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Outcomes of dorsal inlay buccal mucosal graft for distal penile urethral stricture; a prospective longitudinal study

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ABSTRACT

Introduction: Distal penile urethral strictures are challenging to treat due to their location and risk of complications. The dorsal inlay buccal mucosal graft (BMG) urethroplasty is a minimally invasive technique designed to restore urethral function while minimizing risks.

Objectives: This study evaluates BMG effectiveness for distal penile strictures.

Patients and Methods: This prospective longitudinal study involved 25 male patients with distal urethral strictures who underwent BMG urethroplasty and were referred to Al-Basrah teaching hospital in Iraq between February 2022 and March 2024. Data collection included patient interviews to gather symptom type, followed by baseline measurements of post-void residual (PVR) volume, maximum urine flow rate, and urethral caliber using ultrasonography, uroflowmetry, and micturating cystourethrography. Patients were reassessed six months after BMG treatment, and follow-up measurements were compared to baseline to evaluate the surgical outcomes.

Results: The study involved 25 men with an average age of about 39.36 ± 4.26 years. Six months after surgery, significant improvements were observed compared to baseline in key urinary parameters: maximum urine flow rate increased, PVR volume decreased markedly, urethral caliber enlarged substantially, and symptoms were markedly improved.

Conclusion: This study demonstrates that the dorsal inlay BMG is an effective surgical treatment for distal penile urethral strictures, leading to significant improvements in urinary flow, reduced residual urine, increased urethral caliber, and marked symptom relief, thereby successfully restoring normal urinary function.

Implication for health policy/practice/research/medical education:

In this prospective longitudinal study, treatment with a buccal mucosal graft (BMG) significantly improved urinary function, enhanced bladder emptying, effectively resolved urethral strictures, and alleviated symptoms, demonstrating the success of BMG surgery in restoring normal urinary function.

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Introduction

Penile urethral stricture disease represents a complex and challenging condition within the spectrum of anterior urethral pathology (1). Penile urethral strictures account for approximately 30% of all anterior urethral strictures, with combined bulbar/penile strictures comprising an additional 9.9%, meaning that 40.4% of all men presenting with anterior urethral stricture disease will have penile urethral involvement alone or in combination with bulbar urethral stricture (2). The etiology of penile urethral strictures is largely idiopathic, but other important causes include lichen sclerosus and iatrogenic factors such

as failed hypospadias repair, which collectively account for approximately 60% of all cases (1,3). Traumatic etiologies, while less common in the penile urethra, can occur following severe penile fractures where rupture of the cavernous bodies is associated with urethral injury (1).

Buccal mucosal grafts have revolutionized the surgical management of urethral stricture disease since their introduction to urologic reconstruction by Humby in 1941 (4-6). The unique properties of buccal mucosa make it an ideal urethral substitute, including ease of harvest, excellent surgical handling characteristics, hairlessness, compatibility in wet environments, and its ability to

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withstand early ingrowth and graft survival (5,6). Buccal mucosa has become the preferred graft material for urethral reconstruction due to its excellent histological properties, with systematic reviews demonstrating significantly higher success rates compared to penile skin grafts (83.7% vs. 76.1%) (7). These characteristics have made buccal mucosa particularly valuable in reconstructing complex penile urethral strictures, where local tissues may be compromised by inflammatory conditions such as lichen sclerosus or previous surgical interventions (6).

The dorsal inlay technique, popularized by Asopa and colleagues in 2001, represents a significant evolution in urethral reconstruction methodology; this approach involves a ventral sagittal urethrotomy with dorsal inlay placement of the buccal mucosal graft, claiming advantages of easier technical performance and reduced tissue ischemia due to the absence of need for circumferential urethral mobilization (8). The technique has shown particular promise in managing penile urethral strictures, with studies demonstrating success rates ranging from 77% to 96% for penile and fossa navicularis strictures (9). The dorsal inlay approach offers theoretical advantages over traditional onlay techniques, particularly in the penile urethra, where the corpus spongiosum is relatively deficient, as the graft receives mechanical support and vascularization from the underlying tunica albuginea of the corpora cavernosa (5,10).

