Penile and Urethral Reconstructive Surgery

Jonathan Kiechle, MD
Reconstructive Urology Fellow
University Hospitals
Case Western Reserve University School of Medicine

Introduction

Penile and urethral reconstructive surgery is a broad area of urologic care that encompasses the surgical treatment of urethral stricture disease and voiding dysfunction, erectile dysfunction, urologic issues subsequent to cancer treatment, and many other diseases of the male external genitalia and lower urinary tract. This article discusses various surgical options for the treatment of urethral stricture disease and male stress urinary incontinence (SUI).

A urethral stricture begins as a scar within the corpus spongiosum surrounding the anterior urethra (urethral meatus, fossa navicularis, penile urethra, bulbar urethra). Contraction of this scarred tissue results in narrowing of the urethral lumen and can lead to lower urinary tract symptoms. A bladder neck contracture (BNC) or urethral stenosis refers to narrowing of the bladder neck or posterior urethra (membranous urethra, prostatic urethra), respectively, usually as a result of prior surgical intervention or pelvic trauma. Urethral strictures and bladder neck contractures both present significant treatment challenges for urologists and can necessitate multiple surgical procedures to keep patients voiding without substantial difficulty. These procedures vary from endoscopic dilation of the urethra to formal urethral repair requiring excision of the stricture or the use of autologous grafts for urethral augmentation.

The incidence of urethral stricture disease is not well defined, but a recent analysis of Medicare data found the prevalence of male urethral stricture disease to be 0.9 percent. Many underlying conditions can lead to the development of urethral strictures including pelvic trauma, lichen sclerosis, previous lower urinary tract instrumentation and sexually transmitted infections. Unfortunately, for many patients it is not possible to determine the underlying cause of their stricture disease, as the factor inciting the development of spongiosfibrosis may occur many years prior to the onset of lower urinary tract symptoms.

Male SUI is associated with intrinsic sphincter deficiency and can occur following radical prostatectomy or be associated with pelvic trauma, congenital conditions and other surgical procedures. A recent meta-analysis of incontinence outcomes following robotic radical prostatectomy reported an overall incidence of SUI of 4 – 31 percent at 12 months following surgery. The treatment of male SUI following radical prostatectomy is also highly variable, ranging from observation to the use of external clamps to the implantation of prosthetic devices to improve continence.
Urethral Dilation and Direct Vision Internal Urethrotomy

Indications/Contraindications

Urethral dilation and direct vision internal urethrotomy (DVIU) offer minimally invasive approaches to the management of urethral stricture disease in appropriately selected patients. Dilation may be the procedure of choice for patients who cannot safely undergo general anesthesia, have limited life expectancy or present emergently in acute urinary retention. However, the repeated use of urethral dilation is contraindicated in patients appropriate for urethroplasty who present with recurrent stricture disease.³

DVIU may be considered in patients with symptomatic bulbar urethral strictures less than 2cm in length.³ DVIU is not recommended for strictures in the penile urethra, and repeated treatment with DVIU following an initial recurrence is unlikely to provide durable long-term success.⁴,⁵ Importantly, both urethral dilation and DVIU are less technically demanding than open urethroplasty is, and one approach does not appear to offer an advantage over the other.

Patient Preparation

Patient preparation for urethral reconstruction involves a history and physical exam and diagnostic testing to determine the full extent of the patient’s stricture disease. The history and physical exam focuses on the patient’s lower urinary tract symptoms and includes an International Prostate Symptom Score questionnaire to objectively measure the patient’s urinary symptoms. A thorough surgical history is taken to determine if the patient has had prior surgery on the lower urinary tract.

Diagnostic testing may include a urinalysis, post-void residual, retrograde urethrogram (RUG), voiding cystogram (VCUG), ultrasound and cystoscopy. A RUG allows for anatomic evaluation of the urethra, while a VCUG provides both anatomic and functional information about the lower urinary tract (Figure 1 of normal and strictured RUG; Figure 2 of cystoscopic view of stricture and normal urethra). Ultrasound has also been shown to allow accurate determination of total stricture length through assessment of the extent of spongiofibrosis.⁶

Approach

Urethral dilation is generally performed by passing sequentially larger caliber dilators past the point of stricture within the urethra. The goal of dilation is to widen the scar without causing more significant scarring. There are numerous techniques available for urethral dilation including urethral sounds, filiforms and followers, and dilating balloons (Figure 3 of different instruments).

