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Review – Reconstructive Urology

What is the Best Technique for Urethroplasty?

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Abstract

Context: There is no clear evidence that determines which type of urethroplasty to perform under which particular circumstance.
Objective: To review the options for urethroplasty at different sites in the urethra and for different types of stricture indicating which procedure should be used in which circumstances according to the best available evidence.
Evidence acquisition: Recent publications have been reviewed and supplemented with the authors' personal experience.
Evidence synthesis: Currently, in the developed world, the most common types of stricture are relatively short and are situated in the bulbar urethra. There is good evidence that these are best treated by excision and end-to-end anastomosis if they are short enough or by patch urethroplasty using a buccal mucosal graft if they are longer.

Distal penile urethral strictures are the next most common type of stricture, but the evidence base is weaker, although there is agreement that penile strictures due to lichen sclerosus often require a staged approach to reconstruction, again using buccal mucosal grafts.

Urethroplasty for pelvic fracture urethral injury is an altogether different type of technique for an altogether different type of pathology. There is good evidence that this is best treated by bulbo-prostatic anastomotic urethroplasty.

Other types of strictures and salvage surgery have no good evidence base and are specialised areas where experience and judgement are necessary.
Conclusions: The evidence base for urethral surgery has been developed for the more common types of urethral strictures in the last 20 yr, but it is still as much an art as it is a science.

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1. Introduction

Urethral strictures have always been common. Urethral dilators dating to 3000 BC have been found in the tombs of pharaohs to allow them to dilate their strictures in the afterlife. Internal urethrotomy does not have a history spanning 5 millennia—only 2 millennia! The ancients knew that having a

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stricture meant having it for life, even if treatment was only occasional, but only recently has this idea been given an evidence base [1–3]. For patients in whom dilatation and urethrotomy proved impossible, there were only three alternatives. The first, natural, solution was to hope for the development of a urinary fistula so that at least the urine could escape somehow. The other two options were dangerous: either external urethrotomy, cutting down into the perineum blindly until the urethra proximal to the obstruction was found, or alternatively a cystostomy, either suprapubic or transrectal. That was all that was available until the pioneering developments in urethroplasty, mainly in the 1950s and 1960s. Since then, there have been essentially two principal surgical approaches available: anastomotic urethroplasty for a short stricture and substitution urethroplasty for a long stricture. Anastomotic urethroplasty became successful when techniques were developed to relieve tension at the anastomosis [4]. Substitution urethroplasty originally used skin grafts or flaps to restore urethral calibre and was technically demanding [4–7], but the introduction of buccal mucosal grafting [8] and its widespread application in the last 15 yr has made substitution urethroplasty quicker and easier for both surgeons and patients.

The other (and more important) recent change is the change in the patient population presenting for urethroplasty. Twenty years ago urethroplasty was only considered after instrumentation had become impossible or produced bleeding and septicaemia or had been used for many years. Patients commonly presented in retention with a suprapubic catheter, and they were usually older and less fit than today's patients. As anaesthetic care, antibiotic treatment, and other medical improvements have made the procedure safer and as patients are presenting earlier with their problems, so urethroplasty has become easier and more popular—so easy and popular, in fact, that recent assessment of the cost-effectiveness of urethroplasty compared with dilatation and urethrotomy suggests that there is no advantage to doing more than one urethrotomy before proceeding to urethroplasty [9,10]. Indeed, some would suggest that if a patient has a significant stricture, then a primary urethroplasty is the best treatment [9]. Nonetheless, many, if not most, urologists believe that there is a ''reconstructive ladder'' and that treatment should always start at the bottom with dilatation and urethrotomy and work up the ladder to urethroplasty as a last resort [11]. This is nonsense. Unless a patient has a single, previously untreated, short, membrane-like stricture of the bulbar urethra, in which case there is a 50% chance of a cure with dilatation or urethrotomy, the only predictable cure for a urethral stricture at present is a urethroplasty.

This review addresses the types of stricture problems and their frequencies; as well as the options for urethroplasty at different sites and for different types of stricture, indicating which procedure should be used in which circumstances according to the best available evidence.

