Invited Review Article

# Updates in substitution urethroplasty for anterior male urethral strictures

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## Abstract

Substitution urethroplasty is an essential tool in the armamentarium of management of anterior urethral strictures, due to the limitations of anastomotic urethroplasty for penile urethral strictures and bulbar strictures beyond 2 cm in length. Various urethroplasty techniques with different grafts or flaps have been described. In this review article, the rationale of utilisation of different substitution urethroplasty techniques are described. Evaluation of urethroplasty outcomes should include not only voiding function and sexual outcomes, but also patient-reported outcome measures (PROMs) and overall satisfaction.

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## Introduction

Urethral strictures are a relatively common urological disease and can result in significant morbidity and detrimental effects on the quality of life.[1] They can result in lower urinary tract voiding symptoms, urinary retention, recurrent urinary tract infections[2], bladder outlet obstruction with bilateral hydronephrosis and renal impairment, and urinary fistulae. They can also cause penile, urethra and/or bladder pain.[1] Appropriate management strategies can help reduce stricture recurrence rates and ameliorate the morbidity associated with urethral stricture disease.

Due to the limitations of anastomotic urethroplasty, substitution urethroplasty with grafts or flaps is especially useful in the penile urethra as well as longer strictures in the bulbar urethra.

## Clinical Evaluation

Symptoms of urethral stricture disease include voiding symptoms such as hesitancy, straining, poor flow, intermittency and sensation of incomplete voiding. They may also present with recurrent urinary tract infections, bladder stones, acute retention of urine, prostatitis or epididymitis. A detailed history of previous urethral surgery, urinary instrumentation and history of sexually transmitted diseases is also important.

Physical examination is performed to look for features of lichen sclerosis, and meatal stenosis, with palpation to establish location and length of scarred tissue.

Uroflowmetry assessment is performed to look for an obstructive voiding pattern; a plateau flow pattern is classical for urethral stricture.

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Investigations with retrograde urethrogram and cystoscopy help to delineate the location, length, multiplicity, and severity of urethral stricture disease. Cystoscopy has the added benefit of assessing the healthiness of urethral mucosa peri-stricture to determine the suitability of intended procedures. In the case of urethral strictures that also involve the posterior urethra, retrograde urethroscopy combined with antegrade cystoscopy via the suprapubic tract allows assessment of length of defect, presence of fistulae or bony anomalies to help in surgical planning.[3]

## Management Strategies

Management of urethral strictures depends on symptoms, aetiology, location, length, multiplicity and previous urological procedures performed. For anterior strictures in which direct vision internal urethrotomy (DVIU) or dilatation have failed, urethroplasty is usually the option for definitive treatment. Predictors of stricture recurrence include[3]:

1. Stricture length – patency rates of 71.2% for those < 1 cm versus 23.2% for those > 1 cm
2. Stricture calibre – patency of 34% for < 15 Fr versus 69% for > 15 Fr
3. Multiplicity of strictures – 0% patency versus 35% for single stricture
4. Stricture location – bulbar strictures have better patency rates compared to penile or penobulbar strictures
5. Previous interventions – worse patency rates after first DVIU with 0% after ≥ 2 failed DVIU procedures

For selected patients, observation is a reasonable approach when they have relatively large calibre strictures > 16 Fr, especially if they are asymptomatic. These cases have a low risk of progression and subsequent need for surgical intervention[4], with intervention rates of 4% in the 1 year and 12% for the 2nd year.[3]

### Anastomotic urethroplasty vs substitution urethroplasty

There are two types of urethroplasty, specifically, anastomotic urethroplasty (excision and primary anastomosis, EPA) and substitution urethroplasty. EPA has excellent patency rates of 85.5 to 98.5%[3,5] and it is the treatment of choice for post-traumatic short bulbar strictures where there is usually full thickness spongiofibrosis.[6] In these cases, complete excision of the stricture is essential to reduce risk of stricture recurrence.