DVIU is performed by visually identifying the area of stricture with a cystoscope and incising the scar tissue. The goal of DVIU is to cut the urethral scar, leading to healing by secondary intention so that the urethral lumen remains wider than prior to surgery. If the urethra re-epithelializes prior to significant wound contraction, the urethra will remain patent. However, if significant and rapid wound contraction occurs, the stricture will recur.

Various instruments have been used for DVIU including “cold” knives without energy, knives utilizing cutting current and various types of laser fibers. There is no definitive data proving the benefit of one technique over
another; however, in general a cold knife should be used within the urethra whereas a hot or cold knife can be used within the prostate or bladder neck. Additionally, significant debate exists about where the DVIU incision should be made. The classic DVIU involves a single incision at the 12-o’clock position, but multiple variations exist without definitive evidence proving the efficacy of a specific technique.

**Post-Procedure Care**

Patients will have a urinary catheter placed following the procedure to drain the bladder post-operatively. While historically the catheter was often left in situ for an extended period to force the urethra to heal around the lumen of the catheter, it is now accepted that the catheter can be safely removed after 72 hours. Some patients may be started on regimens of self-catheterization following catheter removal, as there is evidence that post-operative self-catheterization can improve long-term patency rates. Finally, patients require follow-up to evaluate for stricture recurrence, as urethral dilation and DVIU have high rates of stricture recurrence.

**Reducing Complications**

Complications of urethral dilation and DVIU include bleeding secondary to aggressive tearing of scar tissue, urinary tract infection, urethral perforation and rectal injury. Patients are given a dose of antibiotics per-procedurally to help reduce the risk of urinary tract infection. The risk of urethral perforation and rectal injury can be reduced by endoscopically passing a wire into the bladder and dilating over the wire.

DVIU can also lead to de novo erectile dysfunction (ED). Reported rates of ED following DVIU range from 2.2 to 10.6 percent. The risk of ED following DVIU increases with long, dense strictures, as post-DVIU ED is thought to occur secondary to injury to the corpora cavernosa during the scar incision leading to veno-occlusive dysfunction. Limiting the use of DVIU to relatively short strictures in the bulbar urethra may limit the development of post-DVIU ED.

**Outcomes and Evidence**

Outcomes data following DVIU and dilation is hampered by the lack of prospective, randomized trials and the varying definitions of surgical success used in different studies. A randomized study from a single surgeon including 210 patients found no difference in the rate of stricture recurrence between DVIU and dilation. About 60 percent of patients who underwent DVIU or dilation for strictures less than 2cm remained stricture-free with a maximal follow-up of 48 months. However, for strictures longer than 4cm, the stricture recurrence rate by 12 months was 80 percent; for strictures between 2cm and 4cm, patients initially did well with a recurrence rate of 50 percent at one year, but this success rate decreased to 25 percent by 48 months.

A recent retrospective study of 128 patients found similar success rates, defined by avoiding recurrent stricture, for patients treated with DVIU. Patients were followed for a median of 16 months with an overall success rate following DVIU of 51.3 percent. Median time to recurrence was six months, and repeat DVIU was found to be a risk factor for recurrence on univariate and multivariate analysis.
Urethroplasty

Indications/Contraindications

Urethroplasty refers to the formal open repair of the strictured urethra by either excising the stricture and primarily anastomosing the ends of the urethra (EPA) or performing a substitution urethroplasty with autologous flap or graft tissue. Indications for EPA include a relatively short stricture or stenosis in the bulbar or membranous urethra, respectively, that can be completely excised and repaired with a tension-free anastomosis. Contraindications to EPA include stricture in the penile urethra, as EPA in the penile urethra can lead to chordee and penile curvature. Indications for substitution urethroplasty include long segment bulbar urethral stricture, urethral stricture in the penile urethra and panurethral stricture.

Patient Preparation

As with urethral dilation or DVIU, a full history and physical are required, as is diagnostic testing to determine the full extent of the patient’s stricture disease. If substitution urethroplasty is considered, physical examination of potential donor sites including the foreskin (if present) and buccal (cheek) mucosa should be performed.

