Analysis of a 7-year national online audit of the management of open reconstructive urethral surgery in men

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Objective

To conduct an audit of the management of urethral pathology in men presenting for reconstructive urethral surgery in the UK.

Methods

Between 1 June 2010 and 31 May 2017, data on men presenting with urethral pathologies requiring reconstruction were entered onto a secure online data platform. Surgeon-entered information was collected in 95 fields regarding the stricture aetiology, prior management, mode of presentation, type of surgery and outcomes, with a potential 283 variable responses in the 95 fields. Data were analysed to compare UK practice with that reported in the contemporary literature and with guidelines.

Results

Data on 4809 men were entered by 39 centres and 50 surgeons. Field completeness was 70.7%, 74.3% and 53.7% for preoperative, operative and follow-up data, respectively. Referral for stricture reconstruction frequently followed two prior endoscopic procedures and the stricture was not always assessed anatomically before surgery. Urinary retention was a common symptom in men awaiting reconstruction. Short unifocal strictures of the anterior urethra were the commonest reason for referral, whilst lichen sclerosus and hypospadias generated a significant volume of revisional stricture surgery. Lower numbers of very complex interventions are required for the management of posterior urethral pathology. Although precise criteria for determining success are not clear, management of urethral reconstruction in the UK was found to have a low risk of Clavien–Dindo grade 3 or higher complications, and was associated with outcomes similar to those reported in contemporary series except in the management of posterior urethral fistulae.

Conclusions

Online databases can provide volume data on the management of reconstructive urethral surgery across a multiplicity of centres in one country. They can also indicate compliance with accepted standards of, and expected outcomes from, this tertiary practice.

Keywords

database, urethra, reconstruction, urethroplasty, complications, outcomes

Introduction

The use of large-scale audit is an established means of optimizing clinical care [1,2], with measurable positive impacts on outcome [2,3]. In 2008 the BAUS expanded its remit from online oncological audit [4,5] to include benign conditions, such as stone disease [6]. In 2009 an open urethral surgery database was developed which has accrued a significant amount of data encompassing presenting urethral pathologies, initial assessment, surgery and outcomes over 7 years. Although the management of open reconstructive urethral surgery is well reported from national or international centres of excellence [7–12], this database provides a broad view of urethral reconstruction across a spectrum of UK institutions.

Materials and Methods

A paper-based dataset of information was agreed in 2009, and trialled on an online platform as a national data repository for men undergoing reconstructive urethral surgery. This was funded by the BAUS, hosted by Nuvola™ from February 2010, transferred to a Dendrite™ platform in June 2015 and was open to all members of the BAUS. The extent to which the BAUS platform was used was determined by comparison against Hospital Episode Statistics [13] data on hospital discharges for the same period.

Secure access to the platform was obtained by individual password to an encrypted server. Patient-specific identifiers, the National Health Service (NHS) number and date of birth,

generated a unique, anonymised, audit identifier for data entry. After login, the operating surgeon or nominated deputy could input information into a drop-down list of single-option, and free-text strings. These were in 28 fields with 102 variables for pre-operative data, 50 fields with 123 variables and 17 fields with 58 variables for operative and post-operative data respectively (Table 1). Patient consent and ethical approval were not obtained, and validated questionnaires were not used for urinary and sexual symptom assessment, at the inception of this audit in 2009; this methodology was not changed until after the end of the study.

Three-month follow-up data were accrued after the intervention. Stricture recurrence was determined subjectively according to presence of obstructive voiding, and objectively according to urinary flow rates, post-void residual urine volumes or at endoscopy or urethrography. Fistula occurrence or recurrence were determined by physical examination or imaging, either urethrography, endoscopy or MRI.

The audit was performed, after a familiarization period, between 1 June 2010 and 31 May 2017; several modifications to the scope and format of data acquisition were made during this time. Data entry was voluntary, so not all fields had to be completed. Accrued data were archived as flat files, then exported to Excel and Tableau™ for analysis. Only data fields with completed strings were analysed.

The aims of the present analyses were to provide 'snapshots' of: the aetiology, presentation and investigation of patients requiring urethral reconstruction; the size of the surgical populations and how these were treated operatively; and the complication rates and subjective and objective outcomes from surgical management.

Results

Audit Enrolment and Data Completeness

During the audit, 4809 men were enrolled by 50 surgeons from 39 centres. Hospital Episode Statistics returns between 2014 and 2016 suggested that ~93% of all UK reconstructive activity was collected by the BAUS database. Three centres reported 49.5% of all of the BAUS data, and nine centres 74.2%. Stricture, anterior fistula, posterior fistula and primary hypospadias repair were performed by 100%, 32%, 20% and 41% of the surgeons reporting, respectively, over the audit period.