2. Incidence, anatomy, and aetiology

Urethral strictures are uncommon in children and become increasingly common in a linear fashion until the age of about 55 yr. Thereafter the incidence increases sharply [12,13], probably as peripheral vascular disease causes urethral ischaemia. Strictures are rare in women but not unknown [14]. Symptomatic strictures requiring treatment are the best indicators we have of exactly how common they are, and these are most easily identified by hospital admission data such as the Hospital Episode Statistics (HES) produced by the United Kingdom's Department of Health. These indicate that on average a hospital's urology department that serves a population of half a million expects to see about 115 symptomatic patients per year that require urethrotomy or dilatation by currently accepted indications. By comparison, only about six or seven patients from that same population will require urethroplasty, again using current indications [13,15,16]. This gives an incidence of symptomatic stricture of about 1:2000 men rising to about 1:200 in later life.

The urethra is traditionally divided into anterior and posterior parts. The anterior part is that part which is surrounded by the corpus spongiosum. It includes the bulbar urethra, which is enclosed by the bulbospongiosus muscle and the penile urethra that runs from the distal margin of the bulbospongiosus to the fossa navicularis and external meatus. The posterior urethra is the part between the bladder neck and the bulbar urethra and includes the bladder neck proper, the prostatic urethra, and the membranous urethra surrounded by the external urethral sphincter mechanism [17].

Each of these areas is prone to strictures of its own particular type (Table 1). A narrow calibre meatus is a common finding in asymptomatic males. Symptomatic meatal stenosis occurs most commonly in the absence of more proximal disease, and usually the cause is unclear. Some meatal strictures may be congenital and associated with other abnormalities such as hypospadias, or they

Table 1 – Types of stricture

Anterior urethra	
Meatus	Idiopathic
	Congenital (including hypospadias)
	Poor hygiene; ammoniacal dermatitis
	Trauma—instrumentation
	Lichen sclerosus
Penile	Idiopathic
	Extension of meatal disease (especially LS)
	Stricture following hypospadias surgery
	Infection (STD)
	Ischaemia
Bulbar	Idiopathic
	Congenital
	External trauma (including surgery for hypospadias)
	Instrumentation
	Infection (STD)
Posterior urethra	
Bulbomembranous	Pelvic-fracture trauma
	Instrumentation (sphincter stricture)
Prostatic	New technology
Bladder neck	Surgery

LS = lichen sclerosus; STD = sexually transmitted disease.

Fig. 1 – Presumptive congenital stricture at the junction of the proximal and middle thirds of the bulbar urethra: typical appearance and typical location.

may occur as an isolated anomaly. Some are due to poor hygiene or to ammoniacal dermatitis affecting the meatus during the nappy/diaper phase of early childhood. Trauma, typically by instrumentation, or lichen sclerosus (balantis xerotica obliterans [BXO]) are other causes. Strictures of the fossa navicularis may be due to instrumentation or, by extension, due to anything causing a meatal or penile urethral stricture.

Penile urethral strictures may be due to instrumentation, gonorrhoea (increasingly uncommon in the developed world), and other urethral infections or inflammations, or they occur in elderly men in whom they are probably ischaemic in origin. Indeed instrumentation strictures, usually due to catheterisation and typically located at the penobulbar junction, are almost certainly ischaemic in origin as well. It is not clear whether penile strictures in association with BXO develop as a result of extension of glanular disease into the penile urethra or whether they are due to chronically obstructed voiding or to instrumentation. Strictures in men who underwent hypospadias surgery in childhood are an increasingly common group (indeed the most common of those patients with penile strictures), typically presenting between the ages of 20 yr and 39 yr.

Bulbar urethral strictures are much more common. Most (in the developed world) are idiopathic these days. Some, indeed most, of these idiopathic bulbar strictures may well be of congenital origin [18,19], occurring where that part of the urethra derived from the urogenital sinus meets that part derived from the penile folds (Fig. 1) [20,21]. It is presumed that where these two meet there is a failure of adequate canalisation which leads to narrowing with growth and presentation as a stricture in late teenage life or in early adulthood. Fall-astride external trauma causes a crush injury of the bulbar urethra against the inferior pubic arch and typically causes full-thickness, severe spongiofibrosis if not frank ischaemic necrosis. More common, but less serious in the degree of spongiofibrosis, are strictures due to instrumentation. Inflammatory strictures due to sexually transmitted disease are much less common than they were, but gonococcal strictures are another cause of dense spongiofibrosis [22].

Much more dramatic are pelvic fracture urethral injuries, most commonly due to motor vehicle accidents. These are best described as pelvic fracture urethral injuries because, as such, they are completely different from the strictures we have been describing so far. Different pelvic-fracture mechanisms result in different injury mechanisms of the urethra (bulbar crush injury or laceration, membranous avulsion, or membranous disruption and distraction). It is clear that the type of fracture does not predict whether or not lower urinary tract injury will be present, but when it is present the type of urethral injury can be predicted by the mechanism of the fracture. The relevance of this is that, for example, a lateral compression fracture can lead to a

bulbar crush injury and considerable loss of urethral length, which may be much more difficult to reconstruct than other types of injury [23].