It is generally recommended that patients with an indwelling urethral catheter or who perform intermittent catheterization have a period of urethral rest prior to undergoing urethroplasty. For patients with severe strictures who are unable to void or are catheter-dependent, a suprapubic tube is placed to keep the urethra free of instrumentation in the weeks leading up to urethroplasty. At least four weeks of urethral rest is preferred, and some urologists recommend three months of rest prior to urethroplasty.

Approach

Urethroplasty can be performed through a penile, penoscrotal or perineal incision depending on the location and length of the strictured urethra. As previously mentioned, substitution urethroplasty utilizes autologous flaps or grafts to repair the urethra. A flap refers to a piece of tissue that is transferred to a new location with its vascular supply intact. Alternatively, a graft is a piece of tissue that has been excised and transferred to a recipient bed without its prior vascular supply. Therefore, a graft must develop a new vascular supply from its recipient bed through a process known as take.

Take has two phases, with each phase lasting about 48 hours. The first step of take is known as imbibition, and during this phase the graft maintains itself by absorbing nutrients from the underlying recipient bed. The second step is known as inosculation, and during this phase, a new microcirculation develops in the grafted tissue. Both recipient bed and graft tissue characteristics influence the success of this process and the ultimate survival of the grafted tissue.

Donor flaps for urethral reconstruction are generally taken from penile skin, prepuce or de-epithelialized scrotal skin. It is imperative that non-hair-bearing skin be used for urethral reconstruction, as the presence of hair in the urethra can cause urinary stone formation, recurrent urinary tract infections and lower urinary tract symptoms.

A wide variety of different grafts have been used for urethral reconstruction including full thickness skin, bladder mucosa, rectal mucosa and a variety of mucosal tissue from the oral cavity. Currently, the buccal
mucosal graft (BMG) is the most commonly used graft tissue for substitution urethroplasty. BMGs are hairless and durable, have hidden donor sites and are associated with minimal post-operative morbidity.\textsuperscript{15,16} BMGs are harvested from the inner cheek, being careful to avoid Stensen's duct, the drainage site of the parotid gland.

Urethroplasty is usually performed as a one-stage procedure whether an EPA or substitution urethroplasty is performed. However, for extremely long segment, recurrent or panurethral strictures, a two-stage urethroplasty may be required. Two-stage urethroplasty involves temporarily moving the urethral meatus proximally while allowing the distal urethral plate to heal. After three to six months, the second stage of the repair is performed with the distal urethra retubularized and the meatus reconstructed in the orthotopic anatomic position. Two-stage urethroplasty can be performed using local skin or BMG as the tissue used to create the neo-urethra.

**Post-Procedure Care**

Post-procedural care varies based on the location and length of the stricture. Invariably, patients will have a urethral catheter to facilitate healing. The urethral catheter may be capped, with the urine drained via a suprapubic tube, or may be kept to gravity drainage based on the location of the stricture. If a BMG was harvested, patients may be advised to use a chlorhexidine-based mouthwash in the immediate post-operative period. Urinary catheters are generally kept in place for 14 – 21 days, and repeat retrograde urethrogram may be performed prior to catheter removal to ensure that there is no urine leak at the repair site.\textsuperscript{7}

**Reducing Complications**

Complications following urethroplasty vary based on the location of the urethral stricture and the urethroplasty technique utilized for repair. Penile curvature, or chordee, is possible following EPA if a long segment stricture is repaired without adequate mobilization of the urethra. Performing adequate urethral mobilization and limiting the use of EPA to strictures of appropriate length limits the risk of post-EPA penile curvature.

Worsening erectile function has also been reported following urethroplasty. In an early report of ED following urethroplasty, EPA was associated with a 5 percent risk of subjective ED, and substitution urethroplasty was associated with a 0.9 percent risk of the same.\textsuperscript{17} A recent meta-analysis reported a 1 percent risk of ED following urethroplasty.\textsuperscript{18} It is thought that ED develops following urethroplasty secondary to surgical injury to the nerves and/or vascular supply to the penis. Injury to these anatomic structures is most likely during bulbar urethroplasty, and strictures in the bulbar urethra are associated with higher rates of post-operative ED than strictures in the other segments of the anterior urethra are.\textsuperscript{19} There is significant debate in the urologic community about how to limit the risk of permanent ED following bulbar urethroplasty, and this topic remains an active area of research.

