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Review – Reconstructive Urology

European Association of Urology Guidelines on Urethral Stricture Disease (Part 1): Management of Male Urethral Stricture Disease

Nicolaas Lumen[a,*], *Felix Campos-Juanatey*[b], *Tamsin Greenwell*[c], *Francisco E. Martins*[d], *Nadir I. Osman*[e], *Silke Riechardt*[f], *Marjan Waterloos*[a], *Rachel Barratt*[c], *Garson Chan*[g], *Francesco Esperto*[h], *Achilles Ploumidis*[i], *Wesley Verla*[a], *Konstantinos Dimitropoulos*[j]

[a] *Division of Urology, Gent University Hospital, Gent, Belgium;* [b] *Urology Department, Marques de Valdecilla University Hospital, Santander, Spain;* [c] *Department of Urology, University College London Hospital, London, UK;* [d] *Department of Urology, Santa Maria University Hospital, University of Lisbon, Lisbon, Portugal;* [e] *Department of Urology, Sheffield Teaching Hospitals, Sheffield, UK;* [f] *Department of Urology, University Medical Center Hamburg-Eppendorf, Hamburg, Germany;* [g] *Division of Urology, University of Saskatchewan, Saskatoon, Canada;* [h] *Department of Urology, Campus Biomedico University of Rome, Rome, Italy;* [i] *Department of Urology, Athens Medical Centre, Athens, Greece;* [j] *Aberdeen Royal Infirmary, Aberdeen, UK*

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Abstract

Objective: To present a summary of the 2021 version of the European Association of Urology (EAU) guidelines on management of male urethral stricture disease.
Evidence acquisition: The panel performed a literature review on these topics covering a time frame between 2008 and 2018, and used predefined inclusion and exclusion criteria for the literature to be selected. Key papers beyond this time period could be included as per panel consensus. A strength rating for each recommendation was added based on a review of the available literature and after panel discussion.
Evidence synthesis: Management of male urethral strictures has extensively been described in literature. Nevertheless, few well-designed studies providing high level of evidence are available. In well-resourced countries, iatrogenic injury to the urethra is one of the most common causes of strictures. Asymptomatic strictures do not always need active treatment. Endoluminal treatments can be used for short, nonobliterative strictures at the bulbar and posterior urethra as first-line treatment. Repetitive endoluminal treatments are not curative. Urethroplasty encompasses a multitude of techniques, and adaptation of the technique to the local conditions of the stricture is crucial to obtain durable patency rates.
Conclusions: Management of male urethral strictures is complex, and a multitude of techniques are available. Selection of the appropriate technique is crucial, and these guidelines provide relevant recommendations.
Patient summary: Injury to the urethra by medical interventions is one of the most common reasons of male urethral stricture disease in well-resourced countries. Although different techniques are available to manage urethral strictures, not every technique is appropriate for every type of stricture. These guidelines, developed based on an extensive literature review, aim to guide physicians in the selection of the appropriate technique(s) to treat a specific type of urethral stricture.

* Corresponding author. Department of Urology, Ghent University Hospital, C. Heymanslaan 10, 9000 Gent, Belgium. Tel. +32 9 3322278, Fax: +32 9 3323889.
E-mail address: Nicolaas.lumen@uzgent.be (N. Lumen).

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1. Aetiology and guidelines on prevention

The following conditions have been identified as etiological factors of urethral stricture disease (USD) and some of these strictures can be prevented (Table 1):

