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REVIEW

Current trends in urethral stricture management



Christopher J. Hillary, Nadir I. Osman, Christopher R. Chapple*

Department of Urology, Royal Hallamshire Hospital, Sheffield, UK

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Abstract The recent International Consultation on Urological Disease (ICUD) panel 2010 confirmed that a urethral stricture is defined as a narrowing of the urethra consequent upon ischaemic spongiofibrosis, as distinct from sphincter stenoses and a urethral disruption injury. Whenever possible, an anastomotic urethroplasty should be performed because of the higher success rate as compared to augmentation urethroplasty. There is some debate currently regarding the critical stricture length at which an anastomotic procedure can be used, but clearly the extent of the spongiofibrosis and individual anatomical factors (the length of the penis and urethra) are important, the limitation for this being extension of dissection beyond the peno-scrotal junction and the subsequent production of chordee. More recently, there has been interest in whether to excise and anastomose or to carry out a stricturotomy and reanastomosis using a Heineke-Miculicz technique. Augmentation urethroplasty has evolved towards the more extensive use of oral mucosa grafts as compared to penile skin flaps, as both flaps and grafts have similar efficacy and certainly the use of either dorsal or ventral positioning seems to provide comparable results. It is important that the reconstructive surgeon is well versed in the full range of available repair techniques, as no single method is suitable for all cases and will enable the management of any unexpected anatomical findings discovered intra-operatively. © 2014 Editorial Office of Asian Journal of Urology. Production and hosting by Elsevier (Singapore) Pte Ltd. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

1. Introduction

Urethral stricture disease is still a prevalent problem with an estimated incidence of 0.6% in susceptible populations [1]. It can result from a multitude of aetiological factors,

with iatrogenic causes, trauma and idiopathic strictures responsible for most cases in the contemporary world. A propensity toward recurrence necessitates repeated urethral instrumentation in many patients leading to significant

* Corresponding author.

E-mail address: c.r.chapple@sheffield.ac.uk (C.R. Chapple).

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impairment of quality of life. The surgical management of stricture disease can be complex and challenging due to the multiple factors that need to be considered including anatomical location, underlying pathophysiology as well as patient comorbidity. Despite the prevalence of urethral strictures, there has been a remarkable lack of consensus on the optimal approach to evaluation and management.

The recent International Consultation on Urological Disease (ICUD) panel on urethral strictures (2010) aimed to bring more consistency to the literature in terms of terminology, definitions and specific management recommendations [2]. In this article we review the recent literature on the evaluation and management of urethral strictures with reference to the recommendations made by the ICUD panel.

1.1. Anatomy

A review of the relevant anatomy is useful in understanding the surgical approaches to stricture disease. The male urethra is approximately 20 cm in length and is composed of the short posterior urethra and longer anterior urethra. The posterior urethra comprises of the bladder neck mechanism, prostate and membranous urethra, which is comprised of the distal urethral sphincter mechanism. The anterior urethra is formed by the bulbar and the penile segments, terminating at the external urethral meatus at the tip of the glans penis. The bulbar urethra is located at the dorsal aspect of the corpus spongiosum, having a thick ventral covering, whereas the urethra has a universally thin corpus spongiosum towards the distal urethra. The membranous urethra does not have a significant corpus spongiosum and as it is fixed to adjacent structures is vulnerable to external injury associated with a pelvic fracture and injuries here may involve the distal sphincter mechanism. The urethra receives a segmental blood supply along its length and hence as a consequence of being a vascular sinusoid can be safely mobilized and if necessary rotated through 180°.

1.2. Pathophysiology

Strictures result due to ischaemia of the spongy tissue of the corpus spongiosum (ischaemic spongiofibrosis) resulting

from an insult for example, infective, inflammatory or a local traumatic process. Macroscopically, the stricture appears white or grey in contrast to the pink appearance of healthy vascularized urethral tissue. As a consequence of this insult, the underlying vascular spongy tissue is lost, and it heals by fibrosis, resulting in the scar that forms a stricture. In the posterior urethra direct trauma leads to a disruption of the urethra as seen in the pelvic fracture urethral injury (PFUI).