Substitution urethroplasty is also associated with recurrent stricture, the formation of urethral diverticula and the development of urethrocutaneous fistulae.\textsuperscript{20,21} Recurrent stricture can occur regardless of the graft material used, the length of the stricture repaired and the location of the original stricture. Urethral diverticula formation is associated with grafts placed on the ventral surface of the urethra (mostly penile urethra), as there is less native supportive tissue overlying the ventral urethra, compared to the dorsal urethra, to prevent the development of excessive laxity in the graft over time.\textsuperscript{22} Similarly, a urethrocutaneous fistula can develop with ventrally placed grafts, as the graft is anatomically closer to the skin, increasing the risk of fistula
Placing the graft in a dorsal position on the urethra can help limit this complication but is more technically challenging.

Outcomes
Interpreting outcome data following urethroplasty is challenging, as the definition of success is not standardized across published series. However, many studies use the surrogate marker of not requiring further surgical procedures or instrumentation to maintain a patent urethra as a success. Reported success rates for substitution urethroplasty are generally higher than 80 percent, with similar success rates for many different surgical techniques. Reported success rates following EPA are also high, with success rates over 90 percent. A recent retrospective analysis of over 500 patients who underwent bulbar urethroplasty (EPA or substitution urethroplasty) reported an overall success rate of 93 percent with a mean follow-up of 65 months. On multivariate analysis, patients with longer strictures, increased Charlson Comorbidity Index scores, obesity and infectious strictures were more likely to fail urethroplasty. Stricture-free rates following substitution urethroplasty may not be as durable as outcomes following EPA. However, there is also the possibility that pre-operative characteristics have led to these long-term differences, as more complex, longer strictures generally require substitution urethroplasty rather than EPA.

Artificial Urinary Sphincter Implantation

Indications/Contraindications
An artificial urinary sphincter (AUS) is an implantable device that consists of an inflatable cuff that surrounds the urethra and acts as an artificial sphincter, a pump that is placed in the scrotum for operation by the patient, and a pressure-regulating balloon implanted in the submuscular abdominal wall or in the prevesical space (Figure 4). The device is indicated for the treatment of moderate-to-severe male stress urinary incontinence.

As described previously, male SUI is associated with intrinsic sphincter deficiency and often presents following radical prostatectomy. There is some debate about the appropriate time following radical prostatectomy to offer an AUS to patients, but many urologists would consider offering a continence procedure for patients with significant stress incontinence as soon as six months after prostatectomy. Absolute contraindications to AUS implant include a noncompliant or poorly compliant bladder that would put the kidneys at risk of permanent damage with high urinary storage pressures in the bladder. Relative contraindications for implantation include recurrent BNCs and concurrent history of bladder cancer, as these patients may require future transurethral surgeries. An additional relative contraindication is poor manual dexterity in the patient, as the patient may not be able to operate the scrotal pump to deflate the urethral cuff and empty the bladder.

Patient Preparation
A thorough history and physical examination are required prior to proceeding with AUS implantation. The history should focus on relevant issues including when urinary incontinence occurs (stress maneuvers vs. urge incontinence), onset of symptoms, number of pads per day and a voiding diary. As with urethral stricture disease, additional diagnostic testing may be required including a urinalysis and urine culture, cystoscopy.
to evaluate for bladder neck contracture, a post-void residual to ensure that patients are not in overflow incontinence and potentially formal urodynamics if the patient presents with symptoms of mixed urinary incontinence.

**Approach**

The AUS can be implanted using a perineal or penoscrotal incision.⁴ In the standard AUS implant, the cuff is placed around the proximal bulbar urethra, the pressure-regulating balloon is placed below the fascia of the rectus abdominis muscle, and the pump is placed in a dependent position in the anterior scrotum with the activation button facing out for easy manipulation by the patient. Urethral cuffs of various sizes exist, and the surgeon measures the urethral diameter, without a catheter in the urethra, using a measuring device to determine the appropriate cuff. The pressure-regulating balloon is filled with isotonic saline or contrast depending on surgeon preference. Following placement of the components, appropriate connections are made and the incision(s) are closed in multiple layers. Some surgeons perform cystoscopy prior to closure to identify proper coaptation of the urethra with the cuff inflated. Variations on this classic technique exist for more complex patients including placing the urethral cuff around the bladder neck, implanting two urethral cuffs simultaneously or placing the cuff in a transcorporal position that incorporates some of the tissue of the corpora cavernosa in the lumen of the urethral cuff.

