Annals of Medicine and Medical Sciences (AMMS)
Volume 04, 2025, *Page No.: 686 to 695*
Available at: *http://ammspub.com*

Original Article

OPEN ACCESS

Reconstructing Success: Insights from a Retrospective Study and Systematic Review and Meta-Analytical Evaluation of Buccal Mucosal Graft Urethroplasty Across the Globe

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Abstract

Background: Buccal mucosal graft urethroplasty (BMGU) is now the gold standard in the treatment of anterior urethral strictures, particularly of long lengths or recurrences. But heterogeneity of outcomes, predictors of recurrence, and complication rates among populations and techniques necessitates a harmonized evidence-based synthesis. ***Aim and Objective:*** To appraise and integrate international evidence regarding the efficacy, safety, recurrence pattern, and quality-of-life at follow-up after BMGU and to determine: "What patient, disease, and surgical variables most reliably affect long-term stricture recurrence and functional recovery in anterior urethral strictures managed with BMG urethroplasty in diverse healthcare settings? ***Material and Methods:*** A systematic review and meta analyses was conducted by searching the electronic databases for published studies from 2015 to 2024 and finally ten studies (n=1228) were taken into consideration. Outcomes assessed included primarily success rate, complications, recurrence and patient related outcome measures (PROMs). Additionally, a retrospective cohort study of 150 patients with Balanitis Xerotica Obliterans (BXO) related anterior urethral strictures treated at Karuna Medical College between 2014 and 2024. ***Results:*** The meta analyses of the global studies yielded a pooled success rate of 85% with recurrence positively correlated with penile site, stricture length and ≥3 prior urethrotomies. Recurrence predictors were penile site, increased stricture length, secondary procedures, and ≥3 previous urethrotomies. Complications of erectile dysfunction and urinary infection were reported but mostly controllable. The Karuna cohort (mean age 45.2 years) showed a 98.7% short term success rate. Complications occurred in 6 patients (4%): 2 each with oral bleeding, wound infection and recurrence requiring redo surgery. Radiological and intraoperative images confirmed technical integrity. ***Conclusion:*** BMGU is a very effective and versatile surgical option for the treatment of anterior urethral strictures. Early surgery, the proper choice of technique, and the incorporation of PROMs can maximize patient-focused results. The validation from a high volume Indian center in BXO cases supports its applicability across disease etiologies and resource levels.

Keywords: ***Buccal mucosal graft, Urethroplasty, Anterior urethral stricture, Recurrence, Global outcomes, PROMs, Balanitis Xerotica Obliterans, Systematic Review, Meta-analyses, Retrospective***

Introduction

Urethral stricture disease is a major urologic condition that occurs in about 0.6% of men worldwide (Almhmd AE *et al*, 2021). Anterior urethral strictures, especially those not responsive to endoscopic management, usually necessitate substitution urethroplasty as final therapy. Among the grafting modalities, buccal mucosal graft urethroplasty (BMGU) has gained widespread use as the procedure of choice because of the ease of tissue harvest, hairlessness, strong integration, and success in moist environments (Foremen J *et al*, 2023).

First described by Barbagli in the 1990s, BMGU has since developed into various surgical forms such as dorsal, ventral, dorsolateral onlay, and combined graft techniques (Barbagli G *et al*, 2006). Although most evidence supports its efficacy, widely differing surgical results result from variation in technique, site and length of stricture, patient comorbidities, and healthcare facilities. Additionally, there is little synthesis of results differentiated by region, resource setting, or PROM utilization.

It is important to validate instruments like International Prostate Symptom Score (IPSS), International Index of Erectile Function (IIEF), Ultrasound-Based Patient Related Outcome

Received: June 20, 2025; **Revised:** July 12, 2025; **Accepted:** July 15, 2025

Measure (USS-PROM), and EuroQol 5-Dimension (EQ-5D) in order to capture the voice of the patient, particularly as care becomes more value based (Churruca K *et al*, 2021). These instruments are still underreported in most datasets, however. Recurrence is also still a problem despite high rates of successful surgery, with some patients needing to undergo multiple procedures.

The present review aggregates, contrasts, and synthesises results from ten publications between 2015 and 2024 in various worldwide environments. By a narrative and quantitative meta-synthesis, it seeks to contribute to a combined body of knowledge of the present state regarding BMGU outcomes, complications, and predictors for recurrence.

Methodology

This systematic review and meta-analysis was conducted following the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines for the period 2015-2024 using the keywords “Buccal mucosal graft”, “Urethroplasty”, and “Anterior urethral stricture” (Page MJ *et al*, 2021). Two authors (S.P and S.M) undertook the review. The quality of the studies was assessed using the New Castle Ottawa Scale. Microsoft Excel version 16 was used for data input. R Studio was used for data analysis and the preparation of graphs.

Inclusion criteria

- Original studies involving ≥10 male patients undergoing anterior urethral stricture repair using buccal mucosal graft urethroplasty (BMGU).
- Studies that reported at least one of the following outcomes: success rate, recurrence rate, complications, or patient-reported outcome measures (PROMs).
- Observational study designs, including prospective and retrospective cohorts.
- Studies from both high-resource and low-resource clinical settings.