Completed data fields available for analysis are shown in Fig. 1. A diagnosis was recorded for 4398 men (91.5%) and 4210 (87.5%) had a procedure recorded. Of the 4210 men for whom a procedure was logged, 66.9% had follow-up data. Field completeness was 70.7%, 74.3% and 53.7% for preoperative, operative and postoperative data, respectively.

### Preoperative Data

Urethral Pathology and Patient Age

Of the 4398 men with complete pathological data, 94% had stricture disease, 3.5% urethral fistulae, and 2.3% untreated hypospadias. A total of 16 men had a urethral diverticulum or false passage; these numbers were too small for meaningful analysis. The mean age at surgery was 44.1 years, with a median (range) age of 51.1 (7–89) years.

Stricture Disease

Presumed aetiology in men with urethral strictures Of 4127 men with urethral strictures, 39% had no definable cause and their disease was classified as idiopathic. The presumed aetiology of the remaining strictures is shown in Table 2.

Of the 339 men with external trauma, 45% had urethral stenosis or obliteration due to a pelvic fracture-related urethral injury, while 35% of the men had a fall-astride (or straddle) injury. Only nine patients had stenoses arising from penetrating trauma. Of the group of 585 men with strictures following instrumentation or iatrogenic trauma, 87.6% had strictures resulting from catheterization or diagnostic endoscopy, and 12.4% had strictures resulting from previous radical prostatectomy, high-intensity focused ultrasonography, cryotherapy or external beam radiotherapy for prostate

Table 1 Data accrual for men requiring surgery for urethral pathology, according to management phase.

Phase of management	Data accrued
Preoperative 28 data fields102 variable strings	Urethral pathology Patient's age Presumed aetiological factors Interventions prior to referral Mode of presentation, urinary and sexual symptoms Preoperative investigation
Operative 50 data fields123 variable strings	Size of surgical populations ASA grading score [14] as a surrogate for comorbidity Site of the pathology and number of procedures Anatomical approach to the pathology Surgical technique, including the use and placement of grafts or flaps, catheter and drain use
Postoperative 27 data fields58 variable strings	Inpatient stay Complications prior to discharge Complications at outpatient review Subjective postoperative urinary and sexual symptoms Objective data from urethrography, uroflowmetry, ultrasonography residuals and endoscopy Evidence of early stricture recurrence, by inference from symptoms, urethrography, endoscopy, urinary flow rates or post-void residual urine volume

ASA, American Society of Anaesthesiology.

Fig. 1 The number of completed data fields available for analysis from 4809 men with urethral pathology.
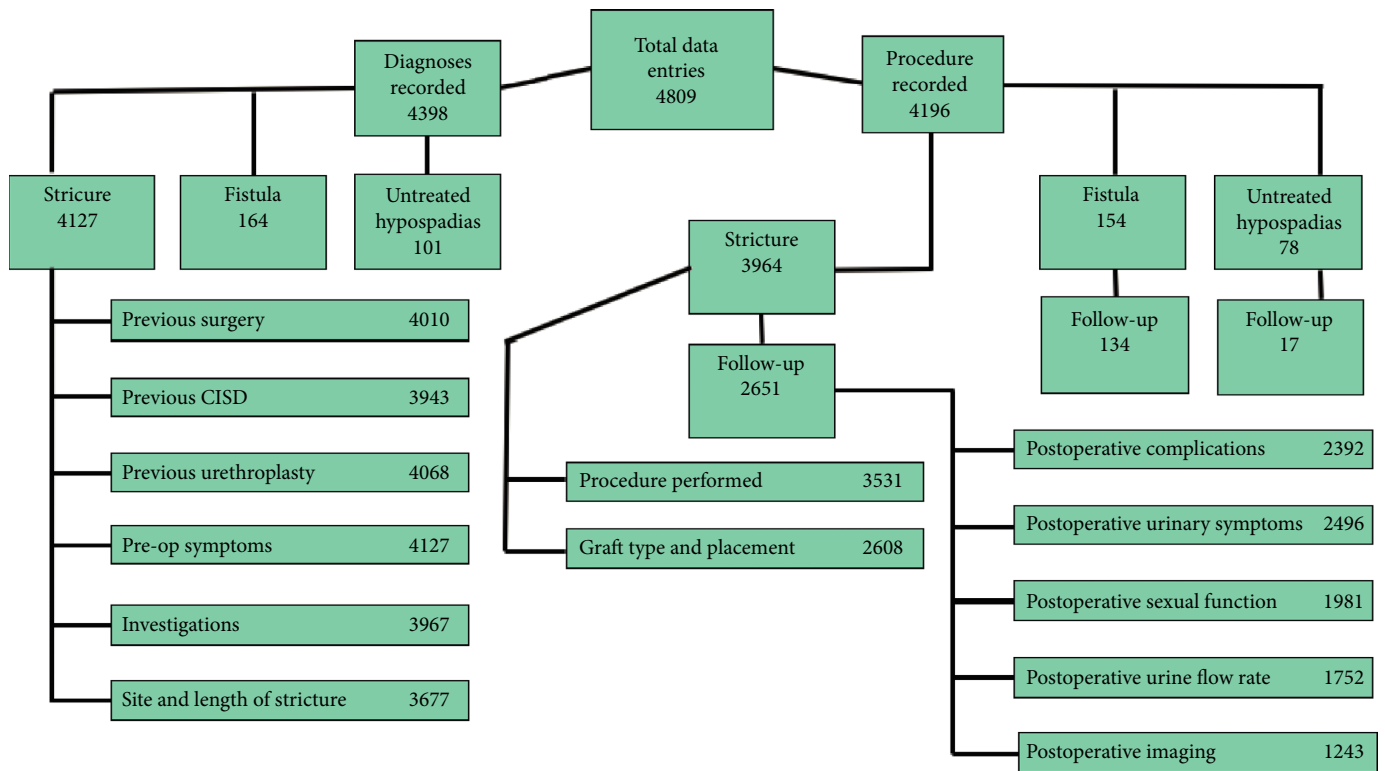
cancer. Table 3 relates the aetiology of the stricture to its location.

