ICUD on Urethral Strictures

SIU/ICUD Consultation on Urethral Strictures: Dilation, Internal Urethrotomy, and Stenting of Male Anterior Urethral Strictures

Jill C. Buckley, Chris Heyns, Peter Gilling, and Jeff Carney

Male urethral stricture is one of the oldest known urologic diseases, and continues to be a common and challenging urologic condition. Our objective was to review all contemporary and historical articles on the topic of dilation, internal urethrotomy, and stenting of male anterior urethral strictures. An extensive review of the scientific literature concerning anterior urethral urethrotomy/dilation/stenting was performed. Articles were included that met the criteria set by the International Consultation on Urological Diseases (ICUD) urethral strictures committee and were classified by level of evidence using the Oxford Centre for Evidence-Based Medicine criteria adapted from the work of the Agency for Health Care Policy and Research as modified for use in previous ICUD projects. Using criteria set forth by the ICUD, a committee of international experts in urethral stricture disease reviewed the literature and created a consensus statement incorporating levels of evidence and expert opinion in regard to dilation, internal urethrotomy, and stenting of male anterior urethral strictures.

METHODS

An extensive review of the scientific literature concerning anterior urethral urethrotomy/dilation/stenting was performed. Articles were included that met the criteria set by the International Consultation on Urological Diseases (ICUD) urethral strictures committee and were classified by level of evidence using the Oxford Centre for Evidence-Based Medicine criteria adapted from the work of the Agency for Health Care Policy and Research as modified for use in previous ICUD projects. Recommendations were graded according to the levels of evidence and agreement of expert opinion.

Incision/Dilation of Male Anterior Urethral Strictures

A recent survey examining the practice patterns of board-certified American urologists found that 92.8% and 85.6% use dilation and/or incision, respectively, to treat anterior urethral stricures 20 years ago, which suggested a cure rate of over 90%. The reported success rates of urethral stricture treatment are critically dependent on the criteria used for stricture diagnosis before and after treatment, and on the definition of success (in some studies this includes eventual outcome, despite multiple treatments).

Modalities used in determining the success of treatment include symptoms, uroflowmetry, urethral catheterization or calibration, urethroscopy, urethrography (radiological or sonographic), post-void residual urine volume, absence of urinary tract infection, and requirement for subsequent treatment. Clearly, the success rates reported in various studies depend not only on the type of treatment given, but on the criteria used for stricture diagnosis before treatment, the type and duration of follow-up, and the modalities and criteria used to determine stricture recurrence and to define success.
strictures. Of the urologists that perform urethral reconstruction, only 0.7% perform >10 per year.\(^{10,11}\) The appeal of DVIU/dilation is its relative ease of performance, minimal resource requirements, and simplicity in not requiring expertise in urethral reconstruction. The procedure can be performed in the office (with the patient under local anesthetics), requires minimal recovery time, and has a low cost burden to the patient in terms of disability precluding work.\(^{12-14}\)

The goal of incision or dilation is to provide a minimally invasive treatment that achieves a patent urethra to allow unobstructed voiding with minimal side effects. For the urethra to remain patent, re-epithelialization must occur at a faster rate than wound contracture.\(^{15}\) For highly selected patients with optimal stricture characteristics (primary bulbar stricture, <1 cm, soft), a stricture-free rate (SFR) of up to 50%-70% can be achieved. Thus, urethrotomy remains the first-line therapy for these select patients.\(^{1-4}\) The SFR is still well below that of anastomotic urethroplasty (90%-95%),\(^{16,17}\) but urethrotomy can be justified by its simplicity and relatively low morbidity to the patient. Reported complication rates vary from 6%-22%, including pain, bleeding, urinary tract infection, and erectile dysfunction.\(^{2,4,8}\) What is clear from the literature is that repeat (>2) DVIU/dilation for early stricture recurrence after previous DVIU/dilation is a palliative maneuver with expected recurrence.\(^{2,4,8,9,18}\) Thus, it is inappropriately and excessively used because of its convenience and familiarity when referral for urethral reconstruction could be curative.

The literature consists largely of case series with diverse patient populations that are not matched for age, stricture etiology, length, location, or primary vs recurrent strictures. Techniques vary from blind urethral dilation and incision to direct visualization and incision urethroplasty with a cold knife, hot knife, or various types of lasers. The definition of success was vague and poorly defined in most series and limited to one of the following: lack of symptoms, “acceptable” flow rates, radiography, and (rarely) urethroscopy. Outcomes were largely based on short-term follow-up (<1 year), often with no definition of how success was determined.\(^{19}\)

**Review of the Literature on Incision and Dilation Outcomes**

One randomized study performed in 1997 by Steenkamp et al\(^3\) sought to determine whether DVIU and dilation were equally efficacious, which had been reported in prior level 3 studies (level 1).\(^{20}\) Two well-matched groups of 104 and 106 patients were randomized to either incision or dilation, respectively. Although there was a higher reported success rate with DVIU, this was not statistically significant and the effectiveness of the 2 procedures was considered equivalent. This study also found that incremental increases in length resulted in higher failure rates and recommended initial dilation for strictures <2 cm, urethroplasty for strictures >4 cm, and a trial of DVIU or dilation for strictures 2-4 cm in length. The same group of patients was analyzed for time to recurrence, outcomes of repeat incision/dilation, and long-term SFRs using Kaplan-Meier curves out to 48 months. Investigators found that early recurrence (<3 months) and repeat incision/dilation were poor prognostic factors. Urethral strictures that recurred at <3 months and underwent repeat incision or dilation had an SFR of 30% at 24 months and 0% at 48 months. If a stricture recurred at >6 months, then a second DVIU could achieve an SFR of up to 40%. Urethral strictures undergoing a third incision or dilation had a 100% recurrence rate.\(^8\) A number of level 3 studies on DVIU with short duration of follow-up have been published over the past 10-20 years. The mean follow-up in these case series was commonly <12 months (range 3-30 months), with a variety of endpoints, stricture locations, and success rates (46%-84%) being reported.\(^{21-23}\)

Two of the better level 3 series were published in the late 1990s. Pansadoro and Emilozzi\(^2\) analyzed 224 patients who underwent DVIU for short urethral strictures, with a median follow-up of 98 months. The overall SFR was 32%, but varied significantly based on the stricture characteristics of location, length, diameter, primary vs recurrent, and single vs multiple strictures. The bulbar, penile, and penoscrotal locations had SFRs of 42%, 16%, and 11%, respectively. Strictures <1 cm had an SFR of 71% vs 18% for those >1 cm. A lumen diameter >15F had an SFR of 69% vs 34% for those <15F. Primary vs repeat incisions had SFRs of 47% and 0%, respectively, and single strictures vs multiple strictures had SFRs of 50% and 16%, respectively.\(^7\)

A second large series by Albers et al\(^1\) looked at 580 patients with over 3 years’ follow-up. They reported an overall SFR of 55% with the best results again seen in short primary bulbar strictures. Longer strictures (>1 cm) that had failed prior DVIU, multiple strictures, and penile strictures had much higher recurrence rates; therefore, the authors concluded that in these patients, urethroplasty should be performed rather than repeat incision or dilation.\(^4\)

These studies indicated that optimal results for urethroplasty can be achieved in patients with a single primary bulbar stricture that is <1-cm long and >15F in caliber. A single DVIU/dilation or primary urethroplasty could be offered as first-line therapy for penile or penobulbar strictures because of extremely poor SFR with DVIU/dilation, whereas repeated (>2) DVIU/dilation is to be considered only as a palliative maneuver.

Contemporary series have also reported a wide range of SFRs.\(^2,4,11,12,24\) Case series published during the past decade have included 13 to 733 patients per study with 2 to 90 months’ follow-up and success rates of 22% to 100%, remarkably similar to studies published during the preceding 2 decades (1980 to 1999), which included 15 to 580 patients with 6 to 72 months’ follow-up and success rates varying from 22% to 95% (level 3), respectively.

Santucci and Eisenberg recently stated that internal urethroplasty has a much lower success rate than previously reported. They performed a retrospective medical chart review of 136 patients who underwent internal urethroplasty from 1994 through 2009. They excluded 36 patients with complex strictures and 24 who were lost to follow-up. The SFRs after 1, 2, 3, 4, and 5 internal urethroplasies were 8%, 6%, 9%, 0%, and 0%, respectively, and the median times to recurrence were 7, 9, 3, 20, and 8 months, respectively (level 3).\(^7\)

Because of the various definitions of success, nonmatched patient populations, unknown stricture length or location, and various standards of success and lengths of follow-up, it is impossible to compare 1 series to another. Contemporary series on urethroplasty/dilation add little additional information on the management of anterior urethral strictures.

**Repeat Direct Vision Internal Urethroplasty/Dilation**

In patients with stricture recurrence but favorable characteristics (single, <1 cm bulbar stricture) and time to recurrence >6 months, a second DVIU achieved an SFR of 9%-53% (level 2/3).\(^2,5,8,9,23\) Longer, multiple, penile, or distal strictures typically do not respond to repeat incision/dilation.\(^25\)

Repeat DVIU offers no long-term cure after a third incision/dilation or if the stricture recurs within 3 months of the first incision. Such patients should be offered urethroplasty.\(^4,5,8\)
Incision/dilation followed by long-term self- or office dilation is an alternative option for men with severe comorbidities or limited life expectancy, or for those who have failed prior reconstruction with no further available surgical options (level 4).

**Side Effects of Direct Vision Internal Urethrotomy**

A review of the literature showed that the most commonly reported complications of internal urethrotomy are urethral hemorrhage and perineal hematoma (each with a 20% incidence). Other complication rates reported in various studies include scrotal edema (13%), creation of a false passage (10%), rectal perforation (10%), epididymo-orchitis, mental stenosis and incontinence (each 9%), fever (3.6%), extravasation (3.4%), bacteremia (2.7%), urinary sepsis (2.1%), and scrotal abscess (1.4%). Erectile dysfunction has historically been reported in 2%-10% of cases; however, Schneider et al found that of the 68 patients who did not have erectile problems before the operation, only 1 complained about erectile dysfunction after DVIU. It should be noted that most of these numbers are derived from single studies, and the reported 10% rate of rectal perforation is exceptional (level 3).

**Cost Effectiveness**

Several recent studies have looked at cost-effective management of anterior urethral strictures and have shown that a single urethrotomy is cost-effective when the expected success rate is >35%-50%. Primary urethroplasty becomes more cost effective if a repeat urethrotomy is required. Wright et al found that the most cost-effective strategy for the management of short bulb urethral strictures is to reserve urethroplasty for patients in whom a single endoscopic attempt fails. For longer strictures, in which the success rate of DVIU is expected to be <35%, urethroplasty as primary therapy is cost effective. Two similar studies confirmed that initial urethrotomy or dilation followed by urethroplasty in patients with recurrent strictures is the most cost effective.

These studies only evaluated the financial costs of the procedures and lost productivity during convalescence in developed countries. In regions of the world with constrained resources, the use of limited operating room facilities to perform urethroplasty rather than surgery for life-threatening urologic conditions should be considered. An article from Nigeria reported the treatment problems in a community in which strictures are common and resources are limited. In 134 men treated between 1993 and 1996, the combination of internal urethrotomy plus intermittent self-dilation had a recurrence rate of 17%, compared to 22% after urethroplasty. It was estimated that internal urethrotomy was 10 times cheaper and faster to perform than urethroplasty, and offered the surgeon better protection from infection with human immunodeficiency virus (level 3).

**Laser Urethrotomy**

A variety of different laser wavelengths have been used for the incision, resection, and vaporization of anterior urethral strictures over the last 30 years. Initially argon, excimer, and diode lasers were used, as were low-power potassium-titanyl-phosphate (KTP) and contact-tip neodymium:yttrium-aluminum-garnet lasers. Over the past 10 years, holmium and thulium lasers have been added to the surgeon’s armamentarium. There are no level 2 studies and only a few small level 3 series with short-term follow-up.

The addition of lasers with a variety of different energy sources has not improved success rates, yet adds considerable cost with no proven benefit over cold-knife urethrotomy.

**Direct Vision Internal Urethrotomy Plus Self-dilation**

Historically, many patients were placed on intermittent self-catheterization after DVIU/dilation – an attempt to prevent stricture recurrence. It is a traumatic procedure that some patients find painful, unpleasant, and burdensome, with risk of false passage, infection, abscess formation, and progression of the extent of urethral scarring potentially compromising future reconstruction.

Culty and Boccon-Gibod retrospectively found that prior urethral dilation was a negative predictor for patients undergoing membranous/bulbar anastomotic urethroplasty. Patients without prior urethral manipulation had a satisfactory result of more than 90%, vs ~60% in patients with previous surgical treatment. Several studies have evaluated a combination of urethroplasty and dilation. The contribution of dilation or clean intermittent self-catheterization to failure rates could not be separated out in several of the series, but it was noted to add to the cost of treatment.

**Direct Vision Internal Urethrotomy With Adjunctive Agents**

In an effort to improve outcomes of DVIU, a few small series have been published on adjunctive agents used in combination with DVIU. A level 2 study randomized 40 patients with short bulbar strictures (mean length 0.75 mm) to DVIU vs DVIU plus mitomycin C (MMC) injection. Recurrence with DVIU alone was 50%, compared to 10% in the DVIU plus MMC group. However, this was a highly selected group of patients with short bulbar strictures and limited follow-up.

The same authors randomized 50 patients to DVIU vs DVIU plus urethral submucosal injection of triamcinolone, and found a decrease in stricture recurrence from 50% in DVIU alone to 21% in DVIU plus triamcinolone. As in the MMC study, this was a highly selected group of young patients with primary short bulbar strictures (<1.0 cm) and limited follow-up. Additional small level 3 series make reference to the use of adjunctive agents with DVIU, but are inherently limited by incomplete or vague follow-up data and/or definition of success.

**Effect on Future Urethral Reconstruction**

A few level 3 series have shown that prior urethral manipulation was a risk factor for urethroplasty failure. A multivariate analysis looking at long-term outcomes of urethroplasty found that prior failed DVIU was correlated with an increased risk of failure after urethroplasty. Similarly, Roehrborn and McConnell found that the failure rate doubled from 14% to 28% when incision or dilation had been performed before urethroplasty. Successful urethral reconstruction can, however, be achieved after failed DVIU, as shown by Barbagli et al, with equal outcomes in primary urethroplasty vs urethroplasty after DVIU.

**Anterior Urethral Stenting**

Although the concept of stenting the urethra dates back to at least 1969, it was propagated by Milroy et al in 1988, when they reported “a new treatment for urethral strictures.” Originally developed for endovascular use, a self-expanding woven tubular mesh stent made from an alloy of stainless steel was implanted in 8 patients with urethral strictures. At a mean of 8-
month follow-up, all had a good caliber urethra. A later series of 10 patients implanted with the same stent for bulbar strictures reported a 30% stricture recurrence rate at 24-month follow-up, with 50% of patients reporting post-void dribbling (level 4).44

Long-term data began to reveal the difficulties and shortcomings of the UroLume stent. De Vocht et al15 evaluated patient satisfaction 10 years after placement of the UroLume stent and found that only 2 of 15 patients were satisfied with their stent. Four patients had their stents removed (2 for intractable pain and 2 for stent obstruction), 50% had stent encrustation or calcification (17%). Additionally, patients experienced postmicturition dribbling (32%) and recurrent urinary tract infections (27%).

The original indication for the UroLume stent was for recurrent short bulbar urethral strictures and the original series placed them in men (average age 52-53 years) who were optimal candidates for bulbar urethroplasty. Long-term follow-up revealed that up to 55% had stent-related complications, 45% requiring surgical intervention for perineal pain, post-voiding dribbling, incontinence, stent migration, stent obstruction, or recurrent strictures proximal or distal to the stent. Patency continued to decline over time, originally reported at 100% in the initial patients with short follow-up and decreasing to 45% at a mean follow-up of 77 months.44,45 Additionally, explanation can result in substantial urethral tissue loss and the need for challenging urethral reconstruction.47-49

The Memokath stent (a removable, densely coiled, thermo-expandable stent made of nitinol) has been used to treat prostatic obstruction and detrusor sphincter dysynergia in the posterior urethra and was recently evaluated for use in the anterior urethra. A phase III multicenter trial randomized 92 patients to dilation/incision followed by temporary Foley catheter drainage (n = 29) vs Memokath stenting (n = 63) for recurrent bulbar urethral strictures. The primary endpoint was urethral patency, defined as the ability to pass a 16F flexible cystoscope. Urethral patency was 3.5 times longer in the Memokath-stented group, with all stents successfully removed. Durability effect on the stricture was not assessed. Side effects of the stent included urinary tract infections, hematuria, and penile pain. Stent migration occurred in 22% of patients. The ease of placement and removal of the Memokath stent may prove useful for recurrent bulbar strictures in medically unfit patients or patients unable to undergo formal urethral reconstruction; however, further investigation is needed.50

**Recommendations**

The following recommendations were made based on review of the available literature and expert opinion.

**Primary Direct Vision Internal Urethrotomy and Dilation**

1. Urethral dilation and DVIU have equal clinical efficacy and the use of either modality is acceptable, depending on the availability of equipment and resources (B).
2. Primary DVIU/dilation is indicated as first-line therapy for short (<1-2 cm), single, bulbar urethral strictures (A).
3. Primary DVIU/dilation may be used as first-line therapy for urethral strictures with unfavorable characteristics (penile, penobulbar, multiple, >1-2 cm) (C).
4. Urethral reconstruction is recommended as a primary management option for long, multiple, and penile or penobulbar strictures when complete urethral obliteration is present (B).

**Repeat Direct Vision Internal Urethrotomy/Dilation**

1. A second DVIU/dilation can be indicated for recurrent urethral strictures with favorable characteristics (<1-2 cm, single, bulbar stricture) with recurrence >3 months after previous treatment (B).
2. A third DVIU/dilation is not recommended, except if necessitated by patient comorbidities or economic resources (A).
3. Urethral reconstruction over repeat DVIU/dilation should be offered for urethral strictures that recur within 6 months or are refractory to a second DVIU/dilation (A).

**Direct Vision Internal Urethrotomy/Dilation and Intermittent Catheterization**

1. DVIU/dilation combined with intermittent self-dilation may be used as a palliative maneuver for patients unwilling to undergo urethral reconstruction or are medically unfit for surgery (B).

**Laser Urethrotomy**

1. Outcomes of laser urethrotomy suggest that it has no advantage over cold-knife urethrotomy; and because of the additional cost associated with the procedure, its routine use is not recommended (A).

**Anterior Urethral Stenting**

1. Permanent urethral stenting is not recommended for patients with strictures who are considered to be candidates for urethral reconstruction (A).
2. Permanent urethral stenting may be considered in patients with a short, recurrent bulbar stricture who are medically unfit for urethroplasty and cannot tolerate intermittent self-dilation (B).
3. The appropriate circumstances for temporary urethral stenting have not been determined. The procedure is still largely experimental (B).