Lichen sclerosus (LS), formerly known as balanitis xerotica obliterans, is responsible for complex strictures of the anterior urethra. Described by Stühmer in 1928 [3], it is an inflammatory condition of unknown aetiology affecting the stratified epithelium of the anterior urethra, which does not extend proximal to the distal sphincter mechanism and hence LS does not affect the posterior urethra. Urethral involvement by LS was first described by Laymon in 1951 [4]. In LS, excess dermal collagen is produced resulting in a hyperkeratotic epidermal layer that leads to its characteristic whitish appearance. LS has a progressive nature, leading to significant recurrence rates in urogenital epithelium, particularly if these tissues are used for urethroplasty [5]. This disease process has historically been regarded as one that progresses from the distal to proximal anterior urethra, however there is evidence to suggest that LS can be identified in isolated bulbar strictures without evidence of disease distally [6]. Furthermore, recurrences in this context were noted distal to the original stricture, contrary to previous evidence.

1.3. Aetiology

The aetiology of stricture disease is a fundamental consideration in planning subsequent treatment. In contemporary practice, most urethral strictures encountered are idiopathic, traumatic, inflammatory or iatrogenic (Table 1).

Although the term posterior urethral stricture is still used, it generally encompasses the terms bladder neck stenosis (or vesico-urethral anastomotic stenosis following radical prostatectomy) and the PFUI affecting the membranous urethra or the bulbomembranous junction [7]. This

Table 1 Stricture aetiology by location [8]. Adapted with permission.

	Penile, No. (%)	Bulbar, No. (%)	Panurethral, No. (%)	Posterior, No. (%)
Prostatectomy	0	3 (2.33)	1 (2.78)	5 (12.50)
Perineal trauma	0	6 (4.65)	0	0
Urethral catheterization	9 (14.29)	13 (10.08)	9 (25.00)	0
Idiopathic/unknown	13 (20.63)	62 (48.06)	5 (13.89)	0
Transurethral resection	7 (11.11)	32 (24.81)	9 (25.00)	4 (10.00)
Hypospadias	18 (28.57)	5 (3.88)	2 (5.56)	0
Pelvic fracture	0	0	1 (2.78)	29 (72.50)
Urethritis	1 (1.59)	6 (4.65)	3 (8.33)	0
Lichen sclerosus	10 (15.87)	0	3 (8.33)	0
Cystoscopy	0	1 (0.78)	2 (5.56)	0
Tumour	3 (4.76)	0	1 (2.78)	0
Penile fracture	2 (3.17)	1 (0.78)	0	0
Brachytherapy	0	0	0	2 (5.00)
Total	63	129	36	40

distinction between these two entities is important, as the pathogenesis and surgical options differ significantly. Following a radical prostatectomy, a stenosis may form at the vesico-urethral anastomosis proximal to the distal urethral sphincter. This can also be seen in posterior urethral stenoses that occur in men following transurethral resection of the prostate (TURP). In this case, the sphincter mechanism is intact and the urethra although stenosed, remains in continuity.

In PFUI, the urethra may or may not remain in continuity. In cases of complete urethral distraction, although the gap between the two distracted ends may be significant, there is often a minimal loss of length. In approximately 60% of patients with PFUI, the distal sphincter mechanism is involved in the injury and continence depends on the integrity of the bladder neck mechanism.

The idiopathic abnormality of the bulbar urethra that gives rise to the short strictures identified in young men, represents the commonest aetiological factor in patients under the age of 45 [8]. Proximal bulbar strictures can also occur following perineal trauma due to distracting forces between the protected bulbar urethra and the vulnerable membranous urethra, the so called "fall astride injury".

Hypospadias, although not directly associated with stricture formation itself, can result in spongiofibrosis as a result of the surgery used to correct the deformity in childhood and patients as a consequence may present as adults with recurrent problems.

Strictures can occur following genitourinary infections, such as gonorrhoea and chlamydia. In clinical practice, infectious causes represent much less of a burden with the advancement of antibiotic therapy, although this still remains as a significant problem in a number of areas in the world as a cause of complex length strictures.