Interventions prior to referral Of 4010 men, only 911 (22.7%) were treatment-naïve, having undergone neither a direct vision internal urethrotomy (DVIU) nor a urethral dilatation prior to referral. A total of 29.6% of men had undergone one DVIU/urethral dilatation, 42.1% had undergone 2–5 and 5.5% had undergone >5 interventions before urethroplasty was performed. A total of 47.9% of men with bulbar and 51.4% with penile strictures had >2 DVIUs/urethral dilatations prior

Table 2 Aetiology of urethral pathology recorded in 4127 men and its relevance to urethral stricture and fistula presentations.

	Stricture		Fistula	
	n	%	*n*	%
No identifiable cause (idiopathic)	1610	39	35	22.5
Lichen sclerosus	557	13.5	3	1.9
Previous hypospadias-related surgery	532	12.9	76	50
Iatrogenic – previous instrumentation*	512	12.4	6	3.8
Iatrogenic – posterior urethral trauma	73	2.6	34	21.8
External trauma – PFUI	191	6.9	0	0
External trauma – straddle	148	5.4	0	0
Other	766	12	0	0
Total	4127	100	154	100

PFUI, pelvic fracture-related urethral injury. *Catheterization or endoscopy.

to referral, and 4.1% and 9.2%, respectively, had >5 endoscopic interventions.

A total of 77% of the 4032 of 4127 men who were recorded as having previous surgical interventions, or not, for urethral stricture had not undergone urethroplasty before referral, 14.9% had undergone one and 8.1% had undergone more than one previous reconstruction. Prior reconstruction was more common in men with strictures distal to the peno-bulbar segment, particularly in those who had undergone previous surgery for hypospadias or lichen sclerosus (Table 4). Of all 526 men with lichen sclerosus, 19.2% had undergone one previous urethroplasty and 4.9% had undergone more than one. Of the 480 men who had previous hypospadias, 34.2% had one prior urethroplasty and 43.5% had undergone more than one. In these two groups, the commonest sites of recurrent stricture were the penile urethra (62%), meatus and navicular fossa (14.6%) and bulbar urethra (9.7%).

Self-dilatation was being used at the time of referral for reconstruction by 30.4% of 3943 men. Of these, 40.1% of 1198 were catheterizing once weekly or less, 34.6% were dilating two to three times weekly and 25.3% daily, or more frequently.

Mode of presentation, urinary and sexual symptoms Of 3792 men whose mode of presentation, urinary and sexual

Table 3 Relationship between aetiology and stricture location in 3585 men.

	Meatus + fossaNavicular	Penile	Peno-bulbar	Bulbar	Posterior including BN	Total
Idiopathic	17	76	76	1317	9	1495
Lichen sclerosus	231	211	23	53	5	523
Previous hypospadias-related surgery	100	327	19	46	1	493
Previous instrumentation	4	53	47	246	12	362
External trauma	2	13	7	159	153	334
Iatrogenic trauma	2	24	15	85	43	169
Urethral infection	1	11	5	50	0	67
Other	15	41	11	73	2	142
Total	372	756	203	2029	225	3585

BN, bladder neck.

symptoms were recorded, 78.5% had symptoms of obstructive voiding alone, 8% had voiding symptoms and at least one episode of retention, and 13.4% presented with retention necessitating placement of a suprapubic catheter (SPC). A total of 76% of men had symptoms for several years before referral, but those with bladder neck or a membranous urethral stenosis only had symptoms for a few months. Retention was commonest in men with posterior urethral strictures.

