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INVITED ORIGINAL ARTICLE

Single-stage tubular urethral reconstruction using oral grafts is an alternative to classical staged approach for selected penile urethral strictures

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Penile urethral strictures have been managed by a staged surgical approach. In selected cases, spongiofibrosis can be excised, a neo-urethral plate created using buccal mucosa graft (BMG) and tubularized during the same procedure, performing a “two-in-one” stage approach. We aim to identify stricture factors which indicate suitability for this two-in-one stage approach. We assess surgical outcome and compare with staged reconstruction. We conducted an observational descriptive study. The data were prospectively collected from two-in-one stage and staged penile urethroplasties using BMG in a single center between 2007 and 2017. The minimum follow-up was 6 months. Outcomes were assessed clinically, radiologically, and by flow-rate analysis. Failure was defined as recurrent stricture or any subsequent surgical or endoscopic intervention. Descriptive analysis of stricture characteristics and statistical comparison was made between groups. Of 425 penile urethroplasties, 139 met the inclusion criteria: 59 two-in-one stage and 80 staged. The mean stricture length was 2.8 cm (single stage) and 4.5 cm (staged). Etiology was lichen sclerosus (LS) 52.5% (single stage) and 73.8% hypospadias related (staged). 40.7% of patients had previous failed urethroplasties in the single-stage group and 81.2% in the staged. The most common stricture locations were navicular fossa (39.0%) and distal penile urethra (59.3%) in the single-stage group and mid or proximal penile urethra (58.7%) in the staged group. Success rates were 89.8% (single stage) and 81.3% (staged). A trend toward a single-stage approach for select penile urethral strictures was noted. We conclude that a single-stage substitution penile urethroplasty using BMG as a “two-in-one” approach is associated with excellent functional outcomes. The most suitable strictures for this approach are distal, primary, and LS-related strictures.

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INTRODUCTION

Strictures involving the penile urethra, which cannot be excised due to resultant shortening of the urethra and penile curvature, require augmentation or substitution using free grafts or vascularized local skin flaps.¹

The options for local flaps include preputial, penile, or scrotal skin. Buccal mucosa graft (BMG) has become the most commonly utilized free graft² due to its availability, relative ease of harvesting, low patient morbidity,^{3,4} the excellent outcomes associated with its use,^{5–7} and its resistance to lichen sclerosus (LS) recurrence.⁸

In many instances, a staged approach is necessary. The classical staged reconstruction includes a first operation, with removal of the scarred tissue and placement of a graft to create an adequate-sized neourethral plate. After a healing time of 3–6 months, once the graft has achieved its neovascularization,^{9,10} the second stage is performed during which the edges of the graft are mobilized and tubularized, and closed in layers to avoid postoperative complications such as urethrocutaneous fistulation (UCF).¹¹

Tubularized substitution (*i.e.*, replacing a diseased segment of urethra by excising it and replacing it by a tubularized flap/graft) is sometimes necessary if there is no remnant healthy spongiosum, as occurs infrequently in LS but is *de facto* in hypospadias surgery-related strictures (absence of a urethral plate as the old skin tube-based reconstruction has failed).^{12,13} However, this type of reconstruction is associated with less satisfactory results and is usually avoided in favor of a two-stage reconstruction.^{12,14}

Nonetheless, in selected cases, we have been able to excise the spongiofibrosis and create a neourethral plate using BMG, as one would do in the first stage of the classical staged approach, and tubularize it in the same surgical procedure. We consider this “two-in-one” approach as distinct from other single-stage repairs using oral tissue to augment the urethral plate such as the dorsolateral onlay¹⁵ or dorsal onlay¹⁶ or inlay techniques.¹⁷

The aim of this study is to evaluate the suitability of selected patients with penile urethral strictures for this two-in-one stage approach to penile urethroplasty. Outcomes were evaluated and compared to those

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in patients undergoing a classical staged reconstruction using BMG for penile strictures during the same time period.

