]. With consistent cycling, the device acts as tissue expander, straightening and also reducing hourglass deformities. The scars of Peyronie's disease are stretched by recurrent inflation and a straight symmetrical penis results. Thousands of patients with penile curvature and ED have been corrected by IPP placement since Wilson and Delk first described the technique in 1994 [19].

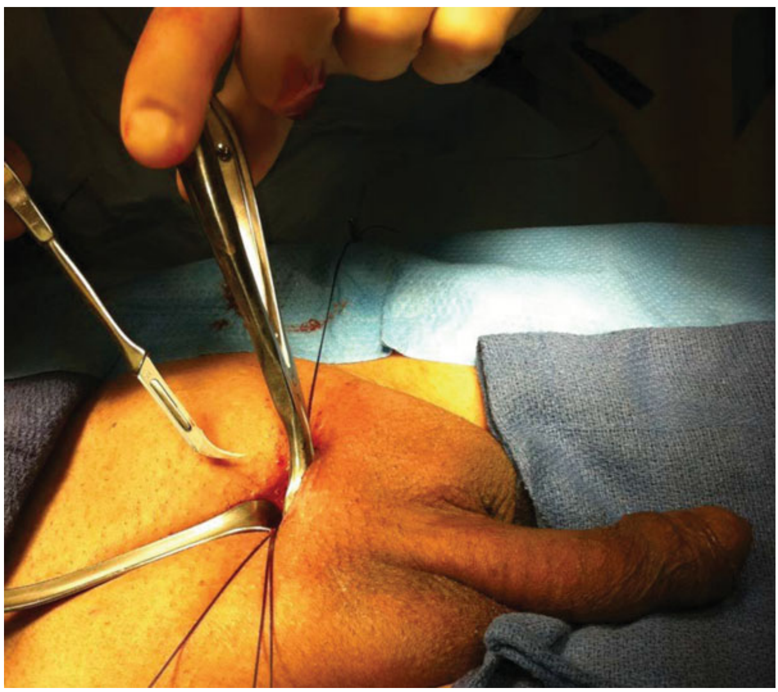
If the curvature after IPP and full inflation is >30º, the modeling procedure can be used to reduce the curvature to acceptable post implant value (<30º). We perform the modeling adjunct to IPP by inflating the cylinders to the maximum rigidity, protecting the pump with rubber shod clamps, and protecting the corporotomies by placing fingers or thumb on the suture lines. Next, the inflated penis is forcibly bent for 90 s in the opposite direction of the curve. After the first modeling session, it is possible to inflate two or three pumps of additional fluid and the maneuver is repeated. Then the prosthesis is fully deflated and reinflated to 70 %. If the curve is ≤30º, the correction is successful and the procedure is terminated [20] (Fig. 47.9).

Perito and colleagues have invented an enhancement to implant placement and modeling for Peyronie's disease. After making the corporotomy, a 3.5″ nasal speculum is passed into the corporal body and forcibly opened to fracture the plaque in a transverse orientation. A hook-bladed knife on a long handle is then inserted into the corporotomy and used to repeatedly scratch the Peyronie's scar [21] (Fig. 47.10). Alternately, long Metzenbaum scissors can accomplish the plaque disruption. This alteration of the Peyronie's plaque makes it more likely that modeling will not be necessary to achieve curvature of ≤30º. If modeling is required, this author feels subjectively that the correction is quicker and easier.

There have been numerous reports of other adjunctive methods to improve the curvature of

Fig. 47.9 Pre- and post-operative Peyronie's disease treated with IPP

Fig. 47.10 Attacking plaque with nasal speculum and knife prior to cylinder placement



Peyronie's disease following IPP implantation. Some physicians incise the tunica over the diseased area as a relaxing incision when implanting the prosthesis. Others, in an attempt to increase length, excise the bulk of the plaque and cover the defect with a natural material such as porcine intestine (small intestine submucosa) or cadaveric pericardium [22]. Alternately, some authorities utilize the 16-dot plication sutures described by Lue and associates prior to placing the cylinders [23] (Fig. 47.11). If the correction is satisfactory with implantation of the IPP, the sutures are removed.

Lastly, Morey and colleagues at University of Texas Southwestern employ penile plication to

Fig. 47.11 Placement of plication sutures prior to placing cylinders as an adjunct to correcting Peyronie's disease with IPP (Courtesy of T. Lue, MD)

ameliorate the curvature due to Peyronie's disease before placement of the IPP. Tunical plication achieves a reduction in curvature by the sequential placement of sutures and the number of sutures utilized is dictated by the degree of curvature [24]. The obvious advantage to this procedure is that there is no wait for complete straightening to occur.

Insertion of Cylinders into Scarred Corporal Bodies

Improvements in Insertion of Penile Implant Cylinders in Difficult Challenges

One of the most difficult challenges that exists in prosthetic urology is the insertion of penile implant cylinders into scarred corporal bodies. Often, this is a result of removal of a previously infected implant or following an episode of priapism. It can also result from severe vascular insufficiency. Sheets of fibrotic scar tissue have replaced the typically easy to dilate erectile tissue in these formidable cases. A paramount difference is that the fibrosis is worse proximally in previously infected implant patients and worse distally in patients post priapism.

Penile shortening is particularly noticeable in patients whose implant was removed secondary to infection. The resulting corporal fibrosis prevents traditional dilatation with instruments, e.g., Hegar or Brooks dilators, commonly used in patients without scar development.

Traditional methods used to create the space necessary for placement of cylinders encompassed extensive corporal resection and secondary coverage of defects with synthetic material. In these demanding cases, even very experienced implanters documented a mere 50 % 1-year implant survival [25]. Obviously, the chance of successful implantation in the fibrotic corpora by occasional implanters was considerably lower.

Introduction of two novel instruments in the late 1990s improved the chances of success in these difficult surgical challenges. First was the Carrion-Rossello cavernotomes. The inventor, Dr. Rossello, originally manufactured these reusable metal devices and they were sized from 9 to 12 mm. AMS later marketed a plastic single use version of the instrument. In 2012, Coloplast began to market a metal reusable version that is sized from 8 to 12 mm. The dilating surface has a wood rasp configuration with backward cutting teeth [26] (Fig. 47.12).

To create a channel in the scar tissue, a deep corporotomy is created and stay sutures are placed. A 2 cm space distally or proximally is made in the fibrotic corpora to allow the cavernotome teeth to be engaged and "walk" the instrument forward. Backward cutting scissors or a #15 knife blade to make a cruciate incision is useful to make the space for engagement of the cavernotome teeth. Then the cavernotome is advanced via an oscillating motion. The teeth actually keep the operator from making a sudden abrupt movement that would be dangerous to adjacent structures like the urethra. This abrupt movement has been designated a "QBM" that stands for *quick birdlike movement* usually accompanied by an expletive.

Withdrawing the advanced cavernotome into the corporotomy allows the backward cutting teeth to "rip" a channel in the scarred corpora. If the cavernotome does not advance easily, the corporotomy is extended and a new set of stay sutures are placed for traction against the oscillating cavernotome.

Mooreville in 1999 described a new cavernotome, the Uramix. These instruments contain a

Fig. 47.12 Rossello cavernotomes manufactured by Coloplast sized 8–12 mm

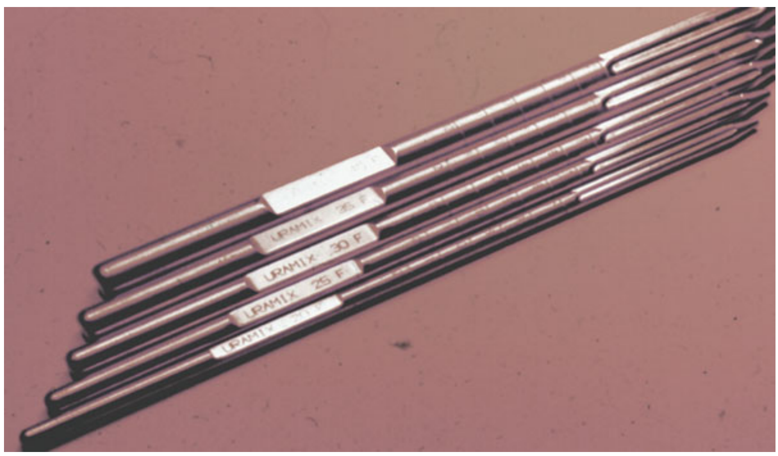


Fig. 47.13 Uramix cavernotomes sized 6–13 mm

recessed knife blade and are sized size 6–13 mm [27] (Fig. 47.13). The operation technique of these cavernotomes is similar to the Rossello's. A deep corporotomy is made and stay sutures applied for traction. These instruments must be engaged as with the Rossello's requiring creation of a space distal or proximal to the corporotomy. With an oscillating movement, the dilators are walked forward. The embedded knife blades shave tiny slices of scar tissue as the dilator is advanced (Fig. 47.14). These dilators have the advantage that they are available in sizes 6 and 7 mm making them particularly valuable distally. The Rossello dilators are more useful proximally because their unique bayonet configuration allow superior penetration.

Inflatable penile prosthesis manufacturers have facilitated success in these difficult implantations. Both manufacturers have created implant cylinders with narrower bases that require dilata-

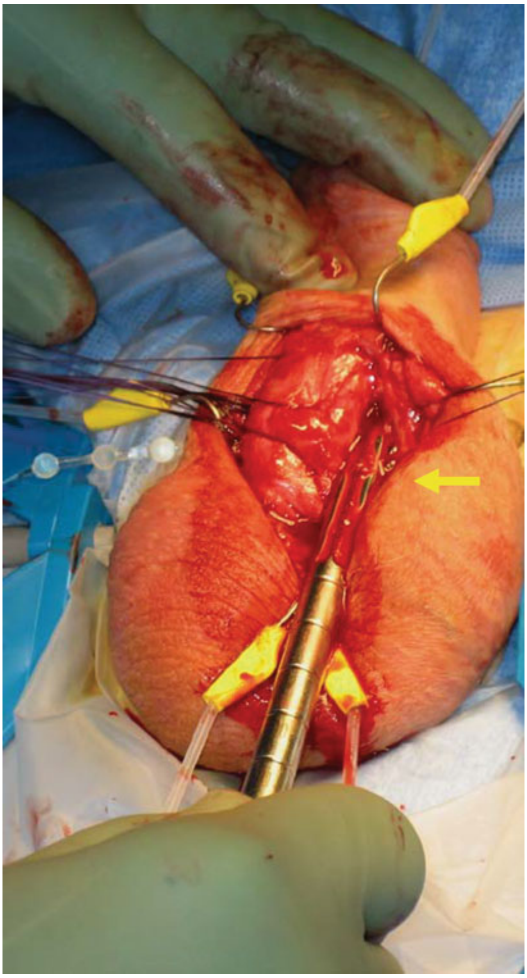


Fig. 47.14 Uramix cavernotomes may shave slices of scar tissue while creating the cavity for the cylinder

tion to only 9 or 10. Proximal insertion is further facilitated by Coloplast's new 0º cylinder/input tubing angle.

While the surgeon relishes triumph in these challenging cases, many patients are disappointed with the resultant penile length. In comparison to the size used in the original procedure, typically the cylinder reimplanted is 4–6 cm shorter. Scar transformation of the erectile tissue also contracts the girth of the penis. Patients are encouraged by the possibility of being able to accept a longer and wider cylinder following a period of usage with the reimplants. Analogous to tissue expansion documented above in the section on Peyronie's disease, pumping up the cylinders for prolonged periods each day stretches the scar tissue. After 8–12 months, the downsized cylinders can be removed and standard-sized cylinders substituted. We have seen that 2–3 cm longer cylinders with standard diameter bases can be inserted in these patients resulting in much improved patient satisfaction [12] (Fig. 47.15a–c).

Device Infection in the Era of Coated Implants

Incidence of Device Infection Drastically Reduced

For the first 30 years of IPP availability, the incidence of infection was quoted at 3–5 % for patients without risk factors [28], 5–8 % for people with diabetes [29], and 10 % for individuals undergoing revision operations [30]. In 2001, AMS introduced a coating of rifampicin and minocycline to the surface of most of the IPP components. The InhibiZone® coating allowed most of the antibiotics to elute into the implant spaces within 72 h of the surgical insertion of the components. Traces of the drugs were noted up to 3 weeks postoperatively. Multiple studies published over the past 12 years have demonstrated that this coating decreased device infections over 50 % when compared with non-coated AMS devices [3–5]. These studies included manufacturer-tabulated studies from submitted patient information forms (PIF) [3, 4] and also single-surgeon series [5]. In June of 2009, the data was a basis for an FDA claim of infection reduction when compared to the non-coated devices. AMS does still sell and promote non-coated product for specific cases such as patients with known allergy to tetracycline.

Late in 2003, Mentor (now Coloplast) began to coat their device surfaces with a hydrophilic coating. This coating was covalently bonded to all the implant surfaces. This coating adsorbs multiple times its weight when dipped in an aqueous solution, thus generating a lubricious device surface designed to deter bacterial attachment. Bacteria cannot be absorbed into the coating as a result of the large molecular weight of

Fig. 47.15 (**a**) Cylinders act as tissue expanders. Penile appearance after removal for infection. Scrotal scar confirms same patient in all photos. (**b**) Appearance after placement of narrow-based prosthesis size 14 after months of daily inflation—cylinders too short. (**c**) Appearance of penis with substitution standard-sized cylinders 2 cm longer

the organisms. If the physician prefers to use a solution containing water-soluble drugs or antibiotics, these medications subsequently elute into the implant spaces following implantation. The reduction of infection with the Coloplast coating was very similar to the AMS reduction when it was compared to its predecessor, the non-coated Mentor devices. Serefoglu and colleagues published a manufacturer-tabulated PIF series of 36,391 primary implants. At 11 years of follow-up, 4.6 % of the non-coated implants had been removed or replaced as a result of infection, whereas a mere 1.4 % infection rate was reported for the hydrophilic-coated implants. Notably, a variety of drugs were used in the immersion solution, however, and the various drug effects were not tabulated individually [4].

A single-surgeon series of over 2,000 patients implanted over 10 years revealed just how valuable these coatings are. Dr. Eid et al. calculated a 5 % infection rate with non-coated implants. When he switched to coated implants, he noted a decline in infection to 2 %. He then instituted his double-drape, "no touch" surgical enhancement and further decreased his infection rate to 0.46 %. His successful technique involves placing a plastic barrier over

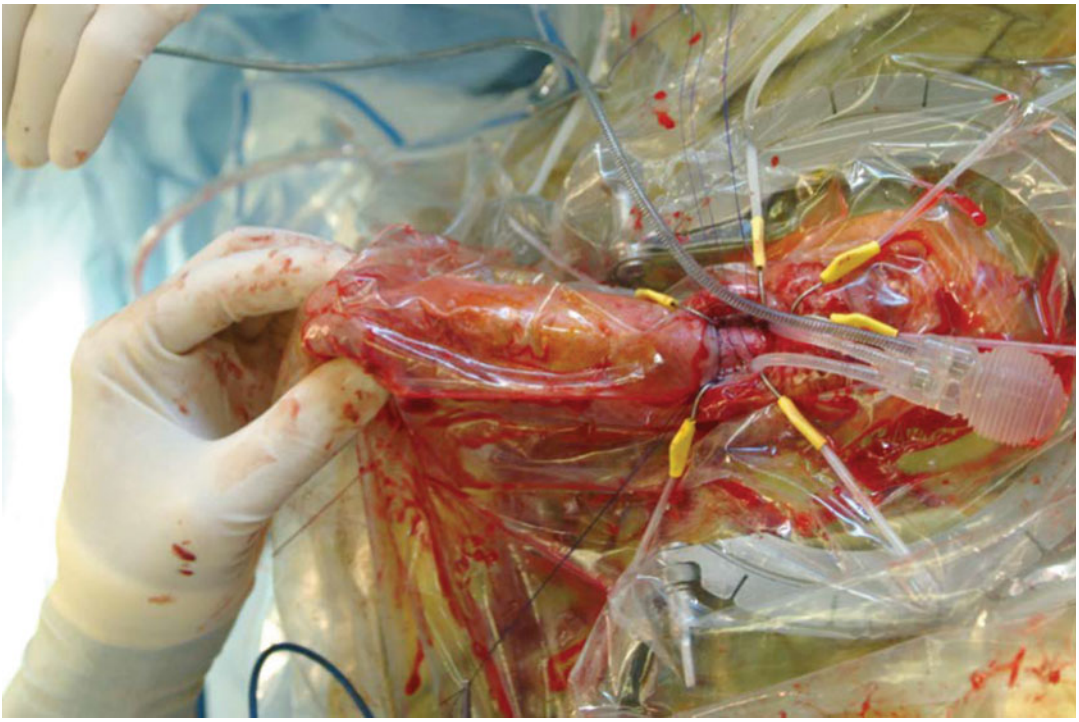


Fig. 47.16 No touch technique keeps implant components from contact with skin of patient

the skin to prevent prosthesis components from ever contacting anything that has touched the patient's skin. Throughout the series there was no significant difference in the rate of infection of AMS or Coloplast devices even though the Coloplast devices were dipped in saline without addition of any antibiotics [31] (Fig. 47.16). Mandava and colleagues did a meta-analysis of all available studies of coated and non-coated IPPs a decade after the availability of infection-retardant-coated IPP components. This study included Eid's patients and confirmed significant infection reduction with the infection-retardant-coated implants [32].

The Concept of Biofilm and Its Importance in IPP Infections

Device infection is initiated with contamination of the implant by organisms prior to or during implantation. These organisms are considered free floating or "planktonic" as they are present individually in the spaces surrounding the implant. As the bacteria begin to multiply, Costerton et al. envision a "race for the surface" where the bacteria try to gain attachment to the surface of the components and the host is trying to kill the organisms with the body's defense mechanisms as well as antibiotics administered prophylactically to the patient. The bacteria secrete adhesion molecules allowing them to attach irreversibly to the component surface. These attached microcolonies produce extra cellular polymers and matrix formation that define a biofilm [33]. The biofilm is sufficiently complete to protect the bacteria at 46 h. The biofilm's structure becomes complex over time with the development of channels facilitating the transport of nutrients, oxygen, and water. Biofilms blunt the host immune response. Phagocytic and intracellular killing capacities of neutrophils are paralyzed. It takes 1,000 times the dosage of antibiotics to kill a biofilm-protected organism compared to a genetically similar planktonic bacterium. Biofilm-protected organisms also undergo exchange of genetic material with their relatives, creating different phenotypes with antibiotic resistance [33] (Fig. 47.17).