Instrumentation, and in particular transurethral resection of the prostate, can lead to a stricture of the membranous urethra called a ''sphincter stricture'' because of the fibrotic involvement of the urethral sphincter mechanism. Prostatic urethral strictures used to be rare but are now increasingly common due to new technology used to treat the prostate such as brachytherapy, cryotherapy, and laser treatment; presumably these prostatic strictures will increase in frequency as enthusiasm for these technologies increases [24].

Bladder neck strictures are also usually the consequence of treatment of prostatic disease, as the consequence of either transurethral resection of the prostate (for what was actually a dyssynergic bladder neck obstruction) or a contracture that develops at the vesico-urethral anastomosis after radical prostatectomy [25,26].

Outside of a highly specialised centre, most strictures are treated by internal urethrotomy or urethral dilatation. In a centre where there is a surgeon with an interest in urethroplasty, but only part-time, Hospital Episode Statistics (HES) data suggest that that surgeon will probably do anastomotic urethroplasty and substitution urethroplasty for bulbar strictures and maybe a few penile urethroplasty procedures but probably not much more. A regional centre will do more of the same but will proportionately deal with more distal penile urethral strictures as a consequence of previous hypospadias surgery or because of lichen sclerosus [15]. They may do an occasional urethroplasty for a pelvic-fracture urethral injury, but even in a regional centre, there may be insufficient cases to develop and maintain adequate experience, and therefore such cases are probably best referred to national centres. A major national centre serving a population of up to 10–15 million patients with one or more full-time specialised urethral surgeons will do proportionately more pelvic-fracture related urethroplasties and distal urethroplasties as well as carrying a significant burden of salvage surgery [16].

Thus, in the context of the frequency of the different types of urethroplasty (Table 2), this review concentrates mainly on anastomotic and substitution urethroplasty of the bulbar urethra and substitution urethroplasty of the distal penile urethra with a brief mention of urethroplasty for pelvic fracture–related urethral injury. This review includes discussion on the debates about graft (and specifically buccal mucosal graft) versus flap repair; about ventral versus dorsal stricturotomy and patch repair for bulbar substitution urethroplasty; and about whether practice is different when there is a residual lumen to the urethra or when the lumen has been obliterated.

We shall start in each instance by considering where there is good evidence and will then discuss where the evidence is less convincing as to what is best practice.

Table 2 – Incidence of types of urethroplasty in practice in the United Kingdom [15]

Anterior	Penile substitution	36%
	Bulbar substitution	31%
	Bulbar anastomotic	26%
Posterior		7%

3. Bulbar urethroplasty

The gold standard for the first-time treatment of a short, sharp stricture of the bulbar urethra is excision, spatulation of the two ends, and an

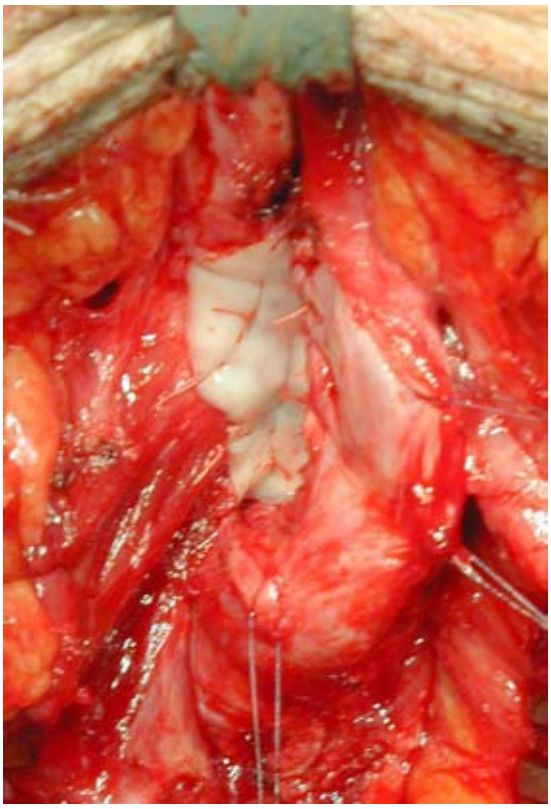

Fig. 2 – Barbagli procedure. The bulbar urethra has been mobilised, rotated through 180°, and opened in the dorsal midline into healthy urethra on either side of the stricture. A buccal mucosal graft has been quilted onto the tunica albuginea and the left margin of the urethra has been sutured to the left margin of the graft.