PATIENTS AND METHODS

Study design and population

An observational descriptive study was designed. The data from patients who underwent penile urethroplasty in a single institution (Institute of Urology, University College London Hospitals, London, United Kingdom) during the 11-year period between January 2007 and December 2017 were collected from our prospective patient outcome database. This study was conducted in accordance with the Declaration of Helsinki. No specific local ethics committee approval was required for this study due to its nature. All informed consent forms used were previously reviewed by the Ethics Committee.

Inclusion and exclusion criteria

Only patients undergoing penile urethroplasty using oral grafts (from the cheeks and/or tongue), either in a single-stage or a staged approach, were included in the analysis. A minimum follow-up of 6 months was required after a single-stage procedure or after the final stage of a staged approach to assess the outcomes. Patients having posterior auricular grafts, local skin flaps, and marsupialization procedures were excluded from the study. In the group of patients with a single-stage reconstruction, only those with a “two-in-one” reconstruction of the damaged segment were selected, and patients undergoing urethral augmentation procedures were excluded.

Data collection

The information was collected prospectively with outcomes updated during regular follow-up appointments at 3 and 12 months and annually thereafter. The data related to stricture etiology, location, and length, as well as previous failed treatments, were retrospectively collected by analyzing patient charts and operation reports. Outcome was assessed clinically, radiologically, and by flow-rate analysis.

Outcome measurement

Failure was defined as recurrent stricture on ascending/descending urethrogram or if the patient was not satisfied with the surgical outcome. The need for any subsequent surgical intervention, including urethral dilatation, repair of UCF, or repeat urethroplasty, was also considered as failure.

Statistical analyses

A descriptive analysis of the patients undergoing the single-stage repair for penile urethral strictures was performed. Comparison with the classical staged approach group over the same period was made using the Chi-squared test for categorical variables, and Wilcoxon rank-sum test for continuous variables, as normal distribution was not confirmed. A binary logistic regression model was used for analyzing temporal trends. All *P* values were two-sided with significance considered at *P* < 0.05. Statistical analysis was performed using Stata 13.1 for Mac (StataCorp LLC, College Station, TX, USA).

Two-in-one stage approach: surgical technique

All patients underwent preoperative evaluation including ascending and descending urethrogram and flow-rate analysis (**Figure 1**). Patients were appropriately counseled and consented for both a single-stage repair or a staged repair and the decision as to which procedure was performed was only made after careful intraoperative assessment (see below). Antibiotic prophylaxis (gentamicin and co-amoxiclav) was administered on induction of anesthesia. Nasal intubation was performed in all cases to allow unobstructed access to the mouth for harvesting the oral graft.

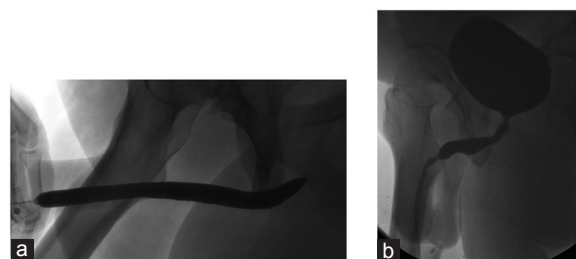


Figure 1: Preoperative urethrograms of patients included in the study. (a) Ascending urethrogram showing a short navicular fossa stricture. (b) Descending urethrogram showing a long penile stricture.

A ventral stricturotomy was performed. The glans was incised in the dorsal midline to deepen the glans cleft and develop the glans wings in patients with hypospadias. In patients with LS-related navicular fossa strictures (and those associated with failed previous hypospadias surgery), all scar tissue was excised down to the corporal heads to create a well-vascularized graft bed (**Figure 2**). A circumcoronal incision and degloving of the penis was used when the stricture extended proximally into the penile urethra. The stricturotomy was extended proximally into healthy mucosa. An appropriately sized buccal mucosal graft was then harvested and prepared, trimming all the fatty and muscular tissue. The graft was then quilted dorsally to create a neourethral plate wide enough to allow tubularization over at least a 20/24F Clutton's metal sound.

