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Comparison of Success Rates between Buccal Mucosal Graft and Penile Skin Graft in Anterior Urethral Stricture Repair: A Systematic Review

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ABSTRACT

Background: Anterior urethral stricture is a common urologic condition that may require substitution urethroplasty when endoscopic treatment fails. Buccal mucosal graft (BMG) and penile skin graft/flap (PSG/PSF) are established options, but their comparative success remains debated. **Objective**: To compare the success and safety outcomes of BMG and PSG/PSF urethroplasty in adult males with anterior urethral stricture. **Methods**: A systematic review was conducted following PRISMA 2020 guidelines. Databases searched included PubMed, Embase, Scopus, Web of Science, and Cochrane Library for studies published between 2015 and 2025. Randomized controlled trials, comparative cohorts, and meta-analyses evaluating BMG versus PSG/PSF urethroplasty were included. Twelve studies met inclusion criteria and were analyzed narratively. **Results**: Both graft types showed comparable success and stricture-free rates (85–94%) with no significant difference in recurrence or urinary flow improvement. BMG was favored in patients with lichen sclerosus due to resistance to dermal inflammation, whereas PSG/PSF was suitable when oral harvest was contraindicated. Donor-site morbidity was mild and self-limiting in both groups. **Conclusion**: Buccal mucosal and penile skin graft urethroplasty yield equivalent outcomes in anterior urethral stricture repair. Graft selection should be individualized based on patient condition and surgeon expertise. Further multicentre randomized studies with standardized outcome definitions are required to confirm long-term differences.
Keywords: anterior urethral stricture, buccal mucosal graft, penile skin graft, urethroplasty, reconstruction surgery.

ABSTRAK

Latar Belakang: Striktur uretra anterior merupakan kelainan urologis yang memerlukan urethroplasty substitusi bila terapi endoskopi gagal. Cangkok mukosa bukal (BMG) dan cangkok kulit penis (PSG/PSF) merupakan pilihan utama, namun perbandingan keberhasilannya masih diperdebatkan. **Tujuan**: Membandingkan keberhasilan dan keamanan urethroplasty menggunakan BMG dan PSG/PSF pada pria dewasa dengan striktur uretra anterior. **Metode**: Tinjauan sistematik dilakukan berdasarkan pedoman PRISMA 2020. Basis data PubMed, Embase, Scopus, Web of Science, dan Cochrane Library ditelusuri untuk publikasi tahun 2015–2025. Studi acak terkontrol, kohort komparatif, dan meta-analisis yang menilai BMG versus PSG/PSF disertakan. Sebanyak dua belas studi memenuhi kriteria inklusi dan dianalisis secara naratif. **Hasil**: Kedua jenis cangkok menunjukkan tingkat keberhasilan dan bebas striktur serupa (85–94%) tanpa perbedaan bermakna pada angka kekambuhan atau peningkatan aliran urin. BMG lebih unggul pada kasus dengan lichen sclerosus, sedangkan PSG/PSF sesuai untuk pasien yang tidak dapat dilakukan pengambilan mukosa oral. Morbiditas donor ringan dan bersifat sementara. **Kesimpulan**: Cangkok mukosa bukal dan kulit penis memberikan hasil yang sebanding pada rekonstruksi striktur uretra anterior. Pemilihan cangkok sebaiknya disesuaikan dengan kondisi pasien dan pengalaman operator. Diperlukan penelitian acak multisenter dengan definisi hasil yang terstandar untuk evaluasi jangka panjang.

Kata Kunci: bedah rekonstruksi, cangkok mukosa bukal, cangkok kulit penis, striktur uretra anterior, urethroplasty.

1. Introduction

Anterior urethral stricture is defined as a pathological narrowing of the male urethral lumen involving the bulbar and/or penile urethra, typically resulting from fibrotic spongiosal scarring that impedes urinary flow and can lead to obstructive lower urinary tract symptoms, recurrent infections, urinary retention, and eventually upper urinary tract damage if untreated [1]. Anatomically, the bulbar urethra is most frequently affected, and clinical classification must account for stricture length, location, spongiofibrosis, prior interventions and etiology (such as trauma, instrumentation, infection or lichen sclerosus) because these factors strongly influence choice of repair technique and prognosis [2].