**References**

In this systematic review of the literature, a search of the PubMed database was conducted to identify articles dealing with augmentation/substitution urethral reconstruction of the anterior urethral stricture. The evidence was categorized by stricture site, surgical technique, and the type of tissue used. The committee appointed by the International Consultation on Urological Disease reviewed this data and produced a consensus statement relating to the augmentation and substitution of the anterior urethra. In this review article, the background pathophysiology is discussed. Most cases of urethral stricture disease in the anterior urethra are consequent on an ischemic spongiositis. The choice of technique and the surgical approach are discussed along with the potential pros and cons of the use of a graft vs a flap. There is research potential for tissue engineering. The efficacy of the surgical approach to the urethra is reviewed. Whenever possible, a 1-stage approach is preferable from the patient’s perspective. In some cases, with complex penile urethral strictures, a 2-stage procedure might be appropriate, and there is an important potential role for the use of a perineal urethrostomy in cases where there is an extensive anterior urethral stricture or where the patient does not wish to undergo complex surgery, or medical contraindications make this hazardous. It is important to have accurate outcome measures for the follow-up of patients, and in this context, a full account needs to be taken of patients’ perspectives by the use of appropriate patient-reported outcome measures. The use of symptoms and a flow rate can be misleading. It is well established that with a normally functioning bladder, the flow rate does not diminish until the caliber of the urethra falls below 10F. The most accurate means of following up patients after stricture surgery are by the use of endoscopy or visualization by urethrography. Careful consideration needs to be made of the outcomes reported in the world literature, bearing in mind these aforementioned points. The article concludes with an overview of the key recommendations provided by the committee.

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	here are many management options available for urethral stricture disease commencing with less invasive urethral dilatation, urethral stenting, and urethrotomy, progressing to anastomotic and substitution urethral reconstruction. Each patient must be treated on the basis of their individual circumstances and with due regard for consent. In this article, we present the consensus decision of the committee appointed by the International Consultation on Urological Disease (ICUD) on the management of anterior urethral strictures that are too lengthy for an anastomotic procedure.

METHODS

A committee was appointed by the ICUD. The chair conducted a literature search in September 2010 through PubMed (US National Library of Medicine—National Institutes of Health) for peer-reviewed articles on strictures of the anterior urethra treated by substitution/augmentation urethral reconstruction. Search terms included: substitution urethral reconstruction, augmentation urethral reconstruction, dorsal onlay, ventral onlay, lateral onlay, bulbar urethral reconstruction, penile urethral reconstruction, Asopa, Palminteri, and panurethral urethral reconstruction. Non-English articles and articles dealing with solely pediatric cases were excluded. After removal of duplicates, 80 articles were identified. From these, 11 were further excluded because the outcomes could not be categorized for the mixed populations described, and 3 review articles were excluded because the data were not original. The remaining 66 articles were categorized by technique according to the site of surgery and the graft used.
The committee met at the SIU meeting in Marrakech, Morocco in October 2010 to discuss the presented evidence and provide recommendations for the proposed techniques for substitution of the bulbar and penile urethra. The evidence for each graft was also considered. Recommendations were formulated by consensus committee opinion and are based on the ICUD modified system.

PREOPERATIVE ASSESSMENT

It is important to have a clear anatomic assessment of the site and length of the stricture. It is recognized that most men will usually have a tight stricture at the first presentation. Indeed, it was first described in 1968⁵ that the effective diameter of the unobstructed male urethra was in the order of 10F, and until the stricture narrowed beyond this point, there would be no significant interference with flow.

The current standard of care is to use a combined ascending and descending urethrogram to image the urethra, supplemented where necessary by urethroscopy. An ischemic urethra looks white or gray, and healthy well-vascularized tissue appears pink. The length of urethral narrowing might not correspond directly to the length of ischemic spongiosis and thus to the length of graft required (Fig. 1). It has been suggested that intracorporeal injection of contrast³,⁴ or ultrasonography⁵,⁶ might be useful.

PREOPERATIVE COUNSELING

Preoperatively, the patient must be warned about the risks of the procedure and of possible complications, the failure rate, the need for additional procedures, the need for follow-up, and the rate of recurrence.

Three retrospective studies have reported that anterior urethral reconstruction has an insignificant long-term effect on erectile dysfunction.⁷⁻⁹ Alterations in penile appearance and sexual performance might occur after anterior urethral reconstruction, but these are usually transient and more likely with longer strictures, advancing age, and preceding history of erectile dysfunction. A prospective study has recently reported that there is a risk of erectile dysfunction within the first few months after surgery,¹⁰ but with time this improves, and most men will have full recovery by 7 months. The authors did note the persistence of erectile dysfunction in some men, but long-term follow-up would be necessary before they could categorically provide advice on the basis of this information.

CHOICE OF URETHRAL RECONSTRUCTION TECHNIQUE

In determining the type of urethral reconstruction that is appropriate, one must consider the length of the stricture, its cause (in particular lichen sclerosus), and any previous surgery. The etiology of a stricture has an influence on any decision, because inflammatory strictures and those associated with lichen sclerosus have a tendency to be longer and also have a tendency to recur because of recrudescence of the underlying disease process.

The bulbar urethra is surrounded by the thickest portion of the corpus spongiosum and is eccentrically placed toward the dorsum. Thus, the dorsal aspect of the surrounding tissues of the corpus spongiosum is thin, whereas ventrally they are thick. Distally, the urethra becomes more centrally placed, and through the glans it is relatively ventrally placed (Fig. 2).

Anastomotic urethral reconstruction involves stricture excision and primary anastomosis of the urethral ends. Surgeons cannot simply excise a stricture and restore continuity because of the potential for causing chordee. It is a useful rule that the bulbar urethra should not be mobilized distal to the penoscrotal junction, and therefore for longer strictures, a substitution procedure might be necessary. Similarly, it is very uncommon to be able to perform an anastomotic urethral reconstruction in the penile urethra, except in the context of a very limited traumatic injury.

Traditionally, only bulbar strictures < 3 cm were considered suitable for an anastomotic procedure.
However, using techniques (covered elsewhere) such as freeing up the urethra and separating the corpora and straightening the natural curve of the urethra (Fig. 3) another few centimeters might be gained when dealing with bulbar strictures.

Morey and Kizer\(^1\) compared anastomotic procedures carried out for a stricture length ranging from 2.6 to 5.0 cm and reported success rates of 91%, as compared with a control group with stricture lengths <2.5 cm. However, the series had only 11 patients in each group, and the mean follow-up period was 22 months.

Three large series looking at the success rates of anastomotic urethral reconstruction have recently been reported, with Santucci et al.,\(^12\) Barbagli et al.,\(^13\) and Eltahawy et al.,\(^14\) reporting success rates between 91% and 98%.

Clearly, the amount of length that can be gained will depend on the anatomy of the individual male patient, including the length and elasticity of the distal urethral segment, and more particularly, the size of the penis and urethra. It is now clearly established that anastomotic urethral reconstruction in the bulbar urethra, when performed by an experienced surgeon, is associated with a success rate of up to 95%.\(^12\)-\(^14\) The remainder of this analysis gives an overview of the various techniques for augmentation urethral reconstruction and reviews the evidence relating to their use.

**AUGMENTATION URETHRAL RECONSTRUCTION**

Augmentation urethral reconstruction can be a 1-stage or a 2-stage procedure. There are 3 potential options with a 1-stage procedure:

1. Augmented anastomosis—excise stricture and restore a roof strip of native urethra augmented by a patch,
2. Onlay augmentation—excise stricture and carry out patch augmentation,
3. Tube augmentation—excise stricture and insert a circumferential patch. This method has a high failure rate of up to 30%.\(^15\)

A 2-stage procedure involves excision of the stricture and the abnormal urethra and reconstruction of a roof strip, which is allowed to heal before second-stage tubularization.

**GRAFTS vs FLAPS**

Controversy previously existed regarding whether one should use a graft or flap, but it is now clearly established from a review of the literature that the stricture recurrence rate is 14.5%-15.7% using a flap or a graft.\(^16\) It can therefore be concluded that in most instances, there is no advantage of a flap over a graft in terms of stricture recurrence rate. A randomized controlled trial confirmed that the efficacy of grafts and flaps was identical, but there was a much higher morbidity with penile skin flaps, which were also technically more complex and were thus less likely to be preferred by patients.\(^17\)

In carrying out an augmentation procedure, one must also consider whether full-thickness tissue or partial-thickness tissue should be used; partial-thickness tissue has a greater propensity to contract.

Alternative options that have been suggested in the past include scrotal skin,\(^18\) extragenital skin,\(^19\) bladder epithelium,\(^20\) and colonic mucosa.\(^21\) In contemporary practice, genital skin and oral mucosa are most commonly used, although there is interest in the potential for tissue engineering in the future.\(^22\) Genital skin flaps are particularly useful when dealing with strictures in the penile urethra, where an onlay flap of penile skin can be especially helpful.
Jenkins et al\textsuperscript{23} found the scrotal pull-through procedure to have a high incidence of complications, and Blandy reported on the significant long-term morbidity associated with the use of scrotal skin, which should not be used except in unusual circumstances.

A number of flap designs have been described, varying in terms of the orientation of the skin island and the dissection of the fascial pedicle. When considering a penile flap, identify an area of hairless penile skin of adequate length for use in the reconstruction of the urethral defect. Ensure that the patient is not shaved so that the position of hair can be identified perioperatively. Next, on the basis of the anatomy of the penis, decide the configuration of the flap, that is, transverse, longitudinal, or oblique. Thereafter, determine the elevation technique of the fascial pedicle. Remember that the skin is a “passenger” on the subcutaneous tissues/fascial tissues. Ventral onlay skin flaps are particularly useful in the management of penile strictures with etiologies other than lichen sclerosus.

In the bulbar urethra, the current standard of care is to use a graft in most cases, because the efficacy of grafts and flaps appears to be virtually identical. Indeed, it is well recognized that a number of complications can occur after flap reconstruction, including penile hematoma, skin necrosis, fistula formation, and if one is using a distal flap derived from the prepuce, penile, and glans torsion. In the longer term, flaps are associated with a higher risk of sacculation (diverticulum formation).

Barbagli et al\textsuperscript{24} have reviewed their experience using dorsal onlay skin graft urethral reconstruction and reported a series of 38 patients, of which 65.8% of cases were considered successful at a mean follow-up of 111 months. It is of interest that most recurrences in this series occurred within the first year. A similar experience has been reported in patients with no underlying progressive condition, such as lichen sclerosus, who underwent augmentation urethral reconstruction objectively assessed using urethrography or endoscopy.\textsuperscript{25}

Andrich et al\textsuperscript{26} reported that in the longer term, the recurrence rate after an augmentation procedure is far worse than would be expected according to the existing literature, with a recurrence rate of 42% at 15 years for augmentation and 14% for anastomotic procedures. However, this study reported on a mixed population of cases at a tertiary center and probably represents a worst-case scenario.

The results of the different configurations of augmentation urethral reconstruction are summarized in Table 1. The complete data set is included in Tables 2-9.

**ORAL MUCOSAL GRAFTS**

Most patients undergoing augmentation urethral reconstruction, and particularly patients with lichen sclerosus, are optimally managed by an oral mucosa patch augmentation. Oral mucosa is simple to harvest, tough, resilient, and easy to handle. It is taken as a full-thickness unit, and for most patients, the donor areas are adequate. It takes very effectively and has a thick epithelium with a thin lamina propria and a dense panlamellar vascular plexus, which allows early inosculation. This mucosa is used to being wet and appears to be resilient to skin diseases such as lichen sclerosus. Conversely, preputial grafts are semiwet, and scrotal and penile grafts are used to a dry environment. Skin has a higher rate of lichen sclerosis recurrence. Oral mucosa also has a privileged immunology, and preclinical work suggests that it shows fibroblast behavior that results in less fibrosis, offering quite a different profile than that of skin.

In harvesting buccal mucosa, the parotid duct is identified opposite the upper second molar tooth. Infiltration with 1 in 200,000 adrenaline is helpful, and the buccal mucosa is excised in the plane superficial to the underlying muscle. Labial (lip) mucosa can be managed in a similar fashion, but is thinner and more difficult to handle and is associated with greater morbidity. Lingual (tongue) mucosa is harvested from the under surface of the tongue.\textsuperscript{27} Lingual mucosa is slightly thinner than buccal mucosa. The landmarks to be identified are the lingual duct and nerve. A comparative study of buccal and lingual mucosa has reported that grafts from these sites are very similar in macroscopic appearance.\textsuperscript{28} The initial results using lingual mucosa have been reproduced by others and appear to be equivalent to those of buccal mucosa.\textsuperscript{29,30}

Reported complications of oral mucosal grafts include intraoperative hemorrhage, postoperative infection, pain, swelling, and damage to salivary ducts. In some cases, patients note initial limitation of oral opening, although this is usually transient. Occasionally, there can be loss or alteration of sensation within the cheek and even more so on the lower lip.\textsuperscript{31,32} A permanent palpable scar because of the formation of a fibrous band might be noticed by the patient. Both numbness and deformity have also been reported, particularly after the harvesting of tissue from the lower lip.

Barbagli et al\textsuperscript{13} in a survey of 295 patients reported that 98.4% would undergo the surgery again and concluded that harvesting from a single cheek with closure of the donor site was a safe procedure with high patient satisfaction.

Contemporary evidence suggests that closure of the donor site is not essential.\textsuperscript{14} Gentle apposition might be

<table>
<thead>
<tr>
<th>Technique</th>
<th>Total Patients Reported (N)</th>
<th>Average Follow-up (mo)</th>
<th>Average Success Rate (%)</th>
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<td>Dorsal onlay bulbar</td>
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<td>Ventral onlay bulbar</td>
<td>563</td>
<td>34.4</td>
<td>88.8</td>
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<td>Lateral onlay bulbar</td>
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<td>77</td>
<td>83</td>
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<td>Asopa</td>
<td>89</td>
<td>28.9</td>
<td>86.7</td>
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<tr>
<td>Palminteri</td>
<td>53</td>
<td>21.9</td>
<td>90.6</td>
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<tr>
<td>One-stage penile</td>
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<td>32.8</td>
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<td>Two-stage penile</td>
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<tr>
<td>Panurethral</td>
<td>240</td>
<td>30.1</td>
<td>88.2</td>
</tr>
</tbody>
</table>

**Table 1. Average data for the different configurations of augmentation urethroplasty**
<table>
<thead>
<tr>
<th>Authors</th>
<th>No. Treated</th>
<th>Follow-up (mo)</th>
<th>Type of Graft</th>
<th>Follow-up Method</th>
<th>Definition of Failure</th>
<th>Success Rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Morey et al 1996</td>
<td>13</td>
<td>18</td>
<td>BM</td>
<td>Uroflowmetry/symptom score</td>
<td>Any instrumentation</td>
<td>100</td>
</tr>
<tr>
<td>Wessells et al 1996</td>
<td>27</td>
<td>23</td>
<td>BM 7</td>
<td>Uroflowmetry 3 and 12 mo</td>
<td>Any instrumentation, radiographic presence of stricture</td>
<td>100</td>
</tr>
<tr>
<td>Pansadoro et al 1999</td>
<td>7</td>
<td>20</td>
<td>BM</td>
<td>Uroflowmetry</td>
<td>Stricture recurrence on urethrography</td>
<td>86</td>
</tr>
<tr>
<td>Andrich et al 2001</td>
<td>29</td>
<td>48-60</td>
<td>BM</td>
<td>Uroflowmetry 3, 6, and 12 mo, then annually</td>
<td>Development of symptoms leading to urethrogram or urethroscopy</td>
<td>86</td>
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<tr>
<td>Meneghini et al 2001</td>
<td>20</td>
<td>6-28</td>
<td>BM</td>
<td>Uroflowmetry 3, 6, 9, and 12 mo, then annually</td>
<td>Any objective or subjective modification of uroflowmetry leading to urethral instrumentation</td>
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<td>Palminteri et al 2002</td>
<td>24</td>
<td>18</td>
<td>BM</td>
<td>Uroflowmetry 4, 8, and 12 mo, then annually</td>
<td>Uroflowmetry 6 and 12 mo</td>
<td>95.8</td>
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<td>Lewis et al 2002</td>
<td>22</td>
<td>12-54</td>
<td>BM</td>
<td>Uroflowmetry 3 and 12 mo, then annually</td>
<td>Recurrence on radiological studies and requiring intervention</td>
<td>94</td>
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<tr>
<td>Kane et al 2002</td>
<td>53</td>
<td>25</td>
<td>BM</td>
<td>Uroflowmetry 3, 6, and 12 mo, then annually</td>
<td>Failure after repeat intervention (some patients also performing ISD)</td>
<td>81.6</td>
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<tr>
<td>Heinke et al 2003</td>
<td>38</td>
<td>22.8</td>
<td>BM</td>
<td>Uroflowmetry 6 and 12 mo and PVRU estimation</td>
<td>Recurrence of symptoms</td>
<td>89</td>
</tr>
<tr>
<td>Pansadoro et al 2003</td>
<td>9</td>
<td>41</td>
<td>BM</td>
<td>Uroflowmetry—periodic</td>
<td>Abnormal voiding Need for intervention (includes 5 penile)</td>
<td>87</td>
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<tr>
<td>Elliott et al 2003</td>
<td>60</td>
<td>47</td>
<td>BM</td>
<td>Uroflowmetry 3 wk, 6 and 12 mo, then annually</td>
<td>If stream reduced or symptoms recurred</td>
<td>90</td>
</tr>
<tr>
<td>Dubey et al 2003</td>
<td>18</td>
<td>45.7</td>
<td>6PS 7 BM 6BLM</td>
<td>Uroflowmetry 6 mo (all patients performed ISD 16F up to 6 mo)</td>
<td>Need for urethral calibration/dilatation with/without DIVU after 18 mo</td>
<td>77.8</td>
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<tr>
<td>Fichtner et al 2004</td>
<td>32</td>
<td>82.8</td>
<td>BM</td>
<td>Uroflowmetry 6 and 12 mo with symptom score and PVRU estimation</td>
<td>Symptomatic recurrence</td>
<td>87</td>
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<tr>
<td>Kellner et al 2004</td>
<td>18</td>
<td>50</td>
<td>BM</td>
<td>Uroflowmetry 3, 6, and 12 mo, then annually</td>
<td>Abnormal voiding Need for intervention</td>
<td>87</td>
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</tbody>
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Continued
<table>
<thead>
<tr>
<th>Authors</th>
<th>No. Treated</th>
<th>Follow-up (mo)</th>
<th>Type of Graft</th>
<th>Follow-up Method</th>
<th>Definition of Failure</th>
<th>Success Rate (%)</th>
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<tbody>
<tr>
<td>Berger et al 2005</td>
<td>7</td>
<td>70.7</td>
<td>BM</td>
<td>Uroflowmetry 3, 6, and 12 mo, then annually Urethrography 3 wk</td>
<td>If stream or symptoms deteriorate</td>
<td>43</td>
</tr>
<tr>
<td>Barbagli et al 2005</td>
<td>17</td>
<td>42</td>
<td>BM</td>
<td>Uroflowmetry 3, 6, and 12 mo, then annually Urethrography 3 wk, then as required Urethroscopy as required (Qmax &lt; 14 mL/s)</td>
<td>Any instrumentation</td>
<td>83</td>
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<tr>
<td>McLaughlin et al 2006</td>
<td>58 (48 reported)</td>
<td>29.6</td>
<td>BM</td>
<td>Symptom score at 12 mo No routine urethrography Urethroscopy if deterioration in symptoms</td>
<td>Any recurrence found on urethroscopy if subjective deterioration in symptoms</td>
<td>94</td>
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<tr>
<td>Palminteri et al 2007</td>
<td>1</td>
<td>21</td>
<td>SIS</td>
<td>Uroflowmetry 4, 8, and 12 mo, then annually Urethrography 3 wk and 12 mo or if Qmax &lt; 14 mL/s Urethroscopy 3 and 12 mo</td>
<td>Abnormal voiding Any instrumentation Evidence of stricture on urethrography</td>
<td>100</td>
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<td>Fiala et al 2007</td>
<td>10</td>
<td>31.2</td>
<td>SIS</td>
<td>Urethrography 3, 6, 9, 12, and 18, then annually If Qmax &lt; 15 mL/s or IPSS &gt; 7 then urethrography</td>
<td>Stricture on urethrography</td>
<td>90</td>
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<td>Levine et al 2007</td>
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<td>58.1</td>
<td>BM</td>
<td>Urethrography 2 wk</td>
<td>Any instrumentation</td>
<td>83</td>
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<td>Dubey et al 2007</td>
<td>8</td>
<td>22.6</td>
<td>BM</td>
<td>Uroflowmetry Urethrography 3 wk, then if required Urethral calibration 16F or urethroscopy 1, 3, 7, 10, and 16 mo, then annually</td>
<td>Recurrence of stricture (includes bulbar)</td>
<td>89.9</td>
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<td>Barbagli et al 2008</td>
<td>93</td>
<td>36</td>
<td>OM</td>
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<td>Any instrumentation</td>
<td>91.4</td>
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<tr>
<td>Barbagli et al 2008</td>
<td>6</td>
<td>15.25</td>
<td>OM</td>
<td>Uroflowmetry 4, 8, and 12 mo, then annually Urethrography 3 wk, 6 and 12 mo IF Qmax &lt; 14 mL/s then cystourethrography and urethroscopy</td>
<td>Any instrumentation</td>
<td>100</td>
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<tr>
<td>Dalela et al 2010</td>
<td>13</td>
<td>16.4</td>
<td>BM</td>
<td>Uroflowmetry and PVR estimation Urethrography if Qmax &lt; 14 mL/s Urethroscopy if Qmax &lt; 14 mL/s</td>
<td>Qmax &lt; 14 mL/s</td>
<td>84.6</td>
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BLM, bladder mucosa; BM, buccal mucosa; CM, colonic mucosa; DIVU, direct internal visual urethrotomy; GS, groin skin graft; IIEF, International Index of Erectile Function; IPSS, International Prostate Symptom Score; ISD, intermittent self-dilatation; LBM, labial mucosa; LM, lingual mucosa; OM, oral mucosa; PAS, postauricular skin graft; PS, penile skin; PVRU, postvoid residual urine; Qmax, maximum urine flow; SG, full-thickness skin graft; SIS, porcine small intestinal submucosa; SS, scrotal skin; TA, tunica albuginea; TV, tunica vaginalis.
Table 3. Outcomes and follow-up of dorsal onlay bulbar urethroplasty