Voiding problems, including hesitancy, poor stream or incomplete emptying, were the principal symptoms in 94.3% of 4127 men with stricture. Storage issues alone were the primary symptom in only 2.4% of men. Secondary urinary symptoms were reported by 45% of the 3892 patients with obstructive voiding. These included post-micturition dribble (PMD, 25.6%), infective/inflammatory problems (23.6%), storage symptoms (17.5%) spraying (13.3%), pain on voiding (10.9%) and haematuria (8.2%). PMD was surprisingly uncommon in men with distal anterior stricture.

Sexual dysfunction was common among the men with urethral stricture. A total 28% of 3555 patients had at least one sexual symptom (Table 5), with 15.4% of men having erectile dysfunction (ED), most commonly in association with bulbo-prostatic strictures and bladder neck stenoses. Ejaculatory problems were also reported by men with penile, peno-bulbar and bulbar strictures. Of 188 men with anxiety about the appearance of their penis, 83.5% had penile urethral, navicular fossa or meatal strictures. Penile curvature was almost exclusively reported by men who had had previous hypospadias or long-segment lichen sclerosus surgery for stricture.

Preoperative investigation A total of 81.9% of the 3967 men referred with stricture disease had some form of contrast imaging, either retrograde (38.9%) or retrograde and antegrade (43%), urethrography. Of these, 62% had no other preoperative investigation and 26% had a supplementary endoscopy. Of 718 men with no urethrography, 57.5% had an endoscopic assessment of the urethral anatomy alone, and

Table 4 Incidence of recurrent stricture after previous urethroplasty in 903 men when stricture aetiology data fields were complete.

Stricture aetiology	Previous urethroplasty	
	n	%
No identifiable cause (idiopathic)	162	10.4
Lichen sclerosus	135	24.1
Hypospadias-related surgery	373	77.7
Previous endoscopic surgery	44	6.7
Physical/iatrogenic trauma	61	14.3
Other causes	128	11.4

7.78% had no preoperative imaging. Of this last group, 247 men (81%) had penile urethral, meatal or navicular fossa strictures assessed by inspection, but there were 58 men who had no imaging prior to more proximal reconstruction. Ultrasonography was never used as the only urethral imaging method and MRI was only used in 26 men.

Most men (92.9% of 3677 men) had one stricture, 4.1% had two and 3% had more than three strictures. Multifocal strictures were most frequently associated with previous hypospadias or lichen sclerosus. Most strictures were short: 36% of 3380 men had strictures 1–2 cm, 51.7% had strictures 2–7 cm and 4.4% had strictures >7 cm long. Stricture length was related to location and to aetiology: 82% of 712 penile strictures were >2 cm in length and 21.5% were >7 cm. Of 644 men with strictures >2 cm long in the penile urethra, navicular fossa or meatus, 43% were associated with lichen sclerosus and 38.7% with previous hypospadias.

Urethral Fistulae

Of 154 men with anterior urethral fistulae, previous hypospadias was the cause in 76. In 34 men a complex fistula was the consequence of iatrogenic injury to the posterior urethra (Table 2).

With regard to symptoms, 41% with anterior urethral fistulae presented with urinary leakage, 31.5% experienced spraying during micturition, 18.5% had unspecified voiding symptoms and 5.4% had PMD. Of those 133 men who had undergone

Table 5 Total number and percentage of 3555 men with recorded preoperative sexual function data, stratified by stricture site.

Stricture site	Total cases (n)	No sexual symptoms	Erectile dysfunction	Ejaculatory problems	Poor cosmesis	Penile bend
		%				
Meatus and navicular fossa	401	67.6	11.7	2.7	13.7	4.2
Penile	685	59.9	11.8	5.5	14.9	7.9
Peno-bulbar	375	62.4	25.1	5.6	4.8	2.1
Bulbar	1910	82.4	10.9	5.6	6.8	3.1
Bulbo-prostatic	163	31.3	66.9	1.8	0	0
Bladder neck	21	57.1	42.9	0	0	0

previous penile surgery, 27.7% were reported as being dissatisfied with the cosmetic appearance of their penis, 13.9% had a penile curvature and 9.7% had associated ED. Men with posterior fistulae had almost universal perineal leakage, voiding and sexual dysfunction.

Men with fistulae were recorded as having 146 preoperative investigations. Forty men (25.9%) with distal fistulae had their management dictated by clinical examination alone, 39.6% had some form of urethrography and 19.3% had an endoscopy. Fifteen patients (10%), all with posterior urethral fistulae, had anatomical evaluation with a pelvic MRI.

Untreated Adult Hypospadias

In these 101 men, spraying on micturition (47.5%), dissatisfaction with penile cosmesis, (41%) and curvature (24.3%), were the commonest presenting symptoms. Unspecified voiding problems were present in 22%.

Management was dictated by clinical inspection alone in 50% of men, however, 99 men had 49 investigations: 25.5% had an endoscopy and 23.5% underwent urethrography.