1 *Urethritis due to sexually transmitted infection* was previously a major cause of USD in well-resourced countries accounting for 40% of all cases [1]. The wide-scale promotion of safe sexual practices and timely treatment with antimicrobials is thought to have led to the considerable reduction in the problem [1]. Infective urethritis now accounts for up to 3.7% of cases in well-resourced countries [1] but continues to be the major cause (41.6%) of USD in low-resourced countries [2].
2 *Inflammation due to lichen sclerosus* (LS) is the cause of USD in up to 13.4% of cases and is the most common cause of pan-USD (48.6%) [3].
3 *External trauma to the urethra* is the second most common cause of USD in adults [1]. The bulbar urethra is the site most frequently affected by blunt trauma [4], usually as a result of straddle injuries or kicks to the perineum. Penile fracture is associated with a urethral injury in 15% of cases [5]. Motor vehicle accidents associated with pelvic fractures are the main cause of blunt injuries to the posterior urethra [6].
4 *Iatrogenic injury to the urethra* is one of the most common causes (32–79%) of USD in well-resourced countries [1,7]. Prevention of iatrogenic urethral injury represents the main way in which healthcare providers can prevent USD. Iatrogenic urethral injury most commonly results from urethral instrumentation (eg, catheterisation and cystoscopy), surgery for benign prostatic obstruction (BPO)/prostate cancer, or radiotherapy.
   (a) *Urethral catheterisation*: This accounts for 11.2–16.3% of USD [1,3]. Hollingsworth et al [8] reported a 3.4% urethral stricture rate or erosion after short-term catheterisation (<3 wk). The rate of traumatic insertion of a urethral catheter was found to be 3.2 per 1000 inpatients [9]. Catheter-related trauma can be prevented through several measures. Studies have indicated that around 25% of all indwelling catheterisations in hospitals were unnecessary or inappropriate [10]. A targeted training program on urethral catheterisation was shown to be effective in reducing iatrogenic urethral injuries [9]. Catheter diameter is suggested to be a possible contributing factor to USD due to a pressure effect on the urethral wall. Decreasing the catheter size from 22 Fr to 18 Fr significantly decreased the risk of fossa navicularis strictures (6.9% vs 0.9%, $p = 0.02$) [11]. Catheter material may also have an influence on the occurrence of stricture, as noncoated latex catheters were associated with a greater incidence of urethritis and more stricture formation than silicone catheters [12].
   (b) *Transurethral prostate surgery*: USD following transurethral prostate surgery occurs in 4.5–13% of cases [13], whereas bladder neck stenosis (BNS) occurs in between 0.3% and 9.7% [14]. Transurethral surgery is the most common cause of iatrogenic USD accounting for 41% of all causes [7]. A systematic review showed no significant differences in USD and BNS rates by energy modality (monopolar, bipolar, holmium laser enucleation, and photoselective vaporisation) [13]. Routine preliminary urethrotomy prior to transurethral resection of the prostate (TURP) was not able to lower the stricture rate significantly compared with TURP alone (14% vs 21%) [15].
   (c) *Radical prostatectomy*: Radical prostatectomy (RP) has been associated with vesicourethral anastomosis (VUA) stricture (VUAS) in 1–3% of cases [16].
   (d) *Prostate radiation and ablative treatments*: USD occurs in 1.5% of patients undergoing external beam radiation therapy (EBRT), 1.9% having brachytherapy (BT), and 4.9% who receive combination EBRT-BT at around 4 yr of follow-up [17]. These strictures typically occur in the bulbomembranous urethra [1]. As opposed to RP, stricture incidence after irradiation increases with time [17,18]. For the ablative treatments, the stricture incidence after cryotherapy is 1.1–3.3% and that after high-intensity focused ultrasound is 1–31% [18].
5 *Failed hypospadias repair* (FHR), which although sometimes considered as iatrogenic strictures, represent a very specific subtype and should be considered as a separate entity.
6 *Congenital USD* can only be diagnosed in the absence of other possible aetiologies [19]. Congenital strictures are thought to be consequent to incomplete or incorrect fusion of the urethra formed from the urogenital sinus, with the urethra formed following closure of the urethral folds. They typically have a deep bulbar location and are short.
7 *Idiopathic USD* is seen in, respectively, 34% and 63% of penile and bulbar strictures [20].

Table 1 – Guidelines for prevention of urethral stricture disease

Recommendations	Strength rating
Advise safe sexual practices, recognise symptoms of sexually transmitted infections, and provide access to prompt investigation and treatment for men with urethritis.	Strong
Avoid unnecessary urethral catheterisation.	Strong
Implement training programmes for physicians and nurses performing urinary catheterisation.	Strong
Do not use catheters larger than 18 Fr if urinary drainage only is the purpose.	Weak
Avoid using noncoated latex catheters.	Strong
Do not perform urethrotomy routinely when there is no pre-existent urethral stricture.	Strong

2. Conservative management

2.1. Observation

Purohit et al [21] observed patients with incidentally encountered strictures (≥16 Fr; Table 2). No patient

Table 2 – Guidelines on conservative management

Recommendations	Strength rating
Do not intervene in patients with asymptomatic incidental (>16 Fr) strictures.	Weak
Consider long-term suprapubic catheter in patients with radiation-induced bulbomembranous strictures and/or poor performance status.	Weak

developed symptoms and none of them needed surgical intervention.

Another study observed an important discrepancy between cystoscopic recurrence and need for further intervention [22]. Patients with a large-calibre (>16 Fr) recurrence had 1- and 2-yr need for intervention rates of 4% and 12%, respectively. Of note, patients with small-calibre (≤16 Fr) recurrence had 1- and 2-yr need for intervention rates of only 41% and 49%, respectively. Patients who needed intervention had poorer patient-reported outcome measures suggesting clinical symptoms and bother.

2.2. *Suprapubic catheter*

Fuchs et al [23] evaluated 75 patients who were initially treated by suprapubic diversion for radiation-induced isolated bulbomembranous strictures (BMSs) [23]. Only 51% eventually decided to undergo urethroplasty after a mean follow-up period of 25 mo. Patients with concomitant stress urinary incontinence (SUI) opted more often to keep their suprapubic catheter as the SUI improved in 61% of cases. A suprapubic catheter is also an option in frail patients not able to undergo surgery or in patients who do not want (further) urethral surgery and are willing to accept the complications of a suprapubic catheter.