<table>
<thead>
<tr>
<th>Authors</th>
<th>No. Treated</th>
<th>Follow-up (mo)</th>
<th>Type of Graft</th>
<th>Follow-up Method</th>
<th>Definition of Failure</th>
<th>Success Rate (%)</th>
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<tr>
<td>Barbagli et al 1996&lt;sup&gt;16&lt;/sup&gt;</td>
<td>20</td>
<td>46</td>
<td>SG</td>
<td>Uroflowmetry 4, 8, and 12 mo Urethrography 2/3 wk and once more and if Qmax &lt;14 mL/s</td>
<td>Recurrence on urethrography</td>
<td>95</td>
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<td>Barbagli et al 1998&lt;sup&gt;17&lt;/sup&gt;</td>
<td>27</td>
<td>21.5 (13.5 BM)</td>
<td>PS</td>
<td>Uroflowmetry 4, 8, and 12 mo, then annually Urethrography 3 wk, repeat if Qmax &lt;14 mL/s</td>
<td>Any instrumentation</td>
<td>92 (100 BM)</td>
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<td>Pansadoro et al 1999&lt;sup&gt;18&lt;/sup&gt;</td>
<td>23</td>
<td>20</td>
<td>BM</td>
<td>Uroflowmetry Urethrography 2 wk, 6 and 12 mo, then annually</td>
<td>Stricture recurrence on urethrography</td>
<td>100</td>
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<tr>
<td>Iselin et al 1999&lt;sup&gt;19&lt;/sup&gt;</td>
<td>40</td>
<td>43</td>
<td>BM</td>
<td>Uroflowmetry 4, 8, 12 mo, then annually Urethrography 2/3 wk, 4 mo or if Qmax &lt;14 mL/s</td>
<td>Any instrumentation</td>
<td>95</td>
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<td>Dubey et al 2001&lt;sup&gt;20&lt;/sup&gt;</td>
<td>42</td>
<td>48-60</td>
<td>BM</td>
<td>Uroflowmetry 3, 6, and 12 mo, then annually Urethrography 6 and 18 mo, then annually Urethroscopy in last 45 cases</td>
<td>Development of symptoms leading to urethrogram or urethroscopy to confirm recurrence</td>
<td>98</td>
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<tr>
<td>Joseph et al 2002&lt;sup&gt;21&lt;/sup&gt;</td>
<td>14</td>
<td>32</td>
<td>BM or PAS</td>
<td>Uroflowmetry 12 and 18 mo Urethrography 3 wk, 12 and 18 mo</td>
<td>Recurrence on urethrography</td>
<td>100</td>
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<td>Pansadoro et al 2003&lt;sup&gt;22&lt;/sup&gt;</td>
<td>56</td>
<td>41</td>
<td>BM</td>
<td>Uroflowmetry—periodic Urethrography 2 wk, 6 and 12 mo, then annually</td>
<td>Recurrence of symptoms</td>
<td>98</td>
</tr>
<tr>
<td>Dubey et al 2003&lt;sup&gt;23&lt;/sup&gt;</td>
<td>16</td>
<td>22</td>
<td>BM</td>
<td>Uroflowmetry 6 mo (all patients performed ISD 16F up to 6 mo) Urethrography 6, 12, and 18 mo, then as required</td>
<td>Need for urethral calibration/dilatation with/without DIVU after 18 mo</td>
<td>95</td>
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<tr>
<td>Andrich et al 2003&lt;sup&gt;24&lt;/sup&gt;</td>
<td>51</td>
<td>6</td>
<td>BM or SG</td>
<td>Uroflowmetry 6 wk, 3 and 6 mo Urethrography 6 mo</td>
<td>Restructuring on urethrography</td>
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<td>71</td>
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<td>Any instrumentation</td>
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<td>70.7</td>
<td>BM</td>
<td>Uroflowmetry 3, 6, and 12 mo, then annually Urethrography 3 wk</td>
<td>If stream or symptoms deteriorate</td>
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<tr>
<td>Raber et al 2005&lt;sup&gt;27&lt;/sup&gt;</td>
<td>30</td>
<td>51</td>
<td>PS</td>
<td>Uroflowmetry 6, 12, and 18 mo with IPSS and IIEF scores Urethrography 3 wk, repeated if required Urethroscopy as required (Qmax &lt;20 mL/s)</td>
<td>Symptoms requiring intervention (DIVU or ISD)</td>
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<table>
<thead>
<tr>
<th>Authors</th>
<th>No. Treated</th>
<th>Follow-up (mo)</th>
<th>Type of Graft</th>
<th>Follow-up Method</th>
<th>Definition of Failure</th>
<th>Success Rate (%)</th>
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<tr>
<td>Barbagli et al 2005</td>
<td>27</td>
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<td>Uroflowmetry 3, 6, and 12 mo, then annually Urethrography at 3 mo, then required</td>
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<td>Barbagli et al 2006</td>
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<td>16</td>
<td>BM</td>
<td>Uroflowmetry 6 and 12 mo, then annually Urethrography 2 wk, 6 and 12 mo, then</td>
<td>Any instrumentation</td>
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<td>Donkov et al 2006</td>
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<td>SIS</td>
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<td>Decreased flow rate or stricture recurrence Qmax &lt; 15 mL/s Need for instrumentation</td>
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<tr>
<td>Simonato et al 2006</td>
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<td>18</td>
<td>LM</td>
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<td>Any instrumentation</td>
<td>87.5</td>
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<tr>
<td>Xu et al 2007</td>
<td>12</td>
<td>57</td>
<td>BM</td>
<td>Uroflowmetry 14-18 d, 3-6 mo (most patients) Urethrography 14-18 d Urethroscopy in some patients at 12 mo</td>
<td>Any complication 77 (includes tubularized BLM and CM grafts)</td>
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<td>Palminteri et al 2007</td>
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<td>21</td>
<td>SIS</td>
<td>Uroflowmetry 4, 8, and 12 mo, then annually Urethrography 3 wk and 12 mo or if Qmax &lt; 14 mL/s Urethroscopy 3 and 12 mo</td>
<td>Evidence of stricture on urethrography</td>
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<td>Radopoulos et al 2007</td>
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<td>49.9</td>
<td>PS</td>
<td>Uroflowmetry 3/4 and 12 mo Urethrography 3/4 and 12 mo</td>
<td>Abnormal voiding Any instrumentation Evidence of stricture on urethrography</td>
<td>81</td>
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<tr>
<td>Foinquinos et al 2007</td>
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<td>1.5</td>
<td>TV</td>
<td>Uroflowmetry and urethrography</td>
<td>Poor urethrography</td>
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<td>Levine et al 2007</td>
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<td>53</td>
<td>BM</td>
<td>Urethrography 2 wk</td>
<td>Any instrumentation</td>
<td>86</td>
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<tr>
<td>Dubey et al 2007</td>
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<td>22.6</td>
<td>BM</td>
<td>Uroflowmetry Urethroscopy 3 wk, then if required Urethral calibration 16F or urethroscopy 1, 3, 7, 10, and 16 mo, then annually</td>
<td>Recurrence of stricture 89.9 (includes penile)</td>
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<td>Barbagli et al 2008</td>
<td>22</td>
<td>41</td>
<td>OM</td>
<td>Uroflowmetry 4, 8, and 12 mo, then annually Urethrography 2/3 wk</td>
<td>Any instrumentation</td>
<td>77.3</td>
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<tr>
<td></td>
<td>38</td>
<td>111</td>
<td>PS</td>
<td>If Qmax &lt; 14 mL/s then urethrography and urethroscopy</td>
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<td>65.8</td>
</tr>
<tr>
<td>Barbagli et al 2008</td>
<td>6</td>
<td>15.25</td>
<td>OM</td>
<td>Uroflowmetry 4, 8, and 12 mo, then annually Urethrography 3 wk, 6 and 12 mo If Qmax &lt; 14 mL/s then urethrography and urethroscopy</td>
<td>Any instrumentation</td>
<td>100</td>
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</tbody>
</table>

Continued
useful in helping to control bleeding; other techniques include the use of fibrin glue, which can be applied locally (but is very expensive), and standard diathermy hemostasis. Overzealous closure of the cheek donor site appears to worsen pain and might result in perioral numbness, difficulty with mouth opening, and alterations in salivary function.31,34

ACELLULAR MATRICES AND TISSUE ENGINEERING

There has been interest in the use of acellular bladder matrix, with positive results being reported by El-Kassaby et al.35 However, this is a viable option only if there is a healthy, well-vascularized urethral bed with limited residual ischemic spongiosis and healthy urethral mucosa at both ends.36 Regrettably, this is not often the case in which there is a long stricture requiring augmentation. Positive results were reported by Fiala et al17 using porcine small intestinal submucosa matrix. However, a recent update suggests that with longer-term follow-up, the success rate might deteriorate. Hauser et al38 reported a poor success rate using small intestinal submucosa.

In the future, bioengineered buccal mucosa might be of use, particularly for complex strictures where lengthy amounts of oral mucosa are necessary, and ongoing preclinical research is being conducted.32,36 This requires a donation of keratinocytes and fibroblasts obtained from a patient before surgery via a small biopsy carried out under local anesthesia. These cells are cultured and

<table>
<thead>
<tr>
<th>Authors</th>
<th>No. Treated</th>
<th>Follow-up (mo)</th>
<th>Type of Graft</th>
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<th>Definition of Failure</th>
<th>Success Rate (%)</th>
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<tr>
<td>O’Riordan et al 2008</td>
<td>52</td>
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<td>BM</td>
<td>Urethrography 3 wk Symptoms interview</td>
<td>Any instrumentation</td>
<td>86</td>
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<td>Simonato et al 2008</td>
<td>11</td>
<td>17.7</td>
<td>LM</td>
<td>Uroflowmetry 3 and 12 mo Urethrography 2 wk, 3 and 12 mo Urethroscopy 3 and 12 mo</td>
<td>Inability to void, a postvoid residual</td>
<td>81.8</td>
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<td></td>
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<td></td>
<td></td>
<td>Any instrumentation</td>
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<td>Kulkarni et al 2009</td>
<td>88</td>
<td>56</td>
<td>OM</td>
<td>Uroflowmetry every 4, 8, and 12 mo, then annually Urethrography 3 wk, Urethrography if Qmax &lt;12 mL/s</td>
<td>Any instrumentation</td>
<td>91</td>
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<td>Das et al 2009</td>
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<td>9</td>
<td>LM</td>
<td>Uroflowmetry 3 and 6 mo Urethrography 3 wk, 3 and 6 mo</td>
<td>Qmax &lt;15 mL/s, need for instrumentation (includes penile)</td>
<td>83.3</td>
</tr>
<tr>
<td>Kulkarni et al 2009</td>
<td>12</td>
<td>22</td>
<td>OM</td>
<td>Uroflowmetry 4, 8, and 12 mo, then annually Urethrography 3 wk If Qmax &lt;14 mL/s then urethrography and urethroscopy</td>
<td>Any instrumentation</td>
<td>92</td>
</tr>
<tr>
<td>Manoj et al 2009</td>
<td>8</td>
<td>21.7</td>
<td>PAS</td>
<td>Uroflowmetry 3 and 6 mo, annually in some patients Urethrography 3 wk, if required Qmax &lt;14 mL/s</td>
<td>Any instrumentation</td>
<td>100</td>
</tr>
<tr>
<td>Fransis et al 2009</td>
<td>30</td>
<td>23</td>
<td>BM</td>
<td>Uroflowmetry/PVRU 3 and 12 mo, then yearly Urethrography 6 mo Urethroscopy when required</td>
<td>Abnormal voiding, stricture on urethrography and need for instrumentation</td>
<td>94</td>
</tr>
<tr>
<td>Schwentner et al 2010</td>
<td>42</td>
<td>57.2</td>
<td>PS</td>
<td>Uroflowmetry/PVRU 3, 6, 9, and 12 mo Urethrography at catheter removal, then if required</td>
<td>Presence of symptoms and low flow rate</td>
<td>90.5</td>
</tr>
<tr>
<td>Arlen et al 2010</td>
<td>22</td>
<td>10.5</td>
<td>BM</td>
<td>Urethrography 3/4 wk Urethroscopy if symptoms developed</td>
<td>Any instrumentation</td>
<td>83.3</td>
</tr>
</tbody>
</table>

GS, groin skin graft; IIEF, International Index of Erectile Function; LM, lingual mucosa; PAS, postauricular skin graft; SG, full-thickness skin graft; TV, tunica vaginalis; other abbreviations as in Table 2.
attached to the matrix to create a lengthy piece of tissue. Providing the biopsy is taken from the patient undergoing urethral reconstruction, there is no allergic response as long as the underlying matrix is immunologically inert. The principal problems with using biologic matrices relate to a marked exudative process and an unpredictable degree of tissue contraction.

### GRAFT POSITIONING

Barbagli et al.\(^\text{40}\) initially reported dorsal graft urethral reconstruction using skin, and subsequently buccal mucosa (a modification of the Monsen technique).\(^\text{41}\) Initially, this was applied in the context of an augmented anastomotic repair. Recent debate surrounds the advocacy of transection of the corpus spongiosum because of concern over damage to the urethral blood supply. If there is a severely ischemic area of corpus spongiosum, transection is unlikely to be important, as the residual blood flow through the ischemic area is not likely to be significant.

Concerning onlay augmentation, the options are a ventral, lateral, or dorsal approach. A review of dorsal and ventral onlay grafting has suggested comparable success rates of 88% at 3 years, regardless of which approach is used for the onlay.\(^\text{43}\) There is likely to be less bleeding from an incision in this plane and potentially less interference with blood supply as one extends into the proximal and distal “more normal” urethra.

Recently, Kulkarni et al.\(^\text{44}\) reported a 1-sided anterior dorsal approach, preserving the bulbospongious muscle and lateral vascular and nerve supply to the urethra, as having a success rate of 92% in a small series of 24 patients with a short mean follow-up of 22 months. Asopa et al.\(^\text{45}\) described a ventral sagittal urethrotomy transurethral lumen approach, with placement of a dorsal inlay graft. Fifty-eight men underwent treatment, with a mean follow-up of 42 months and a success rate of 87%. Palminteri et al.\(^\text{46}\) have suggested that, in addition to placement of a dorsal graft via the Asopa approach, a ventral onlay could be applied as well. A success rate of 89% with a mean follow-up of 22 months in 48 cases was reported.

One-stage tube repairs should not be used routinely, and it is clear from a review of the literature that the revision rate for a 2-stage procedure before formal closure is on the order of 20%-25%, which equates well with the finding of Greenwell et al.\(^\text{15}\) of a 30% failure rate with a tube urethral reconstruction.

Two-stage reconstruction should be considered whenever there is concern about the success of any reconstructive procedure in the penile urethra, particularly after hypospadias repair or in the presence of lichen sclerosus.

A small literature base reports on staged reconstruction in which a graft is placed during the first stage and later tubularized at the second stage, but it must be emphasized that the literature reports a 22.5% revision rate for a first-stage urethral reconstruction.\(^\text{49}\) When the patient is given information about a 2-stage procedure, he must be warned that the second stage can only be completed when the first stage is adequate for closure.