After careful assessment of the quality of the surrounding tissues, the size of the glans, and the quality of the dartos available, the neourethra was tubularized using interrupted sutures. Three-layered closure was performed using the glans wings and dartos to support the repair. When tissue mobility was inadequate to achieve a tension-free closure or in the presence of a small glans or paucity of dartos, a decision was made in favor of a staged approach.

A 16F silicon Foley catheter was left *in situ*. Two doses of intravenous antibiotics were administered postoperatively. Patients were discharged home the day after surgery. The catheter was removed two weeks later if a pericatheter urethrogram at that time showed no leak. Clinical, flow-rate, and radiological follow-up was carried regularly at time intervals described above.

RESULTS

Cohort selection

Four hundred and twenty-five urethroplasties for penile urethral strictures were carried out during this time period in our institution: 149 in single-stage and 276 in staged procedures. Of these, 275 urethroplasties involved the use of BMG. One hundred and forty-nine were single-stage urethroplasties whereas 126 were staged. In the group having a one-stage repair, 38 patients underwent either a dorsal inlay BMG through a ventral urethrotomy or a dorsal or dorsolateral BMG augmentation via a transperineal approach, leaving 83 patients who satisfied the inclusion criteria for the study, having undergone a pure “two-in-one” penile urethroplasty. After excluding patients who were lost to follow-up or with incomplete follow-up time, our final sample included 139 patients: 80 in the staged repair group and 59 in the “two-in-one.”

Strictures treated by two-in-one stage and staged approaches

Stricture characteristics and outcomes of the repair are summarized in **Table 1**. The etiology of strictures treated in a two-in-one stage was LS in 31 (52.5%) and hypospadias in 23 (39.0%). The other 5 (8.5%) strictures were related to catheterization or following transurethral resection of the prostate (TURP). Strictures were mostly localized

to the navicular fossa ($n = 23$; 39.0%) and distal penile urethra ($n = 35$; 59.3%). 40.7% ($n = 24$) were redo procedures after prior failed urethroplasty. The mean stricture length was 2.8 (range: 1.3–6) cm.

Surgical outcomes

Out of the entire cohort of 59 patients having a two-in-one stage procedure, 53 (89.8%) had a successful outcome at a mean follow-up of 25.6 (range: 6.4–91.2) months. The average maximum flow rate (Q_{max})

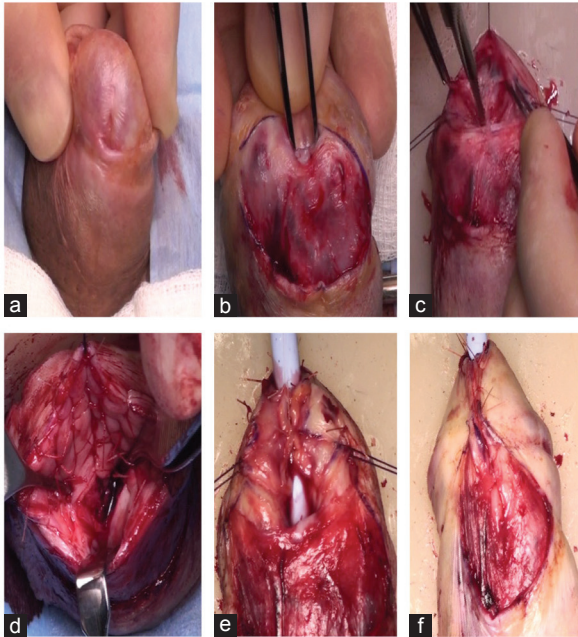


Figure 2: Surgical technique of single-stage penile urethroplasty using BMG. (a) Preoperative appearance in a severe LS fossa navicular stricture. (b) Urethral exposure and location of the stricture. (c) Dorsal incision for deepen the glans. (d) Complete resurfacing using BMG. Neo-urethral retubularization: (e) first layer of closure; and (f) second and third layers of closure. BMG: buccal mucosa graft; LS: lichen sclerosus.

after the repair was 28 ml s⁻¹. In those having a primary procedure, the success rate was 91.4% (32 out of 35). Redo procedures were also associated with an excellent success rate of 87.5% (21 of 24). The success rate was 89.0% in LS-related strictures and 87.1% following hypospadias. Seventeen of the 23 patients with hypospadias strictures underwent a redo procedure, which was successful in 14 (82.4%) of them.