overlapping end-to-end anastomosis, whether or not the lumen is completely occluded [27,28]. Equally the gold standard for a stricture of the bulbar urethra of ≥2 cm in length, where the urethral lumen is relatively well preserved and the spongiofibrosis around the lumen is limited to a millimetre or two circumferentially, is a stricturotomy and dorsal patch substitution urethroplasty using a buccal mucosal graft (BMG), with success rates of in excess of 90% (Fig. 2) [29–31]. This is commonly called the Barbagli procedure.

Between the two extremes of length there are some instances when an apparently short stricture looks as though it could be excised, and the two ends are sufficiently elastic to allow them to be brought together end-to-end without tension but not sufficiently elastic to be able to get an overlapping anastomosis without tension. In these patients trying to achieve an overlapping anastomosis under tension carries a significant risk of ischaemia and recurrent stricture as a consequence. In these circumstances, the gold standard is an augmented anastomotic urethroplasty in which the two ends of the urethra are spatulated dorsally (after excision of the stricture) around the margins of a dorsally placed BMG and the two ends of the urethra are anastomosed around their ventral hemicircumference (Fig. 3) [32,33]. Knowing when to patch as an augmented anastomotic urethroplasty and when not to patch, as in a ''straightforward'' overlapping anastomotic repair, is a matter of judgement which can sometimes be difficult. If in doubt, patch (Table 3).

When a patch is needed, either for augmentation or substitution, the evidence is in favour of using a graft, and although the results with foreskin or penile full thickness skin grafts are just as good, BMG is easier to harvest, the take is more reliable, the regenerative capacity of the donor site is better and there are few donor site complications if the graft is taken with care [34,35]. Relatively high complication rates at the donor site have been reported [36,37], but these can be avoided if the graft is not taken too close to the tonsillar fossa and if a 5-mm strip is left at the gingival margin, the angle of the mouth, and Stensen's duct. We use bipolar diathermy for haemostasis and leave the donor site open to heal by second intention, which it does remarkably quickly [38].

Numerous papers have been written and endless debates have been held about whether such a graft should be placed dorsally or ventrally. Barbagli popularised the principle of the dorsal free graft bulbar urethroplasty [39], and the principle seems to stand the test of time, whatever sort of graft is used.

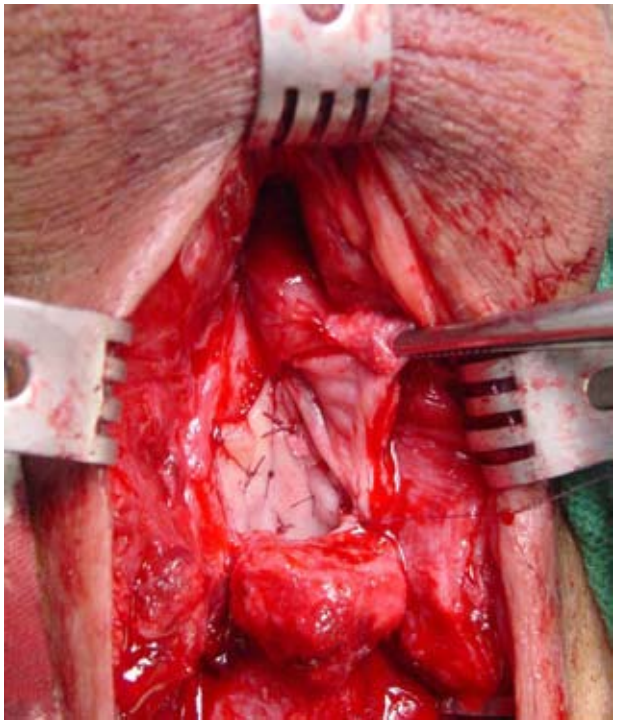

Fig. 3 – Augmented anastomotic urethroplasty. The stricture has been excised, and both ends of the urethra have been spatulated dorsally. A diamond-shaped graft has been quilted onto the tunica albuginea, and the spatulated proximal end of the urethra has been sutured to the margins of the proximal half of the graft. The left side of the spatulated distal end of the urethra has been sutured to the left margin of the distal half of the graft.