In carrying out penile surgery, the important factor to bear in mind is the tendency for chordee, and use of an artificial erection is advised during the reconstruction. After first-stage urethral reconstruction, 10%-39% of patients show contraction because of scarring of the initial graft and this requires new grafting techniques.\(^\text{50}\)

Second-stage closure requires tubularization of the first-stage, and the aim is to achieve a roof of 25-30 mm to provide a satisfactory augmentation of the urethral lumen, allowing for the inevitable contraction that occurs during subsequent healing. It is essential to avoid overlaying suture lines and to provide for tissue to be interposed between urethral closure and skin closure. Thus, if the tissues of the penis are thin, then mobilization of a tunica dartos flap or tunica vaginalis island from the scrotum is appropriate. Complications after second-stage urethral reconstruction (fistula formation, glans dehiscence, and meatal stenosis) have been reported in 30% of patients.\(^\text{50}\)

Andrich and Mundy\(^\text{51}\) reported that there is a tendency for recurrence in the marsupialized segment of the urethra, particularly in lichen sclerosus patients, and that therefore a perineal urethrostomy might be a more reliable form of management for full-length urethral...
<table>
<thead>
<tr>
<th>Authors</th>
<th>No. Treated</th>
<th>Follow-up (mo)</th>
<th>Type of Graft</th>
<th>Follow-up Method</th>
<th>Definition of Failure</th>
<th>Success Rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Venn et al 1998</td>
<td>28</td>
<td>36</td>
<td>BM</td>
<td>Regular uroflowmetry, Urethrography 6 mo</td>
<td>Recurrence on urethrography, Development of symptoms leading to urethrogram or urethroscopy to confirm recurrence</td>
<td>96.4, 54.5, 100</td>
</tr>
<tr>
<td>Andrich et al 2001</td>
<td>41</td>
<td>24-60-</td>
<td>BM</td>
<td>Uroflowmetry 3, 6, and 12 mo, then annually Urethrography 6 and 18 mo Urethroscopy in last 45 cases</td>
<td>Uroflowmetry and urethrography 6 wk, then annually Urethrography 6 and 18 mo Urethroscopy in last 45 cases</td>
<td>96.4, 54.5, 100</td>
</tr>
<tr>
<td>Metro et al 2001</td>
<td>14</td>
<td>63.6</td>
<td>BM</td>
<td>Uroflowmetry and symptom score Urethrography 3 wk</td>
<td>Symptomatic recurrence</td>
<td>88.2</td>
</tr>
<tr>
<td>Andrich et al 2003</td>
<td>20</td>
<td>6</td>
<td>BM or SG</td>
<td>Uroflowmetry 6 wk, 3 and 6 mo Urethrography 3 wk</td>
<td>Symptomatic recurrence</td>
<td>88.2</td>
</tr>
<tr>
<td>Fichtner et al 2004</td>
<td>17</td>
<td>82.8</td>
<td>BM</td>
<td>Uroflowmetry 6 mo Urethrography 3 wk</td>
<td>Symptomatic recurrence</td>
<td>88.2</td>
</tr>
<tr>
<td>Dubey et al 2005</td>
<td>16</td>
<td>36.2</td>
<td>BM</td>
<td>Uroflowmetry 3, 6, 9, and 12 mo with ongoing urethral calibration (16F) Urethrography 3 mo, then as required</td>
<td>Symptomatic recurrence</td>
<td>88.2</td>
</tr>
<tr>
<td>Dubey et al 2005</td>
<td>25</td>
<td>32.5</td>
<td>BM</td>
<td>Uroflowmetry 3, 6, 9, and 12 mo, then every 6 mo with ongoing urethral calibration (16F) Urethrography 3 wk</td>
<td>Symptomatic recurrence</td>
<td>88.2</td>
</tr>
<tr>
<td>Kellner et al 2004</td>
<td>5</td>
<td>50</td>
<td>BM</td>
<td>Uroflowmetry 3, 6, and 12 mo, then annually Urethrography 3 wk, then as required</td>
<td>Abnormal voiding Need for intervention (includes 18 bulbar)</td>
<td>87 (includes 18 bulbar)</td>
</tr>
<tr>
<td>Palminteri et al 2007</td>
<td>1</td>
<td>21</td>
<td>SIS</td>
<td>Uroflowmetry 4, 8, 12 mo, then annually Ureraphy 3 wk and 12 mo or if Qmax &lt;14 mL/s Urethroscopy 3 wk</td>
<td>Abnormal voiding Any instrumentation Evidence of stricture on urethrography</td>
<td>0 (33 bulbopenile)</td>
</tr>
<tr>
<td>Palminteri et al 2007</td>
<td>3</td>
<td>31</td>
<td>SIS (bulbopenile)</td>
<td>Uroflowmetry 4, 8, 12 mo, then annually Urethrography 3 wk and 12 mo or if Qmax &lt;14 mL/s Urethroscopy 3 wk</td>
<td>Stricture on urethrography</td>
<td>55.5 (84 bulbopenile)</td>
</tr>
<tr>
<td>Fiala et al 2007</td>
<td>9</td>
<td>31.2</td>
<td>SIS</td>
<td>Urethrography 3, 6, 9, 12, and 18 mo, then annually If Qmax &lt;15 mL/s or IPSS &gt;1 then urethrography Urethroscopy and flow rate at 3/4 mo and at 1 y</td>
<td>Stricture on urethrography</td>
<td>55.5 (84 bulbopenile)</td>
</tr>
<tr>
<td>Radopoulos et al 2007</td>
<td>5</td>
<td>49.9</td>
<td>PS</td>
<td>Urethrography and flow rate at 3/4 mo and at 1 y</td>
<td>Abnormal voiding Any instrumentation Evidence of stricture on urethrography</td>
<td>30</td>
</tr>
<tr>
<td>Foinquinos et al 2007</td>
<td>4</td>
<td>1.5</td>
<td>TV</td>
<td>Uroflowmetry and urethrography 2 wk</td>
<td>Poor uroflowmetry Poor urethrography Poor urethroscopy Any instrumentation</td>
<td>70 ventral onlay 66 dorsal onlay 78 (82)</td>
</tr>
<tr>
<td>Levine et al 2007</td>
<td>13</td>
<td>45</td>
<td>BM</td>
<td>Uroflowmetry 2 wk</td>
<td>Poor uroflowmetry Poor urethrography Poor urethroscopy Any instrumentation</td>
<td>70 ventral onlay 66 dorsal onlay 78 (82)</td>
</tr>
<tr>
<td>Barbagli et al 2008</td>
<td>45</td>
<td>55</td>
<td>PS (OM 22)</td>
<td>Uroflowmetry every 4 mo until 1 y, then annually Urethrography 2 wk If Qmax &lt;14 mL/s then urethrography, ultrasonography, and urethroscopy</td>
<td>Any instrumentation</td>
<td>70 ventral onlay 66 dorsal onlay 78 (82)</td>
</tr>
<tr>
<td>Kumar et al 2008</td>
<td>41</td>
<td>18</td>
<td>TA</td>
<td>Urethrography—no description of timing</td>
<td>Poor caliber at urethrogram Poor urethral lumen at urethrosionogram</td>
<td>67</td>
</tr>
</tbody>
</table>

Continued
**Table 5.** Continued

<table>
<thead>
<tr>
<th>Authors</th>
<th>No. Treated</th>
<th>Follow-up (mo)</th>
<th>Type of Graft</th>
<th>Follow-up Method</th>
<th>Definition of Failure</th>
<th>Success Rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simonato et al 2008</td>
<td>8</td>
<td>17.7</td>
<td>LM</td>
<td>Uroflowmetry 3 and 12 mo Urethrography 2 wk, 3 and 12 mo Urethroscopy 3 and 12 mo</td>
<td>Patient unsatisfied and dilatation required Qmax &lt;20 mL/s Inability to void, a postvoid residual Any instrumentation</td>
<td>100 penile 60 bulbopenile</td>
</tr>
<tr>
<td>Kulkarni et al 2009</td>
<td>8</td>
<td>56</td>
<td>OM</td>
<td>Uroflowmetry every 4, 8, 12 mo, then annually Urethrography 3 wk Urethroscopy if Qmax &lt;12 mL/s</td>
<td>Any instrumentation</td>
<td>100</td>
</tr>
<tr>
<td>Das et al 2009</td>
<td>6</td>
<td>9</td>
<td>LM</td>
<td>Uroflowmetry 3 and 6 mo Urethrography 3 wk, 3 and 6 mo</td>
<td>Qmax &lt;15 mL/s Any instrumentation</td>
<td>83.3 (includes bulbar)</td>
</tr>
<tr>
<td>Singh et al 2009</td>
<td>8</td>
<td>19</td>
<td>BM</td>
<td>Uroflowmetry, urethrography, urethroscopy—no details on timing Urethrography 3 wk, repeat if Qmax &lt;14 mL/s</td>
<td>Qmax &lt;15 mL/s, abnormal urethrogram or urethroscopy, need for any intervention Any instrumentation</td>
<td>88 (includes 8 panurethral)</td>
</tr>
<tr>
<td>Manoj et al 2009</td>
<td>12</td>
<td>21.7</td>
<td>PAS</td>
<td>Uroflowmetry 3 and 6 mo, annually in some patients Urethrography 3 wk, repeat if Qmax &lt;14 mL/s</td>
<td>Any instrumentation</td>
<td>92</td>
</tr>
<tr>
<td>Xu et al 2010</td>
<td>56</td>
<td>17.2</td>
<td>LM</td>
<td>Uroflowmetry 2 or 3 mo, then 6 mo Urethrography when Qmax &lt;15 mL/s Urethroscopy when Qmax &lt;15 mL/s</td>
<td>Not described</td>
<td>87 (includes bulbar cases)</td>
</tr>
</tbody>
</table>

**Table 6.** Outcomes and follow-up of penile urethroplasty via the 2-stage technique

<table>
<thead>
<tr>
<th>Authors</th>
<th>No. Treated</th>
<th>Follow-up (mo)</th>
<th>Type of Graft</th>
<th>Follow-up Method</th>
<th>Definition of Failure</th>
<th>Success Rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Venn et al 1998</td>
<td>16</td>
<td>36</td>
<td>BM</td>
<td>Not described</td>
<td>Not described</td>
<td>93.8</td>
</tr>
<tr>
<td>Andrich et al 2003</td>
<td>58</td>
<td>6</td>
<td>BM or SG</td>
<td>Uroflowmetry 6 wk, 3 and 6 mo Urethrography 6 mo</td>
<td>Restructuring</td>
<td>98</td>
</tr>
<tr>
<td>Dubey et al 2005</td>
<td>15</td>
<td>24.2</td>
<td>BM</td>
<td>Uroflowmetry 3, 6, 9, and 12 mo with ongoing urethral calibration (16F) Urethrography 3 mo, then as required Uroflowmetry 3, 6, 9, and 12 mo, then every 6 mo with ongoing urethral calibration (16F) Urethrography 3 wk Urethrography 3 wk</td>
<td>Symptom recurrence or inability to pass 16F catheter Symptomatic recurrence</td>
<td>86.7 78.6</td>
</tr>
<tr>
<td>Levine et al 2007</td>
<td>5</td>
<td>36</td>
<td>BM</td>
<td>Urethrography 2/3 wk</td>
<td>Any instrumentation</td>
<td>80</td>
</tr>
<tr>
<td>Meeks et al 2008</td>
<td>6</td>
<td>17</td>
<td>SG</td>
<td>Not described</td>
<td>Failure of graft take</td>
<td>100</td>
</tr>
<tr>
<td>Kulkarni et al 2009</td>
<td>15</td>
<td>56</td>
<td>OM</td>
<td>Uroflowmetry every 4, 8, and 12 mo, then annually Urethrography 3 wk Urethroscopy if Qmax &lt;12 mL/s</td>
<td>Any instrumentation</td>
<td>73</td>
</tr>
</tbody>
</table>

Abbreviations as in Tables 2 and 3.
strictures, particularly in elderly patients. Pererson et al \(^{52}\) also support this view.

**PATIENT FOLLOW-UP**

Follow-up protocols after urethral reconstructive procedures vary among series. The most commonly used method is uroflowmetry.\(^ {46}\) For voiding symptoms to appear and flow rates to diminish, there has to be a significant reduction in the caliber of the urethra to \(<10\)F.\(^ {2}\)

Anatomic assessment of the repair site potentially provides the most accurate information with regard to success and the potential for recurrent stricture formation. Although contrast urethrography is most widely used in

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**Table 7. Outcomes and follow-up of panurethral urethroplasty**

<table>
<thead>
<tr>
<th>Authors</th>
<th>No. Treated</th>
<th>No. of Stages</th>
<th>Follow-up (mo)</th>
<th>Type of Graft</th>
<th>Follow-up Method</th>
<th>Definition of Failure</th>
<th>Success Rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Andrich et al 2003(^ {49})</td>
<td>24</td>
<td>2</td>
<td>6</td>
<td>BM or SG</td>
<td>Uroflowmetry 6 wk, 3 and 6 mo</td>
<td>Restructuring</td>
<td>91.7</td>
</tr>
<tr>
<td>Gupta et al 2004(^ {103})</td>
<td>4</td>
<td>8 (bulbopenile)</td>
<td>12</td>
<td>BM</td>
<td>Uroflowmetry every 3 mo</td>
<td>Qmax &lt;15 mL/s</td>
<td>92</td>
</tr>
<tr>
<td>Dubey et al 2005(^ {13})</td>
<td>12</td>
<td>1</td>
<td>36.2</td>
<td>BM</td>
<td>Uroflowmetry 3, 6, 9, and 12 mo with ongoing urethral calibration (16F)</td>
<td>Symptom recurrence or inability to pass 16F catheter</td>
<td>83.3</td>
</tr>
<tr>
<td>Singh et al 2009(^ {59})</td>
<td>8</td>
<td>1</td>
<td>19</td>
<td>BM</td>
<td>Uroflowmetry 3 or 4 mo Urethroscopy at catheter removal</td>
<td>Qmax &lt;15 mL/s, abnormal urethrogram/urethroscopy, any intervention</td>
<td>88 (includes 8 penile)</td>
</tr>
<tr>
<td>Xu et al 2009(^ {21})</td>
<td>36</td>
<td>1</td>
<td>53.6</td>
<td>CM</td>
<td>Uroflowmetry 3 or 4 mo Urethroscopy at catheter removal</td>
<td>Qmax &lt;15 mL/s, abnormal urethrogram/urethroscopy, any intervention</td>
<td>85.7</td>
</tr>
<tr>
<td>Manoj et al 2009(^ {51})</td>
<td>15</td>
<td>1</td>
<td>21.7</td>
<td>PAS</td>
<td>Uroflowmetry 3 and 6 mo, annually in some patients Urethrography 3 wk, repeat if Qmax &lt;15 mL/s</td>
<td>Any instrumentation</td>
<td>80</td>
</tr>
<tr>
<td>Kulkami et al 2009(^ {44})</td>
<td>12</td>
<td>1</td>
<td>22</td>
<td>OM</td>
<td>Uroflowmetry 4, 8, and 12 mo then annually Urethrography 3 wk</td>
<td>Any instrumentation</td>
<td>92</td>
</tr>
<tr>
<td>Xu et al 2009(^ {104})</td>
<td>25</td>
<td>1</td>
<td>26.8</td>
<td>9BM X 2 7 LM 2 9 LM + BM Uroflowmetry Urethrography if problems</td>
<td>Any instrumentation</td>
<td>92</td>
<td></td>
</tr>
<tr>
<td>Das et al 2009(^ {59})</td>
<td>18</td>
<td>1</td>
<td>9</td>
<td>LM</td>
<td>Uroflowmetry 3 and 6 mo Urethrography 3 wk, 3 and 6 mo</td>
<td>Qmax &lt;15 mL/s</td>
<td>83.3 (includes bulbar)</td>
</tr>
<tr>
<td>Mathur and Sharma 2010(^ {105})</td>
<td>86</td>
<td>1</td>
<td>36</td>
<td>TA</td>
<td>Uroflowmetry and pt satisfaction 6, 12, 24, and 36 mo Urethrography 6, 12, 24, and 36 mo Urethroscopy in 10 patients</td>
<td>Good caliber or partially narrowed urethra (urethrography), Qmax &lt;20 mL/s, requiring &gt;1 dilatation/year</td>
<td>89.5</td>
</tr>
</tbody>
</table>

Abbreviations as in Tables 2, 3, and 5.
this context, direct visualization is likely to provide the best information relating to the stricture and the urethra in general.  

A crucial parameter is patient satisfaction, which can be assessed by a patient-reported outcome measure. Although this will not give an indication of surgical healing or allow for earlier identification of complications, it is designed to give a complete picture of patient improvement and satisfaction. Recently, a urethral surgery patient-reported outcome measure has been validated in English and Italian. However, aspects such as donor site morbidity have not been included in the assessment.

**RECOMMENDATIONS**

1. The first operation is likely to be the most successful, and preference should be given to the simplest technique that is likely to be most effective, avoiding augmentation urethral reconstruction if possible (level 3; A).
2. If augmentation (substitution) urethral reconstruction is being considered, an onlay flap for strictures in the penile urethra can also be considered (level 3; B).
3. In most cases, grafts are preferred over flaps for augmentation urethral reconstruction, particularly in the bulbar urethra, because there is a greater morbidity with the use of flaps compared with grafts, and they have similar efficacy (level 2; B).
4. One-stage penile augmentation (substitution) urethral reconstruction is less successful than a 2-stage procedure, except in carefully selected groups (level 3; B).
5. There is no significant difference in outcome between a ventral, lateral, dorsal, or combined approach to augmentation (substitution) urethral reconstruction (level 2; A).
6. Tube substitution procedures should be avoided (level 3-4; A).
7. Scrotal skin should be avoided where possible because of the high associated morbidity (level 3; A).
8. Oral mucosa is the most versatile augmentation (substitution) material (level 3; A).
9. Oral mucosa is currently considered the substitution material of choice for reconstruction of stricture secondary to lichen sclerosus (level 3; A).
10. Neither bladder nor colonic mucosa is recommended for use as primary alternatives for lengthy

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**Table 8.** Outcomes and follow-up of urethroplasty via the Asopa technique

<table>
<thead>
<tr>
<th>Authors</th>
<th>No. Treated</th>
<th>Follow-up (mo)</th>
<th>Type of Graft</th>
<th>Follow-up Method</th>
<th>Definition of Failure</th>
<th>Success Rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asopa et al 2001</td>
<td>12</td>
<td>8-40</td>
<td>10 PS BM</td>
<td>Uroflowmetry at last follow-up</td>
<td>Any instrumentation</td>
<td>91.7</td>
</tr>
<tr>
<td>Palminteri et al</td>
<td>7</td>
<td>21</td>
<td>SIS</td>
<td>Uroflowmetry 4, 8, and 12 mo</td>
<td>Abnormal voiding</td>
<td>100</td>
</tr>
<tr>
<td>Singh et al 2008</td>
<td>25</td>
<td>12</td>
<td>LM</td>
<td>Uroflowmetry 3, 6, and 12 mo</td>
<td>Qmax &lt;15 mL/s</td>
<td>80</td>
</tr>
<tr>
<td>Pisipati et al</td>
<td>45</td>
<td>42</td>
<td>BM</td>
<td>Uroflowmetry 3 and 6 mo, every 6 mo thereafter</td>
<td>Abnormal voiding</td>
<td>87</td>
</tr>
</tbody>
</table>

**Table 9.** Outcomes of combined ventral plus dorsal onlay bulbar urethroplasty

<table>
<thead>
<tr>
<th>Authors</th>
<th>No. Treated</th>
<th>Follow-up (mo)</th>
<th>Type of Graft</th>
<th>Follow-up Method</th>
<th>Definition of Failure</th>
<th>Success Rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Palminteri et al</td>
<td>5</td>
<td>21</td>
<td>SIS</td>
<td>Uroflowmetry 4, 8, and 12 mo</td>
<td>Abnormal voiding</td>
<td>100</td>
</tr>
<tr>
<td>Palminteri et al</td>
<td>48</td>
<td>22</td>
<td>BM</td>
<td>Uroflowmetry 4, 8, and 12 mo</td>
<td>Abnormal voiding</td>
<td>89.6</td>
</tr>
</tbody>
</table>

| Abbreviations as in Tables 2 and 3. |
11. There is no evidence that transection of the corpus spongiosum during a primary augmentation (substitution) procedure leads to a worse outcome (level 3; B).

12. Patient-reported outcome measures for evaluating the results of urethral surgery require further development for the future (level 4; A).

13. Objective assessment with urethrography or endoscopy is recommended to determine the success rate of surgery in terms of stricture recurrence (level 4; A).

14. Any technique that requires the ingrowth of endogenous epithelial and fibroblast cells using acellular matrix is unlikely to be applicable to an extensive stricture with a poorly vascularized graft bed. The direction for tissue engineering remains investigational and should not be used outside an ethics committee–approved research trial. Future research should be focus on the development of cell-seeded matrices that can be used for long strictures with extensive spongiosis or a poorly vascularized graft bed (level 3; B).