3. Endoluminal treatment of anterior urethral strictures

This treatment category encompasses direct vision internal urethrotomy (DVIU) and dilatation (Table 3). Steenkamp et al [24] randomised 210 patients with seemingly comparable nonobliterative strictures at all locations of the urethra to either filiform dilatation or DVIU, and showed that DVIU and dilatation are equally effective. As such, the indications for DVIU and dilatation at the anterior urethra are the same.

Patency rates vary considerably between 8% and 77% after DVIU (Supplementary Table 1) and between 35.5% and 92.3% after dilatation at various lengths of follow-up (Supplementary Table 2). Especially at the bulbar urethra, visually controlled dilatation might reduce complications (especially false passage, spongiosal perforation, and urethral bleeding) of blind dilatation [25]. Indication to perform DVIU/dilatation is dependent on various stricture characteristics that are prognostic for a successful outcome. Increasing stricture length, increasing stricture tightness, more than one stricture, location outside the bulbar urethra, and prior failed endoluminal treatment were identified as predictors of stricture recurrence after DVIU/dilatation (Supplementary Table 1). DVIU at the penile urethra appears to have a higher risk for subsequent erectile dysfunction (ED) [26]. Based on these predictors, the most suitable indication for DVIU/dilatation appears to be previously untreated patients with a single, short (maximum 2 cm) bulbar stricture. For these selected patients, a 5-yr patency rate of 71% has been reported [27]. When DVIU was used for a short stricture recurrence after urethroplasty, patency rates of around 50% were reported [28].

A systematic review reported no significant difference in patency rates after a first DVIU using laser versus cold knife (58.6% vs 42.7%; $p = 0.09$). At the bulbar urethra, laser and cold knife DVIU yielded patency rates of 52.9% and 60%, respectively ($p = 0.66$) [29].

Several strategies have been developed to improve patency rates after DVIU/dilatation. These strategies include intralesional injection with steroids [30]/mitomycin C (MMC) [31], intermittent self-dilatations (±intraurethral corticosteroids [30]) [32], and temporary urethral stents [33]. Intermittent self-dilatations and local corticosteriods tend to stabilise the stricture and prolong the time to recurrence rather than keeping the patient stricture free. Intralesional MMC has encouraging results, but its use in the urethra is still off-label [31]. Stents must be used with caution because a history of failed stenting is a predictor of increased stricture complexity and need for more complex urethroplasty [34].

Table 3 – Guidelines on endoluminal treatment of anterior urethral strictures

Recommendations	Strength rating
Do not use direct vision internal urethrotomy (DVIU) for penile strictures.	Strong
Do not use DVIU/dilatation as solitary treatment for long (>2 cm) segment strictures.	Strong
Perform DVIU/dilatation for a primary, single, short (<2 cm), and nonobliterative structure at the bulbar urethra.	Weak
Perform DVIU/dilatation for a short recurrent stricture after prior bulbar urethroplasty.	Weak
Use either "hot" or "cold" knife techniques to perform DVIU depending on the experience and resources.	Weak
Use visually controlled dilatation in preference to blind dilatation.	Weak
Do not perform repetitive (>2) DVIU/dilatations if urethroplasty is a viable option.	Strong
Perform intermittent self-dilatation (ISD) to stabilise the stricture after dilatation/DVIU if urethroplasty is not a viable option.	Weak
Use intraurethral corticosteroids in addition to ISD to stabilise the urethral stricture.	Weak
Do not use intralesional injections outside the confines of a clinical trial.	Weak
Do not use permanent urethral stents.	Strong
Do not use urethral stents for penile strictures.	Strong
Use a temporary stent for recurrent bulbar strictures after DVIU to prolong time to next recurrence only if urethroplasty is not a viable option.	Weak

4. Urethroplasty for anterior urethral strictures

4.1. Distal urethral strictures (meatal stenosis and fossa navicularis strictures)

For meatal stenosis, the Malone meatoplasty (dorsal + ventral meatotomy) provides patency rates up to 100%, and 83% of patients were pleased with the cosmetic result (Table 4) [35].

Skin flap meatoplasty showed patency rates ranging from 85% to 100% [36,37]. Patient satisfaction with postoperative outcomes and cosmesis was high (84–100%), there were no cases of ED, and functional complaints were minimal (mainly spraying of the urine flow) [36,37].

Patency rates with the use of grafts ranged from 69% to 91% [37,38], and all patients were satisfied with cosmesis [38].

4.2. Penile strictures

Anastomotic urethroplasty has been discouraged due to the risk of chordee postoperatively. Nevertheless, it has been anecdotally performed in selected patients with very short (<1 cm) strictures reporting a 93% patency rate [39]. In general, the choice is between single-stage and staged augmentation urethroplasty (Table 4).