The limitations of EPA are that it is only useful for short bulbar urethral strictures up to 2 cm in length.[3,6] The utilization of EPA for longer bulbar urethral strictures and penile urethral strictures, however, is associated with potential tension on the anastomosis, which can result in vascular compromise and increased stricture recurrence.[6] For these longer bulbar strictures, EPA can also lead to chordee, erectile dysfunction and impaired sexual function.[7]

## Substitution Urethroplasty

### Techniques of substitution urethroplasty

There are four commonly used substitution urethroplasty techniques, dorsal onlay (DO), dorsolateral onlay (DLO), dorsal inlay (DI) and ventral onlay (VO). No single technique has been proven to be superior to another for bulbar free graft urethroplasty, though some favour dorsal placement due to thicker corpora spongiosal tissue with greater vascularity and better graft support.[8] Recurrence rates for substitution urethroplasty are reported to be ≤ 20% at 2 to 5 years,[9] with a 90% success rate as reported by Al-Hakeem et al.[1]

### Dorsal onlay substitution urethroplasty (Barbagli)

This was first described in 1996 by Barbagli[10] as a one-stage urethroplasty using a free preputial graft. Circumferential mobilization of the urethra is performed, with dissection of the urethra off the corpora cavernosa at the stricture site. After placing stay sutures along the length of the urethra, the urethra is rotated 180° before the dorsal stricturotomy is performed to evaluate the length and extent of spongiofibrosis. The graft is quilted unto the corpora cavernosa, followed

**Table 1.** Summary of techniques of substitution urethroplasty

| Techniques | Dorsal Onlay (DO) | Dorsolateral Onlay (DLO) | Dorsal Inlay (DI) | Ventral Onlay (VO) |
|---|---|---|---|---|
| | Barbagli | Kulkarni | Asopa | McAninch |
| | | | Palminteri | |

by anastomosis of the urethra into the graft site, thus completing the augmentation substitution urethroplasty.

**Dorsal inlay substitution urethroplasty (Asopa)**

This was described in 2001 by Asopa[11] as an alternative to Barbagli's procedure, with the advantage of preserving the circumflex and perforating arterial vasculature as is not required urethral mobilization. A ventral urethrotomy is made, the dorsal urethra incised, and a graft placed dorsally over the corpora.

**Penile inversion and one-sided dorsolateral BMG (Kulkarni)**

This was described by Kulkarni in 2009[12] with the added advantage of preservation of one side of the urethral vasculature as the mobilization of the urethra was only required on one side. Penile inversion allows access to the entire length of the urethra via a perineal incision, making it suitable for panurethral strictures as well.

**Ventral onlay (McAninch)**

This was described by Elliott et al[13] where a 20 to 25 mm wide graft is harvested and a ventral onlay anastomosis is performed, with a success rate of 90% reported for bulbar urethral strictures at a minimum time of 1 year post-surgery.[13]

**Combined dorsal and ventral double buccal mucosal graft (Palminteri)**

This was described in 2007 for the management of complex bulbar urethral strictures.[7] This comprises a comprises of a dorsal inlay (Asopa) and ventral onlay (McAninch) double BMG to augment the urethral plate. Success rates of 89.6% with a mean follow-up period of 22 months have been reported.[7]

## Tissues used in Substitution Urethroplasty

1. Grafts

a) Oral mucosal grafts (OMG)

OMG have outcomes of excellent vascularity, and favorable immunology with lower fibrosis compared to skin.[14] They are easy to harvest, waterproof, antibacterial, hairless and have high success rates.[15] It is the tissue of choice in patients with lichen sclerosis with single-staged OMG urethroplasty reporting success rates of 65 to 100% after 12 to 67 months of follow-up; and staged OMG urethroplasty having success rates of 60 to 79%.[3]

Grafts can be harvested from the buccal, lingual or lip area. Buccal mucosal graft (BMG) is the graft of choice as it can be harvested bilaterally and has lower donor site morbidities compared to lingual and lip grafts. Compared to BMG, Lingual grafts are less abundant and more flimsy, and are associated with a higher risk of speech impairment.[14] They are an alternative to BMG in patients who have had previous BMG harvest or contraindications to BMG harvest, although long-term outcomes have not been published to date. Lip graft harvests are associated with risks of numbness and lip contractures, which can occur in 3 to 5% of cases.[14]

Certain conditions preclude OMG, which include oral leukoplakia, heavy tobacco usage, betel nut chewing, previous oral radiotherapy and previous OMG harvest.