Fig. 47.17 Biofilm found on pump removed for mechanical problem. Patient not clinically infected

Henry and colleagues published a series of papers demonstrating biofilm-protected organisms were present in virtually all implanted patients [34]. They also noted that biofilm-protected organisms from the first surgery were responsible for causing the increased infection rate seen in IPP revision surgery. Additionally the group demonstrated that simply substituting an infection-retardant-coated implant for the previous non-coated implant did not reduce the elevated infection rate noted in revision surgery. Reducing the infection rate of revision surgery required vigorous lavage of the implant spaces with antiseptic solutions [36]. The specific composition of irrigation solutions remains a controversy [37], but it is acknowledged by most authorities that "wash out" of the implant spaces and use of a coated implant reduces revision infection rate from 10 to 2 % [5].

The Bacteria Causing Infection Have Evolved with Infection-Retardant Devices

In the decade of the coated implant, we have noted an evolution of the bacteria primarily responsible for causing device infection. During the 30 years when non-coated devices were employed, approximately 4 % of devices became infected. These infections were typically delayed in presentation and the patient did not appear toxic during evaluation. Cultures, if positive, generally indicated coagulase negative staphylococci (CoNS) with *Staphylococcus epidermidis* being the predominate organism [28–30]. These patients with device infection in the non-coated years generally presented late with intervals of more than 2 months from the surgery and frequently much longer. The patients presented with wound dehiscence, a serous-draining sinus tract, vague pain, or pump adhered to their skin. Fever or purulent wound drainage was absent. In a word, the presentation was that of a local infection. Salvage rescue was frequently successful at preserving the implanted status in these patients with local infections [38].

For the past decade, IPPs in the USA are treated with infection-retardant coatings, and clinicians see vastly fewer infections even in diabetics [39]. Nevertheless, while distinctly rare, when device infection occurs, the clinical picture is vastly different. The patients present early and are systemically ill. When cultures are positive, the offending organisms are *Staphylococcus aureus*, *Enterococcus*, *Pseudomonas*, etc. The wound may still culture CoNS but the infectious etiology is one of the more acute bacteria causing a systemic infection. Kava et al. studied nine implant infections in patients who had received coated implants. There were no CoNS local infections. Instead, when he obtained culture growth, toxic organisms like *Staphylococcus aureus* and *Enterobacter aerogenes* caused the acute systemic infections. All patients developed quick systemic infections and were so ill that he did not contemplate salvage replacement as would have been done with a local infection caused by CoNS [40]. Henry et al. presented similar findings in a multi-institutional group of 17 infected coated devices and found the majority of tissue swabs grew *S. aureus*, *Enterococcus*, *E. coli*, and a minority of CoNS [41]. Again, quite a few infected devices returned "no growth."

Knowledge of biofilm helps explain why culture and sensitivity studies of many device infections are returned from the bacteriology laboratory as "no growth." The swab and plate method of culture typically detects planktonic organisms. The biofilm-protected organism is notoriously difficult to culture with the typical swab and plate technique [42]. A recent study from Mayo Clinic of infected coated devices found that a typical tissue swab might grow CoNS organisms but only after sonication of the biofilm were the actual virulent and infectious organisms cultured [43].

In summary, infection-retardant coatings have drastically reduced IPP infection. The coatings appear to have had the maximum impact on the CoNS local infections. What few infections remain are typically systemic infections presenting early and with substantial patient toxicity. Future studies need to address methods to culture biofilm-protected organisms and identify potential agents that might prevent the microorganisms from manufacturing biofilm.

The Role of Capsule Formation in Inflatable Penile Implants

Capsule Formation Around Cylinders Is Key for Lengthening the Implanted Penis

A foreign body placed in all human body locations with the exception of the peritoneal cavity stimulates the creation of a tough fibrous membrane possessing neovascularity. This capsule formation surrounds all the implant components. Frontier surgeons recognized the body's ability to "wall off" bullets. Gunshot wounds in the limbs were only operated upon to stop hemorrhage and the popular idea of extracting the bullet is simply Hollywood fiction. The frontier physician understood that within 3 months the bullet would be encapsulated and would cause no further mischief.

As a result of capsular formation, prosthetic urologists are educated to be wary of claims of lengthening cylinders. Capsule formation is generally thought to be completed by 3 or 4 months after implantation. Final cylinder length will be limited by capsule formation. If the capsule forms around the fully inflated cylinder, the cylinder will be allowed to lengthen. If the capsule fabricates around the cylinder while flaccid, the capsule will only allow that length of cylinder (Fig. 47.18).

Mature capsule formation around prosthesis cylinders can be broken by girth expansion. This routinely occurs in patients who experienced health issues in the post-operative period following IPP. The issues prevent sexual intercourse and the capsule forms around the deflated cylinders. Several months later forcible inflation can split the capsule girthwise (radially) due to the large amount of cylinder surface area expanding.

To the dismay of both patient and physician, the capsule is unable to be split lengthwise (axially) by forcible inflation. There is simply too small a surface contact at the distal end of the cylinder to the tip of the capsule. Acknowledgement of this principle forces the surgeon to encourage his/her patient to inflate maximally for long periods of time during the first 4 months following implant surgery. This daily inflation is recommended with lengthening cylinders such as the AMS 700LGX or if the patient is provided with an oversized cylinder. Without daily inflation during the capsule formation period, optimal penile length and cylinder expansion cannot be achieved. Inappropriate cylinder expansion in a restrictive capsule can result in a defect or "S"-shaped deformity [44] (Fig. 47.19).

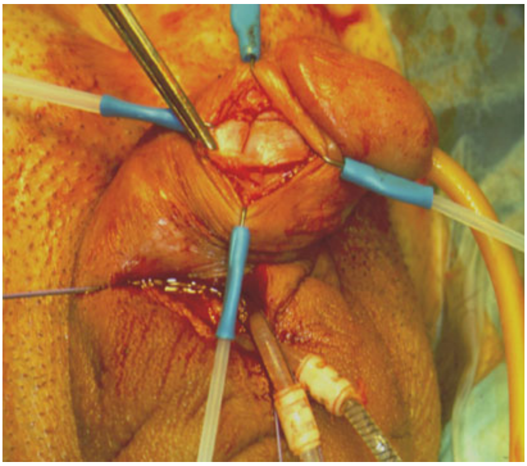


Fig. 47.18 Capsule sheath formed around cylinder

Vacuum Preparation of the Penis for Maximum IPP Length

The largest source of dissatisfaction in IPP patients is that the length of the erect penis following implantation is not as long compared to their natural erection prior to the development of ED [8]. This results from during a natural erection the tunica albuginea expands in both girth and length, whereas, following IPP implantation, the interposed capsule precludes the cylinders from maximally expanding the tunica. Tom Sellers, a physician assistant for Dr. Martin Dineen of Daytona FL, developed vacuum preparation of the penis as a solution to this persistent complaint. Sellers et al. were able to implant cylinders an average of 2–3 cm longer in patients undergoing 7 weeks of vacuum preparation of the penis. The patient places his penis in a vacuum device for 10 min twice daily and marks weekly progress on the vacuum tube (Fig. 47.20). The protocol additionally includes deliberate 1–2 cm oversizing the cylinder at surgery. The implanting surgeon determined the type of cylinder with selective use of the LGX (<21 cm) or Coloplast Titan cylinders (>18 cm). Patients were expected to be compliant with a regime of daily prolonged inflation during capsule development. Patients were reportedly very enthusiastic over resultant penile size, and no patients complained of decreased penile size following this 5–6-month regimen [45].

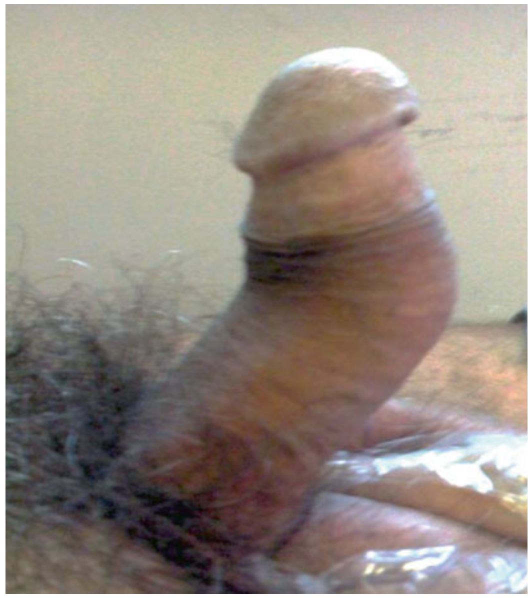


Fig. 47.19 "S"-shaped deformity of LGX cylinder caused by restrictive capsule

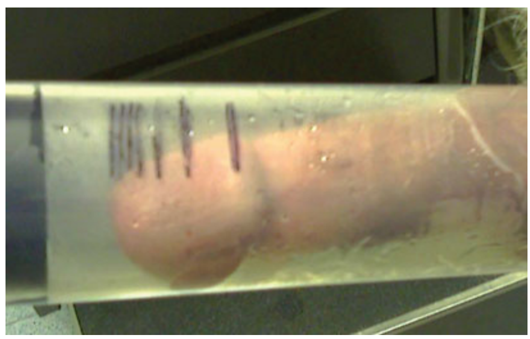


Fig. 47.20 During vacuum preparation of penis, patient marks weekly progress of stretching on vacuum tube cylinder

Utilization of Capsule for Repair of Impending Cylinder Erosion

The tough fibrous capsule can be used in repairs of impending cylinder erosion and reservoir herniation. Mulcahy first described incorporation of the capsule that formed around the cylinder for a distal corporoplasty in order to address the tip of the cylinder ectopically penetrating the tunica albuginea. This tunical penetration threatens to erode through the skin of the penis, through the

Fig. 47.21 Original Mulcahy picture of creation of distal tract but not exchanging cylinder (courtesy JJ Mulcahy, MD)

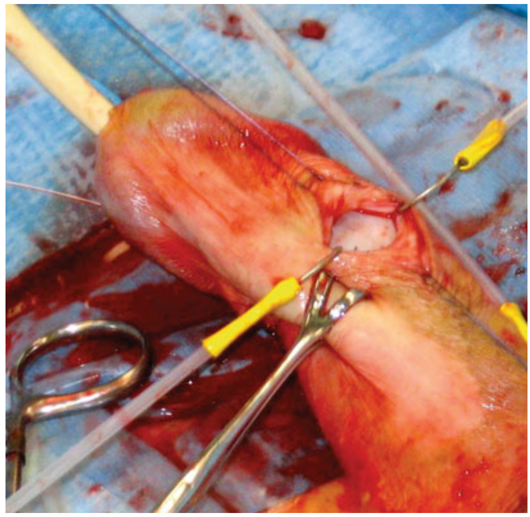


Fig. 47.22 Exposing capsular sheath. Babcock protects urethra. Make incision in posterior wall of capsular sheath

glans, or into the urethra. Mulcahy originally outlined the procedure keeping the original cylinder in situ [46] (Fig. 47.21). Today most authorities change out the components and "wash out" the implant spaces to decrease the risk of device infection [32].

After the components have been removed via penoscrotal or infrapubic incision, a hemicircumcising incision is made on the side of the extrusion. This incision is carried into the cylinder capsule and the medial wall of the capsule is visualized (Fig. 47.22). The medial or back wall of the sheath that contained the cylinders is then incised and a new plane developed behind this capsule underneath the glans penis. This creates a new tract for the distal tip of the cylinder. The new sterile component cylinder tip is guided into this newly created tract with the Furlow inserter (Fig. 47.23). This original interior capsule wall will now provide the outer covering of the penile prosthesis cylinder. Closure is accomplished by suturing closed the old impending erosion tract (Fig. 47.24). Perito reported a simplified distal corporoplasty specifically for cylinders with impending erosion of the tip into glans penis. His method incises the glans over the aberrant tip until the capsule is entered. Then, without removing the cylinder, an incision is made through the lateral capsular wall and a new place for the cylinder tip is developed. The cylinder tip is directed into this new area, and the capsule is closed to keep the tip in its new resting spot [47].

An alternative approach would be to place a windsock of synthetic material over the end of the prosthesis and to replace it into the corporal body as reinforcement for the distal tunica albuginea. However, this substitutes one foreign body close to the skin surface for another. Carson analyzed the two techniques: natural tissue repair versus windsock. He discovered that the former was more successful and less likely to get infected [48]. Carrion et al. used a more natural tissue (cadaveric pericardium) for the same windsock repair. Infection was minimal in his study [49]. It should be noted that the Mulcahy repair has stood the test of time, while the others are more recent developments presented as abstracts at sexual medicine meetings. While easier to perform than the Mulcahy repair, long-term results with these newer techniques must be reported before general adoption is suggested.

Use of Capsule for Repair of Reservoir Hernia

With ectopic reservoir placement becoming ever more popular, we can expect to see continued occasional reservoir hernias stemming from either traditional space-of-Retzius-placed components or abdominal-wall-placed balloons. Reservoir hernias do not require correction if not bothersome to the patient. The IPP functions adequately with a reservoir located in virtually any space. If the patient is disturbed by herniation of the reservoir, the capsule that forms around the herniated reservoir can be used for repair of the hernia if it is allowed to develop.

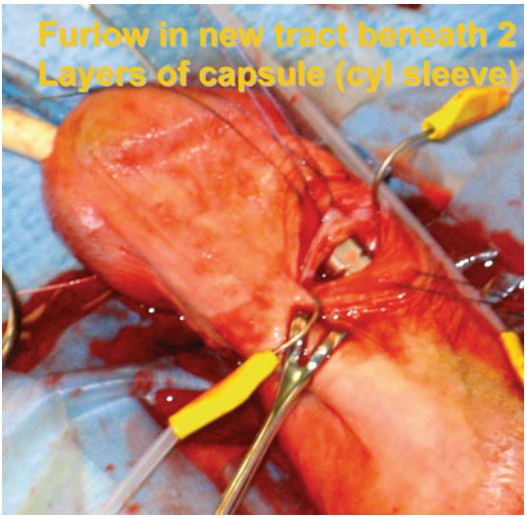


Fig. 47.23 Passage of Furlow medial to old capsular sheath to make new place for cylinder tip to rest

Reservoir hernias usually appear early in the patient's post-operative course. The operating surgeon should counsel patients and resist the temptation to intervene early in the post-operative period for two reasons. First, the reservoir hernia is much less palpable and troublesome to the patient after the capsule has formed around the reservoir and flattened its profile. Second, the tough fibrous capsule that forms around the herniated reservoir can be used as the basis for the repair of the misplaced component (Fig. 47.25).

The repair of reservoir herniation is not complex. The surgeon makes an abdominal incision over the palpable reservoir. The incision should be carried down to the capsule surrounding the reservoir. Incision of the anterior wall of the capsule and removal of the reservoir leaves it attached to the other components by its tubing. After displacing the reservoir out of its capsule, this maneuver allows access to the posterior wall of the reservoir capsule. The surgeon then makes a large incision in the posterior wall of

Fig. 47.24 Pre- and postop bilateral impending cylinder erosion

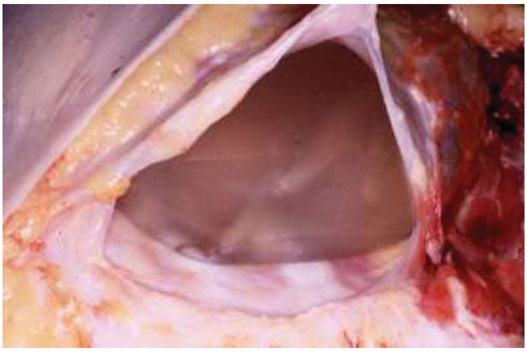


Fig. 47.25 Reservoir capsule formation, posterior wall used for reservoir hernia repair

the capsule. This opening allows for visualization of the transversalis fascia. If traditional reservoir placement is desired, the surgeon can find the old space or pierce the fascia and make a new reservoir location in the prevesical space. If ectopic or submuscular placement is desired, a new tract must be developed cephalad. Using a long ring forceps or nasal speculum, the tract can be developed anterior to the transversalis fascia but posterior to the muscle layers of the abdomen. Following placement of the reservoir in either location, the anterior and posterior walls of the capsule that had surrounded the herniated reservoir are used for closure. This capsule provides a durable hernia closure without the need to dissect out the muscle layers as is necessary with traditional inguinal hernia repair.

Conclusion

The senior author has witnessed 40 years of implantation, training, and involvement in prosthetic urology. At this point in time, revision for mechanical reason, infection, and patient satisfaction rates continue to exceed that of nearly any other mechanical human implant [2, 6]. IPP component technology and implant techniques continue to escalate as young prosthetic specialists cited in this chapter enhance this specialty's landscape. It is with great pride that the senior author has had a chance to view the evolution of such a unique therapy and the opportunity to be part of its enhanced science.

Surgical Pearls and Pitfalls

Key Surgical Points

- Both Coloplast and AMS prostheses can be used for implantation with similar outcomes.
- Both implant companies have devices available with small differences in order to optimize particular situations.
- An upper transverse scrotal incision verses infrapubic pubic incision for implantation can be successfully utilized.
- When an upper transverse scrotal incision is chosen, the corporal bodies can be quickly and most easily exposed by blunt finger dissection, with occasional sharp dissection with Metzenbaum scissors.
- Concomitant placement of a penile prosthesis and an artificial urinary sphincter can be performed via an upper transverse scrotal incision.
- The infrapubic pubic incision is making a resurgence in prosthesis placement.
- If ectopic reservoir placement is required, it should always anterior to the transversalis fascia.
- Device infection is drastically reduced in the era of coated implants.
- Utilizing the "no touch" surgical technique and coated implants, the infection rate can be reduced to 0.46 %.
- Peyronie's disease is present in 12–18 % of patients with penile prosthesis.
- One of the most difficult challenges is the insertion of penile implant cylinders into scarred corporal bodies.
- Post priapism corporal fibrosis is typically severe, and even worse distally.
- Forcible implant inflation can be utilized months later to split the capsule girthwise (radially).
- Unfortunately, forceable inflation is not effective at splitting the capsule lengthwise (axially).
- Vacuum use prior to prosthesis surgery helps to maximize inserted cylinder length.
- Corporal fibrosis often prevents traditional dilatation with the usual instruments, e.g., Hegar or Brooks dilators.