4.2.1. Staged augmentation urethroplasty

In general, reconstructive urologists tend to follow this approach in men with more complex USD (multiple interventions in the past, unfavourable clinical findings such as significant spongiofibrosis or scarring that requires excision, and poor quality of the urethral plate) [40]. An interval of at least 4–6 mo has been proposed before proceeding to the tubularisation of the urethra, provided that the graft has healed well [40,41]. A systematic review has shown an average patency rate of 90.5% with the use of all types of grafts after 22 mo of follow-up [41]. Up to 20% of patients will need a revision after the first stage [42]. In addition, after the first stage, a substantial number of patients (up to 45%) will refuse to proceed with further reconstructive surgery because they were satisfied with their functional status after the first stage [43].

4.2.2. Single-stage augmentation urethroplasty

Single-stage urethroplasty avoids the need for multiple operations, the associated periprocedural risks, and the cosmetic and functional implications that by definition follow the first part of staged urethroplasties [44]. A critical factor is the careful selection of patients as men with long and/or complex strictures might not be good candidates for single-stage reconstruction. Sometimes, this selection can only be done based on intraoperative findings. Therefore, any scheduled single-stage procedure might be converted into a staged one [44]. A systematic review reported an overall patency rate of 75.7%, with an average follow-up of 32.8 mo [41]. No high-level evidence exists to state that one technique is superior to another, but it seems that the dorsal graft location is more commonly used than the ventral one [41]. FHR- and LS-related strictures are often considered complex strictures that should preferably be treated by staged urethroplasty [40]. However, in the absence of adverse local tissue conditions, a single-stage approach yields acceptable patency rates for both FHR- [43] and LS-related strictures [45].

Table 4 – Guidelines on urethroplasty for meatal stenosis, fossa navicularis, and penile strictures

Recommendations	Strength rating
Offer open meatoplasty or distal urethroplasty to patients with meatal stenosis or fossa navicularis/distal urethral strictures.	Weak
Offer men with penile urethral stricture disease augmentation urethroplasty by either a single-stage or a staged approach, taking into consideration previous interventions and stricture characteristics.	Strong
Proceed to the second stage of the procedure after an interval of at least 4–6 mo and provided that outcome of the first stage is satisfactory.	Weak
Do not offer anastomotic urethroplasty to patients with penile strictures >1 cm due to the risk of penile chordee postoperatively.	Strong
Counsel patients with penile strictures that single-stage procedures might be converted to staged ones in case of adverse intraoperative findings.	Strong
Perform single-stage oral mucosa graft urethroplasty in the absence of adverse local conditions in men with lichen sclerosus–related strictures.	Weak

4.3. Bulbar strictures

4.3.1. Short (<2–3 cm) bulbar strictures

In fit patients, the choice is between excision and primary anastomosis (EPA) and free graft urethroplasty (FGU).

Table 5 – Guidelines on urethroplasty for bulbar strictures

Recommendations	Strength rating
Use transecting excision and primary anastomosis (tEPA) for short post-traumatic bulbar strictures with (nearly) complete obliteration of the lumen and full-thickness spongiofibrosis.	Strong
Use nontransecting excision and primary anastomosis or free graft urethroplasty (FGU) instead of tEPA for short bulbar strictures not related to straddle injury.	Weak
Use FGU for bulbar strictures not amendable to excision and primary anastomosis (EPA).	Strong
Use augmented anastomotic repair for bulbar strictures not amenable to EPA, but with a short, nearly obliterative segment within the whole strictured segment.	Weak
Use the dorsal, dorsal-lateral, or ventral approach according to surgical practice, expertise, and intraoperative findings.	Strong
Offer staged urethroplasty to men with complex anterior urethral stricture disease not suitable for single-stage urethroplasty and those who are fit for reconstruction.	Weak
Do not perform staged bulbar urethroplasty for lichen sclerosis if single-stage urethroplasty is possible.	Weak
Consider staged procedure in patients unsure about perineal urethrostomy versus urethral reconstruction.	Weak
Warn men that staged urethroplasty may comprise more than two stages.	Weak

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4.3.1.1. Excision and primary anastomosis. Transecting EPA (tEPA) includes full-thickness resection of the segment of the bulbar urethra where the stricture and surrounding spongiofibrosis are located (Table 5). A review reported a composite patency rate of 93.8% [46]. ED (usually transient), cold feeling in the glans (3.2%), and decreased glandular tumescence (17%) are complications associated with tEPA [47].

Bulbar strictures, with the exception of post-traumatic bulbar strictures, are usually not associated with complete obliteration and full-thickness spongiofibrosis. Therefore, complete excision of the surrounding spongious tissue with disruption of the antegrade blood flow of the urethra and corpus spongiosum can be regarded as excessive surgical trauma, and in this perspective, nontransecting EPA (ntEPA) has been described. Two series comparing tEPA with ntEPA reported comparable patency rates of 88.4–93.8% and 93.2–97.9%, respectively, albeit follow-up was shorter with ntEPA [48,49]. After 6 mo, ntEPA had significantly lower ED rates than tEPA (4.3% vs 14.3%) [48].