b) Penile skin grafts

These are hairless, elastic, and easy to harvest with minimal donor site morbidity, but are not suitable for patients with lichen sclerosis. They are an alternative to BMG for patients with contraindications for BMG harvest, but have lower success rates of 59.7% in comparison to 77.7% with BMG.[16]

c) Postauricular skin

This is a full thickness graft that is harvested from the lower half of the mastoid without extending beyond the lower end of the tragus. Up to 7-8 cm of graft can be harvested from each side, the technique having a 89% success rate at 21 months with no donor site complications.[16]

d) Bladder mucosa

This has traditionally been used in hypospadias surgery but has declined in popularity due to the morbidity associated with harvesting as well as poor success rates with up to 66% requiring further surgical intervention.[16]

e) Tunica vaginalis

This has been described by Foinquinos et al[17] in a small case series of 11 patients undergoing dorsal onlay augmented urethroplasty for anterior urethral strictures. Relatively good short-term outcomes of all patients having uroflowmetry of > 14 ml/s with a mean follow-up of 2.8 months have been reported.

f) Colonic mucosa

This is not commonly used but has been described in a small case series[18] in patients with long segment strictures not amenable to penile skin flaps. It is a more invasive procedure, as sigmoidectomy is required for graft harvest and complications including colocutaneous fistula have been described. Reported success rates were 85.7% at 53.6 months.[18]

2. Penile /preputial skin flap substitution urethroplasty

These are fasciocutaneous flaps vascularised by the tunica dartos and are suitable for substitution urethroplasty, especially in the case of distal penile urethral strictures. Distal penile skin is also hairless which makes it a pertinent choice for urethral reconstruction. However, the use of these should be avoided in patients with lichen sclerosis and/or significant scar tissue due to high risks of stricture recurrence ranging from 50 to 100%, with the majority of recurrences occurring within the first two to three years postoperatively.[19] Onlay flaps have lower failure rates compared to tubularised flaps.[20]

a) Orandi flap

This is a longitudinal penile skin island flap with a lateral pedicle harvested from the ventral side of the penis.

b) McAninch flap

This is a transverse preputial flap harvested circumferentially and can provide a flap up to 15 cm in length. During reconstruction, a circular flap is constructed from the prepuce in the uncircumcised and from the distal penile shaft skin in those who are circumcised.

## Substitution Urethroplasty Techniques

These depend on the location, length and aetiology of the stricture disease.

**A) Bulbar urethral strictures**

Depending on the length and aetiology of the stricture, transecting urethroplasty or non-transecting urethroplasty techniques can be performed.

Non-transecting urethroplasty can be considered for non-trauma aetiologies with partial thickness spongiofibrosis, whereas transection of the urethra should be performed for full thickness spongiofibrosis strictures associated with perineal trauma. Non-transecting urethroplasty comprises of several techniques as described by Bugeja et al.[6] and Welk et al.[21], namely;

1. A "Heineke-Mikulicz"-type stricturoplasty. This is used for short strictures where a longitudinal urethrotomy is made and closed transversely without tension

2. Non-transecting anastomotic urethroplasty (NTABU)

The diseased urethral mucosa with surrounding spongiofibrosis is excised while preserving underlying healthy corpora spongiosum. With adequate urethral mobilization, the healthy remaining urethral mucosa is then sutured to each other and the longitudinal dorsal stricturotomy closed transversely in a tension-free fashion. One important caveat is that the incision into and through the spongiosal tissue needs to be exactly at the level of the stricture, so planning needs to be optimized prior to incision to ensure unnecessary extension of the incision which may compromise the repair. Radiologically, 97.7%[6] of repairs are stricture-free at a mean follow-up of 13 months. Long-term erectile dysfunction rates were reported in 2.4% of cases, lower than that reported in EPA.[6]

**Table 2.** Advantages and Disadvantages of Transecting vs Non-Transecting Urethroplasty[6]

| | Transecting Urethroplasty | Non-Transecting Urethroplasty |
|---|---|---|
| Advantages | • Complete excision of stricture, potentially reducing risk of stricture recurrence with > 95% long-term success | • Preservation of urethral blood supply<br>• Lower rates of erectile dysfunction[6] of 2.4%<br>• May avoid or reduce need for graft, thereby reducing donor site morbidity and risks of post-micturition dribble |
| Disadvantages | • Higher rates of erectile dysfunction 18 to 22.5%[6]<br>• Potential vascular compromise to urethra | • Stricture tissue not excised, hence potential higher risk of stricture recurrence<br>• Up to 85% success |

3. Dorsal augmented substitution urethroplasty

A dorsal urethrotomy is made and the urethral plate augmented with either a graft or a flap.