We also find that a dorsal stricturotomy and patch is better than a ventral stricturotomy and patch. In our experience, the complications of ventral out-pouching or diverticularisation of a ventrally placed patch do not occur with dorsal patching, and the long-term restricture rate after ventral stricturotomy and patch is 14%, whereas that of dorsal stricturotomy and patch is only 4% [40]. However, other groups report satisfactory results with ventral BMG substitution [41,42]. In the end, a surgeon will always prefer to use the particular surgical technique he or she is familiar with. Nobody today would disagree,

Table 3 – Surgery for simple bulbar strictures

Short bulbar stricture	Overlapping anastomotic repair (very short strictures) Augmented anastomotic repair (a little longer)	
Long bulbar stricture	Stricturotomy and dorsal patch urethroplasty	FTSG BMG

FTSG = full-thickness skin graft; BMG = buccal mucosal graft.

however, that buccal mucosal grafts are quicker and easier to prepare than skin grafts (or flaps) and less prone to problems, yet there is no real difference in the restricture rate between using BMG and using a skin graft (or flap), assuming that the patch is placed dorsally or dorsolaterally [43,44].

Because grafts are quicker and easier to prepare than skin flaps in the bulbar urethra, we use flaps only for revision surgery, when there has been radiotherapy to the area, or when there is some other reason why a graft take may be unreliable; that, anecdotally, seems to be the general view. It is worth stressing that a graft is only as good as its bed. If the graft bed is poor, usually due to scarring, radiotherapy, or ischaemia, then the results will be poor. When the graft bed has been affected in one of these ways, it is better to use a flap instead.

4. Obliterative strictures

The literature makes little or no distinction between a urethroplasty for a stricture in which the lumen is more or less completely obliterated and one in which the lumen is significantly narrowed but not actually lost. As a result, evidence gives way to opinion, and there is no gold standard for the treatment of long bulbar (or penile) strictures that are more or less obliterative with spongiofibrosis to a much greater degree than just a couple of millimetres around the lumen. Standard patch urethroplasties do not deal well with this situation although there are approaches described when the corpus spongiosus is well enough preserved to be able to support a more or less circumferential graft [45]. If the obliterated segment is a relatively short component of a long stricture in which the calibre is otherwise better, the augmented anastomotic principle (using BMG or a flap) is very useful, excising the obliterative segment and augmenting the remaining segment with the relatively better calibre. If the whole stricture is more or less obliterative throughout its length the alternatives are a long flap repair, preferably using a patch of penile shaft skin carefully prepared on a generous dartos pedicle [46], or, if there are complications such as periurethral infection or abscess, a staged approach with marsupialisation of the urethra as the first stage (see below).

5. Other difficult strictures

If there is failure of a previous BMG (or other graft) in a young patient with a good blood supply to the urethra, excision of the stricture and redoing the graft may be feasible. Either the remnants of a dorsal patch are removed and a new dorsal patch is placed, or alternatively a ventral graft or flap is placed. Revisional surgery is often technically difficult but may be more than just technically difficult when the stricture reaches up to or involves the sphincter mechanism. In such cases continence is at risk if the bladder neck has been interfered with or if it is interfered with later in life. Strictures across the sphincter mechanism always do better with a flap repair in our view (Table 4).

Revisional surgery (and primary surgery) is also difficult with a full-length stricture involving both the bulbar and the penile urethra because ischaemia is the likely cause and the recurrence rate is therefore higher. Treatment then is a matter of individual judgement based on experience and the circumstances. In truly full-length strictures (rather than long strictures that overlap the bulbar penile parts), we usually prefer a long dorsal BMG patch to augment the entire bulbar urethra from the sphincter to the peno-scrotal junction and then deal with the penile urethra in its own right either by an extended patch [47], an Orandi procedure (see below), or by marsupialisation (see below).

When considering heroic efforts to reconstruct the urethra, it is important to appreciate that complex reconstruction carries a significant failure rate and that creation of a formal perineal ure-

Table 4 – Options for difficult strictures

Failed previous urethroplasty	Excise and redo Ventral graft (instead of dorsal) Ventral flap	
Extension into the urethral sphincter	Ventral flap	
Full-length anterior stricture	Full-length flap Deal with the components separately	 a) Dorsal BMG to bulbar part b) Ventral flap or two-stage to penile part
Salvage	Two-stage Swinney–Johansen Perineal/urethrostomy	

BMG = buccal mucosal graft.