2. Evaluation

2.1. Assessment

Contemporary clinical assessment requires an evaluation of the severity of symptoms, impact upon quality of life and the identification of contributory or causative factors. Most men with urethral stricture disease will present with voiding lower urinary tract symptoms. There may be a feeling of incomplete emptying as obstruction slowly develops, with or without haematuria or urinary tract infection as a consequence. A number of men also experience post-micturition dribbling.

The use of symptom scores as adjuncts to other objective parameters, such as uroflowmetry are widely used in the assessment of stricture disease. Currently, patient's symptoms are often quantified using the American Urological Association (AUA) symptom index, which is not specifically validated for urethral stricture disease. The AUA symptom index in the assessment of urethroplasty outcomes is comparable to the results of uroflowmetry alone [9], providing a greater sensitivity when used in combined with uroflowmetry [10]. Other patient reported outcome measures have been developed specifically for the

harmonization of outcome reporting relevant to stricture disease [11].

Uroflowmetry characteristically shows a plateau pattern with a low Q_{max} . However, it must be noted that the effective calibre of the unobstructed male urethra is of the order 11 Fr [12] and in the presence of a normally functioning bladder, it is not until a stricture narrows beyond this point that an interference with urinary flow may become evident. Therefore, uroflowmetry alone will not diagnose most strictures, until significant narrowing has occurred.

2.2. Urethrography

Retrograde urethrography (RUG) will provide information regarding the stricture location, length and other identifiable pathology affecting the urethra (e.g., diverticulum, fistula, false passage), which can aid in operative planning. An antegrade urethrogram can be performed when a suprapubic catheter is *in situ*.

Synchronous RUG with a voiding cystourethrogram via a suprapubic catheter with a cystoscopy (retrograde or antegrade) is recommended to assess posterior urethral strictures and importantly to assess bladder neck function. This has particular implications in those patients with PFUI.

2.3. Cystourethroscopy

Flexible or rigid urethroscopy can be helpful in the assessment of the location and degree of urethral stricture and to assess the state of the urethra distal to the stricture. Furthermore, urethroscopy may also be used as a method of follow-up for patients undergoing urethroplasty, as uroflowmetry alone may not indicate recurrence of disease until the urethral calibre diminishes significantly [12,13]. Cystourethroscopy can also be undertaken in the context of early catheter realignment in the acute management of high-grade PFUI [14].

2.4. Further imaging

Although ultrasonography is helpful in the assessment of stricture length and the degree of spongiofibrosis, it is not recommended to be used for the sole assessment of strictures and if used should be combined with urethrography, given its anatomical limitations [15]. Other imaging modalities, such as CT or MRI can provide useful information, particularly in those patients with PFUI and can be helpful in identifying injuries that conventional imaging modalities may not demonstrate [16].

3. Posterior urethral strictures

3.1. Pelvic fracture urethral injury

In PFUI, continuity can be restored in the acute setting by performing early endoscopic guided catheter realignment in an attempt to achieve a quicker return to spontaneous voiding. It is however, that this should only be utilized in experienced hands as otherwise significant morbidity can

result leading to increase rates of incontinence and impotence. Early surgical intervention is to be avoided unless open surgery is indicated as management of associated injuries. In most cases, a suprapubic catheter should be placed and a delayed stricture repair can be performed at a later date in a specialist centre.

Stenosis occurring at the bulbomembranous junction following PFUI is usually successfully treated using bulbomembranous anastomotic urethroplasty in the majority of cases via a perineal approach. To obtain sufficient length, one relies upon the elasticity of the bulbar urethra following mobilization. Rarely when sufficient length cannot be achieved, either due to loss of urethra, which is uncommon unless there is a penetrating injury as seen with gunshot wounds, an augmentation may be necessary. Where there is a significant gap following a PFUI, several manoeuvres can be undertaken to foreshorten the urethral course in a step-wise fashion with the aim of reducing the natural curvature of the bulbar urethra. This can be most often achieved by separating the crura of the corpora cavernosa at the penile base. Next, a wedge pubectomy or failing this, urethral re-routing around one of the corpora cavernosa can be used until the course of the bulbar urethra from the apex of the prostate to the peno-scrotal junction is a straight line [17]. Repair of the majority of defects can be achieved by a perineal approach. Long-term patency rates for most bulbomembranous anastomotic urethroplasty procedures are in the region of 90%–98% [18,19] with success rates for re-do procedures similar to primary repair (87% vs. 90%) in experienced hands [20].