- Rossello cavernotomes are useful in scarred corporal bodies to create a channel in the scar tissue.
- Uramix cavernotomes contain a recessed knife blade and are also useful in creating a space in scarred corpora.
- When the corpora are scarred and cannot be dilated to 39Fr easily, consider placement of a narrow based implant.
- Proximal insertion is further facilitated by Coloplast's 0º cylinder/input tubing angle.
- The capsule provides a durable hernia closure without the need to dissect out the muscle layers, as is necessary with traditional inguinal hernia repair.

Potential Problems

- Dorsal penile nerve injury during the infrapubic approach can result in penile shaft and/or glans numbness.
- During a robotic assisted laparoscopic radical prostatectomy, the space of Retzius is dissected, and thus subsequent placement of the reservoir in this space can be very difficult.
- Scrotoplasty is typically preformed during closure of the upper transverse scrotal incision when the skin inserts high on the shaft or there is excessive webbing.
- Reservior placement in an ectopic or submuscular location is necessitated when the prevesical space is obliterated.
- Following implantation, if a biofilm of bacteria develops, the host's immune response can be blunted.
- If the capsule fabricates around the cylinder while flaccid, the capsule will restrict implant length upon inflation.
- Mature capsule formation around prosthesis cylinders can be broken by girth expansion, but length expansion is not possible.
- Inappropriate cylinder expansion in a restrictive capsule or oversizing can result in a "S"-shaped deformity.
- The tough fibrous capsule can be used in repairs of impending cylinder erosion and reservoir herniation.
- The capsule formed around the cylinder can be utilized for distal corporoplasty when the tip of the cylinder penetrating the tunica albuginea is threatening to erode through the skin of the penis, through the glans, or into the urethra.
- An alternative approach would be to place a windsock of synthetic material over the end of the prosthesis and to replace it into the corporal body, as reinforcement for the distal tunica albuginea.
- Resist the temptation to intervene early in the post-operative period for hernia formation.
- Capsule formation around cylinders is the limiting factor for the final length of the implanted penis.
- If the capsule forms around the fully inflated cylinder, the cylinder will be allowed to lengthen.
- Without daily inflation is important during the capsule formation period, in order to achieve maximal penile length and cylinder expansion.
- Reservoir hernias appear early in the patient's post-operative course.

Editorial Comment

This is a comprehensive chapter which provides much useful information; the authors are to be congratulated. We size our IPP cylinders aggressively, but precisely, neither adding nor subtracting from the full measured length of the cylinder. Malleable cylinders, on the other hand, must be intentionally undersized by 1–2 cm to prevent chronic pain and tissue fatigue. We like to use the AMS 700LGX in smaller patients to provide some length expansion. We like to use the Coloplast Titan in larger patients to provide added proportionate girth. For difficult reoperative cases, a longitudinal extension of the incision along the length of penile shaft provides added exposure for a second corporal incision, thereby allowing controlled dilation of the distal corpora. The Mulcahy subcapsular repair has worked well for us, and we have not needed to change out the cylinders in these cases. Any old noninfected reservoirs may be safely left behind ("drain and retain") without putting the patient and surgeon through the unnecessary trauma of a difficult (and sometimes treacherous) groin dissection. We now place all prosthetic balloons and reservoirs via a high submuscular tunnel using a long Foerster lung grasping clamp passed up from the penoscrotal incision. This is a safe and secure dissection plane which is "virgin" in all patients, whether they have had prior implants, mesh hernia repairs, neobladder, renal transplants, or any other major pelvic surgery, as most of our patients have had.

I have not had good luck with implant modeling for correction of angulation or deformity—it just has not proven to be effective in straightening in our hands. Modeling also has inherent risk—I have heard of patients sustaining corporal or urethral rupture during modeling. Instead, we question all patients carefully about curvature preoperatively and correct that via plication prior to cylinder insertion. Obtaining the history of curvature is reliable in our experience—we believe that all patients know what theirs look like! Office injections have not proven to be necessary. We have noted that each plication stitch provides roughly 6° of correction, and we place as many as needed to straighten the shaft. We use 2-0 Ethibond, and the sutures are not bothersome. This approach is controlled and reliable.

—Allen F. Morey, MD

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Artificial Urinary Sphincters: Reoperative Techniques and Management of Complications

48

Landon Trost and Daniel S. Elliott

Abbreviations

AUS Artificial urinary sphincter
SIS Small intestinal submucosa
SUI Stress urinary incontinence
TURP Transurethral resection of the prostate

Summary

Male stress incontinence is a relatively common and treatable condition which significantly impacts quality of life. For over 40 years, the artificial urinary sphincter (AUS) has remained the gold standard therapy for moderate to large volume male stress urinary incontinence. Patients being considered for AUS placement should undergo a full preoperative history and physical examination with further studies, as clinically indicated. Despite excellent first-time success rates, a percentage of men managed with AUS will experience complications including urinary retention, urethral atrophy, erosion, and device malfunction, among others. Available surgical options for patients with either recurrent incontinence following initial AUS placement or those with prior AUS complications include placement of a tandem cuff, transcorporal cuff, cuff downsizing, reservoir upsizing, or tissue interposition with AUS. Here-in is a review of the available literature, as well as a clinical guide to management of AUS complications, and a visual and descriptive overview of reoperative techniques. In addition to technical advancements with the AUS, ongoing research with salvage therapies will continue to improve outcomes for patients experiencing stress incontinence.

Introduction

Urinary incontinence is estimated to affect up to 19 % of men, with 10 % of cases further stratified as stress urinary incontinence [1–4]. Although multiple etiologies exist for incontinence, prostatectomy remains the most common iatrogenic etiology with published rates ranging from 2 to 43 % [5–9]. The wide disparity in outcomes is likely secondary to multiple factors including surgical technique, reporting methodology, and follow-up, among others. Given the prevalence and treatable nature of the condition, stress urinary incontinence remains an important topic with significant implications on quality of life issues.

Since the initial concept was introduced in 1949, the artificial urinary sphincter (AUS) has undergone multiple improvements and modifications which have resulted in its current role as the gold standard treatment for stress

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incontinence. Currently, the most commonly surgically implanted artificial sphincter is the AMS 800 (American Medical Systems, Minnetonka, MN). The device consists of a three-piece system with an inflatable urinary cuff, reservoir, and pump. Cuff sizes vary according to application and range from 3.5 to 14.0 cm, with available reservoir pressures ranging from 41–50 to 81–90 cmH_2O. The pump serves several functions including cuff cycling, permit cuff deactivation, and restrict retrograde transmission of reservoir fluid to the urinary cuff.

Although the AUS has reported success rates of 59–91 %, surgeons who routinely treat stress urinary incontinence frequently are required to manage device and surgical complications, as well as recurrent incontinence resulting from various etiologies [10–15]. To address these issues, the goal of the current chapter is to provide a brief overview of standard AUS placement, preoperative evaluation, and perioperative management followed by discussion of AUS-related complications and surgical description of various reoperative techniques.

Preoperative Evaluation

Patients initially presenting with stress urinary incontinence should undergo a thorough history and physical examination with further testing tailored to each clinical scenario. Important aspects of the preoperative history include a review of the underlying etiology for the incontinence (e.g., prostatectomy, transurethral resection of the prostate [TURP]), degree of incontinence (number of pads, objective pad weights), prior therapies performed, history of urethral or bladder pathology (stricture disease, urothelial carcinoma), radiation therapy, associated lower urinary symptoms, urinary tract infections, bladder calculi, as well as a review of the patient's capacity to maintain his activities of daily living without need for assistance from caregivers. Patients should be at least 6–12 months out from the inciting cause (e.g., TURP, prostatectomy) to assure stabilization of the incontinence. Additionally, pathology requiring repeated transurethral interventions such as recurrent urothelial carcinoma of the bladder should be factored into the decision as to the patient's candidacy for AUS placement.

In addition to obtaining a thorough history, patients should be examined to assess their mental and physical capacity to self-manage the AUS. Patients should have sufficient dexterity to cycle the pump without assistance and should be free of mental pathology (e.g., dementia) which might otherwise compromise overall health. Examination should include direct confirmation of the stress urinary incontinence, either from a standing or reclined position, and may be performed concomitantly with other procedures, such as cystoscopy.

Patients who are candidates for surgery should undergo assessment of surgical fitness as well as routine testing including CBC, electrolyte with creatinine, urinalysis with culture if appropriate, and post-void residual assessment. Additional testing may be obtained when clinically indicated. It is our practice to obtain routine cystoscopies on all patients undergoing AUS placement to rule out concomitant urethral/bladder pathology, as well as to directly visualize the sphincter and degree of incontinence with a filled bladder. Urodynamic testing is not routinely performed and is reserved for patients with suspected elevated bladder pressures, decreased compliance, neurogenic bladder, or those with indeterminate initial evaluations [16].

Surgical Implantation of AUS

Following appropriate anesthetic induction, patients are positioned in the dorsolithotomy position with the perineum shaved and cleansed with antiseptic solution (e.g., chlorhexidine). A 12-French catheter is placed, and the urethra is palpated as it traverses the urogenital diaphragm. A lower midline incision is made in the perineal region, posterior to the scrotum and overlying the proximal bulbar urethra (see Fig. 48.1). The underlying subcutaneous tissues are dissected to isolate the bulbar urethra as proximally as possible to provide additional tissue support for AUS placement. A self-retaining Gelpie and hand-held Young retractor

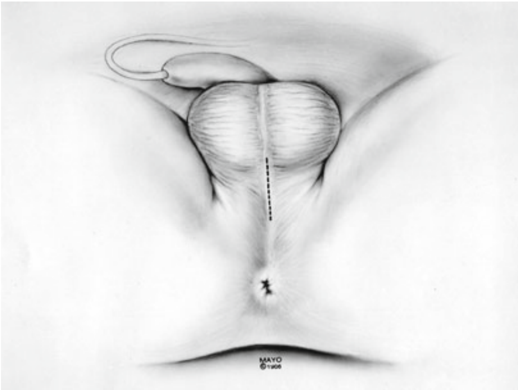

Fig. 48.1 Illustration demonstrating appropriate location of perineal incision for AUS placement

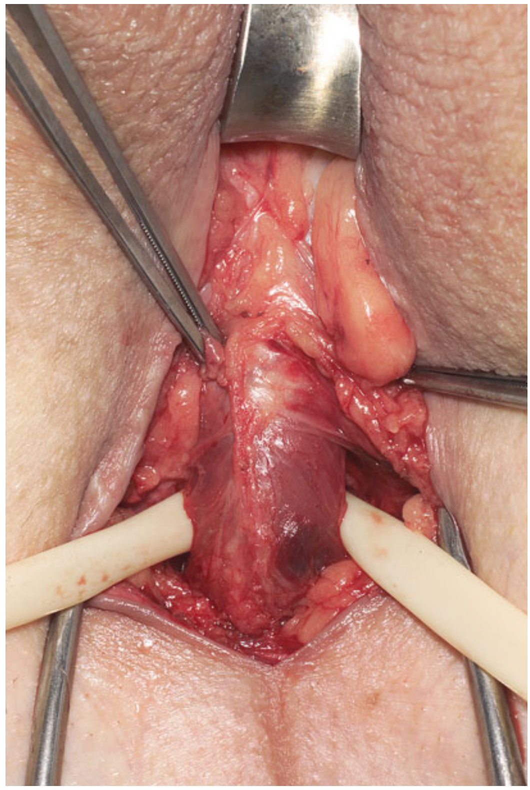

Fig. 48.2 Intraoperative photo demonstrating proximal bulbar urethral dissection

are placed for assistance with visualization. The bulbar urethra is further dissected with a plane created between the corpus cavernosum and spongiosum sufficient to permit placement of the sphincter cuff. Care is taken during dissection to avoid inadvertent injury to the urethra during perforation of the intercorporal septum as the overlying corpus spongiosum is thin in this region. A syringe is next placed alongside the catheter with the urethral meatus occluded and the catheter placed on tension. Indigo carmine is forcefully infused to directly assess any previously unrecognized urethrotomies. Figure 48.2 demonstrates appropriate dissection of the proximal bulbar urethra.

The bulbar urethra is next measured and an appropriately sized cuff size selected. Manipulation of the prosthetic components is minimized during surgery with strict attention paid to sterile technique throughout the procedure. Rubber-shodded clamps are utilized when necessary for occlusion of the device tubing to prevent inadvertent crush injury and damage to the device. If a right-sided pump placement is desired, a right angle instrument is passed deep to the bulbospongiosus from the right to the left with the cuff tab grasped. The cuff is then passed posterior to the bulbospongiosus and secured by passing the cuff tubing through the open tab.

Following placement of the urethral cuff, a reservoir size is selected, with the most common pressure utilized of 61–70 cmH_2O. Decreased reservoir pressure may be selected when concern exists for possible erosion including prior sphincter placements and radiation therapy. An approximately 5 cm, transverse incision is made several centimeters cephalad and lateral to the pubic symphysis on the ipsilateral side to the anticipated pump location. Alternatively, prior surgical scars may be utilized if present. The anterior rectus fascia is incised and pocket created deep to the rectus muscle. A right angle is passed through a separate, more cephalad incision in the fascia, after which the reservoir tubing is grasped and passed. This results in placement of the reservoir deep to the rectus muscle. The reservoir is filled with 22 cc of isosmotic contrast material (24 cc if tandem cuffs are placed) and the tubing clamped. Of note, some surgeons advocate avoiding the use of contrast material with the reservoir so as to avoid hypothetical damage to the prosthetic equipment. It has been our experience that the use of contrast assists in device troubleshooting and has not resulted in deterioration of device functionality.

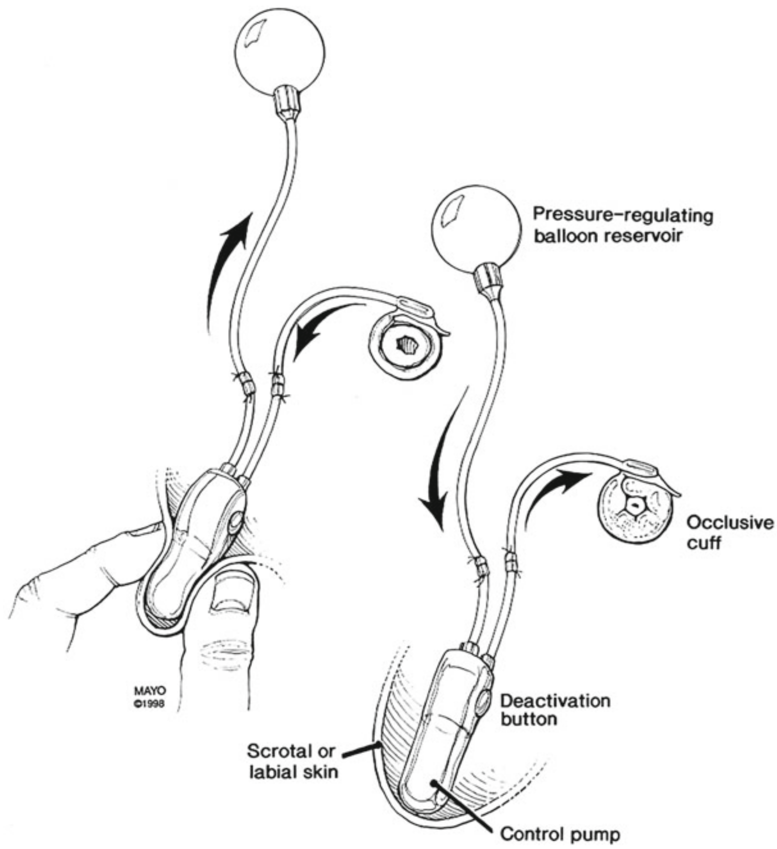

Fig. 48.3 Illustration demonstrating cycling of AUS device

Following reservoir placement, the fascia is closed, and a Hagar dilator is passed from the abdominal incision through the subcutaneous tissue towards the right testicle. Care is taken to direct the dilator to the anterolateral position towards the desired final position for the scrotal pump. The dilator is withdrawn and the pump placed in the newly created space. A Babcock clamp is placed around the pump tubing on the external surface of the scrotum with downward traction applied to prevent proximal migration of the pump during device connection. The pump is then secured to the reservoir using either the Quick Connect System or Prolene suture, according to surgeon preference. A long clamp is then passed from the abdominal incision towards the perineal incision, with the cuff tubing grasped. This is then retracted to the abdominal incision with the second connection secured. The wounds are then closed, and a sterile dressing is applied. Figure 48.3 demonstrates final connections of the AUS.

Perioperative Considerations

At the conclusion of AUS placement, the device is deactivated, and a 12-French catheter is placed overnight. Although perioperative management is surgeon specific, it is our practice to remove the catheter the morning following the procedure and to utilize in-and-out catheterization with a 12-French catheter in the case of postoperative urinary retention. The patient is instructed to retract the pump caudally twice daily until the 6-week follow-up, at which time the device is activated.

For antibiotic management, patients are administered one dose of vancomycin and gentamicin preoperatively, which is continued for 24 h following the procedure as per the AUA best practice statement on antimicrobial prophylaxis [18]. Although not discussed in the consensus statement, it is our practice to dismiss patients on a 7-day course of cephalexin to assure appropriate coverage of likely pathogens [19].

Table 48.1 Comparison of outcomes with single-cuff AUS placement for male SUI

Authors	Pts (no.)	Mean f/u (years)	Success (%)	Explanation (%)	Complications (%)
Arai et al. [15]	58	4.2	91.4	20.3	Mechanical failure (6.5 %) Infection (14 %) Erosion (4.7 %)
Kim et al. [13]	124	6.8	82	36 (incl revision)	Mechanical failure (29 %) Infection (7 %) Erosion (10 %)
O'Connor et al. [11]	25	6.2	61	16	Mechanical failure (0 %) Infection (8 %) Erosion (8 %) Atrophy (4 %)
Lai et al. [10]	218	3	69	27.1 (incl revision)	Mechanical failure (6 %) Infection (5.5 %) Erosion (6 %) Atrophy (9.6 %)
Gousse et al. [12]	71	7.7	59	29 (incl revision)	Mechanical failure (25 %) Infection (1.4 %) Erosion (4 %)
Venn et al. [14]	23	Median 11	84	37	Mechanical failure (34 %) Infection/erosion (37 %)

Management of Complications

Intraoperative Complications

The most common complication encountered intraoperatively is injury sustained to the dorsal bulbar urethra at the time of initial dissection. Care should be taken during dissection of the 12 o'clock position of the bulbar urethra and during perforation of the intercorporal septum so as to avoid the urethra. Following bulbar urethral dissection, indigo carmine is forcefully injected alongside the catheter with the catheter placed on tension and the urethral lumen occluded.