**Post-Procedure Care**

Patients are generally discharged within 24 hours of surgery. The AUS is deactivated using the scrotal pump in the operating room and is not reactivated for four to six weeks following the procedure.³⁹ During this period of post-operative healing, patients will continue to experience stress urinary incontinence as they did pre-operatively. After six weeks, the patient returns to the office for a post-operative visit, the pump is activated and the patient is taught how to cycle the device to urinate.

**Reducing Complications**

Complications following AUS implantation include urinary retention, urethral erosion, urethral atrophy, device infection and device malfunction.³⁰-³² Post-operative urinary retention is usually self-limited and can be managed by placing a small-caliber urethral catheter after ensuring that the cuff is deactivated. Urethral erosion occurs when the cuff erodes into the urethra. This requires urgent explantation of all device components, as the device is considered infected following urethral erosion. A urethral catheter or suprapubic tube is placed following explantation to facilitate urethral healing. Reimplantation of a new AUS is possible after the urethral erosion has healed completely. A new location on the urethra should be selected for cuff placement. The incidence of urethral erosion can be limited by ensuring that the cuff is deactivated during the peri-operative period and by avoiding periods of prolonged urethral catheterization.²⁹,³³,³⁴

Urethral atrophy tends to present with worsening incontinence in patients with long-standing, previously functional devices. Atrophy occurs due to chronic compression from the urethral cuff. Treatment involves removing and replacing the cuff in a new location; adding a second, or tandem, cuff to the system; or removing and replacing the cuff with a smaller cuff in the same location.³⁰,³⁵
Device infection, as with any prosthetic implant, is a devastating complication necessitating urgent explantation and potentially leading to sepsis. Reported infection rates for de novo AUS implantation range from 1 to 3 percent.\textsuperscript{32,36} Current devices are coated with antibiotics at the time of manufacture to try to decrease the infection rate. However, a recent single institution, retrospective study found no difference in the rate of AUS infections since the introduction of the antibiotic coating.\textsuperscript{37} Patients are generally kept on post-operative antibiotics for three to seven days following implantation to try to limit post-operative infection.

Device malfunction can occur if any of the device components develop a leak or if the tubing becomes kinked, preventing free flow of fluid through the device. In a recent single institution, retrospective study of over 1,000 patients who underwent AUS implantation, 12 percent of devices developed a mechanical failure, with a median follow up of 4.1 years.\textsuperscript{38}

**Reported Outcomes**

Data regarding functional outcomes following AUS implantation is limited by the retrospective nature of most published studies and the lack of standardization defining success across the literature. Success following AUS implantation is commonly defined as continence (often meaning patients are using zero to one pad per day) or improved quality of life. A recent systematic review of AUS literature reported an overall continence rate of 79 percent from seven studies including 262 patients. Pooling data that included 326 patients, the same review reported an overall dry (no pads) rate of 42.5 percent.\textsuperscript{39}

Male urinary incontinence can significantly affect quality of life, as patients alter their lifestyle to avoid activities that lead to incontinence. In a prospective study of 40 patients (mean follow-up 53.4 months) who underwent AUS implantation, all patients described their pre-operative quality of life as bad or horrible. The patients also reported that their incontinence was significantly impacting their quality of life. Following implantation, the 36 patients who achieved continence with the AUS reported that their quality of life was good, they were satisfied with the procedure and their incontinence was no longer dramatically affecting their quality of life. Overall pad usage decreased from four pads per day pre-operatively to 0.62 pads per day post-operatively.\textsuperscript{40}

**Summary**

Urethral reconstructive surgery is used to treat a broad range of urologic diagnoses. While urethral stricture disease and male SUI do not represent life-threatening conditions, they are life-altering. Severe stricture disease can lead to painful episodes of acute urinary retention and can require multiple surgical interventions. Severe SUI can cause men to significantly limit their activities as they try to avoid actions that will precipitate episodes of incontinence. Men suffering from urethral stricture disease and SUI should be referred to a urologist, as multiple treatment options exist to improve their quality of life.
References