Exclusion criteria

- Studies focusing on posterior urethral strictures, hypospadias repair, or non-BMG techniques.
- Case reports, editorials, expert opinions, conference abstracts, or review articles.
- Studies lacking quantitative outcome data or clear methodology.
- Duplicate studies or those with overlapping patient cohorts.

The first author name with the year of publication, study design, sample size, study characteristics and country of study were tabulated (**Table 1**).

A retrospective observational study was conducted at Karuna Medical College, Kerala, India between January 2014 and December 2024. Medical records of male patients who underwent buccal mucosal graft urethroplasty (BMGU) for anterior urethral strictures were reviewed.

Inclusion Criteria

- Male patients aged ≥18 years
- Diagnosed with anterior urethral strictures secondary to Balanitis Xerotica Obliterans (BXO)
- Treated with single-stage dorsal or ventral onlay BMGU
- Minimum follow-up of 6 months

Exclusion Criteria

- Posterior urethral strictures or trauma-related strictures
- Patients undergoing staged or perineal urethrostomy
- Incomplete medical records or <6 months of follow-up

Demographic data, clinical presentation, intraoperative details, and postoperative complications were documented. Preoperative imaging (RGU/MCU), intraoperative photographs, and outcomes at follow-up were analyzed. Recurrence was defined as need for further instrumentation or redo urethroplasty.

Statistical Analysis: Descriptive statistics were used to report frequencies, proportions, and means. Recurrence and complication rates were compared against the pooled meta-analytical data using two-proportion z-tests. A significance level of $p < 0.05$ was considered statistically significant.