Operative Data

Operative details were recorded for 4196 men (Fig. 1); for most men American Society of Anaesthesiology (ASA) grades [14] or 2 were reported. There was no predominant urethral pathology associated with the 4.6% of men who had ASA grade 3. The sub-populations for operative intervention are shown in Table 6.

Surgical Management of Urethral Stricture Disease

The number of cases presenting for stricture surgery is shown in Table 7. In all, 79% of procedures were single- and 21% were multi-stage operations. Of the staged reconstructions, 89% were for strictures distal to the peno-bulbar segment.

Anatomical approach to the stricture The surgical approach to the stricture was perineal in 67.9% of 3609 men, almost

Table 6 Surgical populations, of 4096 men, presenting for reconstruction based on type of surgery performed or their presenting pathology/aetiology.

Patient population	Volume, %
First time, bulbar/ peno-bulbar/penile urethroplasty*	55.2
Lichen sclerosis urethroplasty	14.7
Post-hypospadias reconstructions	13
Posterior urethroplasty and complex trauma reconstruction†	10.7
Primary adult hypospadias repair	2.4
Anterior urethral fistula repair	2.2
Posterior urethral fistula	1
Bladder neck stenosis surgery	0.8

*Non-lichen sclerosis or hypospadias-related surgery. †This does not include surgery for stricture recurrence.

exclusively for posterior and bulbar urethral reconstructions. In the peno-bulbar region 77% of 379 men had access gained perineally, with a penile approach for the remainder. For strictures distal to the peno-bulbar segment, a local penile incision was used in 63.9% of cases and a glanulo-coronal, or perineal, approach in the rest.

Surgical technique The surgical manoeuvres undertaken to treat stricture disease are shown in Table 7. An augmentation procedure was performed on 71.4% of 3531 men; 93.1% of cases involved harvesting and inserting buccal mucosa, with autologous lingual grafts being used 2.7% of cases. Dermal grafts, or skin flaps, were inserted in 102 men; 67% of these were for surgery on the penile urethra or more distally. The approach to graft/flap placement was dorsal in 80%, ventral in 10%, and trans-ventral dorsal in 9% of cases. Lateral augmentation was only used for recurrent strictures where the dorsal graft bed was unsuitable.

Postoperatively, a two-way urethral catheter was placed in 82.9% of cases, and together with an SPC in 16.1% of the cases. In 1% of cases an SPC was placed either alone or in combination with a short urethral stent. A 16-F catheter was preferred for 77.6% of men, and a 14-F catheter was inserted in the remaining men. Of 2196 catheters placed, 36.5% remained in place for 1–2 weeks and 49% for 2–3 weeks. Catheters remaining in place >3 weeks were inserted after posterior urethral reconstruction, or when there was clinical or radiological evidence of a complicating fistula. A drain was

Stricture site	Number of cases (%)	Procedure	Repairs in that area, %
Bladder neck	31 (0.8)	Abdominal-perineal repair	16.7
		Anastomotic repair	72.2
		Augmentation	11.1
Bulbo-prostatic	188 (5.1)	Anastomotic repair	93.6
		Augmentation	4.8
		Augmented anastomotic repair	1.6
Bulbar	2024 (54.9)	Anastomotic repair, unspecified	17.90
		Transecting anastomotic repair	7.60
		Non-transecting anastomotic repair	4.10
		Augmentation	65.30
		Augmented anastomotic repair	4.20
		Perineal urethrostomy	0.90
Peno-bulbar	209 (5.7)	Anastomotic repair, unspecified	0.5
		Transecting anastomotic repair	4.4
		Non-transecting anastomotic repair	3.3
		Augmentation	65.5
		Augmented anastomotic repair	5.3
		Perineal urethrostomy	10.5
		Multi-stage procedure	10.5
Penile	658 (22.5)	Single-stage augmentation	39
		Multi-stage procedure	51.60
		Augmented anastomotic repair	0.10
		Perineal urethrostomy	9.3
Navicular fossa and meatus	421 (11)	Single-stage augmentation	24.90
		Multi-stage procedure	75.10

inserted after bladder neck, bulbo-prostatic, bulbar and peno-bulbar reconstructions in >60% of cases, but were hardly used at all in the distal urethra.

Surgical Management of Urethral Fistula

Anterior urethral strictures were closed with fascial interposition in 55.8% of 95 men; 14.7% had a glansplasty and 23.1% some form of grafted reconstruction. A total of 55% of the operations were staged procedures. Posterior fistulae were treated mainly by layered closure with some form of tissue interposition, or with ileal conduit diversion in one case.

Surgical Management of Untreated Adult Hypospadias

In 64% of 78 men a primary hypospadias repair was conducted, 7.7% of men had staged reconstruction and 10.3% an isolated glansplasty. The remainder of the procedures involved adjustment of the penile skin, correction of chordee or circumcision.