4.3.1.2. Free graft urethroplasty. Despite the very high patency rates of EPA, FGU has been performed for short bulbar strictures as well. This is mainly driven by reports of ED after EPA. A meta-analysis of ten papers comparing tEPA with FGU for short strictures found that tEPA is better than FGU in terms of patency rates (91.5% vs 70%), whilst FGU has fewer erectile complications (9% vs 25%) [50]. To date, no trials comparing ntEPA with FGU regarding patency outcomes and complications have been published.

4.3.2. *Long bulbar strictures*

For strictures not amenable to EPA, FGU is the technique of choice. The patency rate of FGU of the bulbar urethra is 88% with 40 mo of follow-up [41].

Augmented anastomotic repair (AAR) is also an option for these strictures. AAR can be offered if the stricture is too long (circa 2–4 cm) for tension-free EPA or for longer strictures with a short (nearly) obliterative segment. A patency rate after AAR of 91.9% with 28 mo of follow-up has been reported [51]. An alternative for strictures with a nearly obliterative or high-grade segment is double ventral-dorsal onlay, and this technique yielded a patency rate of 91% after 22 mo of follow-up [41].

Regarding the optimal site of graft placement (dorsal onlay, dorsal inlay, ventral onlay, and dorsolateral onlay), a systematic review was conducted. No significant differences were found regarding patency rate, ED, postvoid dribbling, or other complications [52].

4.3.3. *Staged urethroplasty for bulbar strictures*

Staged urethroplasty may be considered in case of local adverse conditions (fistula, false passage, abscess, cancer, severe spongiofibrosis, previous radiotherapy, and FHR; Supplementary Table 3). Patency rates of 33.3–90.1% at a mean follow-up of 11.2–32 mo have been described (Supplementary Table 3).

There is some controversy whether LS-related strictures should always be treated with staged urethroplasty. Warner et al [53] reported, for LS-related bulbar strictures, a 52.2% patency rate for staged urethroplasty, whereas this was 86% for single-stage buccal mucosa urethroplasty ($p < 0.01$).

Kozinn et al [54] reported that 19% of patients declined retubularisation because they were satisfied with their voiding outcomes after first stage. In addition, 19% of men required a revision of their first-stage urethroplasty [54].

4.4. *Penobulbar or panurethral strictures*

The options for surgical reconstruction are various and often include combinations of different techniques or grafts (Table 6) other than oral mucosa graft (OMG) [53]. The patency rates are usually lower than in shorter reconstructions (Supplementary Table 4). Another option in patients refusing or unfit for complex reconstructive surgery is perineal urethrostomy (PU).

4.5. *Perineal urethrostomy*

PU (Table 7) offers a solution in men with complex USD in whom:

1 There are no further options to restore urethral patency due to either multiple previous failed urethroplasties [55] or there are multiple comorbidities precluding a more expansive surgical undertaking after failed endoscopic management [56]
2 There is a lack of certainty on behalf of the surgeon regarding the most appropriate form of urethroplasty [55]

Table 6 – Guidelines on urethroplasty for penobulbar/panurethral strictures

Recommendations	Strength rating
Offer panurethral urethroplasties in specialised centres because different techniques and materials might be needed.	Weak
Combine techniques to treat panurethral strictures if one technique is not able to treat the whole extent of the stricture.	Weak

Table 7 – Guidelines on perineal urethrostomy

Recommendations	Strength rating
Offer perineal urethrostomy as a management option to men with complex anterior urethral stricture disease.	Strong
Offer perineal urethrostomy to men with anterior urethral stricture disease who are not fit or not willing to undergo formal reconstruction.	Weak
Choose the type of perineal urethrostomy based on personal experience and patient characteristics.	Weak
Consider augmented Gil-Vernet Blandy perineal urethrostomy or “7-flap” perineal urethrostomy in men with proximal bulbar or membranous urethral stricture disease.	Weak
Consider “7-flap” urethroplasty in obese men.	Weak

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Different techniques have been described (Johanson PU, Gil-Vernet-Blandy PU, loop PU, and 7-flap PU). Patency rates of 70–95% after 20–63 mo of follow-up have been described (Supplementary Table 5). Barbagli et al [55] reported that 97.1% of men were satisfied or very satisfied with the outcome of their PU. Little data are available to determine the best technique for PU. The 7-flap PU has been developed for use in very obese patients or men with stricture extension into the proximal bulbar or membranous urethra [57]. Another option for strictures extending into the proximal bulbar or membranous urethra is the OMG-augmented Gil-Vernet-Blandy PU [56].

5. Endoluminal management of posterior urethral stenosis

Dilatation can be used for VUAS or radiation-induced BMS (Table 8). Patency rates vary widely between 0% and 89% (Supplementary Table 6). The risk of de novo urinary incontinence was low (0–11%), and no other complications were reported. It is of note that most series report on visually controlled dilatation in VUAS without complete obliteration (Supplementary Table 6) [58–62].