In the case of a small, intraoperatively recognized urethral injury, this may be closed primarily with the AUS placed at a separate location. With larger urethral injuries, AUS placement should be abandoned with the urethrotomy closed primarily and a catheter placed. Final placement of the AUS may be rescheduled following complete resolution of the urethral injury.

Cautery injury occurring on the urethra may be managed with an indwelling catheter alone versus primary debridement with primary anastomosis. In contrast to sharp urethral injury, cautery injuries typically result in a larger region of damage sustained, thus more frequently necessitating cancellation of AUS placement.

Postoperative Complications

Complications occurring with AUS placement are typically categorized as occurring early (<90 days) or late (>90 days) in the postoperative period. The most commonly encountered complications in the early postoperative period include urinary retention, infection, and erosion, while late complications are predominantly urethral atrophy, sphincter erosion, infection, or device malfunction. See Table 48.1 for comparison of contemporary outcomes and complications of AUS placement.

Early Postoperative Complications

Urinary retention occurring in the postoperative period is most frequently a self-limited condition secondary to edema which resolves spontaneously. Although no currently accepted standard for management exists, it is the authors' preference to limit instrumentation to in-and-out catheterization with a 12-French catheter and to avoid indwelling catheters in an attempt to limit the chances for cuff erosion. Persistent urinary retention lasting >30 days is likely secondary to inappropriate cuff sizing, reservoir selection, or device malfunction and frequently requires reoperation.

Infections occurring in the immediate postoperative period are reported in 1–3 % of uncomplicated cases and in 10 % of patients with prior radiation or pelvic surgery and are felt to be secondary to intraoperative contamination [20–24]. Commonly cultured organisms include *S. aureus*, *S. epidermidis*, *Enterococcus*, Methicillin-resistant *S. aureus*, and gram-negative bacilli [19].

Artificial urinary sphincter cuff erosions occurring <30 days from the date of surgery are most likely secondary to unrecognized urethral injury at the time of surgery. These may be managed similar to erosions occurring later in the postoperative course and require device explantation with catheter placement. A device may be reimplanted following an adequate period of healing.

Late Postoperative Complications

Urethral atrophy is one of the most commonly encountered complications from sphincter placement and is reported to occur in 4–10 % of patients at a mean follow-up of 3–6 years [10, 11]. Although the underlying mechanism is not fully understood, continuous compression from the sphincter likely leads to tissue remodeling with a resultant decrease in tissue volume. This would suggest that the 4–10 % reported likely underestimates the true prevalence of the condition given the limited follow-up periods examined. As a prophylactic measure, patients may benefit from nocturnal device deactivation to hypothetically reduce their chances of urethral atrophy and subsequent recurrence of incontinence [25]. Once urethral atrophy has occurred, several possible management strategies exist and are discussed later in the chapter. Figures 48.4 and 48.5 demonstrate intraoperative and cystoscopic findings of urethral atrophy, respectively.

Erosions of the AUS cuff occurring >90 days from the date of surgery may be secondary to progressive urethral atrophy or device instrumentation and likely represent more advanced disease

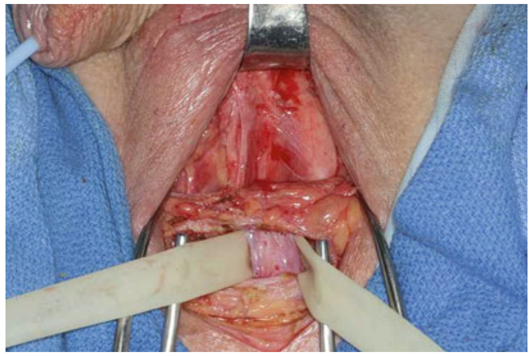

Fig. 48.4 Intraoperative photo demonstrating severe urethral atrophy

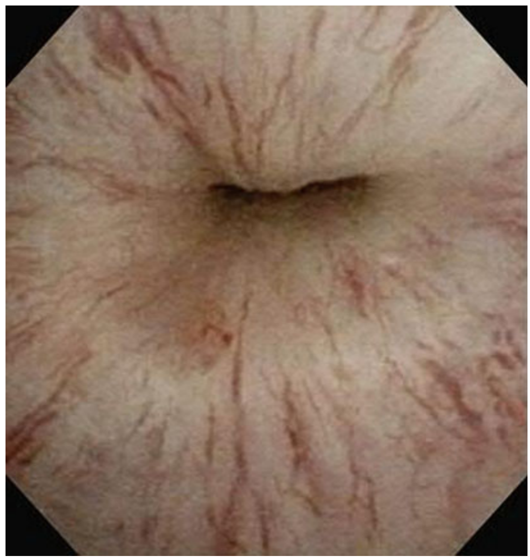

Fig. 48.5 Cystoscopic findings of urethral atrophy

along the urethral atrophy spectrum. Erosions and subsequent infections are reported to occur 1.4–14 % of AUS placements at a mean follow-up of 3–7.7 years [10–13, 15]. With further follow-up, Venn and colleagues reported rates of erosion and infection as high as 37 % [14]. Similar to urethral atrophy, device erosion and infection is likely progressive in nature with increasing rates expected with additional follow-up. Figure 48.6 demonstrates cystoscopic confirmation of AUS cuff erosion.

Infections presenting in a delayed manner are thought to occur through hematogenous spread

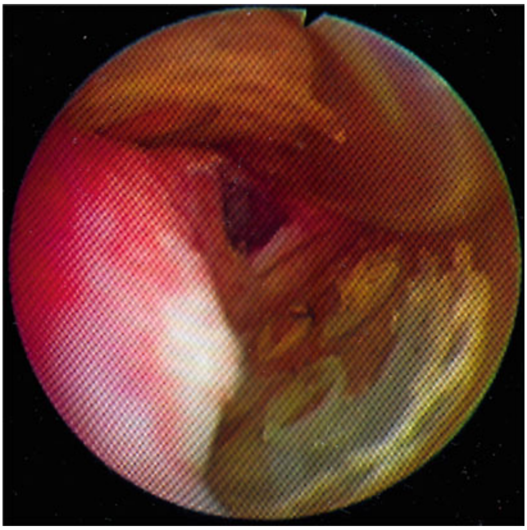

Fig. 48.6 Cystoscopic findings of urethral erosion

of bacteria. Due to this finding, some urologists recommend antibiotic prophylaxis in patients undergoing dental or other surgical procedures which may result in hematogenous spread of bacteria. However, there is no current consensus on the need for further antibiotic prophylaxis following the initial 24-h period [18].

As with any mechanical device, the AUS has a limited life expectancy prior to device malfunction and failure. Current estimates are difficult to accurately capture given the ongoing nature of device improvements and limited prospective data. Contemporary studies examining device failures with follow-up over 5 years have reported a malfunction rate of 25–34 % [12–14, 17]. A longer-term analysis performed in Japan revealed 5- and 10-year failure-free rates of 74.8 and 70.1 %, respectively, suggesting a leveling-off of malfunction rates after the initial 5-year period [15]. It is expected that ongoing improvements in design will result in further advancements in device longevity.

Clinical Evaluation of Complications

Patients who experience postoperative complications typically present with varied symptoms including frequency, urgency, dysuria, hematuria, urinary tract infection, diminished urinary stream/urinary retention, recurrent incontinence, perineal or scrotal pain/erythema/edema, or systemic signs of infection including fever or chills. Following routine history and physical examination, further testing may be tailored according to clinical impression.

Patients with new onset of urethral erosion or device infection typically present with acute onset of irritative voiding symptoms early in their course including frequency, urgency, and dysuria and may progress to experience localized or systemic signs of infection of scrotal/perineal pain, warmth, erythema, cellulitis, fevers, or chills. Laboratory testing should include a urinalysis with culture to assess for RBC, WBC, and bacteria, with additional blood work and cultures obtained based on clinical presentation. Cystoscopy performed will frequently identify the region of erosion with the cuff material able to be visualized (see Fig. 48.6). In the case of severe infection, a CT of the pelvis may assist in identifying any fluid or gas collections which may require more emergent management.

In contrast to erosions, urethral atrophy typically presents as a progressive return of incontinence over a period of several months to years despite appropriate device function and utilization. Urinalysis and laboratory work are frequently non-revealing, and inflate/deflate films (if contrast was utilized at the time of device placement) demonstrate appropriate contrast shifts. Cystoscopy visualizes an incompetent sphincter mechanism with inability to completely occlude the urethral lumen and preserved ability to cycle the device. Patients with urethral erosion rarely present with localized or systemic signs of infection and require minimal further evaluation.

Other findings which may present with a return of incontinence include device malfunction, inappropriate device utilization (i.e., “patient malfunction”), or de novo detrusor instability. In the case of a malfunctioning sphincter, symptoms are typically acute in onset with either urinary retention or incontinence experienced. Inflate/deflate films will reveal an absence of transfer of contrast from the cuff to the reservoir, and cystoscopy similarly will identify no change in the urethral cuff with device cycling.

Although presenting with a similar initial history to those with device malfunction, patients who are incorrectly utilizing the device (either due to lack of education, dexterity, or cognitive function) will have negative inflate/deflate films and an appropriately functioning sphincter at cystoscopy. These patients may be monitored while attempting to urinate to assess their capacity to function the pump and may ultimately require permanent device deactivation or removal to prevent long-term damage to the kidneys and bladder.

Patients presenting with de novo irritative voiding symptoms following device placement should undergo a full evaluation including urinalysis, cystoscopy, post-void residual, and may be considered for urine cytology and urodynamics as clinically indicated.

Reoperative Techniques and Considerations

Although the majority of AUS placements result in a durable improvement with associated improved quality of life, surgeons treating stress incontinence will frequently encounter the need for repeat operations due to prior device malfunction, erosion, or infections [10–15, 26]. Available surgical options include placement of a tandem cuff, transcorporal cuff, cuff downsizing, reservoir upsizing, or incorporation of alternative materials at AUS placement. The decision as to which procedure is most appropriate for each patient is surgeon dependent and includes variables such as preoperative radiation, presence of prior AUS procedures, erosions, or infections, caliber of bulbar urethra, location of original AUS placement, and time since previous surgery. To our knowledge, there is no current data comparing one surgical technique to another for treatment of recurrent stress incontinence after initial AUS placement.

Explantation of Existing AUS

When performing explantation of an existing device, either for subsequent replacement or due to infection, dissection is performed similar to as described with initial AUS placement. Cautery is predominantly utilized as this will prevent inadvertent damage to the prosthetic equipment with possible retained portions. Additionally, cautery will prevent damage to the mechanics of the device if only portions of the device are to be exchanged. Although the reservoir and pump are commonly replaced at the time of repeat procedures, these may remain in situ according to surgeon preference if the device is relatively recently placed with plans to either perform a tandem cuff and/or conversion to transcorporal cuff placement. This may prevent additional surgical morbidity, need for surgical dissection, and exposure of the device to potential infection.

Tandem Cuff Placement

Patients experiencing recurrent incontinence secondary to urethral atrophy following initial AUS placement are frequently managed with tandem cuff placement [27, 28]. Dissection is performed similar to initial AUS placement with the existing cuff location dissected and the cuff tubing exposed. As many first-time AUS procedures result in cuff placement in the mid-bulbar urethra, the bulbar urethra is further examined to determine whether a second cuff may be placed more proximally. Figure 48.7 demonstrates successful dissection and explantation of an existing, distal primary AUS cuff (located superiorly) with a secondary site of cuff placement identified proximally. Figure 48.8 highlights the significant amount of proximal tissue present (~5 cm) between the existing primary cuff (located superiorly) and the secondarily placed tandem cuff (located inferiorly). A more proximal AUS placement is optimal given the additional tissue support to the bulbar urethra. Distally placed cuffs may result in premature urethral atrophy or inability to place a cuff small enough to provide sufficient tissue urethral occlusion. These images additionally illustrate the need for adequate tissue interposition between cuff placements to avoid premature device erosion, malfunction, and

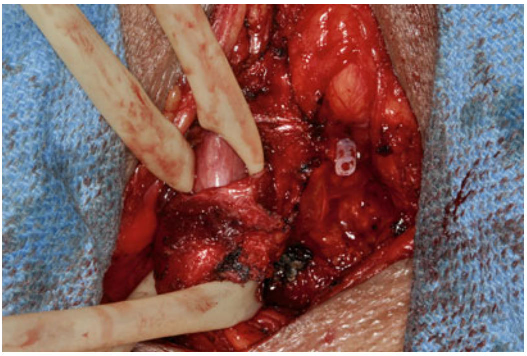

Fig. 48.7 Intraoperative photo demonstrating removal of distal existing cuff and newly dissected proximal bulbar urethral for tandem cuff placement

Fig. 48.8 Intraoperative photo of tandem cuff placement with distal existing cuff and newly placed proximal cuff

excessive urethral pressures. Figure 48.9 further demonstrates the appropriate location of the cuff proximally on MR imaging.

Once the secondary cuff has been placed, a Y-connector device is utilized to join the two cuffs to the pump (see Fig. 48.10). An additional 2 cc of contrast material or saline is then injected into the reservoir to account for the additional 2 cc of necessary fluid volume.

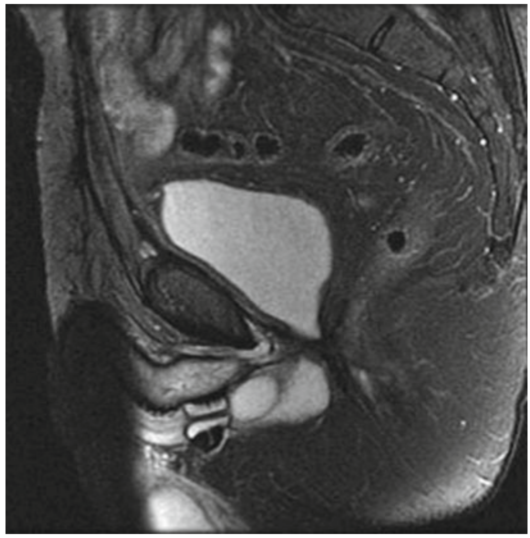

Fig. 48.9 Sagittal MRI demonstrating proximal location of AUS cuff

It is noteworthy that some authors advocate initial placement of a tandem cuff in all patients presenting with SUI. Hypothesized benefits of initial tandem cuff placement include improved initial postoperative incontinence as well as potentially avoiding a secondary procedure in a small percentage of men; however, potential disadvantages are overtreatment of a large percentage of patients and removing tandem cuff as a potential secondary treatment option. To further assess the advantages of one surgical approach over another, O'Connor and colleagues compared initial single to tandem cuff placements and found an increased risk of complications without improved rates of postoperative incontinence [11].

Transcorporal Cuff Placement

An additional technique which may be utilized in a primary or adjunctive scenario is transcorporal AUS cuff placement [28–30]. The procedure is performed similar to primary AUS placement with the proximal bulbar urethra dissected. When an

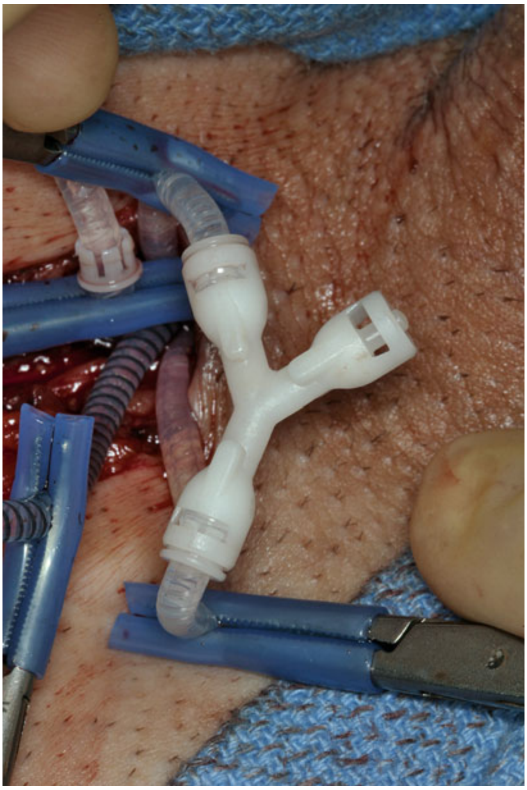

Fig. 48.10 Y-connector used with Quick Connect System for tandem cuff placement

existing cuff exists, dissection is performed predominantly with electrocautery, as previously described. Once a suitable location for AUS placement has been identified with the existing AUS cuff removed (if applicable), further dissection is performed dorsal to the bulbospongiosus. The corporal bodies are perforated with the ventral portion of the corpora included with the bulbospongiosus. Figure 48.11 demonstrates the initial dissection of the corpus cavernosum with the clamp passed deep to the corporal fascia. The plane is subsequently carried through to the contralateral side with the cuff placed as previously described. This ultimately results in additional tissue bulk in an attempt to reduce the incidence of urethral atrophy. See Fig. 48.12 for example of transcorporal tissue dissection. Transcorporal cuff placement may additionally be used in cases where prior erosions have occurred, in distal AUS cuff placements, or when insufficient tissue exists to permit adequate occlusion of the urethral lumen.