Postoperative Data

A total of 2651 men, 66.8% of the surgical patient population, had follow-up recorded after stricture surgery; 98% returned

to their operative centre for review. A total of 88.9% of men were followed up after anterior and 76.7% after posterior fistula repair. Only 17 men (21.8%) were seen after adult hypospadias repair. The length of inpatient stays for men with stricture disease, anterior and posterior fistula repair, and untreated hypospadias were a median (range) of 2 (0–156) days ($n = 3766$), 1 (0–5) days ($n = 109$), 7.5 (5–1170) days ($n = 250$) and 1 (1–10) days ($n = 96$), respectively.

Outcomes from Stricture Surgery

Intra-operative complications and complications encountered at follow-up Intra-operative complications arose in only 1.9% of 3688 men; haemorrhage was the most prevalent issue after posterior urethroplasty. Overall, 15.2% of men with stricture had some form of complication, logged postoperatively or at their follow-up appointment, with most being transient, treatable issues (Table 8).

Wound infection was commonest after bladder neck reconstruction, and wound breakdown occurred mostly after penile urethroplasty using a penile approach. UTIs were unrelated to stricture aetiology, or site, but were more common in men with both urethral catheters and SPCs inserted. Urethral urinary leaks were seen in ≥4% of men who had undergone posterior urethral, or distal penile, meatal or navicular fossa urethroplasty. Wound haematoma incidence was small and was unaffected by the presence of a drain.

Postoperative urinary and sexual symptoms Of 2496 men with postoperative urinary and sexual symptom data, there was marked symptomatic benefit from intervention; 85% improvement in obstructive voiding, 22% in infective/inflammatory symptoms, 17% in PMD, 13% in storage problems and 10% in spraying and pain on voiding. Stricture recurrence was strongly associated with persistent obstructive voiding in the 8.7% of men with this symptom following reconstruction. New storage symptoms were commonest after bladder neck and posterior urethral surgery. Although the overall incidence of PMD decreased after surgery, 150 men (6% of the postoperative cohort) had this as a new symptom; virtually all had bulbar, or peno-bulbar, augmentation procedures.

Of 1981 men with postoperative sexual function data, 81.3% had no subjective sexual symptoms; 39% of men who had undergone anterior urethral reconstructions actually reported an improvement in erectile function, enabling resumption of penetrative sex. The incidence of new, surgically induced, sexual complications was only 7.35%; this was seen in both non-transecting and transecting bulbar urethroplasty, and was commonest following posterior anastomoses and rarest after staged surgery on the distal urethra.

Table 8 Incidence of the 10 most common postoperative complications seen at postoperative review, stratified by site, in 2392 men who had undergone urethroplasty.

Complication	Mean incidence, %	Bladder neck, %	Bulbo-prostatic, %	Bulbar, %	Peno-bulbar, %	Penile urethra, %	Urethral meatus and navicular fossa, %
Wound infection/breakdown	3.6	12.9	2.2	2.7	2.4	7.8	2.9
UTI	3.6	6.5	4.4	3.3	3.3	3	2.9
Leak/Fistula	2.3	9.7	4.4	1.5	-	4.3	3.8
Bleeding/haematoma	1.3	3.2	1.4	1.1	3.3	1.7	0.5
Perineal/wound pain	1.2	–	0.7	1.5	1.6	0.4	0.5
Graft donor site problems	1.1	–	–	0.9	2.4	1.9	0.5
Inability to void	0.6	–	2.2	0.7	0.8	–	–
Obvious recurrence	0.6	–	2.2	–	–	1.1	2.4
Catheter problems	0.5	–	1.4	0.6	–	0.2	0.5
Graft-related issues	<0.1	–	–	–	–	0.4	–

Table 9 Urinary flow and stricture recurrence rates in 1752 men at follow-up after urethroplasty, stratified by surgical site.[*]

Stricture repair site	Q_{max}					Recurrence rate at this site
	6–10 mL/s	<5 mL/s	11–15mL/s	16–20 mL/s	>20 mL/s	
Bulbo-prostatic	15.2	5.4	15.2	22.9	41.3	10.2
Bulbar	4.2	0.9	9.6	18.3	67	2.2
Peno-bulbar	8	4	18.4	23.6	46	4.2
Penile	6.6	1.3	18.3	24	49.8	2.1
Meatal and navicular fossa	6.1	0.7	14.6	16.9	61.7	1.1
Stricture recurrence at this PFR	30.3	54	4.1	0.9	1	

Data are % values. *Only two men who had bladder neck reconstruction had a recorded flow rate postoperatively.