3.2. Bladder neck stenosis and vesico-urethral anastomotic stenosis

Bladder neck stenosis usually results from iatrogenic trauma. Vesico-urethral anastomotic stenosis (VUAS) are well recognized following a radical prostatectomy. Factors contributing to the development of a VUAS are thought to be: tension at the anastomosis, inflammation, urinary extravasation and ischaemia. A step-wise treatment approach in VUAS is recommended, initially with dilatation or direct visual internal urethrotomy (DVIU), yielding success rates of 58%–92% [21,22]. Open reconstruction is challenging and can jeopardize continence [23], while treatment with both temporary or permanent metallic stents are limited by stent migration, tissue regrowth and the production of incontinence and are not in our view appropriate.

TURP can give rise to bladder neck stenosis (or bladder neck contracture), particularly in the resection of smaller prostates. Here, bladder neck incision is the preferred method of treatment [24]. Similarly, posterior urethral stenoses can be observed in patients following external beam radiotherapy (as high as 9% of patients [25]) or brachytherapy (8% of patients [26]), as part of the treatment for prostate cancer. Outcomes of DVIU or dilation are similar, with reported success rates of 51% [27]. Primary anastomotic urethroplasty (excision and primary anastomosis [EPA]) has been used successfully in patients with membranous urethral stenoses following irradiation [28].

4. Anterior urethral strictures

4.1. DVIU and urethral dilatation

Originally introduced by Sachse in 1974 [29], the principle of DVIU is to incise the stricture following which, a catheter is left *in situ* to splint the urethra open, allowing re-epithelialisation. The success of this is dependent upon an adequate blood supply and the underlying pathology, for example LS. The intention of dilation is to stretch the stricture in order to restore a normal calibre urethral lumen, with the hope that it will heal open if there is an adequate blood supply.

DVIU can offer an overall stricture free rate of approximately 55% in short, soft bulbar strictures. These have the most favourable outcome, and the likely success rate declines with longer strictures and those in the penile urethra. Whilst these success rates are significantly lower than those demonstrated by EPA (90%–95%), most urethral surgeons would advocate a single attempt at DVIU in those patients with single bulbar urethral strictures <1 cm in length. Whilst a second DVIU can be offered to those patients with recurrence of their short bulbar stricture >6 months following initial treatment [30], in most cases the success rate is limited and both dilatation and DVIU appear similar in terms of their success [31]. Evidence suggests that the most cost effective treatment strategy for the management of strictures <2 cm following one failed attempt at DVIU is to proceed to urethroplasty [32], while strictures >2 cm that would be expected to recur following DVIU could be considered for primary urethroplasty. Repeat treatment has limited efficacy unless combined with long-term intermittent self dilatation. Meanwhile, the optimal duration of post-operative catheterization following DVIU is unclear and is based on local practices. With some centres opting to leave a urethral catheter *in situ* for 3–10 days, many surgeons advocate that this is not necessary [33].

In healthy patients with stricture recurrence within 3 months of initial DVIU/dilatation or in those who fail a second DVIU, further attempts are likely to be palliative [34]. Repeated DVIU/dilatation in these circumstances can be considered, however, in those either too unfit or unwilling to undergo reconstructive surgery.

There has previously been some interest into the use of urethral stents, both temporary and permanent for the treatment of anterior urethral strictures. Stents were associated with significant complications including perineal discomfort (86%), painful erection (44%) and recurrence (29%) in patients with short strictures using the UroLume stent [35]. Moreover, their use can make later reconstruction technically more difficult.

4.2. Excision and primary anastomosis

The gold standard for the treatment of short bulbar urethral strictures is the EPA. The diseased urethral segment is excised and the two healthy ends are anastomosed. Success rates are reported as high as 98.8% in a study of 260 patients with a mean stricture length of 1.9 cm followed up for 50 months [36]. Barbagli et al. [37], in a study of 153 patients followed up for a mean duration of 68 months,

demonstrated success rates of 90.8%. Interestingly, those who underwent either a single treatment prior to urethroplasty or no treatment at all demonstrated success rates of 92.1%–100%, whereas in those who had undergone multiple previous treatment modalities, stricture free rates were lower at 78.6%.