Comparison between groups

Compared with the group of patients having a staged urethroplasty, the distribution of etiologies is significantly different ($P < 0.0001$), with hypospadias-related strictures being the most common ($n = 59$; 73.8%). Of these, 57 (96.6%) were redo procedures. Stricture location in this group was equally distributed throughout the anterior urethra, with 58.7% of strictures in the proximal or mid-penile urethra and 41.3% in the distal penile urethra or navicular fossa, with a significant difference in distribution ($P < 0.0001$) compared to the two-in-one single-stage group. The mean stricture length was greater (4.5 cm) compared to 2.8 cm in the group managed in a two-in-one stage ($P < 0.00001$). Significantly more strictures treated by a staged approach had had previous attempts at repair (81.2%; $P < 0.0001$). The overall success rate in this group was 81.3%, at a mean follow-up of 32 (range: 6.1–115.3) months. This success rate is not significantly different to

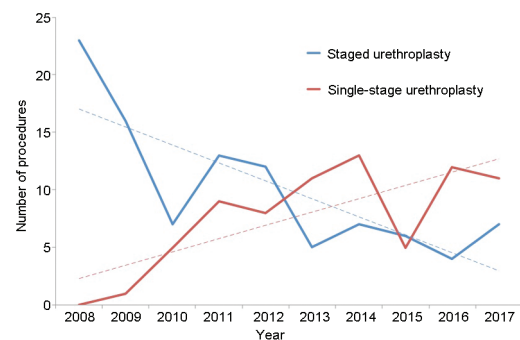


Figure 3: Trends in penile urethroplasty using BMG. BMG: buccal mucosa graft.

Table 1: Stricture characteristics and outcomes of the urethroplasties using buccal mucosa graft

	One-stage repair ($n=59$, 42.5%)	Staged repair ($n=80$, 57.5%)	Comparison (P)
Etiology, n (%)			
LS	31 (52.5)	17 (21.3)	<0.0001
Hypospadias	23 (39.0)	59 (73.8)	
Other*	5 (8.5)	4 (5.0)	
Stricture location, n (%)			
Navicular fossa	23 (39.0)	4 (5.0)	<0.0001
Distal penile	35 (59.3)	29 (36.2)	
Mid-penile	1 (1.7)	18 (22.5)	
Proximal penile	0 (0)	29 (36.2)	
Procedure, n (%)			
Primary	35 (59.3)	15 (18.8)	<0.0001
Redo	24 (40.7)	65 (81.2)	
Stricture length (cm), mean (range)	2.8 (1.3–6.0)	4.5 (2.0–12.0)	<0.00001
Length of follow-up (month), mean (range)	25.6 (6.4–91.2)	32 (6.1–115.3)	0.045
Success rate, n (%)	53 (89.8)	65 (81.3)	0.163
Failures, n (%)			
Restricture	3 (5.1)	8 (10.0)	0.892
Urethrocutaneous fistula	3 (5.1)	6 (7.5)	
Unsatisfied with cosmesis	0 (0)	1 (1.2)	
Mean improvement in Q_{max} (ml s ⁻¹)	28.0	26.2	0.795

*Catheter-related strictures, TURP-related strictures. BMG: buccal mucosa graft; TURP: transurethral resection of the prostate; LS: lichen sclerosus

that obtained with the two-in-one stage approach (89.8%, $P = 0.163$). Eighteen (22.5%) patients required one or more surgical interventions to correct graft contracture before the final tubularization procedure.

Management of failures

Of the 6 failures in those having a single-stage procedure, 3 patients developed recurrent strictures that have been managed endoscopically in one and by self-dilatation in the other 2. Three patients developed urethrocuteaneous fistulae, all of them successfully surgically repaired.