Preoperative ejaculatory dysfunction was improved by reconstruction in 98% of men; however, 35 men with bulbar reconstruction reported this as a novel symptom postoperatively. Its incidence was no different following grafted, transecting or non-transecting anastomotic procedures. Penile cosmesis, or bending, was improved by surgery in 65.9% of 41 men with these problems preoperatively. The incidence of new penile curvature was 0.25%, mostly following grafted bulbar reconstruction. Cold, numb penis was only recorded postoperatively in three cases.

Urinary flow rates Postoperative peak urinary flow rates (PFRs) were used to evaluate outcome from surgery in 1752 men; a Q_{max} of >16 mL/s was found in 80.6% of men (Table 9). Of the 647 men who did not have a PFR recorded, 58.6% had either an antegrade (5.1%) or retrograde (34.8%) urethrogram, a voiding study (1.7%) or an endoscopy (17%). In 268 men, however, no objective investigation of the functional outcome from their urethroplasty was recorded.

Imaging and recurrence Of 2651 men, 46.1% had urethrography or endoscopy to assess surgical outcomes objectively. Of these, 2.8% were shown to have early recurrent stricture, most prevalent in the posterior urethra (Table 9). Of the 1425 men who had a PFR of >16 mL/s, 931 had a

urethrogram or endoscopy, yet only 0.9% had objective evidence of stricture recurrence and 0.45% had associated obstructive voiding symptoms.

The number of strictures and history of previous reconstruction had no bearing on the likelihood of recurrence; however, aetiology and stricture length did, with 26% of recurrences recorded after surgery for pelvic fracture, other trauma-related strictures and strictures >7 cm in length in the peno-bulbar and penile urethra which were associated with lichen sclerosus. There was no alteration in the incidence of recurrence dependent on the surgical technique used for bulbar urethroplasty. All peno-bulbar and more distal recurrences had a graft/flap inserted and were more common after single- rather than multi-stage procedures.

Those men with early recurrent strictures almost universally had a combination of postoperative outflow symptoms, a Q_{max} <10 mL/s or a high ultrasonography-detected post-void residual urine volume.

Outcomes of Anterior and Posterior Fistula Surgery

Following anterior fistula repair, 75% of 69 men had no complications and 73% had no urinary symptoms. A total of 20.9% had spraying or PMD and 3.3% of 61 men had new issues with cosmesis or a penile bend. Overall, surgery

resulted in a dramatic improvement in satisfaction with penile cosmesis; the recurrent fistula rate was 5.5%.

Following posterior fistula repair, there was a 46% complication rate; 50% of this group had urethral incontinence whilst awaiting staged sphincter implantation, and 40% had a fistula recurrence.

Outcomes from Primary Adult Hypospadias Repair

Following adult hypospadias repair 35.3% of men experienced spraying or dribbling postoperatively; all had these symptoms before reconstruction. There were no new issues with sexual dysfunction after repair, but 11.8% had fistulae postoperatively.

Discussion

The present study is the first review of the management, within a public healthcare system, of a whole nation's urethral reconstructive practice, providing substantially more data than previously reported from single- or multi-institution international series [15–17]. Notwithstanding data entry bias implicit in surgeon-reported audits [18], and changes in practice during our 7-year longitudinal study, this audit provides a large amount of data regarding the management of men presenting for urethral reconstruction. This audit is solely a snapshot of global UK practice and does not seek to address local differences in patient management, or outcomes among different centres.

Our data confirm that the largest group of patients presenting for urethral reconstruction had relatively short-duration, unifocal stricture disease in the anterior or spongiose urethra. Longer, multi-focal, or recurrent strictures in the penile and peno-bulbar regions were very strongly associated with lichen sclerosus or previous hypospadias. Aetiologically, whilst nearly 40% of all strictures were of unknown aetiology, iatrogenic, lichen sclerosus and hypospadias constituted a substantial burden to urethral reconstructive surgeons in the UK; this is a substantial difference from previous reports [15,16].

Hypospadias, either untreated or requiring additional intervention, was associated with a high stricture recurrence, emphasizing the need for transitional follow-up from paediatric care [19–22]. We also found, similarly to Barbagli et al.[23], that lichen sclerosus was responsible for long, complex, multi-focal strictures in the penile urethra, often requiring multiple interventions. External and iatrogenic trauma was the most important cause of posterior urethral pathology, although this population was much smaller in the present study than that seen in developing countries [24], or in countries where aggressive treatment for prostate cancer is practised [25,26]. Nevertheless, this subgroup generated a large number of re-operations because of the associated complexity.

More than 20% of the patients included in the present audit either presented with, or developed, retention pending reconstructive surgery. Late referral or a long wait time for evaluation at reconstructive centres, as observed by Hoy et al. [27], may be a reason for this.

Most men who were referred with strictures had symptoms of obstructive voiding; a surprisingly large cohort had PMD, presumably caused by hindered passage of ejaculate, as well as ED. Men with anterior urethral fistulae, or untreated hypospadias, were dissatisfied with their penile appearance, had a penile bend, or leaked. Those men with posterior urethral fistulae were bothered by early-onset retention, severe voiding symptoms and perineal leakage, as well as profound ED.