There is currently debate over the maximal stricture length that can be treated by EPA. It is generally considered that the stricture length should not exceed 2 cm and Guralnick and Webster [38] suggest a limit of 1 cm. The rationale behind this is that after the 1 cm stricture length is excised and 1 cm of proximal and distal healthy urethra are spatulated and anastomosed, the deficit is 2 cm, which can result in chordee. As a general rule, the length that can be obtained is dependent on the individual anatomy of any individual as well as the state of the urethra. However, by freeing the urethra off the corpus cavernosum up to the peno-scrotal junction and separating the corpora, more 2–3 cm may be gained in length. Morey and Kizer [39] report that in young men with proximal bulbar strictures of up to 5 cm, a 91% success rate can be achieved with EPA. Clearly, local anatomical factors play a vital part in the anastomotic repair of long bulbar urethral strictures.

Andrich and Mundy [40] recently described a non-transsecting anastomotic technique, relying upon a dorsal stricturotomy following mobilization of the urethra, leaving the ventral spongiosum intact. The rationale behind this is to limit the neurovascular damage resulting from urethral transection with subsequent improved healing and ED rates at the expense of incomplete stricture excision. In 16 patients followed up for 1 year following this procedure, success rates were 100%. This has previously been reported by other groups using a Heineke-Mikulicz principle [41].

4.3. Augmentation urethroplasty

In those strictures of the bulbar urethra considered to be too long (>2 cm) for EPA or penile urethral strictures, augmentation urethroplasty is recommended in order to achieve a tension free anastomosis and to avoid chordee. This can be undertaken via a one- or two-stage procedure. A two-stage procedure involves stricture excision with the formation of a roof strip of graft, which is then allowed to heal prior to closure. With a single-stage procedure, there are two options: (1) stricture incision with an onlay patch to the native urethral roof or floor strip (onlay augmentation urethroplasty) and (2) stricture excision with urethral anastomosis augmented with a patch (augmented anastomotic urethroplasty). Tube grafts are currently rarely performed due to unacceptable stricture recurrence rates [42]. Using a non-transsecting technique, a dorsal urethrotomy is performed until healthy mucosa is encountered. At this point the decision to perform a dorsal onlay augmentation or an augmented anastomotic repair with buccal mucosa graft (BMG) without completely transecting the urethra is determined by the degree of urethral patency. Success rates in excess of 90% were demonstrated in a study of 44 patients, 23 of whom underwent augmentation urethroplasty, whilst 21 underwent augmented non-transsecting anastomotic urethroplasty. After median

follow-up of 2.3 years, there was no significant difference between the two groups [43].

4.4. Augmentation urethroplasty – bulbar urethra

Urethral strictures longer than 2 cm in length can be treated with stricturotomy and onlay augmentation urethroplasty using a BMG. It is useful when peri-urethral spongiofibrosis is relatively limited and the urethra is patent [44]. Both Andrich et al. [45] and Bhargava and Chapple [46] have found success rates in excess of 90% with the technique.

Recently, the equally popular dorsal and ventral approaches to augmentation urethroplasty have demonstrated similar stricture free rates [47] with the advantage of the ventral onlay graft being ease of approach and limited mobilization of the urethra. The disadvantage to the ventral approach is that of bleeding when one incises the stricture on the thicker ventral aspect as compared to the dorsal bulbar urethra. There is evidence to support the ventral onlay graft in proximal bulbar strictures [48] and dorsal onlay graft technique in distal bulbar strictures [49].

Palminteri et al. [50] suggested that in addition to the placement of a dorsal inlay graft via a ventral sagittal approach, a ventral onlay could be performed with high success rates.

4.5. Augmented anastomotic urethroplasty – bulbar urethra

Considering the treatment of longer, denser strictures of the bulbar urethra, particularly those associated with blunt perineal trauma, the augmented roof strip anastomotic urethroplasty is popular. This allows complete excision of the diseased urethral segment with anastomosis using a graft to avoid chordee. Recent systematic reviews of graft augmentation anastomotic urethroplasty have demonstrated no significant difference between the dorsal or ventral onlay grafts of the bulbar urethra [51].