Reasons for failure in the 15 patients undergoing a staged repair were comparable to those having a negative outcome with the two-in-one stage approach ($P = 0.892$). Stricture recurrence occurred in 8 patients, 6 of whom have been managed with interval dilatations and the other 2 by self-dilatation. Six patients developed urethrocuteaneous fistula after the second stage, all of which were successfully surgically repaired. One patient was unsatisfied with the cosmetic appearance after the staged repair due to pouting of the buccal graft at the meatus, and he underwent surgical revision.

Temporal trend analysis

During the study period, we have seen a definite overall downward trend in the number of penile urethroplasties performed as a staged procedure and a complimentary upward trend in those managed using the two-in-one stage approach ($P < 0.00001$; **Figure 3**). Indeed, since 2013, more patients with select LS and hypospadias strictures were managed using this new technique rather than a traditional staged approach.

DISCUSSION

The treatment of urethral strictures in general is determined by their location, etiology, length, and previous treatments or repairs.¹ Strictures in the penile urethra present conceptual differences from bulbar strictures due to various anatomical considerations.^{18,19} End-to-end anastomotic repairs are not possible due to risk of penile shortening or penile curvature, hence the need for augmentation or substitution techniques. The thinner spongiosum, as compared with the bulbar segment,²⁰ should be taken into consideration when a grafting procedure is planned in this area. In such cases, several options have been described, using different substitution materials for reconstructing the damaged segment in a single or staged procedures.¹⁹

Ventral or dorsal urethral augmentation using local skin flaps, as in the Orandi technique using penile shaft skin²¹ or the preputial skin flap²² are established techniques, with good outcomes in selected patients. The use of alternative grafts becomes necessary in LS patients because of the risk of recurrence when genital or extragenital skin is used for urethral repair.⁸ Buccal mucosa has become the gold standard graft tissue for urethral replacement² due to the ease of harvesting, its good handling properties, a concealed donor site, and the good outcomes associated with its use.¹² Other advantages include the resistance to infection, skin diseases, and urine exposure, as well as a rich subepithelial vascular layer which remains stable after transplant into the urethra.^{12,23} Use of sublingual grafts,^{24,25} in addition to the classical oral tissue harvested from the cheek, guarantees buccal mucosa availability in almost every patient, especially in those with long strictures or having had previous repairs using BMG.

If the remaining urethral plate is adequate, an augmentation procedure can be performed in a single stage, placing the oral graft in a ventral,²⁶ dorsal,¹⁷ or dorsolateral position,¹⁵ with or without complete mobilization of the urethra.²⁷ In the absence of clinical features of LS, the dorsal placement of the graft could also be combined with local

skin flaps ventrally,^{28,29} or even with a ventral oral graft,³⁰ in an attempt to perform the repair in one stage in complex cases.

As a general principle, for a successful repair using a graft, the supportive tissue must provide an adequate blood supply to guarantee the viability of the graft. Grafts placed dorsally have the advantage of a secure scaffold in the corpus spongiosum or the tunica albuginea of the corpora cavernosa,¹⁶ and the degree of spongiosal scarring does not influence the take of grafts when applied in this location.⁵

When the urethral plate is completely scarred, as in severe LS, or inexistent, as in hypospadias, the reconstruction becomes more complex.¹¹ Traditionally, in patients with penile strictures, and particularly those with extensive scarring, a tendency toward a conventional staged approach using grafts is recognized.^{7,14} Excising the spongiobrosis and creating a neourethral plate with oral grafts in the first stage, with delayed tubularization between 3 and 6 months later once the graft has matured, is associated with success rates between 73.5% and 87% in the literature.^{12,14,31,32}

Successful complete tubularized substitution of the urethral segment with buccal graft in one stage was only previously reported for strictures located in the bulbar segment.²⁰ Even in this urethral segment, the single-stage complete resurfacing is only for selected strictures, as the tubularization of grafts had proved to be a poor solution in similar cases.²⁸