Objectives

The objective of this study was to prospectively evaluate the effectiveness of the dorsal inlay buccal mucosal graft (BMG) in treating distal penile urethral strictures by assessing improvements in urinary function, urethral patency, and symptom relief over a six-month postoperative period.

Patients and Methods

Study design and participants

This prospective longitudinal study was conducted at Al-Basrah teaching hospital in Basrah, Iraq, from February 2022 to March 2024. It involved 25 male patients diagnosed with distal urethral strictures, specifically affecting the fossa navicularis and the distal two centimeters of the penile urethra, who underwent inlay BMG urethroplasty. The study aimed to investigate the clinical outcomes and effectiveness of BMG surgical treatment for this subset of urethral strictures.

Inclusion and exclusion criteria

The inclusion criteria for this study were male patients aged 18 years and older diagnosed with distal urethral stricture involving the fossa navicularis and/or the distal 2 cm of the penile urethra, presenting with obstructive

urinary symptoms such as poor stream, dysuria, or incomplete bladder emptying, with the stricture confirmed by diagnostic methods like urethroscopy or imaging. Participants were required to provide informed written consent and demonstrate willingness to undergo surgical treatment and follow-up assessments. Exclusion criteria included patients with strictures caused by malignancy, a history of complex urethral strictures, and participants who were unwilling to continue or had incomplete follow-up.

Data collection

Data collection comprised two stages. First, informed written consent was obtained from the participants, followed by the collection of demographic information, such as age, symptom type, and symptom duration, through participant interviews. Next, clinical data, including post-void residual (PVR) volume, maximum urine flow rate (Qmax), and urethral caliber, were gathered using ultrasonography, uroflowmetry, and micturating cystourethrography. After six months post-operatively of the BMG surgery treatment, patients were re-evaluated, and these data were remeasured and compared to the baseline measurement.

BMG treatment protocol

All participants included in the study underwent BMG surgery performed by a single surgeon following a standardized treatment protocol. Under general anesthesia, the dorsal lithotomy position was assumed, and the stricture length was measured using a 4.5/6.5 ureteroscope gauge, excluding stones smaller than 4 ml. A guidewire was passed through the stricture into the bladder. A sub-coronal ventral penile skin incision was made, followed by dissection through the Buck's and Dartos fasciae. A ventral urethrotomy was performed over the guidewire, and a dorsal midline full-thickness urethrotomy incision was created approximately 1 cm from the metal aperture to the stricture site. A 2 cm wide BMG was harvested and defatted. One end of the graft was sutured to the proximal dorsal urethrotomy incision and the other to the metal orifice using 4-0 Vicryl. The graft was then anastomosed to the edges of the incised dorsal urethra and secured to the tunica albuginea. The ventral urethra was closed over a 16–18 Fr silicone Foley catheter with the same suture, and the underlying tissues and sub-coronal skin were closed. The catheter was removed after three weeks, with follow-up visits scheduled biweekly initially and then every six months for uroflowmetry, ultrasound PVR measurement, clinical examination, and calibration.

Outcomes

The primary outcome of this study was to compare

PVR volume, maximum urine flow rate (Qmax), urethral caliber, and symptom improvement at six months following BMG treatment relative to baseline. The secondary outcome involved evaluating the overall effectiveness of BMG treatment in managing distal penile urethral strictures.

Data analysis

Data were analyzed using IBM SPSS (IBM Corporation, Armonk, NY, USA, version 27). Data normality was assessed via the Shapiro-Wilk test. Although both parametric and non-parametric methods were considered, parametric tests were used due to their greater accuracy and reliability, and the similarity of P-values obtained with both methods. To compare quantitative variables, including PVR volume, maximum urine flow rate (Qmax), and urethral caliber, measured at baseline and six months after BMG treatment, a paired T-test was conducted. The significance level was set at $P < 0.05$ for all tests.