El-Kassaby et al. [52] report the largest series of augmented anastomotic procedures with a mean follow-up of 36 months. The success rates were 93.7% in 233 patients using a ventral onlay BMG. Recent series have demonstrated significantly lower recurrence rates using BMG over penile skin as a graft material for augmented anastomotic urethroplasty (5.8% vs. 21.6% over similar duration of follow-up) [53].

4.6. Flap urethroplasty – penile urethra

In those patients with a normal penis, i.e., the penile skin, urethral plate, corpus spongiosum and dartos are available for tissue transfer, a one-stage reconstruction is feasible.

Orandi [54] first described the reconstruction of the anterior urethra using a pedicled skin flap in 1968. The principles of this single-stage procedure remain the gold standard in the treatment of non-obliterative penile urethral strictures that are not due to LS. More recently, McAninch [55] described the use of a circular fasciocutaneous skin flap in a single-stage reconstruction of complex penile urethral strictures. Whitson and colleagues [56]

reported on the long-term stricture free rates of distal penile circular fasciocutaneous flaps in 2008. A total of 124 patients with complex anterior urethral strictures were followed up for a median duration of 7.3 years with a median stricture length of 8.2 cm. At 1, 3, 5 and 10 years, the overall success rates were 95%, 89%, 84% and 79%, respectively.

4.7. Graft urethroplasty – penile urethra

Snodgrass [57] originally described a repair technique in 1994 by tubularizing the urethral plate without the need for grafts. The use of free grafts, however, has evolved with Hayes and Malone [58] performing an onlay of BMG onto the incised urethral plate in failed hypospadias repair. This technique was taken further in 2001, when Asopa and colleagues [59] developed a similar technique for stricture repair utilizing a ventral sagittal urethrotomy and a dorsal inlay graft.

Both BMG or preputial skin grafts can be used with equal success [60]. Except in a carefully selected subset of patients [61], a two-stage penile augmentation urethroplasty is preferred. Andrich et al. [62] reported a success rate of 98% in a study of 58 patients. Follow-up, however, was limited to 6 months. Kulkarni et al. [61] reported lower success rates of 73% at 56 months using BMG.

Oral mucosa is simple to harvest and associated with minimal donor site morbidity. Although, scarring or nerve injury are described, patient satisfaction with the procedure is high [63]. There are three sites from which to harvest oral mucosa, the lip, the cheek and the tongue. In the majority of cases the cheek is most appropriate, with the lip having the highest donor site morbidity and yielding a very thin graft.

Scrotal skin should not be used in contemporary practice and penile skin is now less often used than oral mucosa. Both non genital and genital skin should never be used in patients with LS because of the high disease recurrence rate.

4.8. Penobulbar strictures

In complex panurethral strictures due to LS, repeated instrumentation or previously failed hypospadias repair, a perineal urethrostomy may be an appropriate and acceptable option in some patients, particularly older individuals and those with significant co-morbidities.

Although one-stage procedures for reconstruction are possible, the original Johanson approach, which involves marsupialization of the urethra followed by tubularization of a strip 3–6 months later is an option for complicated strictures.

Longer strictures necessitate a long length of graft which may require bilateral BMG harvest and sometimes lingual grafts. Various other tissues have been utilized, of note, tunica albuginea, bladder or colonic mucosa. Xu et al. [64] in a study of 36 patients followed up for 53.6 months, demonstrated an 85.7% success rate using colonic mucosa grafts in a single-stage procedure. These however, are not recommended for use in place of BMG given the potential for donor site morbidity and the difficulty involved in

harvest. Kulkarni and colleagues [49] demonstrated a 92% success rate in a study of 12 patients followed up for 22 months using BMG in a single-stage procedure. The approach in this case was a one-sided anterior dorsal BMG urethroplasty, preserving the lateral vascular supply. Their experience using this technique in 117 men with panurethral strictures followed up for 59 months gave a reported success rate of 86.5% for primary urethroplasty and 61.5% in those whom have previously undergone a failed procedure. Andrich et al. [62] utilized a two-stage procedure using BMG or full thickness skin graft, reporting a success rate of 91.7% in 24 patients followed up for 6 months.