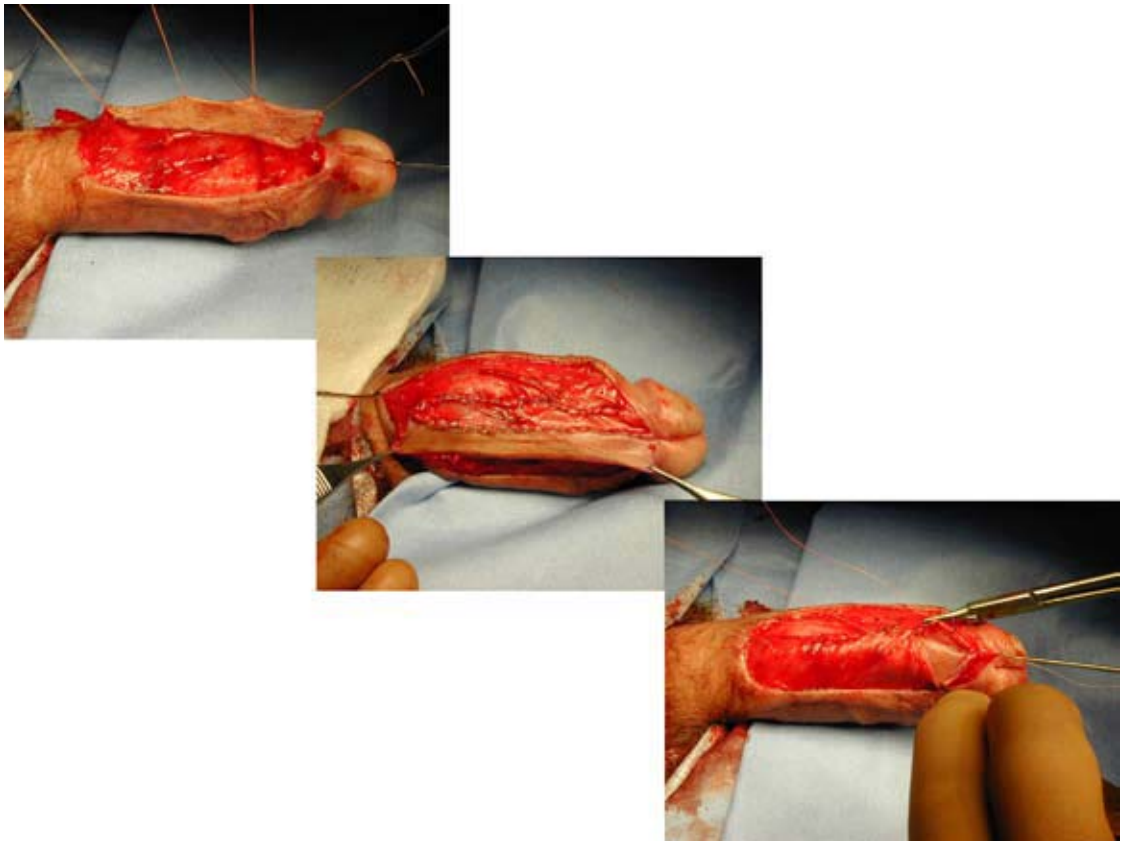

Fig. 4 – The Orandi procedure. An appropriate length and width of penile skin is mobilised on a dartos pedicle. The "free" margin of the skin is sutured to the near margin of the urethra (which has been oversewn in this case). The skin patch is the flipped over and the "dartos" margin is then sutured to the other margin of the urethra.

throstomy may well be a more reliable and satisfactory alternative, particularly in the elderly, who commonly sit down to void anyway [48].

5.1. *Penile urethroplasty*

For the penile urethra the Orandi technique [49] (Fig. 4) is useful for nonobliterative strictures within the penile shaft that are not due to BXO. One has to be careful to get the width of the flap right, and this is not easy to judge which is why the procedure carries a significant complication rate. Nonetheless this remains the gold standard, albeit *faut de mieux*. A dorsal stricturotomy and buccal mucosal graft inlay may be an alternative, provided the urethral calibre is reasonably well preserved and the spongiosum is not too affected by fibrosis so that the urethral plate literally 'springs open' during dorsal stricturotomy. The same is true for the Asopa technique (transventral dorsal stricturotomy and patch from within the lumen) [50], but such strictures are not very common. The drawbacks of all grafts on the penile shaft are potential graft contracture and penile curvature as consequences. In the absence of infection this is a technical complication because the graft was sutured onto the corpora under tension. This is a difficult problem to correct short of excising the whole graft and starting again from scratch. For these reasons penile urethral surgery is technically more challenging than bulbar urethral surgery, and the results are less satisfactory.