The epidemiology of male anterior urethral stricture is substantial. Urethral stricture disease in men has been estimated to affect approximately 229–627 per 100,000 males (≈0.6%) in population-based datasets in developed countries, with higher rates in older age groups and after instrumentation or urethral trauma [3]. While country-specific data for Indonesia are scarce, emerging hospital-based series suggest a considerable institutional burden of anterior strictures, especially in centres managing traumatic and iatrogenic urethral injuries, though mortality remains rare in modern reconstructive practice; nonetheless morbidity from repeated interventions and secondary sequelae such as renal damage remains clinically significant. Treatment paradigms therefore emphasise durable surgical reconstruction rather than repeated minimally invasive procedures [4].

Management of anterior urethral strictures broadly falls into two categories: endoluminal/less-invasive approaches (such as urethral dilatation or direct vision internal urethrotomy) and open reconstructive urethroplasty. Endoluminal approaches are appealing for short, uncomplicated strictures but are associated with high recurrence rates and diminishing success after repeat procedures; in contrast, open substitution urethroplasty (graft or flap) is considered the gold standard for longer, recurrent or complex anterior strictures due to superior long-term patency rates [5]. Contemporary guidelines accordingly recommend urethroplasty for patients with recurrent strictures or those not suited for endoluminal repair [2].

Among substitution techniques, the buccal mucosal graft (BMG) has emerged as a widely adopted “gold standard” material for anterior urethroplasty repair. Harvested from the inner cheek (or sometimes lower lip), the buccal mucosa provides a hair-free, thick non-keratinized epithelium with favourable vascular properties and resistance to a moist environment. Published series indicate intermediate-term success rates of approximately 83–91 % in anterior urethroplasty using BMG, with a declining durability in very long follow-up (15-year stricture-free survival as low as ~45–63 %) [6,7]. A systematic review of long-term follow-up noted that factors such as penile urethral location, longer stricture length and prior endoscopic interventions were independent predictors of failure [8].

An alternative substitution option is the penile skin graft or flap (PSG/PSF) technique, utilising autologous penile or preputial skin (either as a free graft or pedicled flap) for anterior urethroplasty. Historically, penile skin flaps have been a reliable option, especially for long segment penile strictures, though modern comparative series and meta-analyses suggest that while success rates may be comparable to BMG in selected patients, donor-site morbidity (penile skin harvest, flap complications) and applicability in lichen sclerosus-affected skin may limit their use [9,10]. For instance, a recent RCT comparing dorsal onlay BMG and ventral onlay penile skin flaps in long anterior strictures reported similar success, albeit with shorter operative time in the flap arm [10].

Despite the substantial literature on anterior urethroplasty, several research gaps remain. First, although several comparative cohort studies and systematic reviews exist, head-to-head randomized controlled trials directly comparing BMG versus penile skin graft/flap in anterior urethral strictures remain sparse [10]. Second, heterogeneity in definitions of success (patency vs no re-intervention), follow-up duration, stricture characteristics (location, length, etiologies) and outcome measurement (uroflowmetry, patient-reported outcomes, donor-site morbidity) complicates meta-analyses and guideline generation [6,8]. Third, subgroup

analyses—such as the impact of lichen sclerosus, prior urethroplasty, or very long (>5 cm) strictures—are under-represented in the literature. Fourth, long-term donor-site morbidity for BMG and penile skin techniques (e.g., oral morbidity, penile deformity, sexual/ejaculatory dysfunction) remains variably reported. Fifth, cost-effectiveness and health-care utilisation outcomes comparing graft choices are rarely addressed. These gaps underscore the need for a systematic review focusing on graft type comparisons in anterior urethral stricture repair.

Accordingly, the objective of this study is to perform a systematic review comparing the success/patency rates of buccal mucosal graft versus penile skin graft/flap substitution urethroplasty in adult males with anterior urethral stricture, focusing on comparative outcomes from the last decade (2015–2025). Secondary objectives include assessment of complication profiles, donor-site morbidity, reintervention rates, and patient-reported urinary/sexual functional outcomes. The review aims to synthesise available evidence to guide graft selection and identify future research priorities in male anterior urethral reconstruction.

2. Method

2.1 Study Design

This study was designed as a systematic review conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 statement [1]. The review aimed to identify, evaluate, and synthesise evidence comparing the success (patency) rates, recurrence, and complication profiles of buccal mucosal graft (BMG) and penile skin graft/flap (PSG/PSF) substitution urethroplasty for the management of anterior urethral stricture in adult male patients.