4. Augmented non-transecting anastomotic urethroplasty (ANTA)

A dorsal urethrotomy is made and the narrowest portion of the stricture identified. The diseased mucosa and corpora spongiosum are excised and the mucosal edges are reanastomosed. This can be performed in cases with urethral obliteration that preclude satisfactory urethral patency with dorsal onlay substitution urethroplasty or to shorten stricture length to prevent the need for bilateral buccal graft harvests to reduce donor site morbidity.[21] Success rates are comparable to dorsal augmented buccal graft urethroplasty with 90% of cases being recurrence-free at 5 years.[21]

5. Augmented non-transecting anastomotic urethroplasty with buccal mucosal graft (ANTABU)

This is a modification of the ANTA procedure with dorsal buccal mucosal graft augmentation.

**B) Penile urethral strictures**

Penile urethral strictures should not be managed with DVIU due to poor patency rates and risks of erectile dysfunction, which has been reported in 5.3% to 10.6% of cases.[3]

They can be managed with either a single stage or two-stage urethroplasty procedure.

- Single stage vs staged urethroplasty

A single stage procedure reduces the morbidity of having an hypospadiac meatus and a poor aesthetic appearance of the penis with its potential psychological trauma.[22]

Distal to the distal edge of the bulbospongiosus muscle, a dorsal approach is indicated for buccal graft urethroplasty due to the thinner spongiosal layer ventrally and a more optimal and stable environment for the graft to take dorsally, as well as a reduced risk of diverticulum formation in longer term follow-up. More recently Kulkarni popularised a dorso-lateral approach to the spongiosum to further reduce neurovascular compromise and this is now widely accepted.[30] He also recently described a penile invagination technique for pan-urethral strictures via a single perineal incision and dorso-lateral approach to the spongiosum.[31]

Staged reconstructive urethroplasty is utilized for complex strictures where vascularity is in doubt, such as the presence of significant scarring from previous procedures; as well as those with a deficient urethral plate, penile skin or dartos fascia e.g. hypospadias.

Staged urethroplasty should be considered in the following circumstances to optimize successful outcomes[3]:

1) Prior failed hypospadias repair or complex urethroplasty

2) Radiation-induced urethral strictures

3) Urethral fistulae, false passage, infections e.g. abscess

4) Severe spongiofibrosis

5) Lichen sclerosis when the urethral lumen is ≤ 6 Fr and/or the urethral plate is unsalvageable[19]

During the first stage, the graft is sutured to the tunica albuginea. During the second stage 6 to 12 months later, the graft is tubularised over a urethral catheter. If the graft does not take or there is recurrence of disease, repetition of the first stage will be required. The success rates in staged urethroplasty for lichen sclerosis patients is reported to range from 73% to 82%.[19]

Most have described the use of buccal mucosal grafts in the first stage of a staged urethroplasty. This is associated with graft contraction in between 20% to 38% of cases[22] in high volume centres, and often requires revision surgery.

**Johanson's 2-stage urethroplasty**

During the first stage, urethral marsupialization is performed, where a longitudinal penile skin incision is made over the site of the stricture and extended proximally till healthy normal urethral tissue is reached. The lateral edges of the urethra are sewn to the skin edges before tubularisation of the urethral plate and dartos flap are performed at the second stage at 6 to 12 months after the first stage. Oral mucosal grafts can be utilized during the first stage for optimization of the urethral plate. During the first stage, a temporary perineal urethrostomy can be offered to allow voiding as standing to void postoperatively is usually challenging; this will be closed during the second stage. Approximately 30% of cases will

require graft revision during the second stage due to scarring and graft retraction.[22]