The treatment of distal penile strictures as a result of lichen sclerosus or following previous hypospadias surgery often needs to be individualised. In severe lichen sclerosus (LS), the meatus and fossa navicularis are almost completely obliterated (Fig. 5). In some cases, marked wood-hard fibrosis extends into the pendulous urethra. In these severe cases the penile shaft skin is often affected by LS as well. The general principle here is to excise the diseased segment and to replace it with BMG, because BMG is the material least likely to be affected by recurrent LS (Fig. 6) [51]. This is generally agreed. However, it can be done in one or two stages depending on the extent of the disease, and this is much more controversial. Indeed the more extensive the disease, the more complicated its surgical treatment, and the more it becomes an area of

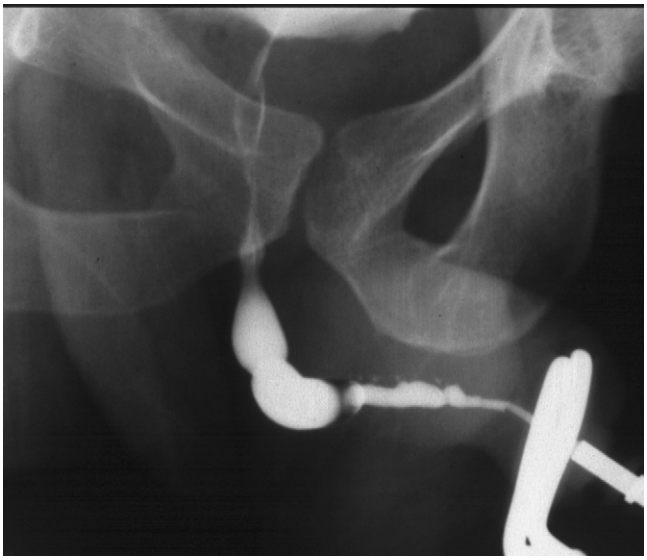

Fig. 5 – The typical appearance of a penile urethral stricture due to lichen sclerosus.

specialised practice; but as with all difficult anterior strictures, a perineal urethrostomy is a commonly acceptable alternative if that part of the urethra has been spared.

Strictures in adults who had a hypospadias repair in childhood is a growing industry. These strictures are commonly irregular and obliterative and involve the skin used for the earlier repair. The longer the previous repair, the more likely a stricture is to develop and the more complicated the stricture is likely to be. Even in relatively straightforward cases there are commonly other problems such as fistulae, scarring, chordee, and an abnormal meatus, often associated with a small glans, and almost always with a deficiency of the dartos layer. There is rarely a patient who needs only simple repair in such circumstances. It is commonly necessary to take the whole thing to bits and start again from scratch. It may be possible to do an excision of the stricture, creation of an adequate glans cleft with inlay of a BMG to create a neoglanular urethra, and reconstruction of the ventral glans in one stage for a very distal and otherwise uncomplicated case of coronal hypospadias. But when these need to be combined with excision of a failed previous urethroplasty, correction of chordee, and a more extensive reconstruction of the urethra in a more proximal hypospadias with deficient skin and dartos, this is best done in stages [52,53]. This, too, is a specialised

Fig. 6 – A "two-stage repair" for the lichen sclerosus stricture shown in Fig. 5, before and then after the first-stage repair using a buccal mucosa graft.