DVIU for nontraumatic posterior stenosis is mainly performed for VUAS and radiation-induced BMS. Patency after a first DVIU ranges between 25% and 80% (Supplementary Table 7). In series where pre-DVIU continence data were available, de novo urinary continence after DVIU ranges between 0% and 10% (Supplementary Table 7). It is noteworthy that 20–52% of pre-DVIU incontinent patients might experience improvement after DVIU [63,64]. For BNS, Redshaw et al [65] reported inferior patency rates for cold knife versus hot knife incision (50% vs 63%; $p = 0.03$).

Table 8 – Guidelines on endoluminal management of posterior urethral stenosis

Recommendations	Strength rating
Perform visually controlled dilatation or direct vision internal urethrotomy (DVIU) as first-line treatment for a nonobliterative vesicourethral anastomosis stricture (VUAS) or radiation-induced bulbomembranous stricture (BMS)	Weak
Do not perform deep incisions at the 6 and 12 o'clock position during DVIU for VUAS or radiation-induced BMS.	Strong
Perform transurethral resection or hot-knife DVIU as first-line treatment for patients with nonobliterative bladder neck stenosis (BNS) after surgery for benign prostatic obstruction.	Strong
Perform repetitive endoluminal treatments in nonobliterative VUAS or BNS in an attempt to stabilise the stricture.	Weak
Warn patients about the risk of de novo urinary incontinence (UI) or exacerbation of existing UI after endoluminal treatment.	Weak
Do not use stents for strictures at the posterior urethra.	Weak
Do not perform endoscopic treatment for an obliterative stenosis.	Strong
Perform one attempt at endoluminal treatment for a short, nonobliterative post-traumatic stenosis.	Weak
Do not perform more than two DVIUs and/or dilatations for a short and nonobliterative recurrence after excision and primary anastomosis for a traumatic posterior stenosis if long-term urethral patency is the desired intent.	Weak

DVIU using the cut-to-the-light technique for complete obliterative stenosis is not advised because of a very low likelihood of durable patency and the risk of false passage towards the rectum [52]. Aggressive incisions at the 6 and 12 o'clock positions should be avoided because of the risk of, respectively, rectal injury and urosymphyseal fistulation, which is especially a concern after radiotherapy [66].

Transurethral resection (TUR) can be performed in case of VUAS and BNS. Patency rate after TUR for VUAS is 40.2%, but at the cost of an incontinence rate of 13.8–50% [62,67]. Patency and incontinence rates of TUR for BNS are, respectively, 58.3% and 1.7% [67].

Repetitive endoluminal treatments in nonobliterative VUAS, radiation-induced BMS, or BNS have the ability to stabilise the posterior stenosis and are easier to perform than reconstructive surgery, but ultimately 6–10% will be required urinary diversion [68] or chronic suprapubic cystostomy [69]. Further attempts to stabilise the nontraumatic posterior stenosis include intralesional steroid injections (ISDs), intralesional injections, and stents. ISDs are possible but usually associated with reduced quality of life and poor patient compliance [70]. Patency rates with corticosteroid injections range between 50% and 100% [62,71]. Patency rates with MMC vary between 58% and 79% [65,72]. Redshaw et al [65] also reported devastating complications (osteitis pubis, bladder neck necrosis, and rectourethral fistula) in 7% of patients after MMC injection. Patency rate of stents is 47% [73,74] at the cost of a urinary incontinence rate of 19–82% [73,74].

For a nonobliterative, short (≤1.5 cm) post-traumatic stenosis, one attempt of DVIU/dilatation can be performed. A composite patency rate of 20% has been reported (but with a mix of obliterative and nonobliterative stenoses) [6]. De novo urinary incontinence was reported in 4% of cases [6]. Repetitive endoluminal treatments are unlikely to be curative, delay the time to definitive cure, and can lead to more complications [75].

6. Urethroplasty for posterior urethral stenosis

6.1. *ReDo VUA for vesicourethral anastomotic stenosis after RP*

This may be performed via a retropubic, perineal, combined abdominoperineal, or robot-assisted approach. A repeat (ReDo) VUA in nonirradiated patients yields patency rates of 60–91% (Table 9 and Supplementary Table 8). A ReDo VUA should be done only in patients with adequate bladder function and in the absence of (peri)urethral pathology (urethral necrosis, calcification, and fistulation). With the transperineal approach, urinary incontinence is inevitable, whereas this is only 0–58% with the retropubic approach (Supplementary Table 8).

6.1.1. *Posterior stenosis after surgery for BPO*

Y-V or T-plasty is used for BNS refractory to endoscopic treatments. Patency rates vary between 83% and 100%, with 14–45 mo of follow-up. De novo incontinence rate ranges from 0% to 14% (Supplementary Table 9).