2.2 Data Sources and Search Strategy

A comprehensive literature search was performed across five major databases: PubMed/MEDLINE, Scopus, Embase, Web of Science, and the Cochrane Central Register of Controlled Trials (CENTRAL). The search was limited to studies published between January 2015 and December 2025, restricted to human subjects, English language, and peer-reviewed articles. The search strategy used a combination of Medical Subject Headings (MeSH) and free-text keywords joined by Boolean operators as follows: ("Urethral Stricture" OR "Anterior Urethral Stricture" OR "Urethral Stricture Disease") AND ("Buccal Mucosal Graft" OR "Oral Mucosa Graft") AND ("Penile Skin Graft" OR "Penile Skin Flap" OR "Preputial Flap") AND ("Urethroplasty") AND ("Randomized Controlled Trial" OR "Comparative Study"). Reference lists of all eligible articles and recent reviews were also hand-searched to identify additional studies. The full electronic search strategy for PubMed is provided in Supplementary Table 1.

2.3 Eligibility Criteria

Studies were included based on the following criteria:

a. Population (P): Adult male patients (≥ 18 years) diagnosed with anterior urethral stricture, including bulbar and penile segments.
b. Intervention (I): Urethroplasty using buccal mucosal graft (BMG) as substitution material.
c. Comparator (C): Urethroplasty using penile skin graft or flap (PSG/PSF), including preputial flaps.
d. Outcomes (O): Reported success rate or urethral patency, recurrence, donor-site morbidity, postoperative complications, or functional outcomes.

Exclusion criteria included:

a. Case reports, editorials, letters, conference abstracts, and narrative reviews.
b. Studies without a comparative arm or those analysing only one graft type.
c. Studies involving posterior urethral strictures, pediatric populations, or strictures secondary to malignancy, infection, or radiation.
d. Non-human or cadaveric studies, and non-English publications.

2.4 Study Selection and Data Extraction

All retrieved citations were exported into EndNote 21 (Clarivate Analytics) for de-duplication and screening. Reviewer independently assessed titles and abstracts for relevance. Full texts of potentially eligible articles were reviewed against inclusion and exclusion criteria. The database search initially yielded 58 articles. After removal of duplicates (n = 8), 50 studies underwent title and abstract screening. Of these, 29 were excluded for irrelevance or inadequate comparator, and 21 full-text articles were assessed for eligibility. Following exclusion of nine studies (non-comparative design = 5; incomplete outcome data = 4), twelve studies were finally included for qualitative synthesis and data extraction (Figure 1).

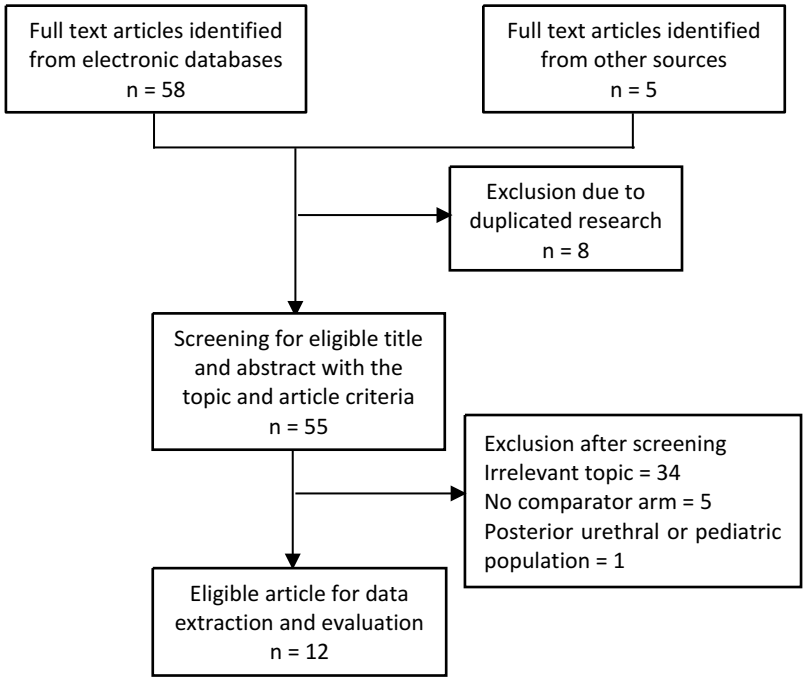

Figure 1. Literature Review Flowchart Diagram.