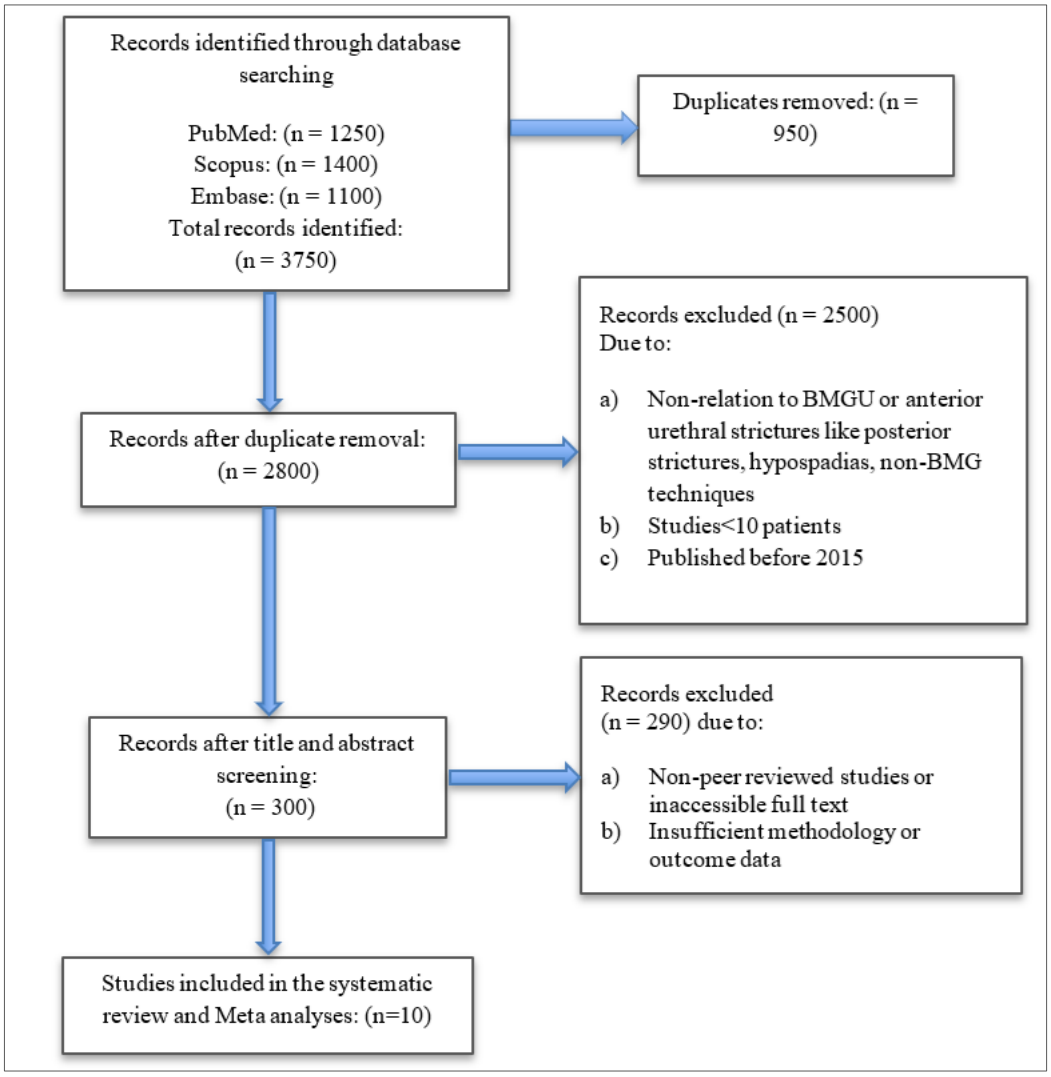

Figure 1: Flow chart for systematic review and meta analyses

Results

Screening Flow

A total of 3750 articles were retrieved from the databases of PubMed, Scopus and Embase out of which 950 duplicate records were excluded. Out of the 2800 articles, 2500 articles were excluded in the title and abstract screening process. The rest of 300 articles were checked for full text eligibility of which 290 articles were excluded to render 10 articles that were finally considered for the systematic review and meta analyses.

Ten studies comprising 1,228 patients were analyzed. These studies spanned high-income countries (USA, UK, Germany, Belgium), middle-income countries (Turkey, India), and low-income settings (Nigeria, Sudan, Nepal). Initial and redo surgeries had significantly higher success compared to secondary procedures. Recurrence was strongly associated with penile location, longer strictures, and patients with ≥3 prior endoscopic procedures. PROMs, when used, showed marked improvements in urinary and sexual function. Infections and wound-related complications were reported more frequently in resource-limited settings.

The first author's name with year of publication, sample size, success rate (%), effect size in proportion, standard error (SE), lower and upper CI (95%) were tabulated (**Table 2**).

The forest graph was plotted (**Figure 2**). The pooled success rate for BMGU was 85% (95% CI: 82-88%). The heterogeneity (I^2) was 28.7% with a p-value of 0.19 indicating that the heterogeneity exists but to a small extent.

Funnel and Egger's Test

The funnel plot was asymmetrical attributed to the geographical and chronological variations (**Figure 3**). The Egger's test p-value was 7.88×10^{-9} being less than 0.05 suggesting publication bias and strong evidence of funnel plot asymmetry.

The bubble meta-regression graph was plotted (**Figure 3**). There was no significant linear relationship between sample size and effect size in this meta-analyses ($(\beta \approx 0)$. The CI bank likely crossed $y = 0.845$ around all sample sizes supporting the previously mentioned null hypothesis of no association between sample size and effect size. The slope (m) = 0 indicated no change in effect size with increasing sample size, the intercept came out to be 0.8453 (average effect size) when the sample size approached zero. The flat slope further supported the fact that the sample size did not affect the effect size, overall there was no significant deviation of individual study effects from the overall trend. A total of 150 patients treated with BMGU for anterior urethral stricture due to BXO were retrospectively studied. The mean age was 45.2 years (range: 20-78). All underwent dorsal or ventral onlay BMGU. Postoperative complications were noted in 6 patients (4%), including 2 with oral bleeding, 2 with surgical site infection, and 2 with recurrence requiring redo urethroplasty. The short-term success rate was 98.7% with no major donor site morbidity. These results compare favorably to global outcomes, indicating that BMGU is effective even in chronic inflammatory settings like BXO. The demographic characteristics, surgical approach, and complication rates of the Karuna institutional cohort were summarized (**Table 3**).

A comparative analysis of recurrence rates between the meta-analytic sample (15%) and the Karuna cohort (1.3%) revealed a statistically significant difference ($\chi^2 = 20.18$, df = 1, $p < 0.001$), indicating superior short-term outcomes in the institutional series (**Table 4**).

Table 1: Study Characteristics

S. No	First Author (Year)	Sample Size	Country	Study Design	Study Characteristics
1	Blaschko *et al*. (2015)	13,700	USA	Retrospective	Large national database; comorbidity stratification
2	Eshiobo *et al*. (2016)	11	Nigeria	Prospective	Ventral onlay; low-resource setting
3	Spilotros *et al*. (2017)	128	UK	Retrospective	Penile/bulbar; PROMs & complications documented
4	Pathak *et al*. (2017)	112	India	Retrospective	Compared dorsal, ventral, dorsolateral placements
5	Vetterlein *et al*. (2018)	534	Germany	Multicenter Retrospective	Stratified by surgical sequence
6	Soave *et al*. (2019)	83	Germany	Retrospective	HRQoL and PROMs focused
7	D'hulst *et al*. (2020)	97	Belgium	Prospective	PROMs & erectile function recovery tracked
8	Awad *et al*. (2021)	60	Sudan	Prospective	High UTI/infection rate; low-resource proof
9	Coguplugil *et al*. (2022)	24	Turkey	Retrospective	Recurrent strictures; linked to prior urethrotomies
10	Gupta *et al*. (2024)	130	Nepal	Retrospective	Penile site linked to recurrence; 48-month follow-up