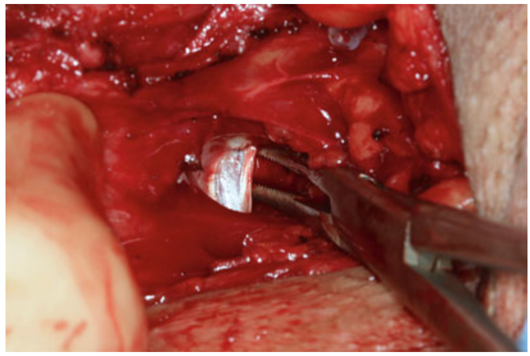

Fig. 48.11 Intraoperative photo demonstrating initial dissection plane for transcorporal cuff placement

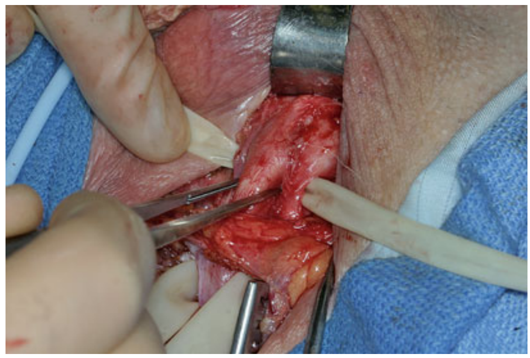

Fig. 48.12 Intraoperative photo demonstrating transcorporal dissection for tandem cuff placement

Cuff Downsizing/Reservoir Upsizing

With the release of a smaller, 3.5-cm AUS cuff, patients with urethral atrophy may undergo cuff downsizing in addition to or in lieu of tandem or transcorporal cuff placement. The surgical procedure is performed similar to primary AUS placement with the smaller cuff exchanged in place of the existing cuff. Device attachments and reservoir pressures are similar to those previously described. Although limited data and no long-term results are currently available on this technique, Hudak and colleagues recently reported on 45 patients undergoing 3.5-cm cuff placement with similar outcomes, infection rates, and erosions encountered compared to patients undergoing a larger cuff size placement [31]. Further study and long-term follow-up is required

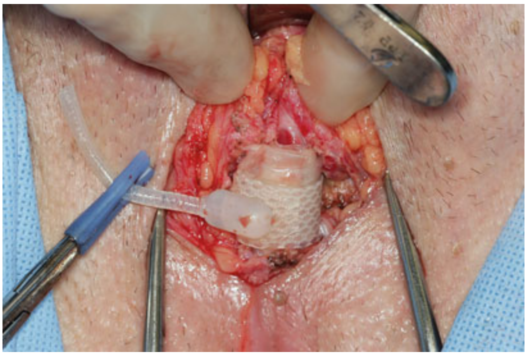

Fig. 48.13 Intraoperative photo of SIS urethral wrap and AUS cuff in situ

to assess the utility of the 3.5-cm cuff as a salvage option for management of recurrent incontinence secondary to urethral atrophy.

Similar to cuff downsizing, the reservoir pressure may be increased to provide additional occlusion to the urethra. To our knowledge, there is no current literature reporting on outcomes of patients managed in a salvage fashion with increased reservoir pressure alone. One potential concern with either cuff downsizing or reservoir upsizing is further progression of the underlying urethral atrophy with possible increased risk of eventual urethral erosion. However, this remains inconclusive without additional data available.

Tissue Interposition

Patients with numerous prior erosions, infections, and procedures including primary and salvage AUS placements represent a challenging treatment population for whom few therapeutic options exist. Rahman and colleagues initially reported on five patients undergoing placement of a porcine small intestinal submucosal wrap (SIS) around the urethra as a bulking agent in patients who would otherwise be unable to receive a 4.0-cm cuff (prior to release of 3.5-cm cuffs) [32]. The procedure is performed similar to standard AUS placement with the exception of the SIS material being folded and wrapped circumferentially around the segment of bulbar urethra. The material is then sutured to itself to prevent unraveling and the cuff placed over top. An intraoperative cystoscopy is subsequently performed to assure urethral patency and coaptation with sphincter cycling. Consideration is also given towards intraoperative placement of a suprapubic tube, as these patients may experience a higher rate of postoperative urinary retention. See Fig. 48.13 for image demonstrating final placement of SIS urethral wrap with AUS cuff.

To assess the efficacy of tissue interpositioning, our group subsequently reported on long-term outcomes of eight patients with refractory, total incontinence having undergone a combined 19 prior AUS procedures including six tandem cuffs and eight prior erosions. Three patients (38 %) experienced a long-term return of continence with the remaining five (63 %) experiencing recurrent total incontinence. Four of the five treatment failures had undergone radiation previously, highlighting the importance of appropriate patient selection prior to consideration of this treatment. To our knowledge, no additional alternative therapies currently have been described for this difficult to treat patient population.

Conclusion

Stress urinary incontinence is a challenging problem with significant impact on a patient's overall quality of life. Although primary placement of an AUS results in a high rate of success, a percentage of patients will experience postoperative complications including, retention, erosion, infection, urethral atrophy, and recurrent incontinence. Following appropriate management of acute complications, long-term options for recurrent SUI may include tandem or transcorporal cuffs, cuff downsizing, reservoir upsizing, or additional tissue interposition. While further advancements in prosthetic design and surgical techniques will likely result in continually improved outcomes, ongoing study is required to further identify appropriate treatment strategies among patients with recurrent or refractory incontinence.

Surgical Pearls and Pitfalls

Key Intraoperative Surgical Points

- Strict sterile technique; minimal prosthetic handling
- Utilize shod clamps for occluding prosthetic tubing
- Perform dissection of bulbar urethra as proximally as possible
- Following bulbar dissection, indigo carmine is forcefully injected along the catheter to assess for urethral injury
- With tandem cuff placement, place second cuff several centimeters apart from original cuff with tissue interposition
- Assure caudal placement of pump in scrotum; grasp with Babcock to prevent proximal migration

Potential Intraoperative Surgical Problems

- Careful dissection of bulbar urethra at 12 o'clock position to avoid urethral injury
- Limit dissection posterior to proximal urethra to avoid rectal injury
- Assure caudal placement of the scrotal pump to prevent proximal migration

List of Preferred Surgical Instruments for AUS Placement

Favorite Surgical Instruments

Gelpie retractor

Young retractor

Hagar dilator

Babcock

Editorial Comment

Urinary incontinence after prostatectomy is a disastrous complication which exerts profoundly negative effects on quality of life for the patient and his family. All efforts should be channeled towards resolving the problem in a single operation following the principles of proper patient selection, careful technique, proximal bulbar cuff placement, and appropriate cuff sizing.

Although slings have attained mainstream status for the treatment of men with mild SUI, the AUS remains the treatment of choice for severely incontinent patients. Although sling placement after AUS has been described for those with persistent SUI, we have abandoned that approach. Similarly, we have abandoned tandem cuff placement since the distal bulb uniformly has sparse spongiosum resulting in poor coaptation. We continue to see men with persistent SUI after tandem cuff procedures who have been successfully salvaged after replacement with a new single proximal 3.5-cm cuff. Although transcorporal cuff placement may be helpful for salvage procedures, we relegate this for cases with prior cuff erosions or those with prior urethroplasty.

Most authorities now agree that AUS cuff placement is best performed via a perineal incision (as opposed to penoscrotal), especially in reoperative cases given the additional scar in the surgical field. We consider AUS surgery to be a "game of millimeters"; we avoid cuff oversizing, often associated with suboptimal coaptation and persistent SUI. The 3.5-cm cuff continues to be the predominant size utilized in our institution; erosion rates have been slightly higher (virtually always in radiated patients), but revision rates are very low in comparison to other cuff sizes. In the event of erosion, we perform in situ ventral urethral reconstruction with full-thickness 2-0 Monocryl sutures at the time of cuff explantation to avoid stricture, followed in 6 months by transcorporal cuff placement.

—Allen F. Morey

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Reconstruction and Salvage of Failed Male Urethral Slings

49

Jack M. Zuckerman and Kurt McCammon

Summary

Male urethral slings are becoming an accepted treatment for men with persistent post-prostatectomy incontinence (PPI) who do not desire, or are not candidates for artificial urinary sphincters (AUS). Initial and midterm results following AdVance sling placement have been encouraging, with success rates approaching 70–80 %. Patients with persistent or recurrent PPI following sling placement may be candidates for salvage treatments, depending on patient preference. After removal of the original mesh, repeat AdVance slings are placed in a similar manner to the primary procedure, other than being placed more distal on the corpus spongiosum. Patients competent and willing to operate an AUS may undergo AUS placement following failed AdVance. This is easily accomplished without removing the sling mesh, by placing the cuff around the spongiosum distal to the urethral sling. Early success rates following repeat AdVance placement has approached 70 %, and success following salvage AUS is expected to be similar to a primary AUS placement.

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Post-prostatectomy Incontinence

Radical prostatectomy (RP) remains one of the treatment options for men with clinically localized prostate cancer. While curative for the majority of men who require it, the urinary and sexual dysfunction associated with a radical prostatectomy can have deleterious effects on a patient's quality of life (QOL). Specifically, post-prostatectomy incontinence (PPI) has been shown to negatively impact QOL even in those patients with minimal incontinence [1]. After removal of the postoperative Foley catheter, nearly all patients will experience at least transient stress urinary incontinence (SUI). Continence rates in these patients improve dramatically over the first 12–24 months following surgery at which time improvement seems to plateau [2–4]. The prevalence of PPI has a wide range reported in the literature with rates anywhere from 3 to 89 % [1–9]. This disparity can be attributed in part to the definition of post-prostatectomy incontinence that was used (e.g., subjective/objective pad count, validated/nonvalidated questionnaires, urodynamics, surgeon interview) and the postoperative interval at which incontinence was assessed. Additional factors that have been shown to be associated with PPI include patient age, body mass index (BMI), baseline urinary function, prior prostate procedures, surgeon experience, nerve sparing technique and post-op bladder neck contractures, among others. Artificial urinary sphincters (AUS)

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continue to be the gold standard for treatment of stress urinary incontinence; however, the unique nature of post-prostatectomy incontinence has inspired the development of multiple less invasive surgical treatments.

The use of male slings has increased over the last decade with the introduction of numerous different types. If used for the right patient, they have been shown to have reasonably good success rates. Unfortunately slings are not appropriate for all patients, and there are times when they need to be revised or replaced, and patients occasionally need to undergo another procedure for persistent or recurrent incontinence.

Development of the Transobturator Male Sling

Bulbourethral slings were designed to be an alternative to artificial sphincters in the treatment of stress urinary incontinence. Initial models used either allograft or polypropylene mesh and achieved continence through urethral compression. These initial slings were "anchored," first to the rectus muscle and subsequently bone-anchored slings were developed. In 2007, Rehder and Gozzi developed a novel sling design for the treatment of SUI [10]. Their sling was a polypropylene mesh that was placed using a transobturator technique. The procedure was initially demonstrated in a cadaver series, which showed that the proximal urethra was repositioned into the pelvic outlet 3–4 cm and a retrograde urethral leak point pressure greater than 60 cmH_2O following tensioning of the mesh. They subsequently placed the sling in 20 men with SUI. Video urodynamics showed an increase in urethral closure pressure from 13.2 to 86.4 cmH_2O and an increase in membranous urethral length from 3 to 17.2 mm after tensioning of the sling. At 6 weeks postoperatively, 40 % of the patients were not using pads, and an additional 30 % were improved and only using 1–2 pads per day. Rather than a compressive mechanism, they theorized that the sling was effective secondary to a repositioning of the proximal urethra without disturbing residual sphincter function.

Procedure

To approach the patient who has failed an AdVance male sling, one must understand the correct surgical procedure in placing the sling. The patient is placed in the dorsal lithotomy position with the knees approximately shoulder width apart and bent no more than 90°. After a standard prep, a midline perineal incision approximately 5 cm in length is made. The dissection is carried through the subcutaneous tissue to the bulbospongiosus (BS) muscle. The BS muscle is opened in the midline to expose the corpus spongiosum, which is mobilized distally, laterally, and inferiorly to the central tendon. Prior to dissecting the central tendon off the CS, the area is marked either with an absorbable stitch or a marking pen. The central tendon is easily identified and then dissected off the CS until it is no longer palpable (Fig. 49.1). In patients with mild incontinence, the central tendon does not need to be taken down completely. The reason to mobilize the central tendon off the CS is to increase its mobility.

An incision is made approximately 1–2 cm below the adductor longus tendon and lateral to the ischiopubic ramus. The proper site is usually easily palpable, but a spinal needle may be used to identify the area of insertion. A small incision is made for the needle entry. The AdVance helical needle is held at 45° angle to the patient and placed straight through the incision. A finger is placed in the incision below the ischiopubic ramus to protect the urethra and guide needle placement. Two "pops" are felt, after the second "pop" the needle is turned approximately a quarter turn. The needle is palpable on the physician's finger. Prior to bringing the needle through the fascia, the surgeon's hand is dropped, and the needle is brought out as high as possible in the triangle between the ischiopubic ramus and the urethra (Fig. 49.2). The mesh is secured to the needle and then brought

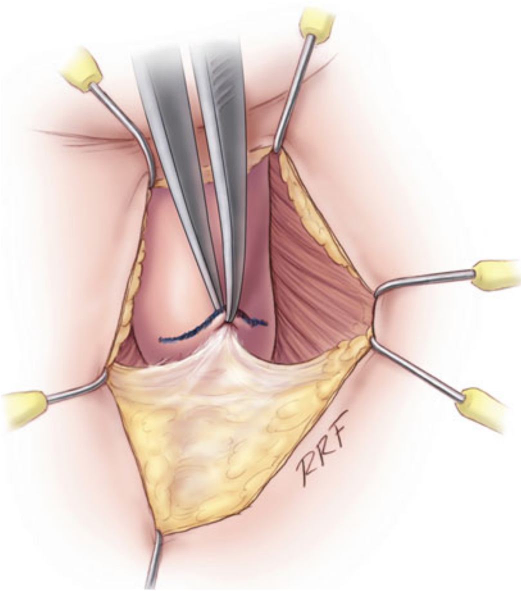

Fig. 49.1 After mobilization of the corpus spongiosum, the central tendon is identified and marked prior to taking it down

back through the incision. This needle pass is repeated on the opposite side. The central portion of the mesh is fixed to the CS with the proximal aspect of the mesh being fixed at the level of our previous mark where the central tendon was taken down. Two sutures are placed proximally and two distally (Fig. 49.3).

Tensioning of the sling is done by pulling firmly on both arms of the sling (Fig. 49.4). Cystoscopy is performed to confirm coaptation of the external sphincter. If no coaptation is identified, this is usually because the sling has been placed too proximal. The four sutures are removed, and the sling is repositioned approximately 0.5–1.0 cm distally. Once coaptation is confirmed, the muscle is closed as well as the subcutaneous tissues. A 14 Fr. Foley catheter is placed and left overnight. The outer covering of the mesh is removed, and the mesh is tunneled back to the midline incision and the incision is closed.

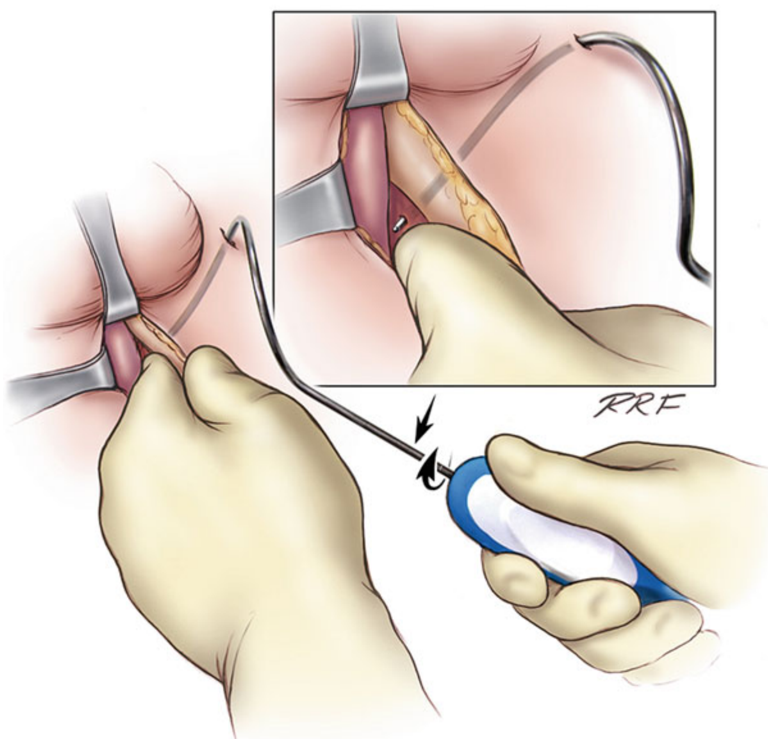

Fig. 49.2 The AdVance needle is held at a 45° angle and passed coming out as high as possible in the triangle between the ischiopubic ramus and the corpus spongiosum

It is imperative that the patient follows the postoperative instructions which include refraining from strenuous activity, lifting greater than 15 lbs, and squatting or climbing for at least 6 weeks. Since these patients will have minimal post-op pain, they may want to return to normal activity sooner than 6 weeks, but it is important to strongly counsel the patient against doing so. A Foley catheter is left and removed postoperative day 1. If the patient is unable to void, the catheter is replaced, and a voiding trial is attempted in approximately 1 week. If the retention lasts longer than 1 week, a voiding trial is attempted again 5–7 days. The patient can also start clean intermittent catheterization. The long-term risk of retention is less than 1 %. In the rare patient with retention >6 weeks, the sling can be removed with the patient returning to his previous status.

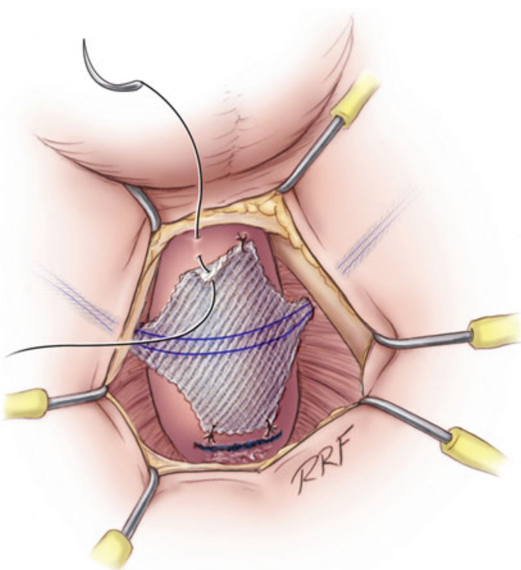

Fig. 49.3 The broad portion of the mesh is fixed to the corpus spongiosum with 4 sutures, two proximal and two distal. The proximal aspect of the mesh is fixed at the level of our previous mark

In patients not continent after AdVance placement who might have done something in the first 6 weeks to loosen the sling, a repeat sling can be performed. In those patients reexploration through the previous incision is done. The BS muscle is opened and the CS is identified. Once the CS is identified, dissection is carried proximally until the top edge of the mesh is palpable. The arms are then identified laterally with a right angle clamp. These are transected (this allows the bulb of the CS to be pulled towards you). The broad portion of the mesh, which was attached to the CS, is then excised. Another sling is then placed as described above.