References


Pelvic fracture urethral injuries (PFUIs) are injuries to the urethra that result from disruption of the pelvic ring. Minor pelvic fractures are rarely associated with urethral injury, and most of the urethral injuries that do occur will be associated with unstable disruptions of the pelvic ring, in particular, fractures of the anterior pelvic ring combined with disruptions to the sacroiliac joint of the posterior pelvic ring. PFUI complicates pelvic ring disruptions in 25% of patients (level 3). PFUIs can occur in isolation but are more commonly associated with injuries to other organs within or outside the pelvis. PFUIs have been most frequently associated with traffic accidents and can also occur after a fall from a height or from severe pelvic compression.

Injuries of the posterior urethra associated with a pelvic fracture were traditionally known as pelvic fracture urethral injuries (PFUDD)—a term introduced by Turner-Warwick—on the assumption that the vast majority of these injuries were complete. However, current evidence has indicated that they are not usually complete, and, even when they are, they are not necessarily distracted. The term “pelvic fracture urethral distraction defect” has therefore been discontinued and replaced by PFUIs.

Although most PFUIs affect the posterior urethra and, specifically, the bulbomembranous junction, so-called switchblade injuries can affect the bulbular urethra, and these injuries have been included in the category of PFUIs.

The presence of physical signs is directly related to the time elapsed since the injury. PFUIs must therefore be anticipated in the absence of definitive clinical signs in any patient with a pelvic ring disruption.

PFUIs are rarely life-threatening in the acute stage; therefore, their management is usually subordinate to the management of associated injuries—including that of the pelvic fracture. In the long term, significant morbidity from strictures, erectile dysfunction (ED), and incontinence can cause lifelong disability. The severity and duration of such complications can be reduced considerably if the urethral injury has been diagnosed and treated promptly and efficiently.

MECHANISM OF PFUI

The posterior urethra is susceptible to PFUI because of its intimate relationship with the bones of the pubic arch, to which it is tethered by the attachments to the puboprostatic ligaments and perineal membrane. Between the 2, the membranous urethra runs from the apex of the prostate to the perineal membrane, beyond which it becomes the bulbular urethra. Between these 2 fixed points, the urethral sphincter mechanism is vulnerable to injury.
PFUIs were typically described as prostatomembranous disruption injuries. More recently, it has been recognized that most injuries occur at the bulbomembranous junction, where the urethra passes through the perineal membrane (level 2; level 3). Accurate delineation of the site and degree of injury is desirable but problematic because, in the acute phase, retrograde urethrography (RUG) cannot clearly define the severity (completeness) of the injury, even if the site is clearly shown, which is by no means always the case. Because the injuries usually occur in or on either side of the membranous urethra, the demonstration of contrast in the prostatic urethra and bladder has been taken to indicate that the injury is complete. Thus, by implication, failure to demonstrate the prostatic urethra and bladder is taken to indicate that the injury is incomplete. However, the injury is usually just below the urethral sphincter mechanism, which is an area of resistance to flow in either direction. Injected contrast can, therefore, fail to pass through the area of the urethral sphincter mechanism, because it provides too much resistance, or because the path of least resistance is to extravasate, regardless of whether the injury is complete or incomplete. Thus, urethral trauma can be diagnosed, but the completeness of the injury can only be estimated. Intraoperative diagnosis at the time of injury is difficult because of the distortion and distracting effects of the trauma itself. Identification of the site of injury at delayed repair of the urethra can be confused and distorted by the healing process and the fibrosis associated with it. Thus, on postoperative RUG or endoscopy after delayed repair, the site of the anastomosis will almost always be distal to the urethral sphincter mechanism.

**Pelvic Fracture Pattern**

Pelvic fractures are typically classified by the mechanism of injury and the pattern of stability and/or instability. The most widely used classification has been Tile’s classification, which classifies the fracture according to the compromise of the pelvic ring and the degree of instability. Type A fractures are pelvic ring fractures that are stable. Type B fractures are rotationally unstable but vertically stable and include anteroposterior compression (open-book) and lateral compression fractures. Type C fractures are rotationally and vertically unstable and include Malgaigne’s fracture.

Some studies have reported a correlation between the type of pelvic ring disruption and the likelihood of rectal and lower urinary tract injuries. Aihara et al retrospectively reviewed 362 pelvic fractures and found that a widened symphysis and sacroiliac joint involvement were predictive of bladder injury and that a widened symphysis pubis plus fracture of the inferior pubic ramus were predictive of urethral injury. Although these associations were statistically significant, the overall prevalence of rectal and urologic injuries was low. Therefore, the predictive value of these radiologic findings was also low, only 5% for urethral, 9% for rectal, and 20% for bladder injuries (level 3).

Another study revealed that patients with a straddle fracture combined with diastasis of the sacroiliac joint had the greatest risk of urethral injury (25 times greater than the rest of pelvic fractures), followed by straddle fracture alone (3.58 times more common) and Malgaigne’s fracture (3.4 times more common). PFUI was consistently associated with the combination of a pubic arch fracture and disruption of the posterior pelvic ring (level 3). The injury typically occurred at the bulbomembranous junction (level 3).

**Mechanism of Urethral Injury**

Despite these correlations, the pattern of pelvic ring disruption does not, in itself, predict the presence of lower urinary tract injury. Most patients with pelvic fractures will not experience a lower urinary tract injury. This is because the injuries will be mediated by the effect of the supporting ligaments in response to the force applied to them by the pelvic ring disruption. Any ligament can either be torn away from its attachment at either end or can rupture in midsubstance. Thus, a ligamentous attachment between the pubis and urethra can be torn from its bony attachment, can rupture between the bone and urethra, or can be torn from its attachment to the urethra. It is only in the latter instance that the urethra will be damaged (eg, when the perineal membrane ruptures). Following this principle, Andrich et al correlated the urethral injury mechanisms with the mechanism of pelvic ring disruption according to Tile’s classification (level 3). This showed that most patients do not experience a PFUI and explained why and how some patients do. Urethral injury can also occur by direct “switchblade” laceration of the urethra (generally the proximal bulbular urethra) by a fragment of bone; however, this has been uncommon.

In children, the injury is usually more proximal, commonly through the bladder neck (BN) or the prostatic urethra. This is because the prostate is comparatively underdeveloped and poorly supported. Unlike BN and prostatic urethral injuries in adults, which tend to be longitudinal, pediatric BN and prostatic urethral injuries will more frequently be transverse (level 3).

**CLASSIFICATION**

Accurate classification of trauma can be an important guide for clinical management and the evaluation of outcomes. Several classifications have been proposed for PFUI (level 3; level 4), but none has achieved widespread acceptance, in part, because they have not been comprehensive or not clinically useful (or both), but mainly, because no certain method exists for distinguishing between partial and complete injuries.

All classifications have been based on the radiologic evaluation findings and not all patients will have undergone RUG as a part of their emergency assessment. This is because many patients have been catheterized in the emergency department to monitor fluid output and the
response to resuscitation, and, in such patients, urethral injury is only suspected or detected if they are found to be “uncatheterizable.”

The best-known classification is that proposed by Colapinto and McCallum based on the patterns of contrast extravasation on RUG (level 3). This was the first classification to be used to any degree in clinical practice, but it did not include injuries to the BN and prostatic urethra. Also, although they described 3 types of injuries, no type 2 injuries were included and 85% of injuries were type 3 (level 3, 18, 19; level 4, 22).

Goldman et al revised the Colapinto and McCallum categories in an attempt to provide a more useful classification system (level 3); however, similar to the original Colapinto and McCallum classification, the revised version failed to distinguish between partial and complete injuries, which can have totally different treatments and outcomes.

The American Association for the Surgery of Trauma developed a classification system with a different approach that focused more on the degree of injury and disruption than on the anatomic location of the injury (level 4). Their classification included proposed treatments for each of the injury types identified; however, the weakness of their proposal was the previously described problem of distinguishing between partial and complete disruption. This explains the wide variation in the reported incidence of partial vs complete disruption (level 3). The incidence of complete disruption ranged from 6% in 1 series (level 4) to 97% in another (level 3). Webster et al summarized several series and found an average of 65% complete disruptions vs 34% partial injuries (level 2).

More recent attempts at classification have included those proposed by Al Rifaei et al (level 3), Moore et al (level 3), and the European Association of Urology. The fundamental problem that remains with all classifications is that they have depended on the distinction between urethral contusion, partial urethral disruption, and complete urethral disruption and that although RUG can be accurate in locating the injury site, it is insufficiently accurate in defining the degree of the injury (level 4).

**CLINICAL PRESENTATION, DIAGNOSIS, AND IMAGING**

PFUIs should be suspected in all patients with a pelvic fracture, in particular when disruption of the pelvic ring causing rotational or vertical instability has occurred. These injuries are commonly associated with other internal injuries (level 3). Although the incidence of PFUIs in pelvic fractures has ranged from 2%-25% in published studies (level 3), these data came from single-institution cohort studies. Also, in a study by Bjurlin et al using data from the National Trauma Data Bank, the overall incidence of bladder and urethral injury in both sexes was 4.6% and the incidence of urethral injury was 1.1%, mainly in men. However, with more severe forms of pelvic trauma, the incidence of PFUI will increase (level 3), and in those with unstable disruptions of the pelvic ring, the incidence of PFUI will be about 20% (level 3).

The classic sign of PFUI is blood at the urethral meatus, commonly associated with an inability to pass urine and a distended bladder. Blood at the meatus will be present in 20%-100% of cases (level 3). The incidence will vary according to the interval between the injury and the presentation for assessment and treatment. Other clinical features suggestive of PFUI are also time related and include scrotal or perineal hematoma and a high-riding prostate on digital rectal examination (DRE). In practice, DRE is of value in the diagnosis of anorectal injuries, which can be associated with PFUIs; however, it is of little to no value in diagnosing PFUIs because of its low sensitivity (level 3).

Ideally, all patients suspected of having a urethral injury should undergo RUG to confirm this clinical impression. However, this is not always possible, even under ideal circumstances in a level 1 trauma unit. Outside of such a unit, RUG might never be possible. This is particularly true for patients who are hemodynamically unstable because of the severity of their injury. In a hemodynamically stable patient, the first investigation will usually be computed tomography of the abdomen and pelvis, with RUG to follow, ideally with oblique views—depending on the severity of the pelvic fracture and the possibility of a spinal injury. An alternative to maneuvering the patient is to tilt the x-ray machine (level 4).

In patients requiring emergency laparotomy, alternatives to RUG include a trial of catheterization or flexible cystoscopy. Blind urethral catheterization carries the potential risks of introducing infection or of making the injury worse; however, no definitive studies have been published to prove that these theoretical risks occur in practice (level 3). With the increasing use of flexible cystoscopy for the purpose of “primary realignment” (see below), this has been used as a substitute for RUG (level 3). However, the accuracy of this, compared with RUG, has never been tested.

**ACUTE MANAGEMENT**

The uncontroversial immediate management of PFUIs is to place a suprapubic catheter to provide urinary drainage and reduce the risk of urinary extravasation. Thereafter, 2 alternative management approaches are available, and the choice between them has been extremely controversial. The first is simply to leave the suprapubic catheter (SPC) in place and perform an interval urethroplasty some months later. The alternative is to realign the urethra.

The rationale for SPC and interval urethroplasty has been that it allows the patient to recover and that routine, straightforward anastomotic urethroplasty can
then be performed under ideal conditions 3 months or so after the initial injury. The rationale for realignment has been that the incidence of stenosis will be reduced and that, even if stenosis develops, subsequent urethroplasty will be easier. This approach actually stems from historical experience, before the development of urethroplasty, because any stenosis was extremely difficult to treat by dilation (the only treatment available) owing to posterior displacement of the bladder and prostatic urethra above the site of the injury and because open realignment of the urethra over a urethral catheter made subsequent dilation easier. However, open realignment was associated with significant morbidity and, parallel with the development of a satisfactory technique of urethroplasty for PFUIs, this was discarded in favor of SPC and interval urethroplasty, only to be replaced by endoscopic primary realignment (EPR) as flexible cystoscopy and other minimally invasive techniques became available.

In patients with concomitant BN or prostatic urethral injury, or with rectal injury, immediate open primary repair of the BN and prostate, or of the rectum, and urethral catheter repair for the PFUI itself is still indicated to reduce the risk of pelvic sepsis and subsequent sphincter weakness incontinence. Otherwise, open catheter realignment is no longer performed because of the greater incontinence and impotence rates associated with it (level 3). SCP and Interval Urethroplasty SCP is the simplest approach. The SPC can be placed transcutaneously under ultrasound guidance or at laparotomy if the patient requires emergency surgery for other intra-abdominal injuries. A urethral stenosis or obliteration is almost inevitable (92%), but it is difficult to know whether the rate is actually greater than the incidence after EPR, because, in contemporary series, most patients who have undergone SPC and delayed reconstruction have done so either because they were more seriously injured and required emergency laparotomy for other injuries or because EPR had been tried and failed.

The particular advantage of SPC and interval reconstruction is that they allow time for the patient to recover from their other injuries and to undergo urethroplasty in a specialist center under ideal conditions.

Endoscopic Primary Realignment EPR has 2 potential advantages compared with SPC and delayed urethroplasty. First, EPR appears to reduce the risk of subsequent urethral stenosis and obliteration by about 30%. In all reports comparing realignment with cystostomy alone, fewer strictures were reported after EPR, with a range of 8%-86%. There appears to be no risk of increasing the incidence of incontinence or ED compared with SPC alone, such as was found with open realignment. Second, it has been suggested that EPR facilitates any subsequent urethroplasty (level 4), and when the surgeon prefers to attempt dilation or urethrotomy before definitive urethroplasty, the percentage of responders to dilation or urethrotomy has been fivefold greater after EPR than after SPC alone. EPR therefore can provide a significantly shorter time to spontaneous voiding than SPC alone (35 vs 229 days).

Several methods can be used to pass a urethral catheter into the bladder across an injured urethra, starting, obviously, with simple retrograde catheterization. If this fails, flexible cystoscopy is the next step. This can be combined with flexible or rigid cystoscopy through a suprapubic track (level 4). A guidewire passed retrograde or antegrade can facilitate the procedure. Interlocking sounds were used in older studies, and at 1 point, magnetic interlocking sounds blindly placed antegrade and retrograde were advocated; however, these have fallen out of favor, along with other more invasive techniques, since the introduction of flexible cystoscopy and the passage of guidewires.

EPR should be performed as soon as practically possible (level 4) and has generally been achievable at a mean of 32 hours after the injury. Most centers will attempt blind placement of a Foley catheter as soon as the injury has been diagnosed. The timing of EPR does not appear to be critical (level 3), and some reports have described EPR at 7-19 days after the injury with good results (level 3). The urethral catheter should not be placed under tension by traction (level 4). This can cause ischemia, progressing to necrosis and either stenosis or BN incompetence (level 3). The duration of stenting and/or catheterization has varied from 3-8 weeks (level 4). Most investigators have seemed to favor 3-4 weeks. The success rates have ranged from 70%-87% (level 3). and 1 unit has reported that with increased experience, the success rate can increase from 80% to 93% (level 3). Suggestions have been made that rather than facilitating any subsequent urethroplasty, if it becomes necessary, EPR might actually reduce the success of urethroplasty (level 3). The hypothesis that realignment might actually increase the stricture length has been refuted by 1 study of 10 children (level 3). Although most units believe that no significant complications develop after EPR, even if it fails (level 4), reports have been published of occasional episodes of sepsis (level 3).

Confounding Issues The 2 main problems in interpreting these data have been the lack of any comparative studies with comparable groups of patients in comparable situations and the lack of a defined outcome or endpoint. The proponents of SPC and interval urethroplasty have accepted that the development of stenosis is inevitable. Thus, they consider the “cure rate” of their preferred method of management to be the cure rate of definitive urethroplasty. It is more
difficult to define the endpoint of EPR. In some studies, it has been the success rate of the EPR itself, whether or not a stricture developed and whether or not the patient required definitive urethroplasty. In others, it has been whether that urethroplasty was easier to perform, and, in many units, if not most, it has been the avoidance of urethroplasty that has implied a “successful outcome,” even if the patient required lifelong internal dilation or self-catheterization to maintain urethral voiding thereafter. Therefore, no definite evidence has been provided to indicate which approach would be best.

**RECONSTRUCTION OF URETHRAL STENOSIS OR OBLITERATION AFTER PFUI**

The standard approach to the treatment of PFUI stenosis or obliteration has been single-stage excision of the stenosis or obliteration and any associated fibrosis and an overlapping spatulated end-to-end anastomosis of the 2 ends. At a time when the injury was thought to occur at the prostaticmembranous junction, the procedure came to be known as bulboprostatic anastomotic urethroplasty. Now that we know it occurs at the bulbomembranous junction, the procedure should be termed “a bulbomembranous anastomosis” (BMA). This is typically performed 3-6 months after the original injury, allowing time for the acute hematoma to be reabsorbed and replaced by mature fibrous tissue (level 4) and for the patient to recover from their other injuries.

**Operative Procedure: Bulbomembranous Anastomotic Urethroplasty**

**Preoperative Preparation.** The patient’s erectile function should be documented before bulbomembranous anastomotic urethroplasty. Perioperative antibiotics in accordance with the findings from urine culture should be instituted. An up-to-date RUG should be available, and the patient should be counseled regarding, and give consent for, the possible need to convert from a perineal to an abdominoperineal procedure should the operative findings dictate it.

Many surgeons will use a standard lithotomy position; however, some centers have preferred an exaggerated lithotomy position. These surgeons believe the perineal exposure is better. This is debatable, but it certainly gives a better view to an assistant. However, the exaggerated lithotomy position carries a risk of neuropraxic injury and rhabdomyolysis (level 3), particularly when the operative time is >5 hours.

**Incision.** The choice of incision to use is a matter of personal surgeon preference.

**Surgical Steps.** There are 2 principles for the surgical steps. The first is that the bulbar urethra has elasticity; thus, it can be stretched to overcome the gap between the 2 ends after excision of the fibrotic tissue to allow for an overlapping spatulated anastomosis. The second is that the natural course of the normal bulbular urethra approximates to a half-circle from the penoscrotal junction to the membranous urethra owing to the presence of the fused corporal bodies and the underlying pubic symphysis. By managing the causes of the curvature, the surgeon can straighten the bulbular urethra to further reduce any gap between the 2 ends or to reduce tension at the overlapping spatulated anastomosis. These procedures are normally performed in a stepwise fashion, with the straightening of the natural curve of the urethra performed in 4 component parts.

1. Bulbar urethral mobilization—from the perineal membrane as far distal as necessary
2. Separation of the crura of the penis where they are fused together over the inferior aspect of the pubic symphysis and before they have become integrated into a single conjoined component—the crura can be separated in the midline (remembering that the midline could have become rotated by the injury) to enter a virtual space (the intercrural plane) that can be deepened onto the surface of the pubic symphysis, extending upward to the point where the crura are fused
3. Inferior pubectomy—in which a wedge of the inferior aspect of the pubic symphysis and of the pubic bones on either side is excised
4. Supracrural rerouting—in which the urethra is rerouted around the crus or the shaft of the penis when the previous maneuvers alone will not allow a tension-free anastomosis, having extended the separation of the intercrural plane as far as possible

These steps were originally described by Marion, Paine and Coombes, and Waterhouse et al. Turner-Warwick then modified the approach and performed it using an abdominoperineal approach. Finally, Webster and Ramon popularized this stepwise perineal approach (level 3). The use of the first 2 steps alone has been categorized as the simple perineal approach, and the inclusion of steps 3 and 4 is known in the same categorization as the elaborated perineal approach (level 3).