Table 2: Meta-analysis Inputs

S. No	First Author (Year)	Sample Size	Success Rate (%)	ES	SE	Lower CI	Upper CI
1	Blaschko *et al*(2015)	13700	93.4	0.934	0.00212122	0.929842	0.938158
2	Eshiobo *et al* (2016)	11	90.9	0.909	0.08671741	0.739034	1.078966
3	Spilotros *et al* (2017)	128	81	0.81	0.03467483	0.742037	0.877963
4	Pathak *et al* (2017)	112	81	0.81	0.03706895	0.737345	0.882655
5	Vetterlein *et al* (2018)	534	85.7	0.857	0.01514913	0.827308	0.886692
6	Soave *et al* (2019)	83	78.3	0.783	0.04524512	0.69432	0.87168
7	D'hulst *et al* (2020)	97	90.7	0.907	0.02948895	0.849202	0.964798
8	Awad *et al* (2021)	60	90	0.9	0.03872983	0.82409	0.97591
9	Coguplugil *et al* (2022)	24	79	0.79	0.08314145	0.627043	0.952957
10	Gupta *et al* (2024)	130	84.6	0.846	0.0316573	0.783952	0.908048

Table 3: Clinical Profile and Surgical Outcomes of Patients Undergoing Buccal Mucosal Graft Urethroplasty at Karuna Medical College

Parameter	***Observation***
Total Patients	150
Age Range	20–78 years
Etiology	All cases due to BXO
Stricture Location	Anterior urethra
Graft Technique	Dorsal or Ventral Onlay BMGU
Complication Rate	4% (6/150 patients)
- Oral Bleeding (Immediate Post-op)	2 patients (1.3%)
- Surgical Site Infection	2 patients (1.3%)
- Stricture Recurrence (Redo BMGU)	2 patients (1.3%)
Mean Follow-up Duration	6 to 24 months
Short-term Success Rate	98.7%

Table 4: Comparative Analysis of Recurrence Rates between Karuna Institutional Cohort and Global Meta-Analysis

Comparison Group	Recurrence Rate (%)	Total Patients	Recurrences	p-value
Meta-analysis (global)	15.0	1228	184	
Karuna cohort	1.3	150	2	**<0.001***

Table 5: Key Findings

S. No	First Author (Year)	Important Findings
1	Blaschko (2015)	Large-scale data showing increasing BMG use; comorbidities affect outcomes.
2	Eshiobo (2016)	High success rate in low-resource settings; 90.9% success; minimal complications.
3	Spilotros (2017)	Penile site predictive of recurrence; ED 12.5% and PMD 16% resolved conservatively.
4	Pathak (2017)	Ventral graft best for proximal strictures; 57% of failures at proximal site.
5	Vetterlein (2018)	Secondary BMGU had highest recurrence; HR 2.42 compared to primary/redo.
6	Soave (2019)	PROMs showed 81.9% satisfaction; stricture-free rate 78.3%.
7	D'hulst (2020)	Erectile function restored over time; significant IPSS/UDI improvement.
8	Awad (2021)	First report from Sudan; 90% success; infection rates higher (UTI 23.3%).
9	Coguplugil (2022)	All recurrences occurred in patients with ≥3 prior urethrotomies.
10	Gupta (2024)	Penile site was the only independent predictor of recurrence; 48-month data.

Table 6: Merits and Gaps

S. No	First Author (Year)	Merits and Gaps
1	Blaschko (2015)	Merit: Large national data; Risk factor analysis. Gap: No PROMs or long-term follow-up.
2	Eshiobo (2016)	Merit: First Nigerian study; High success. Gap: Small size; short follow-up.
3	Spilotros (2017)	Merit: Penile stricture analysis; Complication tracking. Gap: Retrospective; no PROMs.
4	Pathak (2017)	Merit: Onlay technique comparison. Gap: Lacks PROMs and baseline Qmax/IPSS.
5	Vetterlein (2018)	Merit: Stratified by surgery type; strong stats. Gap: No PROMs; retrospective.
6	Soave (2019)	Merit: Robust PROM usage. Gap: Modest sample; retrospective.
7	D'hulst (2020)	Merit: Prospective; PROMs tracked. Gap: Limited PROM variety; short follow-up.
8	Awad (2021)	Merit: First Sudanese data; strong results. Gap: High UTI; lacks PROMs/flowmetry.
9	Coguplugil (2022)	Merit: Key recurrence predictor. Gap: Small cohort; retrospective.
10	Gupta (2024)	Merit: Long-term LMIC data; site-specific outcomes. Gap: Retrospective; variable techniques.