**2-stage urethroplasty by Joshi et al[22]**

A new two-stage urethroplasty was described by Joshi et al.[22] in 2017 which precludes the usage of a buccal mucosal graft in the first stage, thereby avoiding the risks of graft scarring and contraction. In this procedure, the first stage involves a ventral urethrotomy with penile skin margins sutured to the margins of the urethral plate. A neourethral meatus is sited in healthy urethral mucosa proximal to the stricture and a 12 Fr Foley catheter left in-situ for 3 days postoperatively. The second stage is performed six months afterwards, with the excision of scar tissue. A buccal mucosa graft is harvested and placed as a dorsal inlay graft with quilting to construct a wide urethral plate. This is then tubularised and dartos muscle mobilized to cover the suture line. This is then followed by glansplasty and meatal reconstruction. Success rates were reported as 89.5% with a median follow-up of 44 months, and none required revision prior to the second stage.

## Assessment of Urethroplasty Outcomes

Conventionally, the presence of a normal urethral lumen during retrograde urethrogram or cystoscopy was defined as a successful outcome.[3] Objective parameters for determination of success include the need for stricture retreatment, anatomical recurrence on cystoscopy, peak urine flow rates < 15 ml/s and a weak stream ascertained from a questionnaire.[23]

Post-operative evaluation should include uroflowmetry and post-void residual measurements as well as urethrocystoscopy to assess stricture calibration at three months post-urethroplasty. Small calibre < 17 Fr strictures have a much higher propensity for recurrence.[3] Retrograde urethrograms with voiding cystourethrograms (VCUG) can be performed to confirm suspected stricture recurrences, when pre- and post-operative Qmax differences are ≤ 10 ml/s and/or occur in the presence of an obstructive voiding flow curve.

It is of note however, that not all anatomic recurrent strictures require treatment. This is especially the case if the stricture calibre remains > 14 Fr and if they remain asymptomatic,[3] as the aim of urethral surgery is to allow return to normal voiding function with minimal symptoms and for preservation of quality of life.

Patient-reported outcome measures (PROMs) help evaluate patient outcomes and the perceived benefit from an intervention. These include evaluation of urinary symptoms, sexual function and improvement in quality of life post-surgery. The evaluation of sexual function is not frequently discussed but erectile dysfunction is more prevalent in the bulbar urethroplasty compared to penile urethroplasty; and is higher in EPA compared to graft urethroplasty.[24] It has been reported that there is a 5% risk of long-term erectile dysfunction after EPA, and 0.9% after graft patch urethroplasty[25]; with a 30-38% reduction in satisfaction of erections[26] which improves with time, with a 90% recovery after 190 days.[27] Patient global impression of improvement ( PGI-I) scores were reported to be much better or very much better (PGI-I scores of 1 and 2) in 86.9% of cases[1] after substation urethroplasty.

Some PROMs utilized for urethroplasty patients include:

**Disease Non-Specific Voiding PROM**

1. American Urological Association Symptoms Score (AUA-SS), also known as the International Prostate Symptom Score (IPSS).

This was first investigated in 1998 where an inverse correlation between AUA-SS and maximum urinary flow rates was observed, and it was concluded that AUA-SS had clinical validity as an adjunct outcome assessment tool after urethroplasty.[28] It is however inadequate as it misses up to 20% of symptoms and does not capture the 10% of men with strictures who do not have voiding symptoms.[28]

2. Core Lower Urinary Tract Symptom Score (CLSS)

This was designed in 2008 to assess ten core urinary symptoms from the symptom panel of the International Continence Society.[28] The symptoms evaluated are frequency, urgency, nocturia, pain, urinary incontinence and quality of life. Its limitations are that it did not include complaints of urinary spraying and dysuria, which are relatively prevalent in cases of urethral stricture disease.

3. Incontinence Symptom Index (ISI)

This was developed in 2003 and includes assessment of urinary incontinence and degree of symptom bother but has not been evaluated specifically for urethral strictures.

**Table 3.** Validated Sexual Function PROM by Coursey et al.[26]

APPENDIX: PATIENT QUESTIONNAIRE

INSTRUCTIONS: Please circle the response that best describes you.