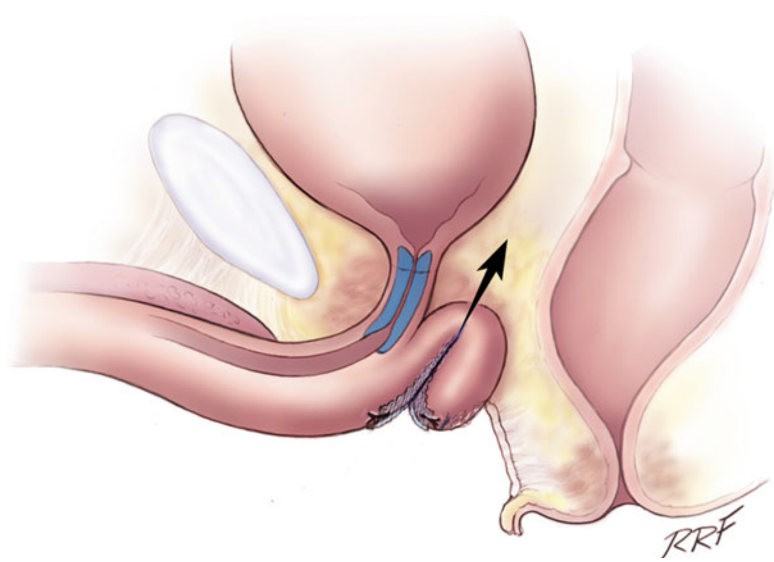

Fig. 49.4 With tensioning of the sling, the corpus spongiosum is pulled proximally causing coaptation of the urethra

Efficacy

Since its introduction, the AdVance sling has accumulated a body of research from multiple centers treating men with SUI. Compared with the AUS, which has follow-up data that is measured in decades, follow-up for the AdVance sling is modest at best. That being said, midterm results are beginning to emerge and are showing encouraging, durable results compared to initial reports [11, 12]. In their original study, Rehder and Gozzi reported a cure rate of 40 % and an improved rate of 30 % [10]. These numbers have been used as a benchmark to which others have compared their results. Many, but not all, published trials have either met or surpassed that early success [11–19].

There are many difficulties comparing trials published by different investigators, and incontinence research adds its own challenges. One of the unique difficulties encountered when comparing success rates among different trials is the definition of success that is used. In the strictest sense, success should be defined as the absence of pad use during daily activities and no observed incontinence on urodynamic evaluation. For the majority of publications, patients were considered "cured" or "dry" if they were using no pads or only a safety pad daily. Overall success rates, however, also usually include those patients considered to be "improved." Often this is defined as patients who had a greater than 50 % improvement in their preoperative pad count. The degree to which patients were leaking prior to the procedure is also an important consideration when discussing results from incontinence surgery as patients with worse incontinence will be more difficult to cure.

There have been seven studies published reviewing initial results of the AdVance sling with follow-up out to approximately 1 year [13–19]. For five of these seven, cure rates from 51 to 85 % were observed. Two authors reported cure rates significantly less than the others at 9 and 28.5 %. The reason for the poor outcomes noted in these studies is not readily apparent, but comparatively they reported on fewer patients. Although cure rates are easiest to compare across studies, many patients not "dry" postoperatively are significantly improved from their baseline. Including these patients, short-term overall success is higher in each of these early trials, ranging from 54.5 to 90.6 %.

As the AdVance sling remains a relatively new treatment option for SUI, to date there are only two trials reporting midterm outcomes [11, 12]. Both of these studies are essentially an extended follow-up of previously outcomes. Bauer et al. reported on 137 patients a mean 27.2 months following AdVance placement. Their extended results are very similar their own and others' initial results; 51.6 % of patients were using no pads or only a safety pad daily. An additional 23.8 % of patients were greater than 50 % improved from baseline and were using less than 2 pads per day for an overall success rate of 75.4 %. Analyzing success over time revealed a durable response, with only a small and statistically insignificant reduction of cure rate over time (55.8 % cured at 1 year compared with 51.6 % at 2 years).

Cornu et al. have also reported their midterm outcomes in 136 patients at a mean follow-up of 21 months. Similar to Bauer, they found a 62 % cure rate and a 16 % improved rate for an overall success of 78 % at final follow-up. They performed a multivariate analysis attempting to find prognostic factors for treatment failure. This analysis suggested that history of radiation, worse preoperative incontinence, and prior urethral stricture or urethrovesical anastomotic stenosis procedure were associated with treatment failure.

Success rates of the AdVance sling are affected by radiation treatment. Bauer et al. reported 50 % success rates in 24 patients with a mean follow-up of 18 months. We have noted similar finding with 24 of 27 patients (89 %) of patients having significant improvement at 3 months but 9 (38 %) of these patients noting a decrease in success at a mean of 14.6 months.

Options for a Failed AdVance Sling

When a patient who has undergone an AdVance sling suffers from persistent incontinence, there are numerous options to consider.

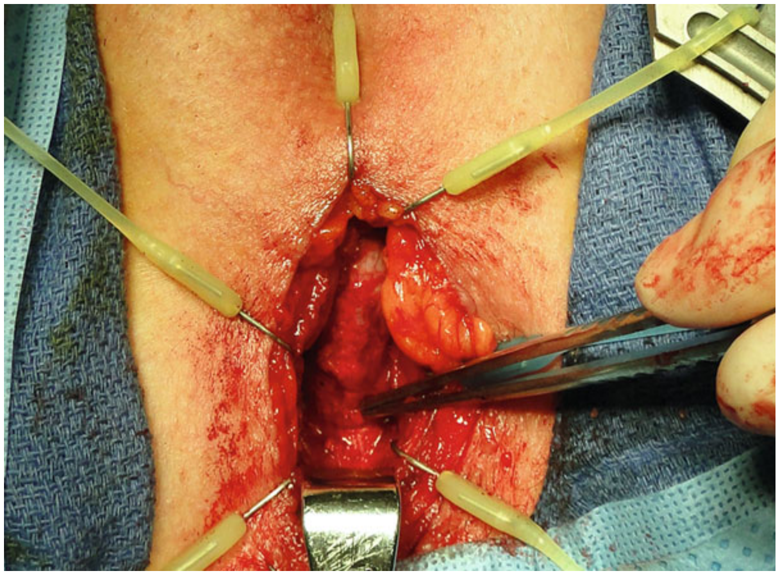

Fig. 49.5 Corpus spongiosum is mobilized, and distal aspect of previously placed AdVance sling is identified

For a patient with minimal incontinence, one option is to consider injectables. We have had limited success with injecting Macroplastique® (Uroplasty, Inc., Minnetonka, MN) at the area of coaptation in patients with minimal persistent incontinence. One needs to be aware that this can cause worsening of the patient's incontinence and they need to be warned of that.

Another option to consider, although not available in the US, is ProACT™ balloons (Uromedica, Plymouth, Minneapolis). Al-Najar et al. used the ProACT™ system in ten patients who had persistent incontinence after their sling [20]. All ten of these patients were pad free with a mean follow-up of 6 months (range 3–9).

One may consider a repeat AdVance sling in a patient who has failed a previous repair [24]. The surgical procedure is not much different than the initial procedure. In starting the dissection we have found it easier to start further distal on the corpus spongiosum. Doing this allows you to start your surgery in a virgin plane. We will also free up the corpus spongiosum slightly more than normal. Once the distal aspect of the sling is identified, we are able to place a right angle clamp around the sling and transect the arms. This maneuver allows the corpus spongiosum to move towards you (Figs. 49.5 and 49.6). At this point we will excise the previous sling off the spongiosum. This is usually difficult and approximately 40 % of the time we enter the spongiosum; however, we have not injured the urethra during this dissection (Fig. 49.7). The spongiosum is closed with an absorbable stitch, and the procedure is completed. The needles are passed as previously described, and the sling is placed usually slightly distal to the first sling. In reviewing our initial success with this technique, we have approximately 70 % success rates with short-term follow-up.

Soljanik et al. published their data in patients who underwent a repeat AdVance male sling. In their technique they did not remove the previous placed sling, stating that the sling was not a hindrance to correct placement of this sling. They did use nonabsorbable stitches again assuming that sling slippage was the reason for failure of the first sling.

One can also consider placement of an AUS 800 (American Medical Systems, Minnetonka, Minneapolis) in patients who have failed AdVance. The technique of the AUS is essentially the same as if the patient had not undergone another procedure. The AdVance is not usually encountered in this approach, and the AUS cuff is placed distal to the AdVance sling.

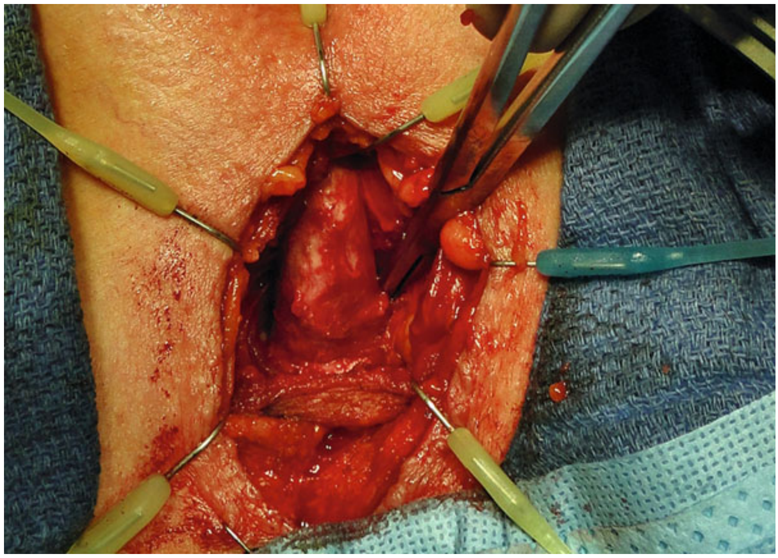

Fig. 49.6 A right angle clamp is placed behind the arms of the AdVance sling. These arms will then be transected allowing movement of the corpus spongiosum

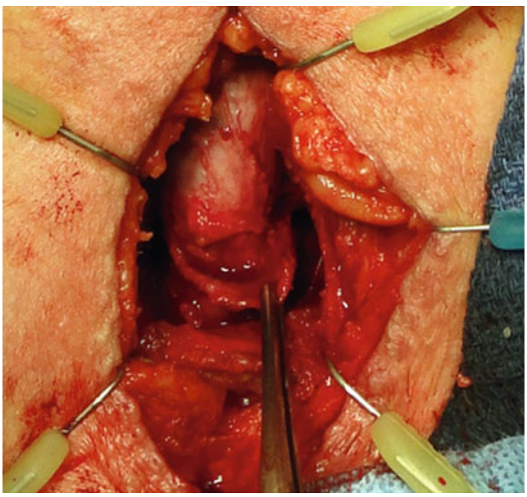

Fig. 49.7 Small injury to the corpus spongiosum after removing mesh. This will be closed with an absorbable suture

Complications

It is becoming apparent that one of the advantages of AdVance slings compared to the gold standard artificial urinary sphincter may be a more favorable complication rate. Complication rates for AUS have been reported around 35 %, including mechanical failure, infection, and erosion [21]. In contrast, complications related to AdVance placement have been minimal both in number and severity. Intraoperative complications, primarily urethral injuries during trocar passage, have been described in only a couple of cases [22, 23]. Early postoperative complications include minor wound infection or urinary tract infections in less than 2 % of cases, all successfully treated medically [15, 18, 22]. Infrequently patients complain about transient mild perineal discomfort or dysuria. Urinary retention is the most common early complication with widely variable ranges reported, from 0 to 21.3 % [12, 16, 19, 22]. The majority are transient and resolve within several weeks. Midterm and long-term complications are only now beginning to emerge but also appear to be very acceptable. There has been only a single case report of urethral mesh erosion, and this was in a patient with prior radiation [24]. The rate of explantation for any reason appears to be less than 2 % with most series reporting no patients requiring explantation. To date, there has been no report of any mesh infections requiring removal.

Conclusions

Artificial urinary sphincters remain the gold standard surgical treatment for stress urinary incontinence. Many patients, however, either do not want or cannot reliably manipulate an AUS, and these patients have been the driving force behind the development of more minimally invasive, less mechanical surgical options. The AdVance transobturator sling is emerging as an effective, well-tolerated alternative to an AUS for many patients. Early and midterm results are encouraging, and the complication rate is favorable when compared to the AUS. As long-term data becomes available for this and other minimally invasive slings, the gold standard for treatment of male stress urinary incontinence may be challenged.

Surgical Pearls and Pitfalls

Key Points

- The central tendon should be marked prior to dissecting it free from the corpus spongiosum. This serves as a guide facilitating proper sling placement
- Fully removing the spongiosum off the central tendon allows proper mobilization of the urethra and theoretically improved outcomes
- The helical trocar should be brought out as high as possible in the triangle between the ischiopubic ramus and the urethra
- Adequate sling tensioning is essential and can be done without concern for urethral obstruction
- Salvage AUS can be placed without sling excision if positioned distal to the failed sling

Potential Problems

- Slings placed too proximally will not effectively promote urethral coaptation. If noted on intra-op cystoscopy, the sling should be moved approximately 1 cm distally and re-tensioned
- If not careful, excision of a failed sling from the corpus spongiosum may results in spongiosal injury. This can be closed primarily without aborting completion of the procedure
- Placing a repeat AdVance sling in the same location on the corpus spongiosum increases the chance for failure. Redo slings should be positioned at least 1 cm distal from the original placement
- Proper patient selection facilitates optimal surgical outcomes in both the primary and salvage setting. Candidates for slings are men who demonstrate SUI and also have adequate urethral coaptation on cystoscopy

Preferred Urethral Sling Instruments

- Flexible cystoscope
- Lone Star retractor
- 15 blade scalpel
- Fine Metzenbaum scissors
- Fine forceps
- Mono- and bipolar cautery

Editorial Comment

The AdVance male urethral sling is a safe and reliable option for men with mild post-prostatectomy stress incontinence. The macropore transobturator mesh has proven resistant to infection, and the bulky spongiosum protects nicely against erosions. The AdVance sling may be easily combined with IPP placement; we prefer placing the sling first in lithotomy position, then lowering the adjustable stirrups to a flat position for IPP placement via a penoscrotal incision. Optimal candidates are healthy men with robust spongiosum and mild SUI; those with prior XRT, bladder neck contracture, or severe SUI do not fare as well and should be counseled about this thoroughly so they do not have inappropriate expectations.

Reoperative sling surgery is hard. In planning these procedures, the surgeon must be certain that the patient was a good candidate for the sling originally, with mild SUI. If the SUI was moderate or severe (3+ pads per day), an AUS is usually more appropriate. Invariably, poor results in good sling candidates are related to proximal sling placement. We have achieved good results by placing the second sling more distally (usually at least 2 cm). We have not bothered to excise the old sling since this is tedious and difficult unless the patient has worsened incontinence after the original sling, in which case we will incise one arm to resolve sphincteric distortion. We emphasize a higher needle entry point, 1 cm below the insertion of the adductor longus tendon in the groin crease, at reoperation which promotes more distal sling placement and thus better sling mobilization with tensioning. All patients should be counseled about the risk of transient urinary retention, which usually lasts no longer than 1 week and is often actually a good prognostic sign.

—Allen F. Morey

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Post-prostatectomy Incontinence (Evaluation and Practical Urodynamics)

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H. Henry Lai and Timothy B. Boone

Summary

Post-prostatectomy incontinence (PPI) may be caused by intrinsic sphincteric deficiency (ISD) resulting in stress urinary incontinence (SUI), or bladder dysfunction (e.g. detrusor overactivity resulting in urgency incontinence, loss of detrusor compliance, or detrusor underactivity resulting in retention and overflow incontinence). Many PPI patients have concomitant sphincteric and bladder dysfunction. Most PPI patients have ISD secondary to sphincteric damage thought to arise from nerve or vascular damage to the distal urethral sphincteric complex. Detrusor factors contributing to incontinence are common, though rarely the sole cause [1, 2]. Conservative management such as pelvic floor exercises or anticholinergic medications may commence early after surgery with minimal workup. However, if bothersome PPI persists 6 to 12 months after prostatectomy [3], additional evaluation such as urodynamic testing should be considered so a rational management plan can be formulated. This is particularly important if surgical treatment is contemplated.

Evaluation of the Male Patient with Post-prostatectomy Urinary Incontinence

The evaluation of PPI begins with a comprehensive history, which focuses on the type (e.g., associated with cough, valsalva, upright activities, supine position, urgency), severity (number of daily pads used, "how wet is the pad"), and associated bother of the incontinence. A 3-day diary may help to differentiate between stress and urgency incontinence. The history should inquire about neurologic disease, spinal injury, diabetes, history of pelvic radiation, bladder tumor, recurrent bladder neck contracture or stricture, urethral surgery, preexisting voiding issues prior to prostatectomy, complications of prostatectomy, and prior medical and surgical treatment of the incontinence. All prescription, over the counter, and herbal medications should also be reviewed.

Physical examination should assess patients' cognitive function, manual dexterity, and body habitus (these factors can impact the decision to implant an artificial urinary sphincter, AUS). The abdomen is palpated to evaluate for a distended bladder and surgical incisions. Genitourinary examination includes a digital rectal examination to assess the prostatic fossa, resting rectal tone,

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ability to voluntarily tighten the anal sphincter, and the bulbospongiosus reflex. The bulbospongiosus reflex is elicited by squeezing the glans penis and assessing if the anal sphincter contracts [4]. Absence of this reflex is indicative of a neurologic lesion. Neurologic examination should also focus on the S2–S4 spinal segments. The skin should be inspected for signs of breakdown, secondary infection, or rash from the incontinence; these need to be treated prior to any prosthetic surgery.

It is extremely important to perform a standing cough test with a half-full bladder to document the presence and degree of stress urinary incontinence (SUI). The patient stands upright with his feet shoulder width apart and is asked to cough and valsalva (mild, moderate, severe). It would be helpful if patient is specifically instructed not to empty his bladder prior to this upright cough test. He is then asked to void in a uroflowmeter to measure his maximal flow rate, followed by a bladder scan to record post-void residual volume. Twenty-four-hour pad tests and validated questionnaires can be administered to assess the severity of the incontinence and its impact on quality of life [5, 6]. Urine analysis and cultures are performed prior to any invasive procedures.

Obviously, incontinence associated with valsalva, coughing, or upright activities suggests SUI and ISD, while incontinence preceded by urgency ("a sudden compelling desire to pass urine which is difficult to defer") or occurring at night when the patient is supine suggests urgency incontinence or loss of bladder compliance. However, the pattern is not always so clear-cut. Patients may present with mixed symptoms (e.g., leaks day and night), insensate incontinence (e.g., unable to describe any aggravating triggers), have uncontrollable voiding after valsalva (which suggests stress-induced detrusor overactivity), or void with a weak stream (which suggests bladder neck contracture, urethral stricture, or a hypocontractile bladder). Urodynamics helps to differentiate between stress and urgency incontinence in patients with confusing symptoms.