When necessary, usually when adequate access to the membranous urethra and the apex of the prostate cannot be provided by these 4 steps, an abdominoperineal approach could be required, with or without transpubic exposure (level 3).

**Staging Investigations That Might Predict the Surgery Type Required**

It is not clear whether the exact type of surgery can be predicted from the preoperative staging investigations. Andrich et al believed that the findings from conventional contrast studies might not predict the type of repair, mainly because the BN and prostatic urethra are not always visualized. Thus, the gap between the 2 ends cannot be determined radiologically. Also, urethrography and cystography are 2-dimensional representations of a 3-dimensional problem, and the degree of elasticity of
the bulb urethra is variable and unpredictable. They concluded that a surgeon treating PFUI should be competent in all the described steps, because any of them could be required (level 3). 97

However, Koraftim believed that this type of surgery could be predicted, not only by the simple length of the gap between the 2 ends (level 3), 96,98 but also by the ratio of the length of the gap between the 2 ends and the measured length of the bulb urethra. Koraftim 99 termed this the “gapometry urethrometry index” (level 3).

Surgical Results
In competent hands and with uncomplicated PFUIs, the success rate of BMA has been 90%-98%. 83,84,100-103 The success rate depends not only on surgical competence, but also on the severity of the injury and will, therefore, be related to the number of steps necessary to achieve a tension-free anastomosis. The success rate will also be affected by the age of the patient, because of the technical difficulties that arise as a consequence of an underdeveloped prostate and bulb urethra in young children, as described elsewhere in this chapter. A difference also exists between primary and revisional surgery. Finally, the new procedure can be complicated by the coexistence of an anorectal injury and urorectal fistulation, a BN injury (both of which are in subsequent sections), and a perineal degloving injury.

Surgical Complications
Erectile Dysfunction. ED is a common consequence of pelvic ring disruption. The incidence of ED without urethral injury has been 5% (level 3). 104 When a PFUI is present, the incidence will increase to an average of 42% (level 3). 17,45,46,61,63,104-112 The stricter the criteria, the greater the incidence (level 3). 104,112,113 Just as with the incidence of PFUI itself, the incidence of ED can be related to the nature of the pelvic ring disruption. 104,108,109

As discussed, ED (and incontinence) was associated with primary realignment when performed using open techniques; however, this no longer seems to be the case with endoscopic primary realignment.

The nature of ED after PFUI is not clear and has been reported as being vasculogenic in 28%-96%, neurogenic in 20%-89%, and psychogenic in 4%-38% (level 3). 107,109,112,114-117 In part, the rates have depended on the study method. Given that both the nerves and the vessels responsible for erectile function are vulnerable in pelvic ring disruption, this is not altogether surprising, nor would it be surprising if both were responsible in many patients. However, the nervi erigentes are more closely related to the subprostatic urethra and are partly tethered within the perineal body; thus, the cavernous nerves might be more vulnerable than the arterial inflow (level 3). 115,118 It has also been reported that neurogenic ED can improve with time, implying that it is not caused by complete disruption of the neurovascular bundles but more probably by neurapraxia (level 3). 112

Spontaneous recovery of erectile function has been well documented in 7%-38% of patients 3-30 months after injury, with signs of improvement generally showing within 6 months. 58,109,110,113,119 Such patients would therefore be a suitable group for penile rehabilitation protocols.

The diagnosis of ED usually made using an objective questionnaire such as the International Index of Erectile Function, coupled with nocturnal penile tumescence testing and, if results are abnormal, penile duplex ultrasound studies with intracavernous injection. When abnormal arterial function is present, arteriography can be performed.

Management is usually phosphodiesterase type 5 enzyme inhibitors in the first instance, typically sildenafil. If that fails, intracavernosal injection therapy has been the mainstay of treatment, although penile revascularization might be appropriate in a small group of highly selected patients with demonstrable arterial insufficiency and a failure to respond to any other treatment. If all else fails, a penile prosthesis might be appropriate.

Incontinence. In healthy patients, continence is maintained by the BN and the urethral sphincter mechanism. In those with PFUIs, the urethral sphincter mechanism can be damaged and continence will be maintained by the function of the BN. It is only when the BN has also been injured that incontinence will result (level 3). 120,123 A small number of patients, however, will show evidence of incompetence of the BN functionally without any evidence of direct trauma—this tends to occur in association with sacral nerve injury or, otherwise, presumably, pelvic plexus injury.

Urge incontinence can also occur from time to time but has been unusual. Occasionally, patients will have frank voiding difficulty because of neurologic damage and might be unable to void. Most will be suspected of having a recurrent stricture, and the diagnosis of bladder acontractility will usually be made by endoscopic exclusion of recurrent or persistent stenosis at the repair site. These patients will be best treated by self-catheterization. Otherwise, urge incontinence should be treated with anticholinergic drugs, with sphincter weakness incontinence treated by implantation of an artificial urinary sphincter after the exact nature of the incontinence has been defined using videourodynamics studies.

BN Injury
According to Mundy and Andrich, 124 “typical” BN injuries (80% of all cases) will be found in lateral compression or open-book pelvic ring disruptions when the puboprostatic ligaments have been pulled apart, resulting in a longitudinal anterior rupture of the prostatic urethra secondarily involving the BN. “Atypical” injuries, such as transverse trauma to the BN or a “blow-out,” will account for the remainder. 124 Children are more prone to transverse injuries. 100 The diagnosis will be made by the demonstration of urethral injury.
radiologically, and this should be diagnosed and treated as soon as possible, because a ruptured BN and/or prostate will never close spontaneously, has commonly been associated with cavitation secondary to urinary extravasation, and can act as a septic focus. A ruptured BN or prostate should therefore be diagnosed and treated as soon as possible—preferably by formal reconstruction but, failing that, with sphincter enhancement using an artificial urinary sphincter or some alternative, such as collagen injections or slings.\textsuperscript{120,121,124,125}

URORECTAL FISTULA

Urorectal fistula occurs when a PFUI and anorectal trauma coexist, with or without an associated perineal degloving injury. The incidence has been 1.5%-1.8%,\textsuperscript{24} and the effects of trauma can be complicated by infection, ischemia, and/or iatrogenic manipulation.\textsuperscript{127,128}

Patients can present with local sepsis, with the passage of urine rectally, or with hematuria and fecaluria.\textsuperscript{127} The exact location and size can be demonstrated by contrast radiology or cystourethroscopy and rectal examination with the patient under anesthesia.\textsuperscript{127} The fistula can be closed using an abdominal, perineal, or abdominoperineal approach, but the principles are to divide the fistula, separate the 2 viscera, excise the fistulous track and surrounding fibrosis, repair each side of the fistula, and interpose healthy tissue to keep the suture lines apart (level 3).\textsuperscript{126-130} Fecal and urinary diversion are not essential; however, although a colostomy might be avoided, postoperative urinary diversion with a suprapubic catheter, as well as a urethral catheter across the site of repair, has been almost universal (level 3).\textsuperscript{127-130} Fecal diversion has primarily been used for control of sepsis early after the original injury, in particular to avoid infection of the presacral space or, in the longer term, to allow repair of the anal sphincter mechanism in those in whom it has been damaged. For these reasons, most patients will normally have undergone colostomy before they come to undergo BMA.

RECOMMENDATIONS

The following recommendations were made from a review of the available published data and expert opinion.

Anatomy, Mechanisms of Injury, and Classification

1. The dual urinary sphincter mechanism—internal and external (urethral sphincter mechanism)—is highly advantageous, because each sphincteric unit can independently maintain continence if the other has been injured. In particular, the BN will maintain continence if the urethral sphincter mechanism has been damaged by PFUI. Assessment of possible damage to the BN should always be performed (A).
2. Although the acronym “PFUDD” (ie, pelvic fracture urethral distraction defect) has been traditionally used to describe pelvic fracture-related urethral injuries, its use should be discontinued, because a large percentage will be partial injuries and even complete ruptures will not always present as a separation of the urethral ends; therefore, often neither a distraction nor a defect will be present. The term should be replaced by PFUI (A).
3. Having a useful classification of PFUI would be desirable for management decisions and outcomes evaluation. However, none of the existing classifications is ideal, and each of them has limitations, precluding their widespread clinical application. Therefore, no recommendation is yet possible, and new classification systems are needed (D).

Clinical Presentation, Diagnosis, and Imaging: Associated Injuries

1. Urethral injuries should be suspected and ruled out in all patients with pelvic fractures (A).
2. Urethral injuries should be highly suspected with pelvic fracture patterns that include pelvic ring disruption causing unstable injuries (either rotationally or vertically, or both), in particular, in the absence of more obvious physical signs (blood at the meatus) (A).
3. Although still often considered a diagnostic tool for PFUI, DRE is not reliable and should not be used for this purpose. However, DRE retains its value in diagnosing associated rectal injuries (B).
4. RUG is at present the best technique for establishing the site and nature of urethral injury. It should be performed by an experienced operator with diagnostic and staging intention. Well-performed RUG should visualize the whole urethra, including the BN when possible, to indicate the location and degree of the injury (A).
5. If conditions allow, a single gentle attempt at catheter passage can be performed with fluoroscopic guidance at RUG (B).

Acute Management

1. Because of the high morbidity, early open retropubic primary suture repair or open retropubic catheter realignment is not recommended (A).
2. In patients with concomitant bladder, BN, or rectal injuries, immediate open primary repair of these injuries and urethral catheter realignment of the PFUI is indicated to avoid subsequent urinary incontinence or pelvic sepsis (A).
3. Early endoscopic and/or endourologic catheter realignment performed by a urologist can be considered, provided the patient is stable and the proper instruments and equipment are available (B).
4. Realignment can be obtained by gentle simple retrograde catheterization or with a variety of procedures that includes the use of a flexible cystoscope and retrograde passage of a guidewire or a combination of flexible and rigid cystoscopes passed antegrade or retrograde through a suprapubic tract (B).
5. If successful, urethral catheterization should be maintained for 3-6 weeks (B).
6. Placement of an SPC, either as the acute management of choice or, if an attempt at catheterization or realignment has failed, as the other accepted alternative. Placement can be performed at emergency laparotomy if surgery is needed for other injuries or done percutaneously under ultrasound guidance (A).

**Urethral Stenosis and Obliteration: Reconstructive Options and Their Outcomes**

1. Whenever possible, this surgery should be performed by an experienced surgeon skilled in all technical alternatives that might be necessary, because it might not be possible to anticipate the type of repair required (B).
2. For delayed reconstruction, the perineal midline progressive surgical approach is recommended (B).
3. The standard or extended lithotomy position can be used. However, the extended lithotomy position should be restricted to ≤5 hours to avoid lower limb complications (B).
4. Possible indicators for the need for an elaborated perineal and/or transpubic repair include a gapometry urethrometry index (length of defect and/or length of bulb urethra) >0.35, a urethral gap length >2.5 cm, and lateral prostatic displacement. In such cases, the surgeon must be prepared for a complex procedure (B).
5. Inferior pubectomy and supracrural rerouting in BMA will be of value in some rare cases when extra urethral length is required (B).
6. A widely open BN with irregular margins on cystography and with visible scarring on cystoscopy indicates possible damage to the BN sphincter mechanism. Therefore, the patient should be informed about the likelihood of postoperative incontinence (B).
7. When urethroplasty is successfully accomplished by way of the perineum, BN reconstruction (if necessary) can be postponed for a subsequent session. In perineal-abdominal procedures, BN reconstruction can be performed during the same session (C).
8. For failed BMA, re-do BMA is recommended if an adequate length of bulb urethra is available. In the absence of sufficient bulbular urethral length, substitution urethroplasty using a perineal or abdominoperineal approach is the alternative (B).

**Complex Scenarios and Complications**

1. Management of post-traumatic incontinence should be individualized. BN repair and/or reconstruction, the artificial urinary sphincter, and—when all else fails or is unrealistic—continent urinary diversion are the recommended alternatives (B).
2. Some evidence has shown that early use of phosphodiesterase type 5 enzyme inhibitors can improve erectile function after urethral injury (C).
3. Management of post-traumatic urethral fistula should be individualized. The surgical approach should provide for ample exposure of the fistula, the fistulous tract should be excised completely, and a well-vascularized interposition flap should be applied (B).

**Future Research**

1. Current classification systems are limited and not clinically useful. Validated new proposals are required.
2. The ideal timing of urethroplasty after injury is unknown (standard 3-6 months). The safety and efficacy of earlier repair protocols (3-4 weeks) needs to be established.
3. Prospective studies comparing catheter realignment vs SPC and interval BMA should be conducted.
4. The vascular significance of post-traumatic ED should be studied, just as should the role of microvascular penile revascularization before BMA to avoid bulbular necrosis after urethroplasty.
5. The efficacy of penile rehabilitation protocols using phosphodiesterase type 5 enzyme inhibitors should be evaluated.

**References**


Posterior urethral strnosis can result from radical prostatectomy in approximately 5%-10% of patients (range 1.4%-29%). Similarly, 4%-9% of men after brachytherapy and 1%-13% after external beam radiotherapy will develop stenosis. The rate will be greater after combination therapy and can exceed 40% after salvage radical prostatectomy. Although postradical prostatectomy stenoses mostly develop within 2 years, postradiotherapy stenoses take longer to appear. Many result in storage and voiding symptoms and can be associated with incontinence. The evaluation consists of a workup similar to that for lower urinary tract symptoms, with additional testing to rule out recurrent or persistent prostate cancer. Treatment is usually initiated with an endoscopic approach commonly involving dilation, visual urethroty or with or without laser treatment, and, possibly, UroLume stent placement. Open surgical urethroplasty has been reported, as well as urinary diversion for recalcitrant stenosis. A proposed algorithm illustrating a graded approach has been provided.

As the male urethra courses through the prostate, it is susceptible to injury during prostate cancer treatment. Stenosis of the posterior urethra can lead to recurring problems of urinary retention, dysuria, and urinary frequency and incontinence, with a negative effect on patients’ quality of life. Because the probability of long-term survival after prostate cancer treatment is high, it is important for practitioners to understand the frequency with which posterior urethral stenosis (PUS) occurs after prostate cancer treatment to properly counsel patients regarding the implications of their treatment choice. It is likewise critical to better define the comparative effectiveness of treatment options to manage therapy-related PUS.

MATERIAL AND METHODS

The committee assessed and reviewed the epidemiology, evaluation, and management of PUS after localized treatment of prostate cancer. Studies from the past 15 years from peer-reviewed journals, abstracts from scientific meetings, and published data searches manually and electronically formed the basis of the present review. The search terms used included “prostate cancer,” “radical prostatectomy,” “radiation, brachytherapy,” “cryotherapy,” and “high-intensity focused ultrasound (HIFU).”

As a general term, PUS can be subdivided into bladder neck, vesicourethral anastomotic, prostatic urethral, membranous, prostatomembranous, and bulbomembranous (BM) stenoses. Obliterative lesions can be seen in virtually all these entities. The published data have not always differentiated among the various anatomic locations for stenosis. However, post-RP stenosis will usually be located at the vesicourethral anastomosis and in the sections discussing RP, it is referred to as such.

Specific recommendations and grades of recommendations (GR) were made in accordance with the published results and...
were determined by the levels of evidence (LE).\textsuperscript{3} Consensus of the committee determined the recommendations, which can be found at the end of the present report. Recommendations for future research were also included.

**EPIDEMIOLOGY AND RISK FACTORS**

**Radical Prostatectomy**

PUS after RP manifests as a narrowing of the anastomosis between the bladder neck and the membranous urethra, commonly termed “bladder neck contracture” (BNC), which occurs in 1.4%-29% of patients after RP (Table 1).\textsuperscript{4,8} The number of RPs performed in the United States exceeded 80,000 in 2001 and has continued to remain constant despite concerns about the public health benefit of prostate-specific antigen screening. Using conservative estimates from published studies, it has been calculated that >5000 men will require treatment each year for post-RP strictures of the posterior urethra and bladder neck.

BNC after RP results from fibrotic narrowing of the reconfigured and/or spared bladder neck.\textsuperscript{6,9} The proposed mechanisms have included anastomotic tension, inflammation from urinary extravasation, poor tissue handling, and ischemia. The risk factors identified in case series and large prospective studies can be divided into preoperative, intraoperative, and postoperative categories and have included excessive blood loss, type of bladder neck dissection, postoperative urinary leakage, adjuvant radiotherapy (RT), previous transurethral resection of the prostate (TURP), current cigarette smoking, older age, obesity, and surgeon experience\textsuperscript{4,6,8,18} (Table 2).

![Figure 1. Treatment trends among patients with low-risk prostate cancer aged 75 years. P values for significant trends were as follows: external beam radiotherapy (EBRT), $P = .0005$; brachytherapy (Brachy), $P = .0001$; primary androgen deprivation therapy (PADT), $P = .0492$; and watchful waiting (WW), $P = .0048$. The trend for radical prostatectomy (RP) was not significant ($P = .96$). Data reprinted with permission from Cooperberg et al.\textsuperscript{2}](image)

Better visualization for accomplishing an epithelial-to-epithelial anastomosis might explain the lower BNC rates with a perineal or robotic compared with than an open retropubic approach.\textsuperscript{7,15,16} The risk of complications is much greater after salvage RP than after primary RP, and BNC can occur in 42% of such patients. It has been well documented that most BNC after RP occurs within 2 years of surgery.\textsuperscript{6,19}

Overall, the likelihood of BNC after RP ranges from 1.4%-29% of patients. Most contemporary series have reported BNC rates of 5%-10%.\textsuperscript{4,10} Publications of robotic-assisted prostatectomy to date have suggested that BNC rates of 1%-3% are common; however, longer follow-up is needed to confirm these results.

**Radiotherapy**

RT can be delivered by way of an external beam source (EBRT) or using brachytherapy seeds (BT). BT can be delivered as short-acting nonpermanent seeds (high-dose-rate BT [HDR-BT]) or longer half-life seeds that are permanently implanted (low-dose-rate BT [LDR-BT]).

Radiation causes its therapeutic effect by damaging the deoxyribonucleic acid of actively dividing cells. The long-term effect results from the persistent effect of oxidative stress. Adverse effects such as PUS are secondary to chronic fibrosis and progressive endarteritis in poorly oxygenated submucosal and muscular tissues, with eventual tissue scarring.\textsuperscript{21,22}

Although surgical PUS occurs primarily within the first 2 years after treatment,\textsuperscript{6,19} PUS due to RT continues to accumulate during the long term. Because of the high prevalence of patients living long term after pelvic RT and the accumulation of urinary RT adverse effects over an extended time horizon, it is imperative that we better understand the delayed urinary adverse effects of pelvic RT, including PUS.

**Incidence After BT.** Numerous reports have shown that urethral stenosis is the most frequent late complication reported in patients after BT.\textsuperscript{23-25} The incidence of urethral stenosis after HDR-BT in published studies has been 0%-14%,\textsuperscript{25-27} with most series reporting rates of 4%-9% at 5 years. The rate has been slightly greater when combined with EBRT.\textsuperscript{28}

The urethral stricture rates reported in RT studies have generally identified only strictures resulting in symptoms and might therefore have underestimated the true rate of urethral stricture development.