Referral for reconstruction was relatively rare without prior intervention in the UK. In all, 50% of men referred for bulbar or penile urethroplasty had more than two DVIU/urethral dilatations before referral, contradicting guidelines for considering reconstructive surgery [28,29]. Most men with strictures had undergone imaging prior to reconstruction, but by no means all, again, further contradicting contemporary practice guidelines [29]. In the UK ultrasonographic assessment [30] is not used and MRI [31] rarely used, except for evaluation of posterior urethral pathologies, especially iatrogenic fistulae.

Augmentation urethroplasty was as common in the UK as in other countries [7,12,28] and appeared equally effective. Non-transecting bulbar urethroplasty [32] and single-stage distal anterior urethral repairs [33] were new procedures during the audit. From limited data, we consider that non-transecting bulbar urethroplasty has few downsides compared with transecting reconstruction, whilst single-stage distal anterior urethroplasty has a higher recurrence rate than similar procedures performed elsewhere [33].

Follow-up rates of 66.9%, data completeness of 53.7%, and the use of subjective outcome measures means that only a limited interpretation can be made of postoperative data. The complications of surgical intervention for stritcure disease, against those references, from accepted centres of excellence in stricture surgery[17,34], although the vast majority of complications could be stratified as Clavien–Dindo grade 2 or lower[35]. Higher complication rates followed bladder neck, posterior urethral stricture surgery and posterior urethral fistula repairs.

Global symptomatic outcomes from first-time stricture surgery were good, with significant improvement in urinary symptoms, pain on voiding and infective sequelae. Obstructive symptoms were substantially improved, whilst storage symptoms, spraying and dribbling, were improved but less so [36]. New storage symptoms frequently followed posterior urethral reconstruction, presumably due to bladder neck dysfunction, [37] and PMD was an issue following

bulbar or peno-bulbar augmentation procedures; this was presumably attributable to 'sumping' of urine in baggy, acontractile, urethras.

Although not objectively measured by the International Index of Erectile Function or the Sexual Health Inventory for Men [38], the subjective effect on pre-existing erectile function was a substantial improvement for many men after bulbar or peno-bulbar surgery. This is an interesting difference from the contemporary literature [39,40] that may be attributable to improved well-being postoperatively, or unimpaired seminal flow at orgasm. New ED arose in only 5.1% of men, and was mostly observed after posterior, bulbar or peno-bulbar reconstruction. Patients should be specifically counselled about postoperative ED prior to these types of surgery.

Stricture recurrence, a major treatment failure, was most prevalent after posterior urethral repairs and long augmentation procedures for peno-bulbar strictures and penile strictures due to lichen sclerosus. A combination of symptom review, PFR and residual urine volume measurement seem to be good screening tools for recurrence. Patient-reported outcome measures [41] may be an adjunct to determine 'operative success' but, as yet, the ideal method of following up patients after reconstructive surgery remains to be defined [29,42]. Our follow-up interval, and potential surgeon data entry bias, makes clarification of this issue difficult.

Whilst cosmetic and sexual satisfaction was extremely high after anterior fistula closure and adult hypospadias, there is still a risk of fistulation after reconstruction for these problems, which is something patients need to be especially aware of [34,43]. Global outcomes following surgery for often extremely technically demanding posterior fistulae were initially anatomically or functionally poor, which is disappointing in comparison to systematic review data [44]. This may be reflective of the number of surgeons currently performing this low-volume complex surgery, which should probably only be undertaken in appropriately skilled centres.

In conclusion, practice guidelines were poorly followed with regard to referral for urethroplasty and for delineation of the urethral anatomy. 'First-time' urethral stricture disease of the anterior urethra was the commonest reason for being referred for consideration of reconstruction. Lichen sclerosus, hypospadias and posterior urethral pathologies are complex clinical problems causing urethral strictures, and were associated with higher complication rates and poorer postoperative outcomes. Augmentation urethroplasty was common and usually performed using buccal mucosa in the UK. The complications associated with urethral reconstruction were nearly all lower than Clavien–Dindo grade 2, with outcomes from surgery in the UK generally comparable to other series. Posterior urethroplasty and fistula surgery were associated with higher complication rates and

worse outcomes than other urethral procedures, and may be better provided by increasing the numbers in these subgroups into a smaller number of centres to optimise the patient outcome.

Acknowledgements

Conflicts of Interest

None declared.

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Abbreviations: ASA, American Society of Anaesthesiology; DVIU, direct vision internal urethrotomy; ED, erectile dysfunction; PFR, peak urinary flow rate; PMD, post-micturition dribble; SPC, suprapubic catheter; Q_{max}, maximum flow (Ref ICS nomenclature).