Results

This study involved 25 men with an average age of 39.36 ± 4.26 years and an average symptom duration of 14.52 ± 1.5 months. Most participants had strictures located in the penile urethra rather than the fossa navicularis. The leading cause of these strictures was iatrogenic, followed by idiopathic and inflammatory origins, with trauma being less common. All individuals experienced poor stream quality, incomplete bladder emptying, and dysuria at baseline. Increased urinary frequency and nocturia were also frequently reported symptoms, along with post-void dribbling and intermittency, while urinary retention, hematuria, and urinary incontinence were less commonly observed (Table 1).

The results indicated that six months following surgery, there was a marked improvement in urinary symptoms compared to baseline. The vast majority of patients experienced a resolution or significant reduction in poor stream quality, incomplete bladder emptying, and dysuria. Symptoms such as increased urinary frequency, urinary urgency, nocturia, and intermittency also showed substantial improvement, with most patients reporting minimal to no symptoms. Additionally, urinary retention, post-void dribbling, hematuria, and urinary incontinence resolved completely in all affected individuals. Overall, the postoperative period was characterized by notable symptomatic relief across all measured urinary symptoms (Table 2).

The comparative analysis between baseline and six months postoperatively revealed significant improvements in maximum urine flow rate, PVR volume, and urethral caliber. Postoperatively, there was a notable increase in maximum urine flow rate, indicating enhanced

Table 1. Baseline symptoms frequency, location, stricture etiology, and demographic characteristics of participating individuals in the study

Characteristics	Frequency	Percent
Location		
Fossa navicularis	10	40
Penile urethra	15	60
Stricture etiology		
Iatrogenic	10	40
Inflammation	5	20
Trauma	4	16
Idiopathic	6	24
Symptom frequency at baseline		
Poor stream quality	25	100
Incomplete bladder emptying	25	100
Increased urinary frequency	20	80
Urinary retention	5	20
Dysuria	25	100
Urinary urgency	15	60
Nocturia	20	80
Post-void dribbling	17	68
Intermittency	15	60
Hematuria	2	8
Urinary incontinence	3	12
Characteristics	Mean	SD
Age (year)	39.36	4.26
Symptoms' duration (month)	14.52	1.50

SD, Standard deviation.

Table 2. Frequency and improvement of urinary symptoms six months postoperatively

Symptom frequency at baseline	Number	%
Poor stream quality	1	4
Incomplete bladder emptying	2	8
Increased urinary frequency	2	8
Urinary retention	0	0
Dysuria	6	24
Urinary urgency	3	12
Nocturia	1	4
Post-void dribbling	0	0
Intermittency	1	4
Hematuria	0	0
Urinary incontinence	0	0

SD, Standard deviation.

Table 3. Comparative analysis of maximum urine flow rate, post-void residual volume, and urethral caliber at baseline and six months postoperatively

Parameters	Baseline		Six months postoperatively		Mean difference	P value*
	Mean	SD	Mean	SD		
Post-void residual volume (mL)	3.5	1.13	21.4	8.15	17.9	0.003
Maximum urine flow rate (mL/s)	114.13	22.31	22.10	6.51	- 92.03	0.001
Urethral caliber (Fr)	4.81	1.53	18.06	5.16	13.25	0.008

SD, Standard deviation; Fr, French. *Paired T-test.

urinary function. PVR volume decreased substantially, reflecting better bladder emptying after the intervention. Additionally, urethral caliber showed considerable enlargement, suggesting effective resolution of stricture and improved urethral patency (Table 3).

Discussion

Our results demonstrated that six months after surgery treatment with BMG, significant improvements from baseline in key urinary parameters, including a marked increase in maximum urine flow rate, a substantial decrease in PVR volume, notable enlargement of urethral caliber, and considerable symptom relief. These changes indicate enhanced urinary function, better bladder emptying, effective resolution of urethral stricture, and improvement of symptoms, demonstrating the surgical treatment's success in restoring normal urinary function. These findings align with previous studies, which have shown marked functional improvement and satisfactory outcomes after similar techniques. A study of 21 patients using a single-stage dorsal inlay BMG with ventral urethrotomy showed significant improvements in maximum flow rate (mean Q_{max} of ~20.9 mL/s), postvoid residual volume, and urethral caliber at six months, with good functional and cosmetic results and high patient satisfaction (11). Another large series with 125 patients undergoing Asopa dorsal inlay BMG urethroplasty reported significant Q_{max} improvement from baseline (mean pre-op 8.8 vs. post-op 23.3 mL/s) and an overall 70% success rate, highlighting consistent functional benefit but somewhat variable success depending on stricture complexity and previous interventions (12). These outcomes are comparable to our results, supporting the effectiveness of dorsal inlay BMG for restoring normal urinary function in distal penile strictures.