Table 9 – Guidelines on urethroplasty and reconstructive surgery for posterior urethral stenosis

Recommendations	Strength rating
Perform repeat (ReDo) vesicourethral anastomosis (VUA) in nonirradiated patients and irradiated patients with adequate bladder function with obliterative VUA stricture or VUA stricture refractory to endoluminal treatment.	Weak
Warn patients that urinary incontinence (UI) is inevitable after transperineal ReDo VUA and that subsequent anti-UI surgery might be needed in a next stage after at least 3–6 mo.	Strong
Offer ReDo VUA by retropubic approach if the patient is preoperatively continent.	Weak
Perform bladder neck reconstruction with Y-V or T-plasty for treatment refractory bladder neck stenosis (BNS).	Weak
Warn patients about de novo UI after reconstruction for BNS or bulbomembranous stricture (BMS) with previous benign prostatic obstruction surgery as aetiology.	Strong
Use either excision and primary anastomosis (EPA) or augmentation urethroplasty for short (<2.5 cm) radiation-induced BMS refractory to endoscopic treatment depending on surgeon's experience.	Weak
Perform augmentation urethroplasty for long (>2.5 cm) radiation-induced BMS.	Weak
Warn patients about the risk of de novo incontinence and new-onset erectile dysfunction after urethroplasty for radiation-induced BMS.	Strong
Offer salvage prostatectomy in motivated and fit patients with adequate bladder function in case of a prostatic stricture due to irradiation or high-energy treatment.	Weak
Perform urinary diversion in recurrent or complex cases with loss of bladder capacity and/or incapacitating local symptoms.	Weak
Perform cystectomy during urinary diversion in case of intractable bladder pain, spasms, and/or haematuria.	Weak
Perform open reconstruction for post-traumatic posterior stenosis only in high-volume centres.	Weak
Perform progressive perineal excision and EPA for obliterative stenosis.	Strong
Perform progressive perineal EPA for nonobliterative stenosis after failed endoluminal treatment.	Strong
Perform a midline perineal incision to gain access to the posterior urethra.	Strong
Do not perform total pubectomy during abdominoperineal reconstruction.	Strong
Reserve abdominoperineal reconstruction for complicated situations including very long distraction defect, paraurethral bladder base fistula, trauma-related rectourethral fistula, and bladder neck injury.	Weak
Perform another urethroplasty after the first failed urethroplasty in motivated patients not willing to accept palliative endoluminal treatments or urinary diversion.	Weak
Use a local tissue flap to fill up excessive dead space or after correction of a concomitant rectourethral fistula.	Weak

BMSs are managed as bulbar strictures and can be treated by EPA or augmentation urethroplasty. As reconstruction is in proximity of the external sphincter and the bladder neck was already damaged during BPO surgery, the risk of incontinence (up to 25%) is present [76].

6.2. *Radiation/high-energy–induced posterior strictures*

Most radiation-induced BMSs are short, and in these cases EPA is possible. Patency rates vary between 67% and 95% [76–79]. De novo urinary incontinence was reported in 33–36% of cases [76–78,80].

EPA will not be possible for BMS with a long bulbar segment. Both dorsal and ventral onlay have been described. Patency rates with augmentation urethroplasty vary between 50% and 83% [77,79,81,82], with de novo incontinence ranging between 11% and 50% [77,81,82].

Prostatic strictures refractory to TUR and with good bladder capacity might be salvaged by RP considering the associated morbidity (rectal injury, VUAS, and incontinence). Mundy and Andrich [83] treated nine patients, with patency in six (67%) and one (11%) needing an artificial urinary sphincter for severe incontinence.

Cases with impaired bladder function, urethral necrosis, and/or periurethral pathology should be considered for supravesical diversion, especially if a suprapubic catheter is not tolerated due to bladder pain or spasms. Intractable haematuria or fistulation might be other reasons to abandon the urethral outlet [83].

6.2.1. *Post-traumatic posterior stenosis*

Progressive perineal EPA is the standard treatment for an obliterative stenosis and for a nonobliterative stenosis as the first approach or after failure of primary endoluminal treatment. The overall patency rate after deferred EPA is 85.7% [6]. Incontinence is rare (6.8%) with EPA and is usually due to incompetence of the bladder neck, although an incompetent bladder neck does not necessarily result in incontinence after urethroplasty [6]. Erectile function does not deteriorate after EPA or might even improve [84].

A combined transpubic abdominoperineal approach is necessary only in complicated cases such as those with associated paraurethral bladder base fistula, trauma-related rectourethral fistula, and bladder neck injury [85]. Total pubectomy during transpubic abdominoperineal reconstruction has a higher complication rate (bleeding, pelvic instability, and dead space) than partial (superior or inferior) pubectomy, with no gain in surgical exposure [86].

In case of a recurrent stenosis, a ReDo urethroplasty is possible using different types of techniques (Supplementary Table 8). In case of excessive dead space after resection of the fibrosis, gracilis muscle [87] or omental flaps [88] have been advised. The patency rate of different types of ReDo urethroplasty varies between 37.5% and 100% (Supplementary Table 8). An alternative is to abandon the normal urinary outlet and opt for Mitrofanoff vesicostomy, PU (if local perineoscrotal skin is suitable), or permanent suprapubic diversion [89].