In contemporary practice, complex panurethral strictures are commonly due to LS. BMG urethroplasty can offer high stricture free rates, with recurrences related to the progressive nature of the underlying disease process itself. Often, a significant length of graft is required, which risks morbidity including numbness, scarring and impaired mouth closing.

5. Tissue engineering

The role of tissue engineering in reconstructive urology is rapidly progressing. Given the potential donor site morbidity using grafts, there is a niche for synthetic repair materials, particularly for the treatment of lengthy strictures or in patients with reduced mouth opening. An ideal material should be easy to handle, take well and not undergo rejection or contraction.

Fiala et al. [65] reported an 80% success rate at 31 months follow-up with acellular small intestinal submucosa (SIS) grafts. The recurrences here occurred early (6 months) and were more common in reconstruction of penile urethral strictures. Palminteri et al. [66] described failure rates of 24% in 25 patients undergoing urethroplasty using SIS grafts followed up for 71 months. All cases where a graft in excess of 4 cm was used, failed.

Engineered oral mucosa urethroplasty outcomes were first reported in 2008 [67], where oral fibroblasts and keratinocytes obtained from patient biopsy were seeded onto depeidermised cadaveric dermis and expanded *in vitro*. The five patients involved in the study had complex strictures secondary to LS. Initially 100% graft take was demonstrated, however one patient required complete excision of the graft due to scarring whilst another required partial excision due to a hyperproliferative reaction. Of the remaining three patients, all required some form of instrumentation over 3 years of follow-up. Furthermore, in a recent study by Engel et al. [68], 10 patients with short strictures (1–3 cm) received tissue engineered buccal mucosa grafts. Three weeks following urethroplasty, urethrography demonstrated in five patients a wide, watertight urethra with no donor site morbidity. One patient suffered early recurrence at the graft site.

From the above data, it is clear that although acellular grafts are available “off the shelf” they are associated with recurrence and have issues with failure of cell ingrowth. Cellularized grafts on the other hand do show promise for the treatment of longer strictures, however, this technique necessitates cell expansion for several weeks which incurs significant cost.

6. Conclusion

The treatment of urethral stricture is challenging due the vast differences between individual patients including stricture location, the availability of tissues for reconstruction, previous interventions and disease aetiology. For strictures due to PFUI, bulbomembranous anastomotic urethroplasty can yield success rates in excess of 90%. This technique is associated with higher rates of erectile dysfunction, due to inevitable effects on the erectile nerves and the underlying erectile dysfunction related to the original injury.

For short bulbar urethral strictures, an initial urethrotomy or dilatation may be associated with a success rate of approximately 50%. Anastomotic urethroplasty is associated with the greatest long-term stricture free rates and repeated attempts at DVIU or dilatation following an initial treatment are regarded as palliative. Although the maximum stricture length to be treated with EPA is debated, clearly it is important to consider local factors and surgical experience, which may impact upon success.

Onlay augmentation bulbar urethroplasty versus an augmented anastomotic approach demonstrates similar results in experienced hands, their utilization being dependent upon urethral patency, stricture density and surgeon experience. The ventral or dorsal approaches come with their individual risks and benefits but show similar success rates.

Oral mucosa has become a popular graft material, given its relative ease of harvest, with similar success rates for ventral or dorsal augmentation. Flaps are still generally preferred to grafts in the treatment of penile urethral strictures that are not due to LS, but are associated with a higher morbidity.

Whilst perineal urethrostomy is regarded as a reasonable option for those patients who are either unsuitable for urethroplasty or refuse such treatment, the management of panurethral strictures represents a challenge. The Johanson two-stage technique provides adequate results as a staged procedure, whereas, there is growing popularity of the use of an augmentation urethroplasty using oral mucosa as a one-stage procedure in a highly selected group of patients.

Follow-up with flexible urethroscopy is useful to identify patients with early stricture recurrence that would be missed using uroflowmetry alone. Urethroscopy is often easier to interpret than other available methodologies such as urethrography and certainly more sensitive than symptom scores or flow rate alone.

Conflicts of interest

The authors declare no conflict of interest.

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