In the broader context, dorsal inlay BMG urethroplasty is recognized for advantages such as reduced urethral mobilization, decreased tissue ischemia, and durable graft integration due to graft support on the tunica albuginea (8,13). Studies emphasize its efficacy in penile urethral strictures, particularly where local tissues are compromised. Despite high success rates reported in many series (ranging

from 70% to above 90%), some recurrence risk remains, especially in complex or recurrent strictures (6,12,14,15). Comparative studies also suggest that other techniques, like ventral onlay skin flaps, may have comparable or slightly lower success rates but different complication profiles. The use of BMG is favored due to its histological qualities and graft take superiority (7).

In conclusion, our results reinforce that dorsal inlay BMG urethroplasty offers significant functional improvement and symptom relief in distal penile urethral strictures, consistent with prior evidence from previous studies. The procedure is effective in improving urinary flow, minimizing residual urine, and maintaining urethral caliber, thus restoring normal urinary function. While success rates vary with stricture characteristics and patient history, dorsal inlay BMG remains a mainstay in the surgical management of distal penile strictures, offering a balance of efficacy, morbidity, and patient satisfaction that supports its continued use in reconstructive urology practice (8,11,12).

Conclusion

The findings of this study confirm that the dorsal inlay BMG is an effective surgical approach for managing distal penile urethral strictures. Six months postoperatively, patients experienced significant improvements in urinary function, evidenced by increased maximum urine flow rate, reduced PVR volume, and enlarged urethral caliber, alongside substantial symptom relief. These results demonstrate that the BMG technique successfully restores normal urinary function by effectively resolving urethral strictures and improving bladder emptying.

Limitations of the study

First, the relatively small sample size of 25 patients may limit the generalizability of the findings to a broader population with distal penile urethral strictures. Second, the follow-up period of six months, while useful for short-term outcomes, may be insufficient to assess long-term efficacy and complications of the dorsal inlay BMG procedure. Third, the study was conducted at a single center, which may introduce institutional biases related

to surgical technique and postoperative care, thereby affecting the external validity. Additionally, the exclusion of patients with complex strictures or malignancies restricts the applicability of the results only to a select subset of distal urethral strictures. Finally, the reliance on clinical measures and imaging without incorporating patient-reported outcome measures could limit understanding of the procedure's impact on quality of life and symptom relief from the patients' perspective.

Authors' contribution

Conceptualization: Majed A Mohammad.

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Formal analysis: Firas A Jassim and Sajjad Salim Issa.

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Project management: Ali Malik Tiryag.

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Supervision: Majed A Mohammad.

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Writing—original draft: All authors.

Writing—review and editing: All authors.

Conflicts of interest

The authors declare no conflict of interest.

Data availability statement

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declaration of generative artificial intelligence (AI) and AI-assisted technologies in the writing process

While preparing this work, the authors utilized AI (Perplexity.ai and Grammarly.com) to refine grammar points and language style in writing. Subsequently, the authors thoroughly reviewed and edited the content as necessary, assuming full responsibility for the publication's content.

Ethical issues

The study was conducted in accordance with the principles outlined in the Declaration of Helsinki. Informed written consent was obtained from all participants. This study resulted from research conducted at Al-Basrah Teaching Hospital and was approved by the Research Ethical Approval Committee, College of Nursing, University of Basrah, Basrah, Iraq with Ethical registration number of 3/6/189 dated February 5, 2022. Besides, the authors have ultimately observed ethical issues (including plagiarism, data fabrication, and double publication).

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