Patients contemplating artificial urinary sphincter (AUS) or male sling surgery must undergo office cystoscopy to rule out bladder neck contracture or urethral stricture. Up to 36 % of open radical prostatectomy patients who planned for AUS placement were found to have a bladder neck contracture during preoperative cystoscopic evaluation [7]. Over half of PPI patients (57–67 %) who received pelvic radiation have bladder neck contracture prior to AUS implantation [7, 8]. "Unanticipated discovery" of a contracture at the time of PPI surgery due to inadequate preoperative evaluation can be very disappointing for patients and surgeons. Incision or dilation at the time of AUS/sling surgery is not recommended due to concern of erosion and urethral injury [9]. The AUS/male sling surgery has to be deferred. Contracture or stricture that has been incised must remain patent for at least 3 months prior to AUS/sling surgery, since about one-quarter of patients (25 %) had recurrence within 3 months after the initial incision [7]. Patients contemplating trans-obturator (AdVance) sling surgery should also undergo cystoscopy to confirm that the membranous urethra is mobile, non-scarred, and residual sphincteric function is present (i.e., the sphincter coapts well and demonstrates concentric voluntary contraction with a duration for at least a few seconds) [10]. Poor residual sphincter function and incomplete closure of the sphincter preoperatively are independent risk factors of treatment failure of trans-obturator sling surgery [11].

Practical Pearls of Urodynamic Testing in Post-prostatectomy Incontinence

Patients with voiding and storage symptoms cannot be reliably diagnosed by history and physical examination alone [1, 12, 13]. Urodynamic testing provides objective measurement of bladder and sphincteric function to guide treatment decisions. Urodynamics enables the clinician to evaluate the underlying cause of PPI, confirm the diagnosis of ISD and SUI, rule out pure detrusor dysfunction without SUI, and identify adverse features such as poor detrusor compliance, impaired detrusor contractility, or unrecognized outlet obstruction that may confound treatment decisions. The test can be used to evaluate bladder compliance, overactivity, capacity, contractility, sphincteric function, and outlet obstruction.

The urodynamic armamentarium is extensive, ranging from bedside "eyeball" urodynamics, to noninvasive uroflowmetry, to multichannel studies with or without fluoroscopy [14, 15]. Prior to any study, *specific* questions that the clinician desires to answer must be formulated. A working diagnosis should be in place. The most accurate and least invasive test that is tailored to answer these specific questions is performed.

It is crucial that the test reproduces the patient's symptoms. A study that does not reproduce the patient's symptoms is not diagnostic [16]. Failure to record an abnormality on urodynamics does not rule out its clinical existence. Conversely, not all abnormalities detected on urodynamics are clinically relevant. If urodynamics reveal information that is totally unexpected, reevaluation of the working diagnosis is necessary.

Patients must be told what to expect, how the test is done, and what information the clinician is seeking prior to testing. For example, in evaluating incontinence, patients need to understand that the goal of the test is to demonstrate leakage characteristic of their usual experience, so that they do not voluntarily contract the sphincter to avoid the embarrassment of demonstrating incontinence. In evaluating outlet obstruction, patients are encouraged to void as close to their normal voiding pattern as possible, so that they do not strain excessively or tighten the pelvic floor out of anxiety. Accurate interpretation of urodynamic studies is an art. It is different from reading an EKG. Valuable interpretation relies on patient cooperation and open communication between the patient and the clinician during the testing, so that urodynamic events can be correlated to the patient's symptoms in real-time. Having the clinician who is familiar with the patient's symptoms present at the time of the study can be helpful.

According to the 2008 American Urological Association Best Practice Policy Statement on Urologic Surgery Antimicrobial Prophylaxis [17], single-dose antimicrobial prophylaxis for urodynamic study is not necessary if urine culture shows no growth. Prophylaxis is justified in certain higher risk patients, such as those with anatomic abnormalities, immunodeficiency, externalized catheters, colonized endogenous or exogenous materials, prolonged hospitalization, poor nutritional status, or advanced age. The 2007 American Heart Association guideline no longer recommends the administration of prophylactic antibiotics solely to prevent endocarditis for patients undergoing genitourinary procedures such as urodynamics [18]. For patients with prosthetic joint replacement, the 2010 American Association of Orthopaedic Surgeons recommends one dose of 500 mg oral ciprofloxacin 1 h before urologic procedures [19].

Huckabay et al. [20], published a urodynamic protocol to optimally assess men with PPI. The patient is instructed to come with a reasonably full bladder. Testing is started with noninstrumented uroflowmetry, followed by measurement of post-void residual volume by inserting a 7-French duel lumen into the bladder. The bladder catheter (which measures *Pves*) is secured to the tip of the penis to avoid slippage during voiding and straining. The catheter is taped in such a way that urine flow is not disrupted and stress incontinence can be easily observed. If resistance is encountered during catheter insertion, cystoscopy is performed to rule out bladder neck contracture or urethral stricture. A rectal balloon catheter (which measures *Pabd*) is then inserted beyond the anal sphincter and filled with 3–5 mL of fluid. All catheters are flushed and the transducers are zeroed to the superior edge of the pubic symphysis. Electromyographic (EMG) recording with surface patches is not usually useful in the PPI population, unless neurogenic bladder or voiding dysfunction is suspected. Video-urodynamics is useful to (1) detect the small amount of stress incontinence that may be difficult to visualize by naked eyes, especially in patients whose SUI complaints cannot be verified on physical examination, (2) localize the site of bladder outlet obstruction, and (3) identify anatomic features that may suggest a "hostile" bladder with elevated pressure (e.g., reflux, bladder diverticulum, trabeculation, "Christmas tree" neurogenic bladder).

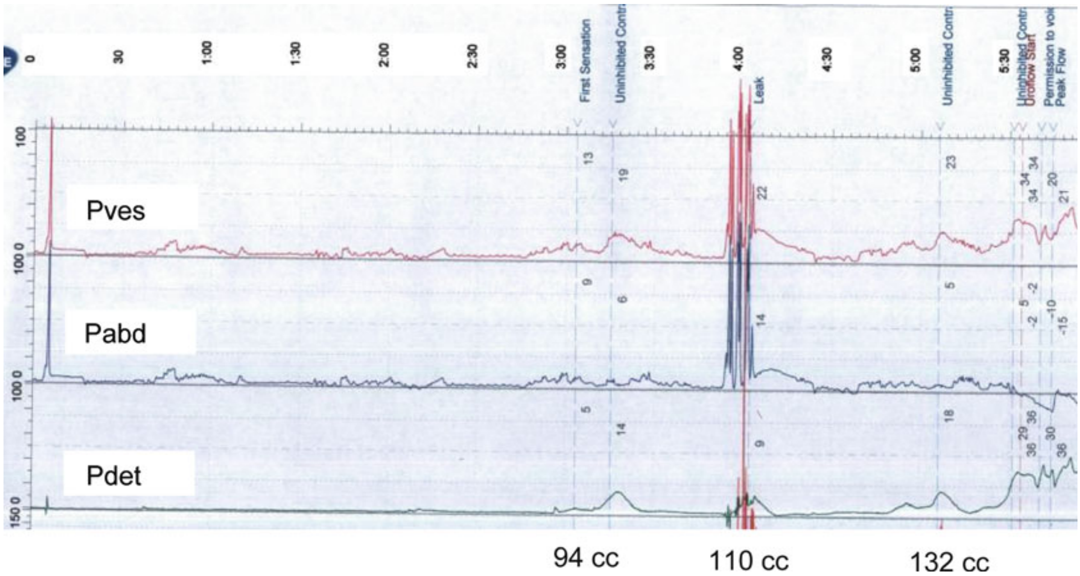

Fig. 50.1 Small amplitude detrusor overactivity was noted at 94 and 132 cc. SUI was demonstrated with coughing at 110 cc. *Pves* measured pressure from bladder catheter, *Pabd* measured intraabdominal pressure from rectal catheter, *Pdet Pves* minus, *Pabd* calculated detrusor pressure

Prior to filling, patient is asked to cough to ensure equal pressure transmission to the bladder (*Pves*) and rectal (*Pabd*) catheters. The subtracted detrusor pressure (*Pdet*=*Pves* – *Pabd*) should remain close to zero during the cough test. If there is uneven transmission of pressure (e.g., from air bubbles or kinks in tubing), the catheters are flushed and/or repositioned. Air-charge catheters may be used to reduce this artifact. Since the detrusor pressure *Pdet* is the calculated difference between *Pves* and *Pabd*, i.e., *Pdet*=*Pves* – *Pabd*, any increase in *Pdet* must be accompanied by a corresponding increase in *Pves* and/or *Pabd*; otherwise, the increase in *Pdet* may represent artifacts rather than true detrusor contractions (see Fig. 50.1).

The bladder is initially filled with room temperature saline (or contrast) at 50 mL/min with the patient standing (most males void by standing). We usually ask patients to perform light valsalva, moderate valsalva, and strong valsalva in the standing position at 150 mL and repeat those maneuvers at 50 mL increments, to detect urodynamics SUI and measure abdominal leak point pressure (ALPP). The ALPP is defined as the intravesical pressure (*Pves*) at which urine leakage occurs due to increased intraabdominal pressure in the absence of a detrusor contraction. Light, moderate, and strong coughing is also performed. It is usually easier to capture the exact moment of stress incontinence and ALPP with slow and steady valsalva rather than quick, jerky coughs. The lowest *Pves* value that corresponds to SUI was recorded (ALPP). Fluoroscopy helps to detect small leakage that may be difficult to spot by the naked eye and quantify the ALPP more accurately. If there are difficulties filling the bladder due to severe ISD and incontinence (e.g., constant dripping with filling), occlusion of the bladder neck with a balloon catheter may be required to assess detrusor compliance and overactivity.

If urodynamic stress incontinence cannot be demonstrated despite a complaint of SUI and/or positive cough test during physical examination, the clinician should be wary of significant bladder neck contracture and/or urethral stricture. Even a small urodynamic catheter may be enough to obstruct a tight anastomotic stricture. In such case, the bladder catheter should be removed, and the rectal catheter pressure (*Pabd*) is used to approximate the ALPP. Office cystoscopy and fluoroscopy helps to identify the site and kind of outlet obstruction. Failure to detect urodynamic stress incontinence may occur if the patient fails to perform a strong valsalva/cough or if he is tested supine.

PPI patients commonly complain of urgency with or without urgency incontinence, or with mixed symptoms (SUI+urge). Urodynamic testing is used to evaluate detrusor overactivity (DO, or involuntary bladder contractions), urgency incontinence, and bladder oversensitivity (early sensation of urgency and reduced cystometric capacity). If significant DO is encountered, the filling rate is slowed down to 25 mL/min, and the test is repeated. Since filling the bladder at a supraphysiologic rate during urodynamics can be provocative, especially in PPI patients with severe incontinence who are no longer accustomed to storing significant volume inside their bladder, the clinical significance of DO, reduced capacity, or bladder oversensitivity detected on urodynamic testing should be interpreted cautiously, within the context of the clinical symptoms (e.g., presence of bothersome urgency) and medical history (e.g., presence of neurogenic bladder or voiding dysfunction prior to prostatectomy). A true sense of functional bladder capacity may be gleaned from the maximal voided volume on a 3-day voiding diary.

Detrusor compliance describes the relationship between changes in bladder volume and changes in detrusor pressure ($\Delta V/\Delta Pdet$). It measures the elastic properties of the bladder. Normal bladder has high compliance and is able to expand to capacity (large ΔV) with minimal changes in intravesical pressure ($\Delta Pdet$ <15–20 cm water). Decreased compliance is defined as $\Delta V/\Delta Pdet$ <12.5 mL/cm (a steep slope during filling), measured from the moment of bladder filling to the point of cystometric capacity or immediately before the start of detrusor contraction that causes significant leakage [21]. If significant loss of compliance is encountered, the filling rate is slowed down to 25 mL/min, and the test is repeated. To distinguish loss of compliance from DO, stop filling and ask the patient to perform pelvic contractions. In the case of DO, *Pdet* usually declines gradually, while in the case of poor compliance, *Pdet* remains elevated and continues to rise once bladder filling is resumed.

The voiding phase is performed in a position that the patient is comfortable with. Some men prefer to void sitting down rather than standing up. Voiding should be done in privacy, with as little distraction and few observers as possible, so that he can relax to void. An anxious patient may be psychologically inhibited and may not be able to empty at all. The patient should be asked whether the voiding is representative with respect to its usual volume, force, and pattern. Voiding parameters may not be interpretable if the patient cannot store enough fluid to void (e.g., with severe ISD and constant dripping). The post-void residual is checked through the catheter after voiding is completed.

Bladder outlet obstruction (e.g., bladder neck contracture, urethral stricture, or retained prostate tissue after TURP) is characterized by elevated post-void residual volume, reduced maximal flow rate ($Qmax < 12$ mL/s), elevated *Pdet* during voiding, bladder obstructive index >40 ($BOI = Pdet@Qmax - 2 \times Qmax$), and an obstructive pattern on the ICS nomogram [22]. Recognition of obstruction mandates further evaluation with fluoroscopy or cystoscopy. On the other hand, impaired bladder contractility is defined by a bladder contractility index <100 ($BCI = Pdet@Qmax + 5 \times Qmax$) [22]. Valsalva voiding is defined as a change of *Pabd@Qmax* from baseline *Pabd* greater than 10 cm water. It is rare for PPI patients to have retention or overflow incontinence unless there is obstruction. Even "abdominal voiders" with detrusor underactivity can usually empty their bladders well with low residual volumes by straining against the minimal outlet resistance (ISD).

Because of the high incidence of bladder neck contracture in the PPI population [7, 8], Huckabay et al. recommend performing a second fill followed by removal of the catheter routinely [20]. In their study, 35 % of men leaked only after removal of the filling catheter. The ALPP may be falsely elevated when it is measured with a urethral catheter in place.

The Role of Urodynamic Testing in the Evaluation of Post-prostatectomy Incontinence

Five clinical questions that are relevant in assessment of PPI are discussed below. For each of the question below, we shall discuss the impact of urodynamic testing on PPI treatment decision and surgical outcome.

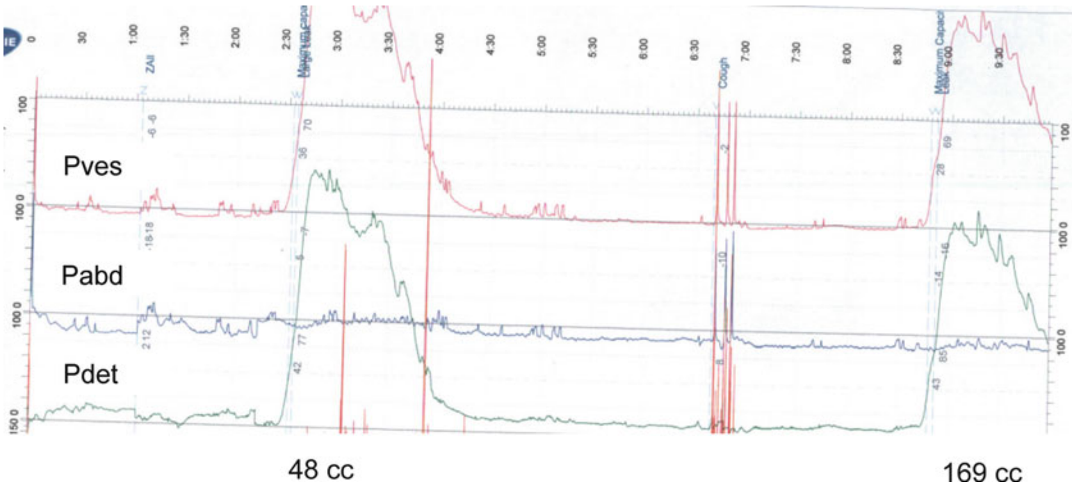

Fig. 50.2 Large amplitude detrusor overactivity and urge incontinence at 48 and 169 cc. This patient may not be a good candidate for PPI surgery if the urge incontinence and urgency symptoms were not controlled

1. Does the patient have a stable bladder without detrusor overactivity or urgency incontinence? **Is there any evidence of stress-induced detrusor overactivity**?

Figures 50.1 and 50.2 show urodynamic tracings of patient with detrusor overactivity (DO, or involuntary bladder contraction) after prostatectomy. The patient complains of incontinence associated with urgency, frequency, or at night when he sleeps supine. There may or may not be storage symptoms prior to prostatectomy or pelvic radiation. As mentioned before, presentation of mixed symptoms (SUI + urge) is common. About 25 % of PPI patients have persistent overactive bladder (OAB) symptoms after prostatectomy, and among them, only about one-third demonstrated DO on urodynamics [23]. Several studies have investigated whether the presence of DO or OAB preoperatively adversely affected the overall continence outcome after AUS or bone-anchored perineal (InVance) sling. The studies showed that although patients with preoperative DO or OAB are more likely to continue to use anticholinergics and have persistent DO or OAB after male incontinence surgery [23, 24], the presence of DO or OAB preoperatively does not negatively impact on the overall continence outcome after surgery [23–28]. Most patients have remarkable improvement of their overall incontinence after surgery. The presence of DO or OAB preoperatively is not a contraindication to AUS or bone-anchored male sling surgery, provided that the patient has stress incontinence as well. However, these patients require careful preoperative counseling regarding realistic expectation of the surgical outcome (i.e., improvement of SUI but persistent OAB symptoms and anticholinergics use) [23]. Patients with intractable urgency or urgency incontinence who are unhappy about their current OAB management may not want to consider PPI surgery yet since the urgency may not improve afterwards. The priority in those patients is to address OAB first (e.g., with botulinum toxin injection, neuromodulation).

Stress-induced detrusor overactivity may be disguised as genuine stress incontinence. Patients present with uncontrollable voiding after valsalva. Urodynamics can reliably distinguish stress-induced detrusor overactivity (urgency incontinence with detrusor overactivity) from ISD (genuine SUI). These patients may benefit from anticholinergic medication, botulinum toxin injection, or neuromodulation instead of ISD surgery.

2. Does the patient have adequate capacity with low storage pressure (i.e., normal detrusor compliance)? If so, what is the detrusor leak point pressure (DLPP)?