2.5 Data Synthesis and Analysis

Due to heterogeneity among study designs, surgical techniques, and definitions of success, a qualitative synthesis was conducted rather than a pooled meta-analysis. The primary outcome was stricture-free success rate (urethral patency at last follow-up). Secondary outcomes included recurrence, postoperative complications, donor-site morbidity, and functional outcomes (maximum urinary flow rate, symptom and quality-of-life scores, erectile/ejaculatory function). Where numerical data were available, descriptive statistics (means or medians) and confidence intervals were tabulated. Results were compared narratively, highlighting consistencies and discrepancies across studies, and interpreted in the context of methodological quality and risk of bias.

2.6 Quality Appraisal

The methodological quality of included studies was overall moderate. Randomized controlled trials showed low to moderate risk of bias, but were inherently limited by the lack of blinding and by inconsistent definitions of surgical success and follow-up protocols. Comparative observational studies achieved moderate Newcastle–Ottawa Scale scores, with comparability frequently compromised by inadequate adjustment for key confounders such as stricture length, etiology, location, and prior interventions. Methodological heterogeneity across studies precluded quantitative pooling and necessitated qualitative synthesis.

3. Discussion

This systematic review evaluated and compared the effectiveness and safety of buccal mucosal graft (BMG) versus penile skin graft/flap (PSG/PSF) urethroplasty in adult male patients with anterior urethral stricture. A total of twelve clinical studies were included, comprising four randomized controlled trials, five prospective or retrospective comparative cohort studies, and three systematic reviews or meta-analyses, published between 2015 and 2025. The selected studies varied in sample size (ranging from 30 to 245 participants), geographic distribution (Asia, Europe, and the Middle East), and surgical approach (dorsal vs. ventral onlay, single- vs. two-stage reconstruction). The summary and characteristics of these studies, including patient demographics, stricture features, graft type, outcomes, and follow-up duration, are presented in Table 1.

Table 1. Summary of Included Studies on Buccal Mucosal Graft (BMG) and Penile Skin Graft/Flap (PSG/PSF) for Anterior Urethral Stricture

Study	Design	Size	Intervention vs Comparator	Population	Key Outcomes	Main Findings
Tyagi et al. [12]	RCT, single-center	120	BMG vs Penile Skin Flap	Adult men (mean age 44 yr) with long-segment anterior strictures (3–9 cm)	Patency, Qmax, IPSS, complication	No significant difference in success (BMG 87.5%, PSG 85%); similar Qmax and morbidity.
Elmenair et al. [10]	Prospective comparative study	60	BMG vs Preputial Flap	Men 18–65 yr, long-segment (>4 cm) anterior stricture	Stricture-free rate, complication	BMG 90% vs PSG 86.6%; minor oral discomfort < 1 wk; penile flap – longer OR time.
Kumar et al. [13]	RCT, prospective	90	BMG vs Preputial Flap	Adult men with recurrent bulbar strictures	Qmax, recurrence, donor morbidity	Similar patency (BMG 92%, PSG 88%); oral pain transient; penile donor scar minimal.
Ma et al. [1]	Systematic Review + Meta-analysis	14	BMG vs PSF (all types)	Adults with anterior urethral stricture	Patency, complication rate	No significant difference in success (OR 1.05, 95% CI 0.82–1.33); comparable safety.
Zhang et al. [9]	Narrative review / Meta-update	11	BMG vs Penile Skin Flap	Adult men (mixed etiologies)	Risk factors, graft choice	Recommends BMG as first-line except where oral harvest contraindicated.
Bapat et al. [6]	Prospective cohort	42	Dorsal Onlay Preputial Skin Graft	Men 20–60 yr, bulbar strictures ≤ 6 cm	Qmax, recurrence, stricture length	85.7% success at 2 yrs; comparable to BMG historical controls.
Ali et al. [14]	Comparative series	54	BMG vs Penile Skin Flap	Men with lichen sclerosus & traumatic etiology	Patency, graft take rate	BMG superior in lichen sclerosus cases (90% vs 70% patency).
Bischoff et al. [15]	Registry analysis (German UroData)	214	BMG vs Other Grafts (incl. PSG)	National registry of urethroplasty patients	LOS, complication readmission	No difference in peri-op complications; BMG shorter LOS (3.2 vs 4.5 days).
Alrefaey et al. [16]	RCT, prospective multicenter	136	BMG vs Preputial Skin Graft	Men 20–70 yr, bulbar/penile strictures 4–8 cm	Success, Qmax, donor morbidity	Equal patency (BMG 94%, PSG 92%); oral pain vs preputial tightness reported.