In this study, we have shown that select penile strictures are suitable for a single-stage urethral substitution with excellent results. This “two-in-one” approach, as we describe it, is highly dependent on a careful intraoperative assessment of the size of the glans and the thickness of the spongiosum, which will eventually provide the vasculature and support for the graft to allow it to be tubularized in the same procedure. This explains why the vast majority of strictures treated by this technique are limited to the navicular fossa and LS-related. Some longer strictures extending into distal penile segment were also treated successfully in this way because they retained an adequate amount of dartos in order to support the graft and allow its tubularization. This highlights the importance of surgeons experienced in making the correct intraoperative decision as to whether or not a particular stricture can be treated in this way.¹⁴

Besides navicular fossa and distal penile strictures which made up 98.3% of the patients treated with this two-in-one stage approach, 59.3% of cases were primary repairs and 52.5% were LS-related (compared to 39.0% associated with hypospadias). In this select group of patients, the single-stage success rate was 89.8%.

Penile urethral reconstruction using oral grafts in a single stage offers several advantages for the patient, and this makes this novel approach relevant. The most obvious benefit would be the avoidance of the second stage of the reconstruction associated with the traditional staged approach.³³ This advantage is even more pronounced when one takes into consideration that almost one out of every four patients undergoing a staged reconstruction in this series needed to have the first stage revised on one or more occasions before an adequate urethral plate was created to allow satisfactory tubularization. This is in keeping with the expected first-stage revision between 20% and 31% published in the literature.^{11,14,31} Avoidance of a proximal urethrostomy and its negative impact on quality of life for the interim period between stages is another obvious advantage.^{13,34} This temporary proximal meatus would generate dissatisfaction on patients, as alters their body imaging and, in severe cases, would lead the patients to void in a sitting position. All penile urethral reconstruction techniques aimed for a repair in the same surgical procedure, even combining dorsal grafting with ventral augmentation with flaps, which is not recommended in LS patients,

when the urethral plate was severely damaged. In this study, we have demonstrated the suitability of selected patients for this single-stage approach using oral grafts for complete urethral substitution.

We have also shown that these patients have strictures with different features when compared with the ones repaired in a staged manner. The outcomes using this two-in-one stage urethroplasty technique are the same as those achieved using the classical staged repair during the study period. These good results are achievable in high-volume centers, with experienced surgeons who are able to decide the suitability of a particular stricture for this “two-in-one” urethroplasty technique intraoperatively.

The limitations of our study arise from the nonrandomized nature of the study and the relatively small number of cases, due to strict inclusion criteria. The data are prospectively collected, but retrospectively analyzed. All patients with incomplete information or less than 6 months of follow-up are excluded. The minimum length of follow-up is relatively short, and some recurrences may not be detected at this stage. We set up this cut-off point considering that if a recurrence is to occur, this usually manifest itself within 12 months of the surgery. However, only a small number of patients have been followed up for only 6 months. The vast majority of patients in both groups have been followed up at least 2 years, with mean follow-up of 25.6 and 32 months. We included also some patients of each technique having more than 5 years of follow-up since the urethroplasty. We hope to report on long-term follow-up for this patient cohort in future. We have designed and validated a Patient-Reported Outcome Measure (PROMS) questionnaire for urethral surgery^{35,36} which we currently use routinely in evaluating subjective outcomes. However, the study period includes patients operated on before the questionnaire was developed and therefore has not been included in this present study to avoid bias.

CONCLUSION

A “two-in-one” urethroplasty using BMG for complete urethral substitution is a suitable option for selected penile urethral strictures, after careful intraoperative assessment of the stricture. LS-related, primary, navicular fossa, and distal penile strictures are usually those more suitable for this technique. An excellent outcome, comparable with the classical staged approach, is achievable in high-volume centers. The advantages include improved patient satisfaction, associated with fewer surgical interventions and avoidance of proximal urethrostomy.

AUTHORS CONTRIBUTIONS

FCJ and SB participated in the study design, performed the literature review, and drafted the manuscript. MD performed the database search and updated the patient outcomes. AVF and SLI contributed to review the literature and updated the patient outcomes. DEA and ARM performed the surgeries, also reviewed the results, discussion and conclusion, and made critical revision and edition of the contents. All authors read and approved the final manuscript.

COMPETING INTERESTS

All authors declared no competing interests.

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