The detrusor function that clinicians are most concerned with is loss of bladder compliance

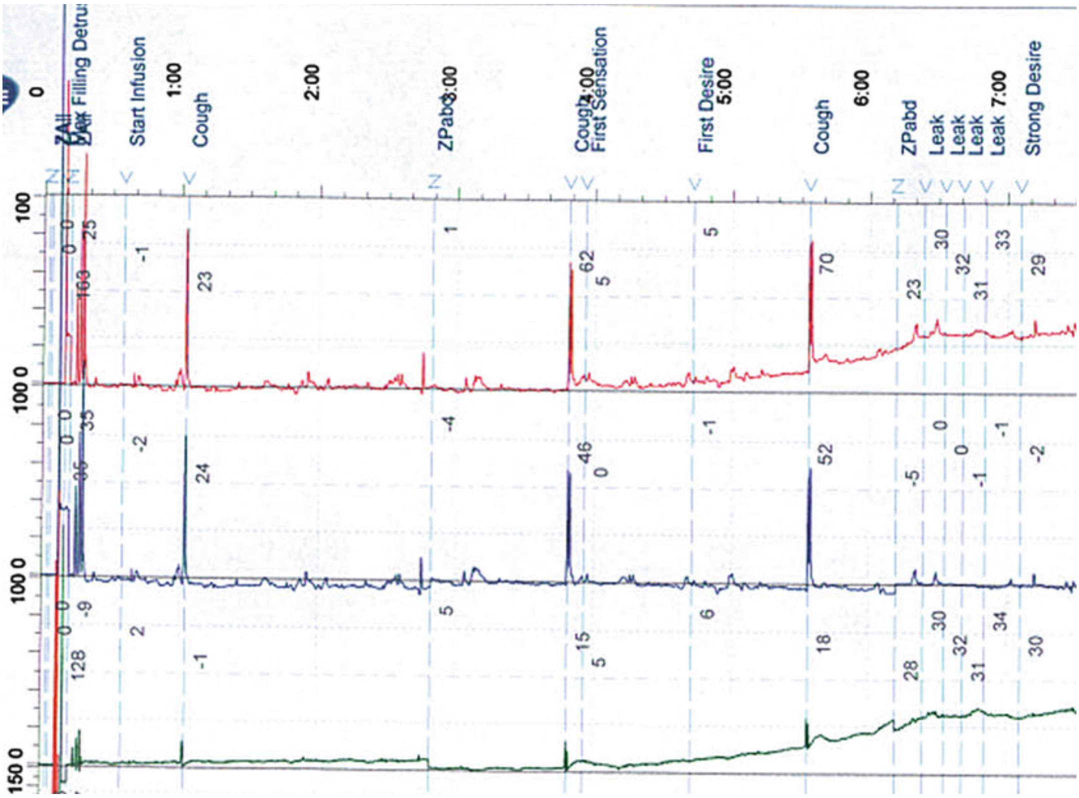

Fig. 50.3 Loss of detrusor compliance beyond 150 cc. Storage pressure was 30 cm when leakage occurred at 250 cc. Detrusor leak point pressure was 30 cm water

(elasticity), resulting in high storage pressure in the bladder. Figure 50.3 shows a patient with poor detrusor compliance with a steep slope during filling. These patients may present with incontinence or no specific symptoms. Patients with low bladder compliance may be floridly incontinent, but their upper tracts are safe since the incompetent outlet (ISD) functions as a "release" valve to relieve the high bladder storage pressure from damaging the kidneys. After AUS/male sling surgery, the outlet resistance is increased, and the patient becomes continent [25, 28]. The problem is that the AUS cuff pressure or sling compression now allows detrusor storage pressure to exceed 51–61 cm of water. The detrusor leak point pressure (DLPP) exceeds 40 cm of water, and this creates a high "head pressure" in the bladder that impedes ureteral peristalsis, and leads to upper tract deterioration [29]. The risks to the upper tracts in patients with neurogenic bladder or myelomeningocele have been well documented [30, 31]. For this reason, patients with known neurogenic bladder and poor detrusor compliance often have bladder augmentation in conjunction with AUS placement. The risks to the upper tracts in adult patients without neurogenic bladder or neurologic deficits are unknown. There are no long-term follow-ups, and the significance of identifying poor detrusor compliance incidentally on urodynamic testing in an otherwise healthy post-prostatectomy patient without any history of neurogenic bladder is unclear [25].

3. Can urodynamic stress incontinence be demonstrated? If so, what is the abdominal leak point pressure (ALPP)?

One goal of urodynamic testing is to demonstrate SUI and ISD, particularly in patients who present with confusing symptoms or in whom the complaint of SUI cannot be demonstrated on physical examination. Failure to demonstrate SUI on urodynamics in patients with ISD (false

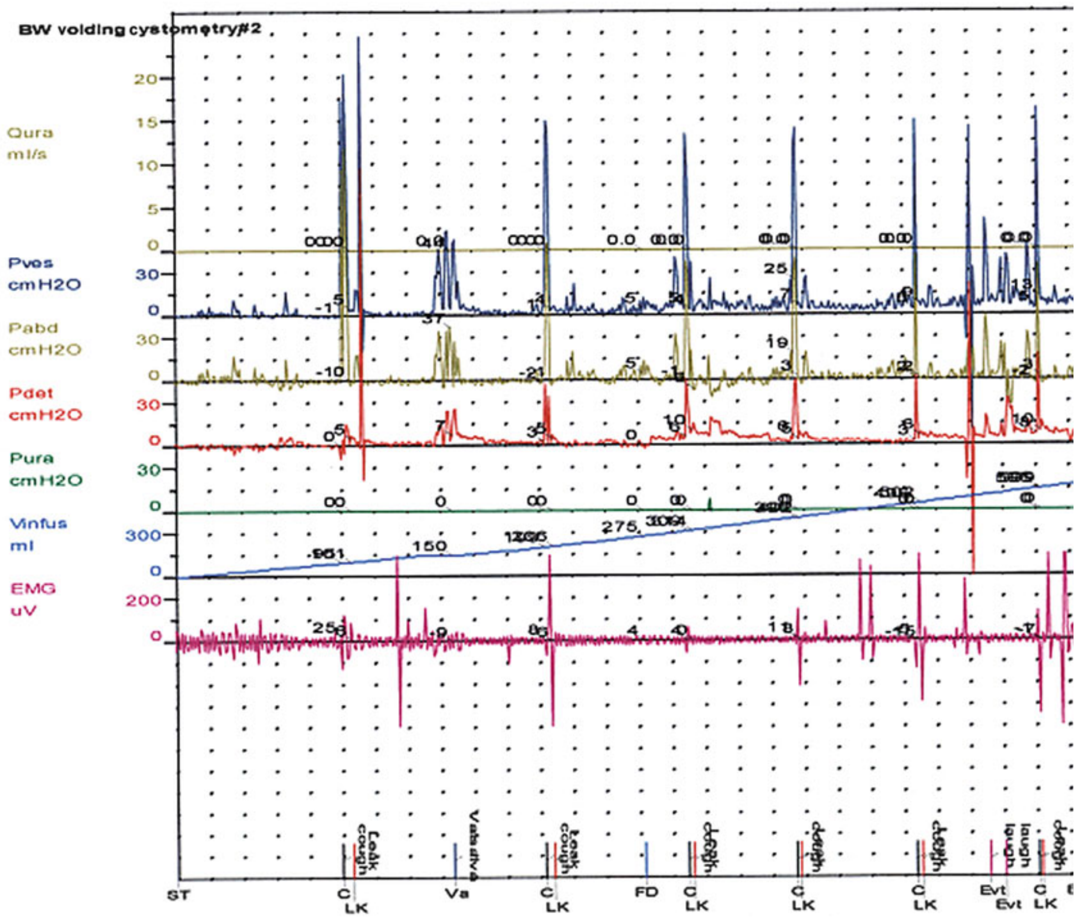

Fig. 50.4 SUI was demonstrated during coughing (100, 200, 300, 400, 500 cc) but not during valsalva (150 cc). *LK* leak, *C* cough, *VA* valsalva (*bottom* of figure)

negative) may occur if the patient fails to perform a significant valsalva or cough, if the test is performed with the patient in the supine position, or if the amount of leakage is small and difficult to detect by naked eyes. But the most common reason is the presence of bladder neck contracture after prostatectomy (discussed later). Videourodynamics may help to identify a trace of contrast that leaks beyond the bladder neck with valsalva or coughing, or pinpoint the exact location of outlet obstruction.

During the stress maneuver, the ALPP is measured (see Fig. 50.4). ALPP is defined as the intravesical pressure (*Pves*) at which urine leakage occurs due to increased intraabdominal pressure in the absence of a detrusor contraction. Patients with ALPP <90 cm water is considered to have ISD. Published literature showed that patients with ALPP <60 cm do poorly with collagen injections [32, 33]. Other than that, there is no evidence in the literature that the actual ALPP values help to guide treatment decisions as long as SUI is demonstrated. ALPP correlates poorly with the severity of incontinence as measured by pad weight [34]. Studies have shown that patients with low ALPP <60 cm did just as well after AUS surgery [25–27, 32, 33], bone-anchored (InVance) sling surgery [35], or trans-obturator (AdVance) sling surgery [36] as patients with higher ALPP. In a study by Fischer et al., success outcome of InVance perineal sling (as defined by global improvement of symptoms) is influenced by preoperative 24-h pad weight (lower success if >423 g or <100 g), not by preoperative ALPP value [35]. ALPP value will not help to guide patient to choose, for instance, between male sling (mild to moderate incontinence) and an AUS (moderate to severe incontinence) or between the various other male slings.

4. Is there any evidence of bladder outlet obstruction (e.g., bladder neck contracture or stricture)?

As mentioned before, if urodynamic stress incontinence cannot be demonstrated despite a complaint of SUI symptom and/or positive cough test during physical examination, the clinician must rule out bladder neck contracture and/or urethral stricture prior to any PPI surgery. Even a small urodynamic catheter may be enough to obstruct across a tight anastomotic stricture or bladder neck contracture (see Fig. 50.5). Without the catheter, patient leaks across the contracture/stricture during coughing due to ISD. During urodynamic testing, the urethra is obstructed by the catheter and no SUI is evident. The urodynamic tracing typically shows an obstructive pattern with high pressure and low (or no) uroflow (Fig. 50.6). In such cases, remove the bladder catheter, leave the rectal catheter in place, then ask the patient to cough and valsalva with a full bladder. Stress incontinence should now be evident. The rectal catheter pressure (*Pabd*) can be used to approximate the ALPP. The site of obstruction is identified with real-time video-urodynamics and/or office cystoscopy.

Because of the high incidence of bladder neck contracture in the PPI population [7, 8], Huckabay et al. recommend performing a second fill fol-

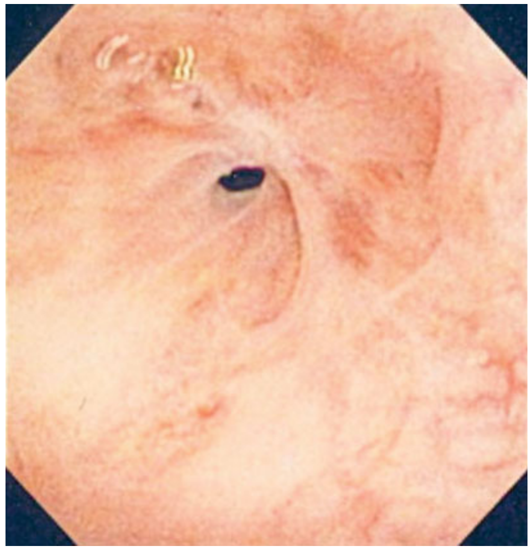

Fig. 50.5 Bladder neck contracture noted during office cystoscopy

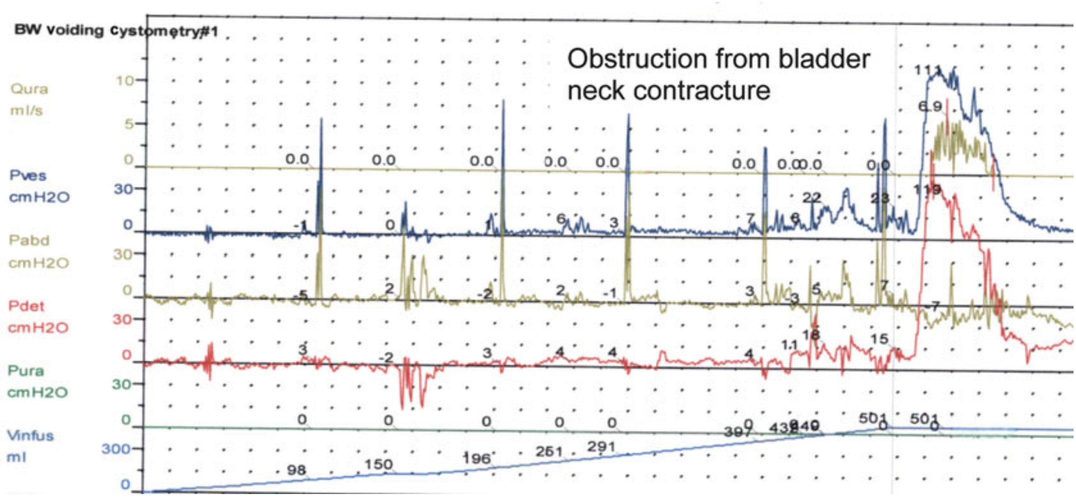

Fig. 50.6 Obstruction by a urodynamic catheter across a tight bladder neck contracture may falsely increase the ALPP and give a false negative cough test (no SUI). Note the voiding pressure (*Pdet*) was elevated (>110 cm) and peak flow (*Qura*) was reduced (6.9 cc/s). The high-pressure, low-flow pattern is consistent with bladder outlet obstruction

lowed by removal of the catheter routinely [20]. In their study, 35 % of men leaked only after removal of the filling catheter. The ALPP may be falsely elevated when it is measured with a urethral catheter in place.

5. Does the patient have an adequate bladder contraction and empty well during the voiding phase?

Impaired bladder contractility and valsalva voiding are present in a considerable percentage of PPI patients (33–82 %) [25, 37–39]. Studies have shown that as long as patients are able to empty their bladder by straining, having poor detrusor contractility on urodynamics does not negatively impact treatment outcome after AUS surgery [25, 40]. It is rare for patients to develop de novo urinary retention after AUS surgery as long as the cuff is sized correctly, since the cuff exerts no resistance on the urethra during voiding. However, some clinicians are reluctant to perform a sling procedure in men with impaired detrusor contractility or valsalva voiding, because of the concern that the detrusor might not be able to overcome the fixed resistance of a sling during voiding [41]. Transient retention rate of 20–25 % has been reported after male sling surgery [36, 42]. This theoretical concern is tampered by a recent study which showed that patients with impaired detrusor contractility actually do well postoperatively with no clinical retention and no increase in residual volumes after bone-anchored perineal or trans-obturator sling surgery (InVance, AdVance, Virtue) [43]. No long-term evidence of urodynamic obstruction was evident after AdVance or InVance sling placement, even in patients who developed transient postoperative retention. In studies where urodynamics was performed before and 6–12 months after AdVance sling placement, no significant change in *Pdet@Qmax*, *Qmax*, bladder obstructive index, post-void residual volume, cystometric capacity, detrusor compliance, overactivity, or hypocontractility was noted after surgery [36, 44]. Similarly, no change in *Pdet@Qmax* or *Qmax* was noted 6–42 months after InVance sling placement [45]. The presence of poor detrusor contractility and/or valsalva voiding does not preclude patient from getting an AUS or male sling as long as he can empty well with low residual volume preoperatively.

Who Should Get Urodynamic Testing for Post-prostatectomy Incontinence?

The purpose of preoperative urodynamic testing is to evaluate the underlying causes of PPI, confirm the diagnosis of ISD and SUI (most patients have this), rule out pure detrusor dysfunction without SUI (few patients have this), and identify adverse features such as poor detrusor compliance (uncommon but important to recognize), impaired detrusor contractility (does not appear to matter as long as residuals are low), or unrecognized bladder outlet obstruction (very common and critical to identify) that may confound treatment decisions. As discussed above, the value of urodynamic testing may be limited in patients with straightforward post-prostatectomy stress incontinence that is unequivocally demonstrated on physical examination and who have no other complicating factors (no urgency, no urge incontinence, no weak stream, no post-void residual, no neurologic history or deficit, no lower urinary tract symptoms prior to prostatectomy, no pelvic radiation history). With rising health-care cost and more scrutiny on the use of diagnostic testing, this streamlined approach is appropriate for the uncomplicated patient with unequivocal stress incontinence and minimal urgency.

On the other hand, preoperative urodynamic testing can offer useful information in selected "higher risk" patients who present with confusing symptoms in whom the diagnosis is uncertain, have a complex medical history (e.g., neurogenic bladder/disease, pelvic radiotherapy), have failed prior incontinence surgeries, or in whom stress incontinence cannot be demonstrated on physical examination. Patients with poor detrusor compliance (<12.5 mL/cm) or intractable urgency symptoms or urgency incontinence with cystometric capacity <200 mL may want to defer AUS surgery, with concern for upper tract deterioration or persistent intractable postoperative urgency symptoms, respectively [23].

Conclusion

Urodynamic evaluation of post-prostatectomy incontinence helps to identify the underlying causes of the incontinence and provide useful information to guide treatment decisions. Patients with straightforward stress incontinence may not need further testing, while those with confusing symptoms, complex history, or uncertain diagnosis will benefit from a urodynamic evaluation.

Editorial Comment

Knowing how to properly read and interpret urodynamic tracings is essential to selecting the best medical and surgical treatment for voiding dysfunction and urinary incontinence. Preoperative urodynamic testing is particularly useful in patients with mixed incontinence (stress and urge) and confusing symptoms where the diagnosis is uncertain and who have a complex medical history confounded by comorbidities such as neurological diseases, have failed prior incontinence surgeries, or have complaints of stress incontinence but cannot be demonstrated on physical exam.

Another essential aspect of PPI evaluation, aside from a good physical and neurological exam, is flexible cystoscopy and urinalysis. Cystoscopy enables evaluation of an associated urethral stricture or bladder neck contracture, assesses external sphincter function (to rule out any sector defects), and assesses for a bladder stone or tumor, as well as mucosal radiation changes (pale mucosa and telangiectasias). Cystoscopy is also a poor man's cystometrogram, assessing bladder capacity and levels of urgency and strong desire to void. Moreover, cystoscopy allows for antegrade bladder filling and then valsalva testing on standing, where we can then visually grade the degree of leakage. Patients who are "leaky faucets" on standing, or "gushers" of urinary leakage with each cough, are good candidates for an artificial urinary sphincter. Patients with lesser degrees of stress incontinence are better served by a male urethral sling.

–Steven B. Brandes

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Erratum

Genital Skin Loss and Scrotal Reconstruction

39

Daniel Rosenstein

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