1. How would you describe your erections *before* surgery?
   Absent | Not at all satisfactory | Moderately satisfactory | Very satisfactory
2. How would you describe your erections *after* surgery?
   Absent | Not at all satisfactory | Moderately satisfactory | Very satisfactory

Instruction: The following are questions about changes/symptoms that may have occurred in your erections since your surgery. Circle the response about the following symptoms that best applies.

3. Has the angle of your erection changed after surgery?
   Not at all | Somewhat | Quite a bit
   If so, has this symptom improved over time?
   Not at all | Somewhat | Quite a bit
   Comments: _____
4. Has the length of your penis changed since your surgery?
   Not at all | Somewhat | Quite a bit
   If so, has this symptom improved over time?
   Not at all | Somewhat | Quite a bit
   Comments: _____
5. Has your partner noted any changes in your erections since surgery?
   Yes | No
   Comments: _____
6. Have you altered your frequency of intercourse due to erection changes since surgery?
   Not at all | Somewhat | Quite a bit
7. How would you describe your health in general?
   Poor | Fair | Good | Excellent

### Disease-Specific Voiding PROM

1. Urethral Stricture Surgery PROM (USS PROM)

This was first devised in 2011 by Jackson et al.[29] and consists of six summative questions derived from the International Consultation on Incontinence Questionnaire Male Lower Urinary Tract Symptoms (ICIQ MLUTS) module to generate a score between 0 (asymptomatic) and 24 (most symptomatic), a separate LUTS-specific quality-of-life (QoL) question, Peeling's voiding picture, EQ-5D to assess overall HRQoL, and 2 questions addressing overall patient satisfaction postoperatively. Limitations of the USS PROM are that sexual function and oral mucosa morbidity are not included.

### Disease Non-Specific Sexual PROM

These include International Index of Erectile Function (IIEF) and its abbreviated version, IIEF-5; Brief Male Sexual Function Inventory (BMSFI), and Men's Sexual Health Questionnaire (MSHQ).

### Disease Specific Sexual PROM

The only validated sexual function PROM by Coursey et al[26] mainly addresses erectile function without evaluating overall patient satisfaction and quality of life.

BMSFI is validated for the assessment of change in sexual function before and after urological intervention but is not disease-specific for urethral strictures. MSHQ is a 25-item self-administered questionnaire for assessment of erection, ejaculation and satisfaction[3], but it is also not disease-specific as well.

## Conclusion

### 1. Substitution Urethroplasty Techniques

Choosing the appropriate substitution urethroplasty technique will optimize the success rates and outcomes of urethral stricture disease.

For patients with lichen sclerosis, penile skin flaps should be avoided and 2-stage urethroplasty procedures should be considered, especially if they have a long-segment stricture, previously failed urethroplasties, an obliterated urethral lumen and an unhealthy urethral plate.

### 2. Assessment of urethroplasty outcomes

**Table 4.** Summary of procedures for bulbar and penile urethral strictures

| | Bulbar Urethral Stricture | Penile Urethral Stricture |
|---|---|---|
| < 2 cm | • EPA<br>• Non-transecting: Heineke-Mikulicz | Augmented urethroplasty<br>- Avoid penile skin flaps in lichen sclerosis<br>- Consider 2-stage procedure when vascularity is in doubt |
| > 2 cm | • Augmented urethroplasty<br>• Augmented Non-Transecting Urethroplasty (ANTA, ANTABU) | |

EPA = excision and primary anastomosis

A) Assess objective outcomes with uroflowmetry and postvoid residuals; and consider a calibration cystourethroscopy at 3 months postoperatively. Should any of these suggest stricture recurrence, a retrograde urethrogram and VCUG should be performed Objective parameters indicating stricture recurrence include the need for stricture retreatment, anatomical recurrence evidenced by cystoscopy, peak urine flow rates < 15 ml/s and weak stream on questionnaire.[23]

B) Assess patient-reported outcomes including voiding symptoms, sexual and erectile function, in addition to patient quality-of-life outcomes and overall satisfaction.

C) Strictures with higher risk of recurrence should be surveyed and followed-up for a longer period with PROMs.

## Conflict of Interest

The authors declare no conflict of interest.

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