**Incidence After EBRT.** Urethral stenosis occurs after 3-dimensional conformal RT in 1%-13% of patients, and the risk increases with long-term follow-up: <7% with <5 years of follow-up but 10%-18% with 5-10 years of follow-up.\textsuperscript{23-25} The risk of stenosis is increased in those with a history of TURP before EBRT.\textsuperscript{20} Although intensity-modulated RT has successfully reduced rectal toxicity through improved targeting of RT beams, urinary
symptoms can actually be worse after intensity-modulated RT than after 3-dimensional conformal RT.32
The incidence of PUS after adjuvant or salvage EBRT has been 3%-8.5%.33,34

Urethral Stricture due to BT.
Pathophysiology. Urethral obstruction immediately after BT implantation is due to therapy-induced inflammation of the prostate. Although the problem is common, it is generally self-limited.15 However, urethral stenosis can develop and is the most common long-term serious urinary adverse effect of BT. This underscores the importance of understanding the delayed urinary adverse effects of pelvic RT.

Time Frame After BT. A Surveillance Epidemiology and End Results—Medicare examination showed that within 2 years of BT, 30% of patients were listed with a diagnosis of urinary obstruction and 10% had a claim for a procedure performed for obstruction, most often dilation of a urethral stricture.28 This compares with median latency periods of 24-36 months in the HDR-BT population.25

Stricture Location After BT. The relatively specific sensitivity of the BM urethra to RT damage appears paradoxical, because this area (lying approximately 20 mm distal to the prostatic apex) should theoretically receive a far lower radiation dose than the prostatic urethra, which rarely develops stenosis.25,37 In the study by Sullivan et al,38 the stricture location was the BM urethra in 92.1%. In the study by Merrick et al,37 29 of 1186 patients developed urethral strictures, and all were in the BM urethra.

Risk Factors After BT. The risk factors for urethral stricture after BT included older age, nonwhite race, low income, more comorbidities, combination therapy with EBRT or hormonal therapy, and a history of previous TURP. Older age was not found to be a significant risk factor in the series by Pellizzon et al.39 Several other series have confirmed that the risk of urethral stricture after BT is increased by combination therapy with EBRT. A review of the Cancer of the Prostate Strategic Urologic Research Endeavour multi-institutional registry revealed a crude risk of treatment of urethral stricture of 1.8% after BT and 5.2% after BT plus EBRT, with a median follow-up of 2.7 years.

Most of the strictures have occurred at the membranous urethra, and early investigators noted the risk was related to the dose delivered to the prostatic apex.37,40,41 Others have countered that the apical dose does not matter; however, a close read of these more recent series will demonstrate that their apical dose was much lower than that in the earlier series.26,27

Of the suggested clinical predictive factors for urethral strictures after prostate BT, previous TURP has consistently been a risk factor for late genitourinary toxicity in patients receiving either HDR-BT or LDR-BT.38

<table>
<thead>
<tr>
<th>Investigator</th>
<th>Year</th>
<th>Modality</th>
<th>Design</th>
<th>n</th>
<th>Rate (%)</th>
<th>Follow-up</th>
<th>Accrual</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Borboroglu et al²⁴</td>
<td>2000</td>
<td>RP</td>
<td>Retrospective cohort</td>
<td>467</td>
<td>11</td>
<td>&gt;12 mo</td>
<td>1991-1999</td>
<td>Risk factors: current smoking, CAD, and EBL in MVLR model Univariate: also DM, OR time; obesity was not recorded</td>
</tr>
<tr>
<td>Erickson et al⁶</td>
<td>2009</td>
<td>RRP</td>
<td>Retrospective cohort</td>
<td>4,132</td>
<td>2.5</td>
<td>44 mo</td>
<td>1983-2000</td>
<td>Multivariate predictors: year of surgery and non-nerve-sparing approach</td>
</tr>
<tr>
<td>Carlsson et al⁴⁷</td>
<td>2010</td>
<td>ORRP vs LARRP</td>
<td>Retrospective cohort</td>
<td>1738 (485 open, 1253 robotic)</td>
<td>4.5 and 0.2</td>
<td>1997-2007</td>
<td>No risk factors discussed</td>
<td></td>
</tr>
<tr>
<td>Gillitzer et al⁸</td>
<td>2010</td>
<td>RPP vs RRP</td>
<td>Retrospective cohort</td>
<td>2918 (866 RPP vs 2052 RRP)</td>
<td>3.8 (RPP); 5.5 (RP)</td>
<td>1997-2007</td>
<td>Multivariate logistic regression risk factors: Gleason score, TURP, prostate volume, tumor stage and grade, transfusions, acute urinary retention treated with suprapubic tube, surgical technique</td>
<td></td>
</tr>
</tbody>
</table>

CAD, coronary artery disease; DM, diabetes mellitus; EBL, estimated blood loss; LARRP, laparoscopically assisted robotic radical prostatectomy; MVLR, multivariate logistic regression model; OR, operation time; ORRP, open radical retropubic prostatectomy; RP, radical prostatectomy (retropubic, perineal, or unspecified); RPP, radical perineal prostatectomy; RRP, radical retropubic prostatectomy; TURP, transurethral resection of the prostate.
Retrospective data have suggested that EBRT or LDR-BT for prostate carcinoma in those with a history of previous TURP resulted in a 15% risk of developing a urethral stricture or BNC, significantly greater than the 6% rate for those without a history of TURP. In another series of >400 patients receiving HDR-BT, all patients with late grade 3 and 4 genitourinary complications (including 7.4% with urethral strictures) had undergone either TURP or urethrotomy within 1 year before or after BT. Patients should be counseled regarding their increased risk of urethral stricture formation when considering BT.

A history of hypertension was also a significant predictive factor for stricture formation and a plausible finding based on toxicity studies from other tumor sites in which hypertension has been shown to increase late severe toxicity, especially in conjunction with diabetes mellitus. It seems prudent, however, to manage vascular risk factors aggressively in patients scheduled to undergo HDR-BT.

Compared with HDR-BT, urethral strictures seem to occur less frequently as a complication after LDR-BT and conformal EBRT. Modern LDR-BT series have reported an incidence of 0%-5.5%. Compared with HDR-BT, urethral strictures seem to occur less frequently as a complication after LDR-BT and conformal EBRT. Modern LDR-BT series have reported an incidence of 0%-5.5%.

**Cryotherapy**

Cryotherapy involves the ablation of tissue by local induction of extremely low temperatures and is used a therapeutic modality for prostate cancer. In 1996, the American Urological Association recognized cryotherapy as a therapeutic option for prostate cancer and removed the “investigational” label from this procedure. Improvements in the technology of cryotherapy have allowed more efficient freezing of the prostate gland and reduced damage to the surrounding tissues. Thus, this modality offers a minimally invasive treatment with low morbidity, minimal blood loss, a short hospital stay, and high rates of negative post-treatment biopsy findings.

The main mechanism of cytotoxicity produced by cryotherapy is the induction of targeted areas of coagulative necrosis in the prostate gland. The freezing injury comprises direct mechanical shock, osmotic shock, and cellular hypoxia. The mechanisms of action include protein denaturation by dehydration, transfer of water from the intracellular space to the extracellular space, rupture of cell membranes from ice crystal expansion, a toxic concentration of cellular constituents, thermal shock from rapid super-cooling, slow thawing, vascular stasis, and increased apoptosis.

One of the most important recent advances has been real-time ultrasound-guided placement of the cryoprobes and continuous visualization of the freezing. Biplanar transrectal ultrasonography allows for transverse and longitudinal views of the prostate and of the frozen area. The views are interchangeable during the procedure. Frozen tissue differs from unfrozen tissue in sound impedance, resulting in a strong echo reflection at the interface of the normal and frozen tissue. To protect the urethra and external urinary sphincter, minimize urethral sloughing, and prevent urinary incontinence, a urethral warming device should be used during prostate cryotherapy.

**Urethral Sloughing and/or Urethral Stricture After Cryotherapy**

Tissue sloughing has been reported to occur in 3.8%-23% of cases. With the current refinement of the freezing technique, however, symptomatic sloughing has been a minor and infrequent event, occurring...
in <3% of patients. Treatment consists of antibiotics and adequate urinary drainage. Intermittent self-catheterization can lead to spontaneous tissue dislodgment. However, transurethral resection or removal of the necrotic tissue could be required if the condition persists. Urethral stricture rarely forms after cryotherapy if an effective urethral warming device has been used. However, if extensive tissue sloughing occurs, stricture at the bladder neck or the middle of the prostatic urethra can occur. In those cases of stenosis, transurethral incision or balloon dilation will usually be successful. Calcification of the stricture can also occur, necessitating transurethral resection. The use of an effective urethral warming catheter is essential to minimize the risk of tissue sloughing.

Rectourethral fistula has been reported to occur in 0%-3% of patients. It has most commonly been seen in patients who had previously undergone RT. In recent series, the rate has been 0% owing to the high accuracy using transrectal ultrasonography and temperature monitoring of the rectal wall.

High-intensity Focused Ultrasound

HIFU is a new technology, and, with time, the incidence of urethral stricture could decrease, just as it did with BT and cryotherapy. However, with the present technology, PUS has been reported to occur in 7%-30% of those undergoing HIFU as first-line treatment and in 20% of those undergoing salvage HIFU.

Epidemiology and Risk Factors With HIFU. HIFU is a minimally invasive alternative technique for the management of both benign prostatic hypertrophy (or hyperplasia [BPH]) and localized primary or recurrent prostate cancer. It was originally introduced in 1992 as a thermoablative treatment option for BPH. The target effect is achieved by the emission of a high-energy ultrasound beam, which is focused on the prostate through a transrectal probe imaging the lesion using simultaneous ultrasonography, and delivering a generated temperature in the range of 100°C, leading to immediate coagulative necrosis.

The most common adverse effect is the development of bladder outlet obstruction from edema and sloughing of necrotic tissue. To reduce the incidence of urinary retention, the concept of combined TURP and HIFU in 1 session was introduced. This reduced the catheterization time to 7 days, with subsequent reports having similar findings, revealing a decrease in the rate of bladder outlet obstruction of 2%-8% by adding initial TURP to HIFU therapy. Long-term follow-up, however, might demonstrate a delayed appearance of bladder outlet obstruction, because many patients do not develop obstructive disease for 15 months to 9 years. A trend was seen toward lower rates of bladder outlet obstruction (12.5%) when a longer interval between TURP and HIFU was used, especially if a large amount of tissue had been resected. The long-term effect of HIFU on the prostate is increased fibrosis, leading to 80%-100% of bladder neck scarring in patients with multiple previous episodes of recurrent obstruction.

HIFU Summary. Bladder outlet obstruction occurred in 25% of patients after the first HIFU thermal ablation of localized prostatic cancer, and 5% had obstruction from multiple episodes. Necrotic tissue accounted for most of the first episodes. TURP performed 3 months after HIFU resulted in a marked decrease in bladder outlet obstruction (30% vs 12.5%). The presence of late post-HIFU BNC has varied from 3.6%-4.8%, irrespective of the addition of TURP to the original HIFU. These were classic vesical neck stenoses requiring conventional remedies of cold knife or laser urethrotomy.

Post-transurethral Prostatectomy

BNC has been a disappointing, but consistently occurring, complication of all forms of prostate surgery. The etiology is not well understood but is undoubtedly related to the type of procedure (surgical, endoscopic, or ablative), prostate size, extravasation of urine, catheterization duration, and a history of previous prostate surgery. BNC can develop as late as 15-19 months after TURP but most cases develop within 2-8 months. BNC is usually identified by the development or persistence of voiding or storage symptoms after initial improvement. In the presence of continued bladder overactivity or a large postvoid residual urine volume, bladder dysfunction should first be distinguished from obstructing BNC.

A meta-analysis of randomized controlled trials of various forms of surgical techniques used for BPH reported an overall rate of 2%-4%.

The occurrence of BNC after TURP has changed during the past 2 decades, from 15% reported in a randomized prospective trial in 1995 to the significant decrease of 3.4% reported in 2004. That study also confirmed the observation that the prostate volume had a significant effect on the incidence of this complication. Patients with a low prostate resection weight (average 11 ± 3.7 g) will be predisposed to bladder neck stenosis. The development of BNC had no correlation with surgeon experience or time of resection. The one most consistent observation was the development of BNC in those with a small prostate. The mechanism leading to this complication after TURP is still unclear, but the key factors proposed have included extensive resection and fulguration at the bladder neck, undermining the bladder neck, a large resection loop that generates excessive heat, and the presence of a small intraurethral adenoma.

Transurethral incision of the prostate, introduced by Orandi in 1973 as an alternative to TURP, has been used primarily in patients with BPH if the gland does not exceed 30 g. Lee et al., in a study of 1470 patients, showed that TURP plus transurethral incision of the prostate could completely prevent the incidence of BNC if the resected adenoma weight was >30 g; the incidence of BNC was 7.7% if the resected weight was <30 g.
**EVALUATION AND PREOPERATIVE MANAGEMENT**

Men who develop PUS after treatment of prostate cancer can present with lower urinary tract symptoms (LUTS), both storage and voiding. The usual timing of the onset of the stenosis is dependent on the type of treatment administered. With RT, both EBRT and BT, it usually occurs within a few years. After RP (with or without EBRT), TURP, or interventions such as HIFU and cryotherapy that result in tissue sloughing, the symptoms of obstructed voiding can occur immediately after catheter removal or, more likely, within the first year.

As yet, no evidenced-based recommended workup is available for new or persistent LUTS after treatment of prostate cancer. The following recommendations were determined from the recommendations for evaluation of LUTS in older men from the Sixth International Consultation on New Developments in Prostate Cancer and Prostate Diseases.73 These recommendations were also incorporated into the updated American Urological Association “Clinical Guidelines in the Management of BPH.”74 Additional recommendations represent the consensus of the committee.

The workup for LUTS after treatment of prostate cancer is determined by the onset and severity of the symptoms. The development of PUS is usually associated with de novo, recurrent, or persistent LUTS. The main complaint can relate to an obstructed voiding pattern, such as a reduced force of stream, although other voiding and/or storage symptoms can predominate. A careful evaluation before the initiation of intervention should be undertaken. The timing of the intervention should be determined by the severity of the symptoms and evaluation findings. As an example, acute urinary retention after Foley catheter removal after radical retropubic prostatectomy might merit immediate cystoscopy and recatheterization.

In general, evaluation of suspected PUS after the treatment of prostate cancer includes (Table 3) the following:

- **History**: (LUTS, validated questionnaires, voiding diary); the reader is also referred to Chapter 2, “Evaluation and Follow-up”
- **Physical examination**: general, abdominal, genital, perineal, rectal, and neurologic, as required
- **Laboratory investigations**
  - Urinalysis: the presence of hematuria could indicate additional pathologic features, such as bladder tumor or complications of bladder outlet obstruction with a bladder calculus
  - Urine culture and sensitivity (or leukocyte esterase screening test): this is necessary before instrumentation; infection could represent or contribute to the underlying cause of the voiding symptoms
  - PSA measurement to rule out persistent or recurrent cancer
  - Renal function tests should be considered (creatinine, blood urea nitrogen), if clinically indicated
  - Uroflowmetry and post-void residual measurement
  - Cystoscopy: retrograde and antegrade (if necessary)
- **Imaging**
  - If unable to delineate length, location, severity, and complexity of stenosis:
    - Retrograde urethrogram and, possibly, voiding cystourethrography
    - Renal and/or ureteral ultrasonography, if indicated
    - Prostate imaging (TRUS), if necessary
    - Other (CT/MRI) if disease is thought to be outside urinary tract (eg, cancer, abscess, prostatic calcification, fistula)
  - Urodynamic evaluation, if necessary

**Table 3. Suggested workup for posterior urethral stenosis after treatment of prostate cancer**

<table>
<thead>
<tr>
<th>History</th>
<th>Physical examination: general, abdominal, genital, perineal, rectal, and neurologic, as required</th>
</tr>
</thead>
</table>
| Laboratory testing | Urinalysis with or without urine culture
- PSA measurement to rule out persistent or recurrent cancer
- Renal function tests (creatinine, BUN), if clinically indicated |
| Uroflowmetry and postvoid residual measurement | Cystoscopy: retrograde and antegrade (if necessary) |
| Imaging studies | If unable to delineate length, location, severity, and complexity of stenosis:
- Retrograde urethrogram and, possibly, voiding cystourethrography
- Renal and/or ureteral ultrasonography, if indicated
- Prostate imaging (TRUS), if necessary
- Other (CT/MRI) if disease is thought to be outside urinary tract (eg, cancer, abscess, prostatic calcification, fistula) |
| Urodynamic evaluation, if necessary | **BUN**, blood urea nitrogen; **CT/MRI**, computed tomography/magnetic resonance imaging; **PSA**, prostate-specific antigen; **TRUS**, transrectal ultrasonography.
In general, imaging should be reserved for cases in which complete cystourethroscopy cannot be performed for various reasons (multiple strictures encountered, complete urethral obliteration, patient unwilling to undergo procedure in ambulatory setting). Performed separately, each provides useful information in evaluating the level of the stricture, but both done simultaneously could allow for evaluation of the whole urinary tract proximal and distal to the stricture level.

Renal and/or ureteral ultrasonography, if clinically indicated

Prostate imaging (transrectal ultrasonography), if necessary to exclude abscess, calcification, and cancer recurrence

Other (computed tomography/magnetic resonance imaging): if disease is believed to be more extensive (eg, cancer, abscess, prostatic calcification, fistula)

Urodynamic evaluation: Reserved for specific cases to evaluate all types of voiding dysfunction, as needed.

TREATMENT

Strictures related to prostate cancer therapy result from a number of interacting mechanisms, including anatomic tissue loss from surgery, postoperative fibrosis, ionizing radiation, and electrical injury. Thus, treatment must take into consideration the surrounding anatomic characteristics, capacity for healing, and ability to support transfer of adjacent or distant donor tissue sites. The continence status of the patient and the relationship of the stricture to the external sphincter further complicate decision making about the treatment of PUS. Taken together, the many variables influencing patient choice argue for an individualized approach to the problem.

Treatment Approach After RT

The increased rate of complications associated with reconstruction of the irradiated urethra underlies the initial selection of endoscopic therapy for the management of strictures after all RT modalities. Strictures after primary EBRT or BT most commonly involve the membranous or bulbous urethra. Rectourethral fistulas can complicate such strictures, but their treatment is beyond the scope of our report.

Endoscopic treatment of radiation-induced PUS has been associated with recurrence rates of approximately 40%-60%, regardless of the location or etiology. In a large series reporting the stricture rate after BT, PUS was initially treated with either dilation (n = 15) or internal urethrotomy (n = 20). With a median follow-up of 16 months, 49% required second-line endoscopic therapy and 9% had third-line therapy in the form of intermittent self-catheterization (ISC) or urethroplasty. Overall, 10.5% of the patients with stricture developed urinary incontinence severe enough to require daily pad use.

Urethroplasty might prove successful when endoscopic approaches fail. In case series, the success rates have been 73%-90%. Excision and primary anastomosis of radiation-induced stenosis proved more successful than other techniques, including stents. Just as in other parts of the urethra, success is more likely with shorter strictures. EBRT was identified as a consistent risk factor for failure.

Management of Post-RP Vesicourethral Anastomotic Strictures

The definitive management of post-RP vesicourethral anastomotic strictures (VUASs) generally requires endourologic or open surgical intervention. Local urethral dilation might facilitate temporary urethral catheter drainage or the initiation of intermittent self-catheterization. A critical consideration in the treatment of these strictures is the risk of urinary incontinence.

Surgical Management—Endourologic. Interruption of the stenotic bladder neck is the central premise of endourologic procedures for VUAS. Most anastomotic strictures after radical retropubic prostatectomy occur within 6 months. For early postoperative stenoses, urethral dilation is indicated. In all such cases, cystoscopic placement of a guidewire and the use of sounds, straight or curved co-axial dilators, or long filiform will reduce the risk of false passage or disruption of a recent anastomosis. The success of dilation in these circumstances has varied, although they usually allow spontaneous voiding, and some series have reported long-term favorable outcomes with this approach.