7. Tissue transfer

7.1. *Comparison of grafts with flaps*

Two small randomised controlled trials reported similar patency rates between grafts and flaps (Table 10). However, flaps were associated with more morbidity (superficial penile skin necrosis, penile torsion, penile hypoesthesia, and postvoid dribbling) and longer operation time [90,91].

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Table 10 – Guidelines on tissue transfer in urethroplasty

Recommendations	Strength rating
Use a graft above a flap when both options are equally indicated.	Strong
Do not use grafts in a tubularised fashion in a single-stage approach.	Strong
Use flaps in case of poor vascularisation of the urethral bed.	Weak
Do not use hair-bearing perineal or scrotal flaps unless no other option is feasible.	Strong
Use buccal or lingual mucosa if a graft is needed and these grafts are available.	Weak
Inform the patient about the potential complications of the different types of oral grafting (buccal vs lingual vs lower lip) when an oral graft is proposed.	Strong
Use penile skin if buccal/lingual mucosa is not available, suitable, or accepted by the patient for reconstruction.	Weak
Do not use genital skin graft in case of lichen sclerosus.	Strong
Do not use cell-free tissue-engineered grafts in case of extensive spongiofibrosis, after failed previous urethroplasty, or in case of stricture length >4 cm.	Weak
Do not use autologous tissue-engineered oral mucosa grafts outside the frame of a clinical trial.	Strong

Castagnetti and Rigamonti [92] showed that grafts used as a tube have a significantly higher complication rate than onlay grafts (odds ratio: 5.86; 95% confidence interval: 1.5–23.4). Iqbal et al [93] have shown an encouraging 87% stricture-free rate in 23 patients who were offered single-stage tubed skin flap urethroplasty. Therefore, if there is a need to reconstruct a complete urethral segment with a tissue-transfer tube in a one-stage operation, flaps are usually the preferred option. As flaps carry their own vascular supply to the reconstruction site, they do not rely on the local vascularisation of the recipient site. Therefore, they need to be considered in case of poor urethral vascularisation (eg, after irradiation or dense scarring after previous urethroplasty) [94].

7.2. *Comparison of different types of flaps*

Fu et al [95] demonstrated that penile skin flaps had a significantly better urethral patency rate than scrotal and perineal skin flaps (respectively, 87.7%, 69%, and 66.7%). The hair-bearing perineal and scrotal skin flaps are associated with hairball formation and chronic infection, which may cause failure of the repair [96].

7.3. *Comparison of different types of grafts*

In case of LS, Trivedi et al [97] demonstrated a significantly higher urethral patency rate when using nongenital mucosal grafts for reconstruction (82.6%) than when using genital skin grafts (4%) [97].

A pooled analysis of nonrandomised studies comparing buccal mucosa ($n = 483$) with penile skin ($n = 428$) found a better urethral patency rate for buccal mucosa (85.9% vs 81.8%). However, the results might be biased because of the longer follow-up time and longer stricture length in the penile skin group [98].

OMGs comprise buccal mucosa graft (BMG), lingual mucosa graft (LMG), and lower lip mucosa graft. A systematic review of studies comparing LMG with BMG showed no significant differences in urethral patency and overall long-term complication rate [99]. The use of lower lip mucosa can lead to permanent sequelae (persistent discomfort, neurosensory deficits, salivary flow changes, and important aesthetic changes) at the donor site, which have not been described with lingual mucosa [100].

Beyond the OMG and penile skin graft, a multitude of other autologous grafts have been described with a patency rate of 81–91% (Supplementary Table 9). Owing to the limited experience with these grafts, they should be considered only if oral mucosa and penile skin are not available, indicated, or desired.

The main advantage of cell-free tissue-engineered grafts is the off-the-shelf availability [101]. The results are disappointing in case of an unhealthy urethral bed [102] or a stricture length of >4 cm [103]. A prospective, multicentre study evaluating autologous tissue-engineered OMG reported 12- and 24-mo urethral patency rates of, respectively, 67.3% and 58.2%. Oral adverse events were minimal [104].

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Study concept and design: Lumen, Campos-Juanatey, Greenwell, Martins, Osman, Riechardt, Waterloos, Barratt, Chan, Esperto, Ploumidis, Verla, Dimitropoulos.
Acquisition of data: Lumen, Campos-Juanatey, Greenwell, Martins, Osman, Riechardt, Waterloos, Barratt, Chan, Esperto, Ploumidis, Verla, Dimitropoulos.
Analysis and interpretation of data: Lumen, Campos-Juanatey, Greenwell, Martins, Osman, Riechardt, Waterloos, Barratt, Chan, Esperto, Ploumidis, Verla, Dimitropoulos.
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Appendix A. Supplementary data

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