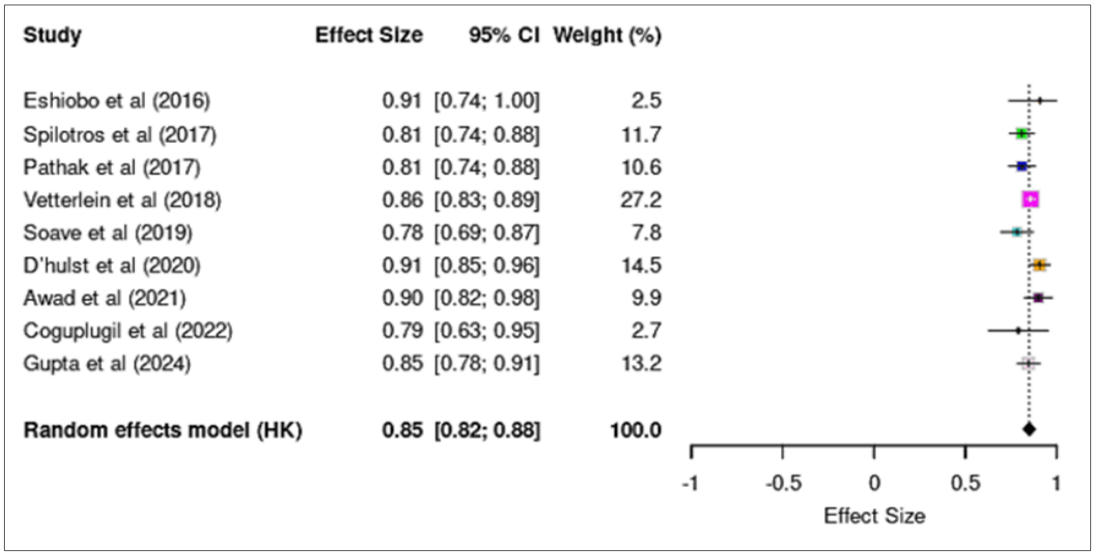

Figure 1: Forest Plot

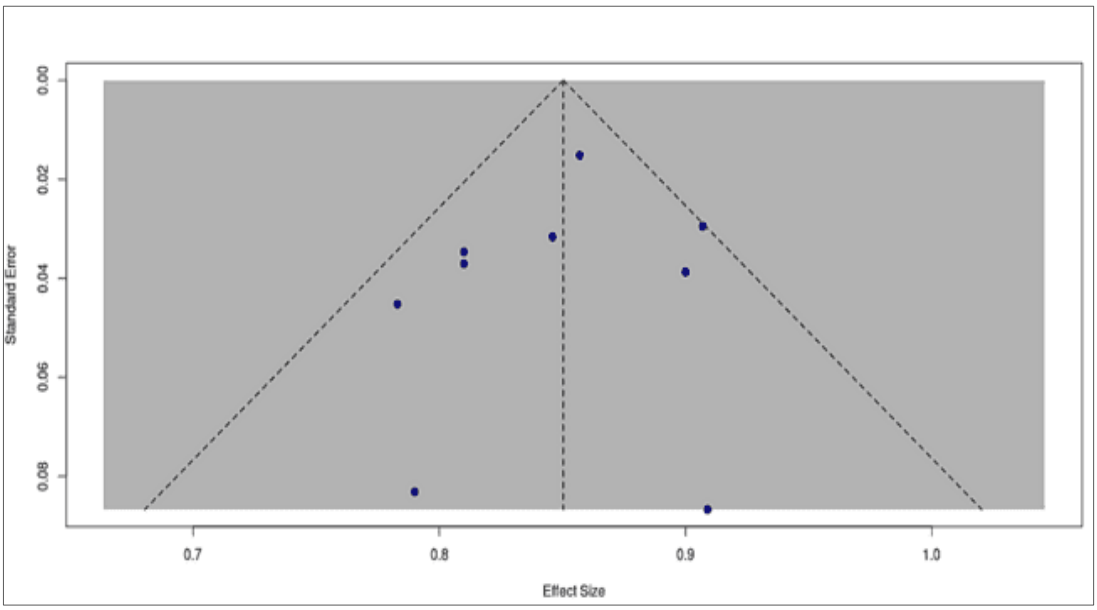

Figure 2: Funnel Plot

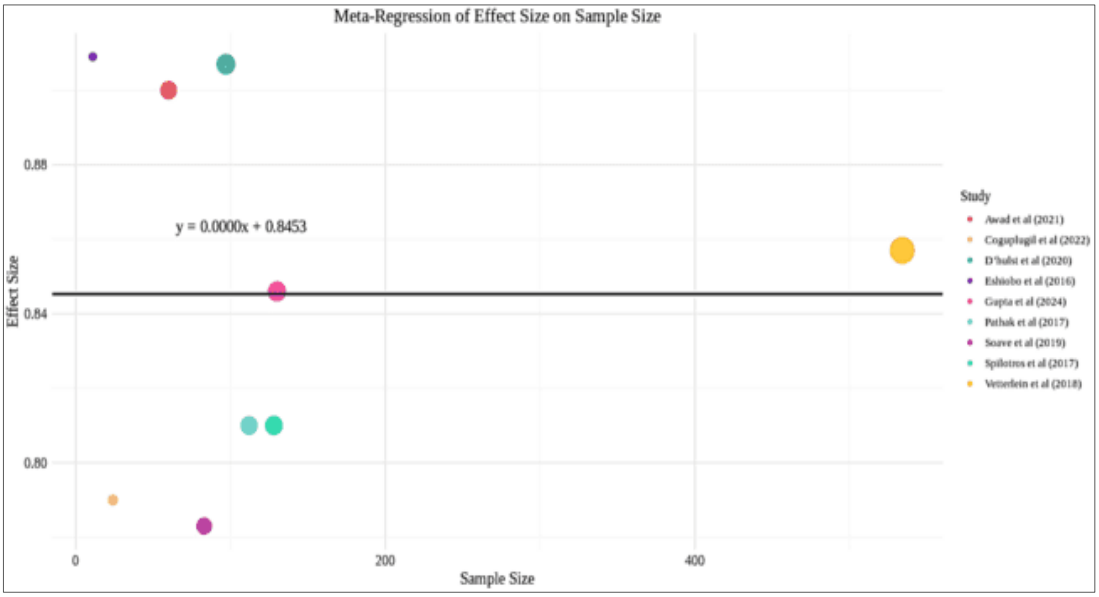

Figure 3: Bubble meta regression plot

Intraoperative Views of BMGU

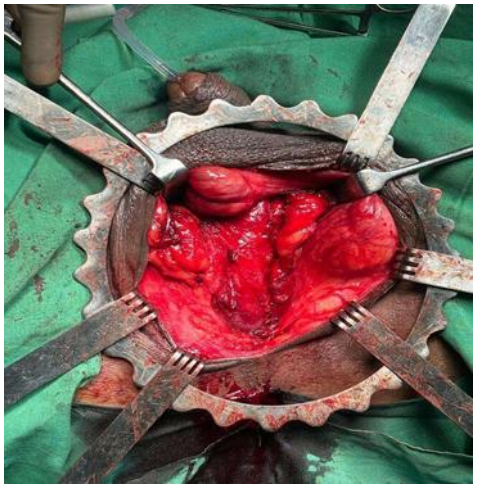

Image 1 a): Exposure of anterior urethral stricture segment

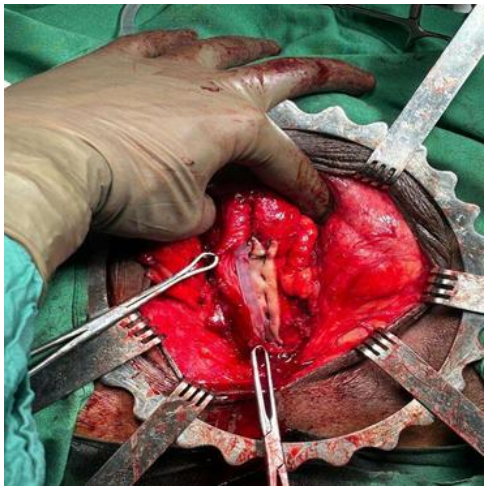

Image 1 b): Quilting of buccal mucosal graft

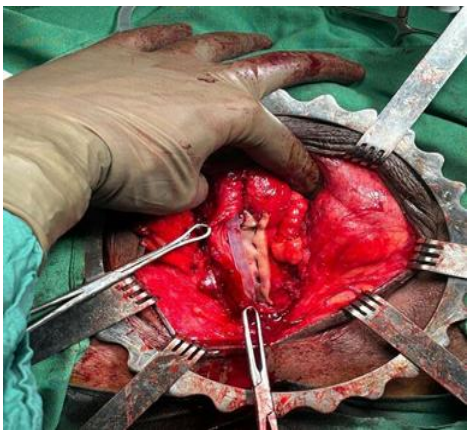

Image 1 c) Dorsal placement of buccal graft

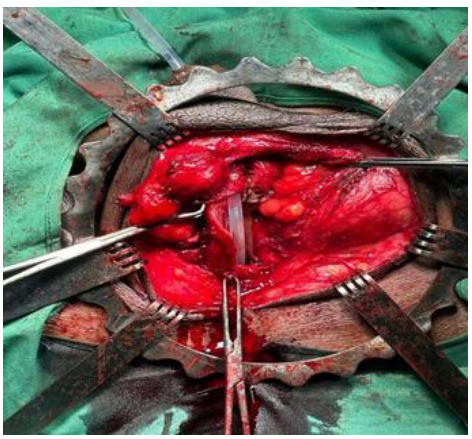

Image 1 d) Catheter positioned through grafted segment

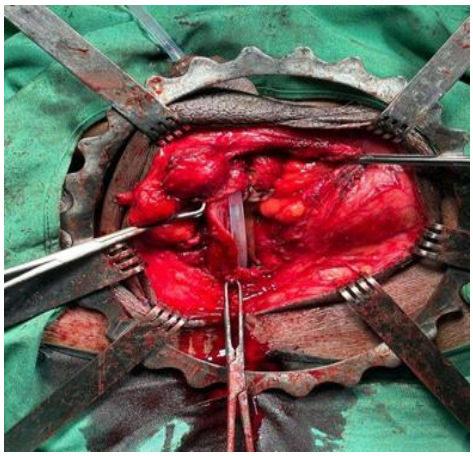

Image 1 e) Lumen inspection after graft placement

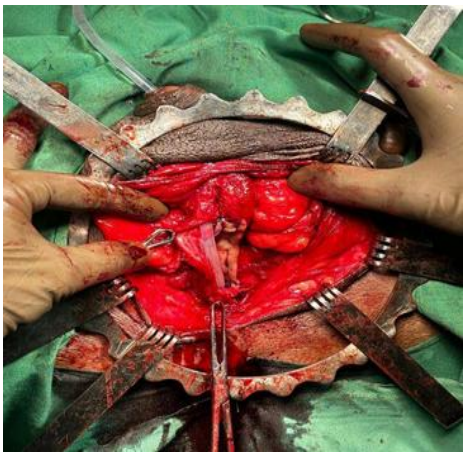

Image 1 f) Final view before closure

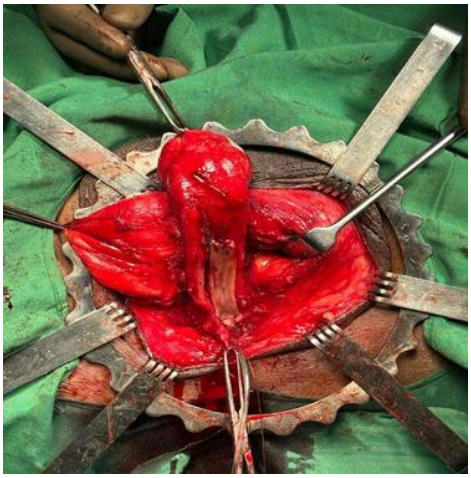

Image 1 g): Graft bed preparation and bleeding control

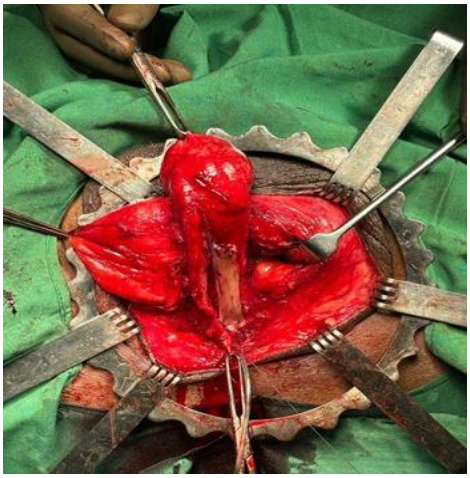

Image 1 h): Mucosal orientation verification before suturing

Radiological Imaging

Image 2 a) Retrograde urethrogram (RGU) (MCU) showing long-segment anterior stricture

Image 2 b) Micturating cystourethrogram showing proximal dilatation and narrowing

Discussion

An author of our study focused on how the comorbidities and age have an impact on complication (Blaschko SD *et al*, 2015). The study gave an insight into urethroplasty outcomes in the US and its huge data set revealed that the hypertensive and diabetic population exhibited higher postop risk. Another author elucidated upon diabetes as a risk factor showing a positive association between