For strictures that fail initial dilation or occur >6 weeks after RP, a stepwise approach with the goal of preserving urinary continence is advocated. Reported series of patients treated with endourologic techniques are listed in Table 4. A low-energy incision has been recommended: either direct vision internal urethrotomy (DVIU) or holmium:yttrium-aluminum-garnet laser. Dalkin11 described deep incisions at the 4- and 8-o’clock positions with a cold-knife urethrotome from the proximal area of the contracture to its distal extent. The incisions should be continued down to bleeding tissue, and a monopolar cautery electrode can be used if hemostasis is required. The role of intermittent self-catheterization in reducing recurrence after dilation has not been established for VUAS.

Transurethral electrosurgical incision has been used when dilation and DVIU have failed. The greater risk of incontinence should be considered against the likelihood of long-term urethral patency. Highly symptomatic patients are generally willing to accept the risks of incontinence and the necessity of subsequent artificial urinary sphincter or male sling surgery.

The outcomes of endourologic treatment of post-RP VUAS are listed in Table 4. Failure of repeated DVIU for VUAS is an extremely challenging problem. Because most open reconstructive techniques compromise
continence, and alternatives such as endourothoplasty and stenting have been proposed as adjuncts to DVIU. Vanni et al. reported using a triradial incision in the bladder neck at the 9-, 12-, and 3-o'clock positions, preceded and followed by interstitial injection of mitomycin C as an antiproliferative agent to prevent recurrence. A full-thickness incision with a cold knife through the fibrotic ring into the periprostatic fat was then followed by 10 days of an indwelling catheter. This approach has had a success rate of 84% in patients with refractory BNC that has failed previous DVIU.

The permanent metallic UroLume stent (American Medical Systems, Minnetonka, MN) has been used sparingly because of challenges with tissue regrowth or intrusion and migration into the bladder. In selected cases of refractory VUAS, several investigators have described successful UroLume implantation. Although the UroLume has usually been described in conjunction with immediate or subsequent anti-incontinence surgery, the use of the shortest possible UroLume stent might preserve sphincter function.

**Surgical Management—Open.** The most severe post-radical retropubic prostatectomy anastomotic stenoses require an aggressive reconstructive approach. Temporary suprapubic cystostomy drainage will allow planning for reconstruction or diversion. In selected patients, suprapubic drainage might be the best long-term strategy. The published data outlining surgical reconstruction consists of case series and has been summarized in Table 5.

The variability of the approach reflects the considerations of surgical exposure, amount of scar to be excised, and sources of healthy vascularized tissue for transfer into the diseased bladder neck region. Patient age, previous surgery or RT, cancer stage, and life expectancy must be assessed before intervention. The primary goal should be urethral patency, with many men requiring insertion of an artificial urinary sphincter at a later date. When repeat vesicourethral anastomosis using a retropubic or abdominal approach is possible without extensive urethral mobilization, preservation of continence can be possible. In most series, incontinence resulted because of sphincter deficiency due to RP; the need for extensive mobilization of the anterior urethra for reanastomosis; or the effects of previous repeated transurethral incision.

Urinary diversion, leaving the bladder in situ, has been reported for patients with radiation necrosis of the bladder neck or urethra, severe bladder dysfunction, complex fistulas, or other factors that make reconstruction of the urethra impractical or impossible.

**CONCLUSION**

The risk factors for the development of VUAS identified in case series and large prospective RP studies can be divided into preoperative, intraoperative, and postoperative categories and include excessive blood loss, type of bladder neck dissection, postoperative urinary leakage, adjuvant RT, previous TURP, smoking, older age, obesity, and surgeon experience (LE 2-3). Other risk factors include open vs minimally invasive surgery.
(LE 2-3) and acute postoperative retention treated with suprapubic tube placement (LE 3).

After BT, stenosis is the most common long-term serious urinary adverse effect (LE 2-3). Most stenoses will develop within 2-5 years and will be in the BM region (LE 2-3). The risk factors included older age, nonwhite race, low income, more comorbidities, combination therapy with EBRT or hormonal therapy, and a history of previous TURP (LE 2-3).

Urethral stenosis after EBRT also increases with long-term follow-up (LE 2-3), with salvage RP associated with the greatest stenosis rate (LE 3).

After cryotherapy, prostatic obstruction can occur with tissue sloughing (LE 3). Urethral warming should be used

Figure 2. Proposed algorithm for postradiotherapy (external beam radiotherapy, brachytherapy, combined modality) vesicourethral stenosis (“prostate in”).

Figure 3. Proposed algorithm for vesicourethral anastomotic stricture. CIC, clean intermittent catheterization; DVIU, direct vision internal urethrotomy; SP, suprapubic. (Color version available online.)
to minimize sloughing and prevent stricture occurrence (LE 3).

After HIFU, necrotic sloughing of the prostate can occur, necessitating TURP (LE 3). Pre- or post-HIFU TURP can decrease the development of bladder outflow obstruction (LE 3). However, long-term BNC can still occur (LE 3).

Patients with a low prostate resection weight (at TURP for BPH) are predisposed to BNC (LE 2-3).

Before surgery, a basic patient evaluation should consist of history and physical examination, urinalysis, and postvoid residual urine measurement (LE 1-2, GR A). Urine (urinalysis, culture, and sensitivity/glucuronidase screening test) and blood (blood urea nitrogen, creatinine, glucose, prostate-specific antigen) testing is recommended. Cystoscopy and appropriate imaging studies of the urinary tract will be helpful in guiding therapy (LE 2-3, GR B). Urodynamics can be helpful to evaluate voiding dysfunc-

tion and/or incontinence (LE 3, GR C).

After RT (Fig. 2), a graded approach to management, beginning with endourologic procedures, should be done. This can be combined with self-dilation. Management failures can necessitate more invasive approaches, including stents, open reconstruction, or diversion (LE 3, GR C).

For VUAS after RP (Fig. 3), a graded approach to management, beginning with endourologic procedures, is recommended. This can be combined with self-dilation. Management failures might necessitate more invasive approaches, including stents, open reconstruction, or diversion (LE 3, GR C). Concomitant or resultant urinary incontinence will require additional evaluation and surgery (LE 3, GR C).

**Recommendations**

Continue to document risk factors and associations with localized treatment of prostate cancer

Standardization is needed in reporting complications from all sources, including surgeons and radiation oncologists

An anatomic classification system is needed to define the location of PUS. The classification could also include a description of incremental anatomic severity. Higher grade lesions would thus be associated with greater morbidity, warrant more complex treatment, and might have a worse prognosis. No accepted grading system is yet available for VUAS

Identify intraoperative techniques of RP that are associated with a lower risk of VUAS

Standardization is needed in the workup for accurate delineation of the stenosis and its morbidity

A registry is needed of surgical cases of stenoses after RP and RT to create larger cohorts

Randomized trials of interventional techniques, both endourologic and open, are needed

**References**


The management of primary and recurrent bulbar urethral stricture disease has been a source of controversy with the choice being between endoscopic urethrotomy and open urethroplasty. Further debate exists with regard to the choice of urethroplasty—either excision and primary anastomosis (EPA) or augmentation with a graft or flap. Using PubMed, a 35-year literature search was conducted (1975-2010) for peer-reviewed articles on bulbar strictures treated using EPA. Exclusions included articles with <10 patients, duplications, reviews, or in which the cohort was mixed and the data could not be separately analyzed. Seventeen articles fulfilled the criteria with a total of 1234 patients. Overall success was 93.8%. Reported complications were <5%, and there was no evidence of persistent loss of sexual function. The authors conclude that EPA is associated with a high success rate with low complication rate. Our recommendation is that it should be performed in patients with short isolated bulbar strictures, when expected success rates of other procedures are <90%.

This review is an attempt to synthesize the extant literature to clarify the outcomes and applications of EPA urethroplasty and to present a consensus to guide management and future research.

**METHODS**

A committee was appointed by the ICUD. The chair (N.W.) conducted a 35-year English-language literature search through PubMed for peer-reviewed articles on strictures of the anterior urethra treated with EPA. In the literature from 1975 to 2010, no randomized prospective trials (level 1) or case control (level 2) series were identified. Only reports of bulbar urethral cases were included in the analysis. A total of 17 level 3 evidence series with >10 patients were included for analysis and were subdivided into 2 groups on the basis of the number of patients: 3 large series of >150 patients from internationally recognized centers of excellence and 14 smaller/mixed series including 13-81 patients. Articles were excluded if they were duplicative listings, review articles, expert opinion without data to support the opinion, case series of <10 patients, or series in which outcomes were not separately identifiable and related to EPA cases.

Before the search, the committee members agreed to extract the following data:

1. Composite success rate of EPA,
2. Cost-effectiveness of EPA vs endoscopic stricture treatment, and
3. Complications of EPA.

The articles providing the data for this review were rated using the ICUD standards for level of evidence and grade of recommendation.

The primary outcome measure was the proportion of men with subjective and/or objective measure of stricture recurrence.

The secondary outcomes were cost-effectiveness, short/long term complications, and quality of life improvements.

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From the Department of Urology, Southwestern Medical School, Dallas, TX (A.F.M.); the Department of Urology, St. George’s Hospital, London, United Kingdom (N.W.); the Department of Urology, Shaare Zedek Medical Center, Jerusalem, Israel (O.S.); Ain Shams University Hospitals, Cairo, Egypt (E.E.); and the Department of Urology, Hospital Italiano, Buenos Aires, Argentina (C.G.)

Reprint requests: Nick Watkin, M.A., M.Chir., F.R.C.S., Department of Urology, St. George’s Hospital, St. James’ Wing, Blackhame Road, London SW17 QQT, United Kingdom. E-mail: Nick.Watkin@stgeorges.nhs.uk

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RESULTS/DISCUSSION

Composite Success Rate of Excision and Primary Anastomosis

Our analysis revealed multiple high-quality reports demonstrating level 3 evidence, thus yielding a robust experience. EPA reported in over 1200 cases spanning 3 decades. Although the definitions of success differed and the durations, stringencies, and methods of follow-up varied, a uniformly high level of success (>90%) was reported in similar patients across all but one series (Table 1).

Although none of the reported series was designed to show superiority of EPA over other methods of urethral reconstruction, the reported results suggest that an anastomotic approach yields superior outcomes compared with any other method of bulbar urethroplasty. The 93.8% success rate revealed in this broad 35-year analysis supports the earlier 15-year single institution analysis of Andrich et al, which demonstrated that substitution urethroplasty is associated with a 5-fold increase in complications and a 4-fold increase in stricture recurrence when compared with EPA. Our meta-analysis suggests that EPA can be expected to deliver a very high success rate in experienced centers.

Despite this evidence, direct vision internal urethroscopy (DVIU) is still the most frequently used treatment for anterior urethral stricture. Although the simplicity and speed of outpatient endoscopic treatment have contributed to its popularity, long-term efficacy data have been lacking. At best, initial DVIU for short, nontraumatic strictures of the bulbar urethra has been associated with a success rate of only 39%-73%, with subsequent attempts performing even worse. Despite the observation that DVIU is almost never curative for those with dense fibrosis or multiple endoscopic recurrences, many urologists undertake repeated endoscopic procedures before referring stricture patients for definitive care.

Cost-effectiveness of Excision and Primary Anastomosis for Short Bulbar Urethral Strictures

None of the 17 studies directly examined the cost-effectiveness of the procedure against DVIU, and the committee can make no specific recommendation.

However, because short bulbar strictures treated with EPA have a consistently high success rate, several authors have proposed that there would be a reduction of overall costs attributed to the performance of EPA in lieu of DVIU, despite its higher initial expense.

Complications of Excision and Primary Anastomosis

We reviewed the available literature concerning the effects of EPA urethral reconstruction on male sexual function, wound related problems including fistula, urinary tract infection, and postmicturition dribble. Co-factors that might influence erectile function after urethroplasty including stricture length, patient age, reconstructive technique, and time elapsed since surgery were also analyzed.

All studies were retrospective in design and none specifically had a robust method of recording complications. The only complication consistently recorded was assessment of erectile function.

EPA appears to have a negligible effect on sexual function. Barbagli et al reported no postoperative impotence among 153 cases. Coursey et al found that bulbar urethroplasty has less patient-reported negative impact on erectile function than reconstruction of long strictures in the penile urethra. Similarly, Anger et al reported no significant change in erectile function in a prospective study of men undergoing urethroplasty for bulbar strictures using anastomotic, augmented anastomotic, or buccal grafting techniques. However, a trend toward worse postoperative sexual outcomes was shown for older patients and those with lower preoperative International Index of Erectile Function scores.

Erickson et al found that when patients do report postoperative erectile dysfunction after urethral reconstruction, it tends to be transient, with the vast majority of patients recovering preoperative erectile function within 6 months of surgery. Interestingly, this study showed an improvement in ejaculatory function in younger patients. Similarly, Andrich et al showed a 10% incidence of erectile dysfunction after substitution urethroplasty, which decreased to 2% over 2-3 months.

In summary, although erectile function might be influenced by patient age, stricture length and location, and method of reconstruction, the long-term sexual dysfunction rate after EPA urethroplasty appears to be very low and predominantly transient.

Limitations

There are several important limitations to interpretation of the data and the conclusions drawn. First, all series were retrospective reviews of individual center experience. There was no prospective recording of complications and no obvious standardization of follow-up and several studies reported outcomes with a mean follow-up of <1 year. Second, the most common definition of failure was reintervention, which requires patients to represent and also be sufficiently bothered to undergo a dilation or revision surgery. A more stringent definition of radiological evidence of stenosis or any decline in flow from baseline was not used in any study. Finally, there might also be publication bias in favor of studies with good outcomes. Specialist centers with poorer outcomes are less likely to report if they are aware of other units with significantly better published data. This said, there does seem to be a clustering of outcome data around the 90% level in all series over an extended period that it is probable that this level is achievable in a high-volume center on the basis of reintervention as the definition of failure. It is not possible to predict what the radiological evidence of recurrent stenosis would be, but it is very likely to be higher.
<table>
<thead>
<tr>
<th>Reference</th>
<th>Number of Patients</th>
<th>Mean Follow-up (mo)</th>
<th>Complications</th>
<th>Success Rate (%)</th>
<th>Definition of Failure (Flow/Reintervention/ Symptomatic Progression)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>34</td>
<td>Mean unknown (total = 10 y)</td>
<td>Erectile dysfunction</td>
<td>87</td>
<td>Symptoms and investigations showing the presence of a recurrent stricture</td>
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<td>2</td>
<td>153</td>
<td>68</td>
<td>Erectile dysfunction</td>
<td>90.8</td>
<td>Any postop intervention including dilation</td>
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<td>3</td>
<td>257</td>
<td>50.2</td>
<td>Decreased sensitivity of glans/penile shaft</td>
<td>98.8</td>
<td>Need for any intervention postop except for scheduled endoscopy</td>
</tr>
<tr>
<td>4</td>
<td>81</td>
<td>44.4*</td>
<td>Wound infection*</td>
<td>84*</td>
<td>Stricture recurrence needing further surgical intervention</td>
</tr>
<tr>
<td>5</td>
<td>64</td>
<td>60*</td>
<td>None</td>
<td>93*</td>
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<tr>
<td>6</td>
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<td>22.1</td>
<td>Erectile dysfunction</td>
<td>91</td>
<td>Questionnaire not specifically defined</td>
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<td>7</td>
<td>168</td>
<td>72</td>
<td>Transient thigh pain or numbness (2%)</td>
<td>95</td>
<td>Need for subsequent dilation, internal urethrotomy or urethroplasty, recurrent obstructive voiding symptoms</td>
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<tr>
<td>8</td>
<td>72</td>
<td>Mean unknown (median = 17)</td>
<td>Not documented</td>
<td>98.6</td>
<td>Need for any postop intervention</td>
</tr>
<tr>
<td>9</td>
<td>23</td>
<td>Mean unknown (Median = 46, total 6.5 y)</td>
<td>Tissue necrosis (3%), Restricture (8%), Reintervention for complications other than restricture (5%)</td>
<td>86</td>
<td>Restructure on urethrogram or endoscopy, flow rate &lt;15 mL/s, recurrent UTI</td>
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<tr>
<td>10</td>
<td>31</td>
<td>Mean unknown (minimum = 12)</td>
<td>Hematoma</td>
<td>97</td>
<td>Any postop instrumentation needed for recurrent obstructive voiding symptoms</td>
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<tr>
<td>11</td>
<td>13</td>
<td>Mean unknown (minimum = 12)</td>
<td>Superficial wound infection</td>
<td>92</td>
<td>Abnormal retrograde urethrogram, obstructive symptoms, urethral sound impassable</td>
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<tr>
<td>12</td>
<td>18</td>
<td>Unknown</td>
<td>Unknown</td>
<td>95.9</td>
<td>Restructure requiring intervention</td>
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<tr>
<td>13</td>
<td>42</td>
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<td>Perineal hematoma*</td>
<td>95</td>
<td>Flow rate &lt;10 mL/s, dilation on voiding urethrography ± UTI</td>
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<td>14</td>
<td>55</td>
<td>Mean unknown (median = 45)*</td>
<td>Superficial wound infection*</td>
<td>92.7</td>
<td>Flow rate &lt;10 mL/s, dilation on voiding urethrography ± UTI</td>
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<td>62</td>
<td>39</td>
<td>Not documented</td>
<td>90.3</td>
<td>Need for further instrumentation or reoperation</td>
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<tr>
<td>16</td>
<td>25</td>
<td>Mean unknown (total = 3 y)</td>
<td>Not documented</td>
<td>96</td>
<td>Symptoms of infravesical obstruction, Qmax &lt;15 mL/s, PVR persistently &gt;50 mL, poor caliber on ascending urethrography</td>
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<tr>
<td>17</td>
<td>24</td>
<td>26.7</td>
<td>Wound infection*</td>
<td>100</td>
<td>Obstructive symptoms, incontinence, postop intervention</td>
</tr>
</tbody>
</table>

PVR, post-void residual volume; Qmax, maximum flow rate; SUI, stress urinary incontinence; UTI, urinary tract infection. * Not specific for bulbar/excision and primary anastomosis.
CONCLUSION

Our review of the published literature suggests that EPA is associated with a high level of successful outcome and that complications are uncommon. Therefore, EPA should be performed whenever deemed possible and appropriate in men with short, isolated bulbar urethral strictures when expected success rates of other procedures (open or endoscopic) are <90%.

RECOMMENDATIONS

Composite Success Rate of Excision and Primary Anastomosis

1. This review has shown that the success rate of EPA urethroplasty is widely reported to be >90% for primary procedures. It constitutes the optimal treatment for healthy men with short bulbar strictures, regardless of etiology or previous treatment. (B)
2. EPA urethroplasty is most readily applicable to strictures of the bulbar urethra. (B)

Cost-effectiveness of Excision and Primary Anastomosis vs Endoscopic Treatment

The analysis could not draw any conclusion on cost-effectiveness of EPA over DVIU because of lack of evidence. No recommendation could be made.

Excision and Primary Anastomosis Complications

1. The risks of erectile dysfunction are very low and should not be considered a contraindication to EPA urethroplasty (C).
2. The risks of wound-related problems including fistula, chordee, and postmicturition dribble were not consistently recorded. No recommendation could be made.

References