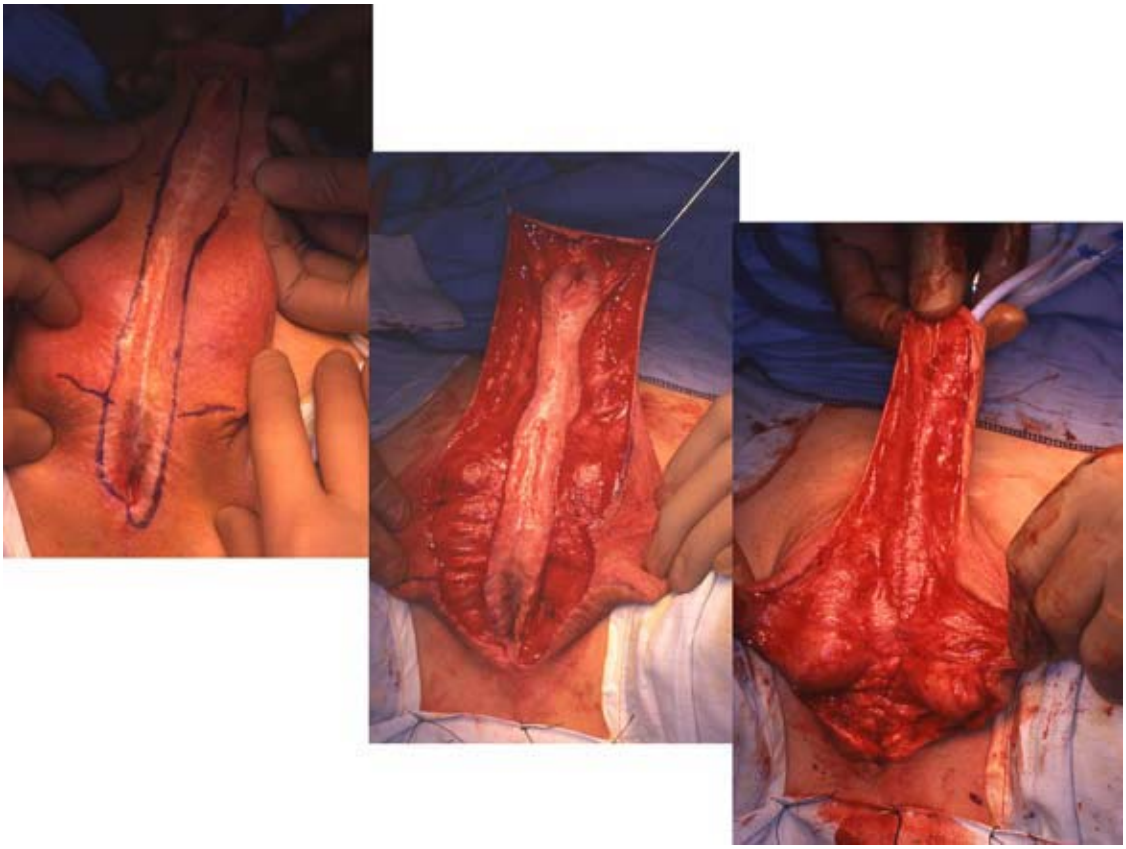

Fig. 7 – A two-stage Swinney–Johansen repair of a full-length urethral stricture. At the first stage, the skin was marsupialised to the margins of a full-length ventral stricturotomy. At the second stage, a neo-urethral strip 3-cm wide is outlined, mobilised, rolled up into a tube, and closed in three layers: neourethra, dartos, and skin.

area, where experience and judgement are necessary and hard evidence is lacking because most of these patients can only be dealt with on an individual basis.

A useful salvage procedure for multiply operated non-LS strictures, particularly of the penile urethra, is a 'staged' Swinney–Johansen approach [54–56], marsupialising the urethra to the surrounding skin, followed by tubularisation of a 2.6-cm– to 3-cm–wide strip 3–6 months later (Fig. 7). This incidentally was the first (more or less) reliable technique of substitution urethroplasty, and Swinney and Johansen's papers are worth reading for that reason alone.

5.2. *Urethroplasty for pelvic fracture urethral injuries*

The gold standard of treatment is a bulbo-prostatic anastomotic urethroplasty [57–59]. In pelvic-fracture urethral injury, the site of the injury depends on the mechanism of the urethral injury which is dependent on the fracture mechanism [23], but generally it is at the bulbo-membranous junction. The site of the injury is approached transperineally, and repair is effected by a series of steps starting with a full mobilisation of the bulbar urethra (to capitalise on its elasticity) and progressing to corporal separation and inferior pubectomy with rerouting of the urethra around the crus of the penis when necessary to straighten out the natural curve of the bulbar urethra and thereby bridge the gap between the two ends of the urethra to allow an overlapping spatulated end-to-end anastomosis without tension. Only occasionally is it necessary to use an abdomino-perineal approach when there is a false passage, bladder-neck injury, or some other coincidental problem which requires that approach or otherwise when the prostatic urethra is inaccessible from below (which is rare), or in a severe bulbar crush injury leaving only the distal bulbar urethra intact. Unfortunately the complexity of urethral reconstruction cannot be predicted accurately by preoperative imaging [60]. The only other help in predicting the potential complexity of surgery is an understanding of the urethral injury mechanism as discussed above [23].

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Study concept and design: Andrich, Mundy.
Acquisition of data: Andrich, Mundy.
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