HbA1c levels and the recurrence of post-urethroplasty stricture recurrence (Kay HE *et al*, 2021). Adverse outcomes like wound infection and extended hospital stay have been correlated after urethroplasty with larger body mass index (Alger J *et al*, 2020). Age is yet another risk factor contributing to complications post urethroplasty due to decreasing physiological reserves and increasing incidences of comorbidities in the elderly (Davenport MT *et al*, 2020). The use of tobacco impairs the microvascular circulation predisposing the wound complications and the recurrence of stricture post urethroplasty (McCaffrey N *et al*, 2022). There might be complications in future urethroplasty due to prior manipulations in urethra with repeated catheterizations or endoscopic procedures (Hoare D T *et al*, 2022).

Another author of our study subsequently presented a prospective Nigerian series with a 90.9% success rate and noted the possibility of BMGU even in low-resource settings (Eshiobo I *et al*, 2016). Another systematic review showed comparable outcomes between bulbar and penile urethroplasties indicating that BMGU as a viable option (Jasionowska S *et al*, 2022). The length and location of the stricture also dictate the urethroplasty type with longer strictures requiring more complex techniques like multi-stage repair or grafts carrying greater complication risk when compared to simpler excision or anastomosis (Güler Y *et al*, 2021).

Another author of our systematic review further contributed that penile urethral strictures are independently linked with increased recurrence, and documented tolerable complications like post-micturition dribbling and erectile dysfunction (Spilotros M *et al*, 2017). This was stressed upon in another study where the success of urethroplasty was found to be intricately linked to conscientious surgical techniques including precise tissue handling, tension free anastomosis sufficient vascular preservation (Otele W H *et al*, 2015).

Yet another study included in our systematic review compared various graft placements and noted better results with ventral onlay for proximal bulbar strictures, noting anastomotic failure as a key predictor of recurrence (Pathak HR *et al*, 2017). An indwelling catheter is an essential component of post-urethroplasty management that prevents stricture formation and diverts the urine flow (Shalkamy O *et al*, 2021). Imaging modalities like retrograde urethrography and voiding cystourethrography are effective in post-operative monitoring that aids in early diagnosis of complications like fistula formation, stricture recurrence or diverticula (Hampson LA *et al*, 2014).

Yet another study from our systematic review reported a stratified analysis according to surgical sequence-primary, redo, and secondary repairs—reaffirming that secondary urethroplasty is at much greater risk of failure (Vetterlein MW *et al*, 2018). This was further stated in another study indicating the need to account for more than factors such as the length of the stricture and mechanism while counselling patients (Chapman D *et al*, 2017).

The evidence was further developed by two authors of our study with the inclusion of patient-related outcomes with improved urinary symptom relief, quality of life and sexual function (Soave *et al*, 2019; D'hulst *et al*, 2020). Urethroplasty is a durable and cost-effective method for urethral strictures, blocking out the direct visual internal urethrotomy outcomes, yet not completely ruling out the hovering fear of recurrence (Zaid UB *et al*, 2015).

Yet another study included in our systematic review demonstrated high success rate at increased infection and wound complication rates (Awad SM *et al*, 2021). Similar findings echoed in yet another study that revealed the correlation between postoperative infection and complications pressing on the need for rigorous sterile measures and the use of prophylactic antibiotics in the enhancement of urethroplasty outcomes (Kim S *et al*, 2021).

Yet another study from our systematic review showed that a history of internal urethrotomy (≥3 times) was a high predictor of recurrence (Coguplugil *et al*, 2022). Urethroplasty was suggested as the most definitive treatment approach since there were considerable risks of recurrence involved post multiple internal urethrotomies (Kinnaird A S *et al*, 2014).

A study finally included in our systematic review suggested that penile location was the primary and sole predictor of recurrence with long term follow-up (Gupta R *et al*, 2024). This was further supported by another study that suggested that the penile urethral strictures were more susceptible to recurrence in comparison to bulbar strictures stressing on the need for tailored surgical interventions on the basis of stricture location (Oyelowo N *et al*, 2020).

The important findings, merits and gaps were tabulated (**Table 5,6**).

The retrospective Karuna cohort supported the findings from the meta-analysis, particularly the low complication rate and recurrence profile. Despite the chronic inflammatory background of BXO, patients showed high procedural success. This real-world validation reinforces the adaptability and efficacy of BMGU in both high-resource and constrained environments. Notably, recurrence was lower than pooled estimates, highlighting the benefits of appropriate technique and early referral.

The surgical technique was documented at each step, including stricture exposure, mucosal quilting, and final graft inspection (**Images 1 a, b, c, d, e, f, g, h**).

Catheter placement through the grafted urethral lumen was illustrated (**Image 1d**), while mucosal orientation verification was shown as well (**Image 1 h**).

Preoperative imaging with RGU (**Image 2a**) confirmed the extent of anterior stricture, while MCU (**Image 2b**) demonstrated proximal urethral dilatation and distal obstruction.

Conclusion

This review synthesizes international evidence confirming buccal mucosal graft urethroplasty as a safe, effective, and versatile treatment for anterior urethral stricture. With a 85% pooled success rate, BMGU reflects consistently positive outcomes in varied healthcare systems. Penile site, prior surgery, longer strictures, and late presentation are the major predictors of recurrence. Multivariate analysis has been done to understand the relationship between risk factors.

To enhance outcomes, prompt referral for complete urethroplasty, wise technique choice, and incorporation of PROMs are highly recommended. BMGU is technically feasible as well as favorable to patient-reported function and satisfaction in both the developed and developing world. Future implications, recommendations, and suggestions include that regular application of PROMs (e.g., IPSS, IIEF, EQ-5D) must be made mandatory in the reporting of outcomes following urethroplasty, there should be discontinuation of repeated urethrotomies (>3) prior to final BMGU, and that penile strictures urethral must require individualized techniques, potentially staged repairs, also there must be an increase in low- and middle-income country reconstructive urology training and there is also a need for subsequent multicenter prospective trials need to confirm results with standard definitions and longer follow-up. The retrospective cohort from Karuna Medical College further supported these findings, showing a remarkably low recurrence rate (1.3%) and high short-term success (98.7%) in BXO-related anterior urethral strictures. Intraoperative and radiological documentation validated surgical precision and preoperative planning.

Strengths and Limitations

The study had its own strengths like universal world representation with 10 studies across various economic environments, concurrency of objective results and PROMs, comprehensive assessment of recurrence predictors and complications, combining with a retrospective cohort design including data from Karuna Medical College. However, it also had limitations like the inclusion of mostly retrospective designs and presence of varying lengths of follow-up across trials.

Declarations

Ethical Approval

Ethical approval was obtained from the Institutional Ethics Committee. Data were anonymized and managed in accordance with ethical standards.

Source of Funding

This research was not supported by any specific grants from public, commercial, or non-profit funding agencies.

Conflicts of Interests

The authors report no conflict of interest.

Acknowledgments

We would like to thank our Principal, Dr. S. Vasanthamalai, and General Manager, Mr. Rahim for their immense involvement.

Article Category

Retrospective systematic review and meta-analyses

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