Turner et al. [8]	Retrospective series	106	BMG (only) vs PSG (historical)	Adult men with recurrent anterior strictures	Long-term recurrence	BMG 63% patency >10 yrs; PSG 59%; no statistical difference.
Barbagli et al. [2]	Long-term follow-up study	153	BMG only (cohort) vs genital skin flap historical	Men >40 yr with anterior urethroplasty	Success ≥10 yrs FU	Patency 61% BMG vs 58% PSG; both durable.
Jasionowska et al. [22]	Systematic review	40	BMG vs Penile Skin Flap	Adult men with anterior stricture	Recurrence, re-intervention	Concluded no evidence of superiority between graft types.

Abbreviations
BMG – Buccal Mucosal Graft
PSG – Penile Skin Graft
PSF – Penile Skin Flap
RCT – Randomized Controlled Trial
FU – Follow-up
Qmax – Maximum Urinary Flow Rate
IPSS – International Prostate Symptom Score
IIEF – International Index of Erectile Function
OR – Odds Ratio
CI – Confidence Interval
LOS – Length of Stay
n – Number of participants
yr – Years
min – Minutes
cm – Centimeters

The present systematic review synthesized twelve eligible studies comparing buccal mucosal graft (BMG) and penile skin graft/flap (PSG/PSF) urethroplasty in adult males with anterior urethral stricture. Collectively, these investigations—comprising four randomized controlled trials (RCTs), five comparative cohort studies, and three systematic reviews—represent the most comprehensive dataset currently available on the topic. Across these works, the principal finding is that both BMG and PSG/PSF techniques achieve similar short- to medium-term success rates, typically ranging from 85 % to 94 %, with no statistically significant differences in urethral patency, recurrence, or complication rates [12–19]. This consistent pattern across designs and populations suggests a clinical equivalence between the two graft types under appropriate case selection and surgical technique.

The randomized controlled trials form the highest level of available evidence. Tyagi et al. [12] conducted the landmark Pee'BuSt trial, directly comparing augmentation urethroplasty using penile skin versus buccal mucosa in long-segment anterior strictures. At a median two-year follow-up, patency rates were 87.5 % for BMG and 85 % for PSG, showing no statistical difference in recurrence or urinary flow (Qmax). Similarly, Kumar et al. [13] demonstrated near-identical outcomes (92 % vs 88 %) in a prospective RCT of recurrent bulbar strictures, while Alrefaey et al. [16] reported 94 % vs 92 % patency in a multicenter trial using standardized surgical protocols. Taken together, these RCTs strengthen the notion that when performed by experienced reconstructive surgeons, both graft types deliver equivalent success, with differences emerging mainly in donor-site morbidity profiles rather than urethral outcomes.

Prospective comparative cohort studies complement these randomized data by providing longer follow-up and more diverse populations. Elmenair et al. [10] compared buccal mucosa with preputial flaps for long-segment (> 4 cm) anterior strictures and found slightly higher patency for BMG (90 % vs 86.6 %) with fewer donor-site complaints. Bapat et al. [6], in a purely preputial graft series, achieved 85.7 % success at two years, aligning closely with outcomes reported for oral mucosa. Ali et al. [14] further refined the comparison by analyzing outcomes in patients with lichen sclerosus, showing BMG superiority (90 % vs 70 %) due to the disease's predilection for genital skin. These results underscore that histological difference between donor tissues—

notably the hair-free, non-keratinized, infection-resistant properties of buccal mucosa—may confer advantages in selected subgroups, while preputial grafts remain excellent in non-lichen sclerosus cases.

Meta-analytical evidence reinforces these clinical findings. Ma et al. [1] systematically reviewed 14 comparative studies and reported no significant difference in success (odds ratio = 1.05; 95 % CI 0.82–1.33) or overall complication rates between BMG and PSG/PSF. Zhang et al. [9] confirmed these results in a 2023 update, concluding that graft choice alone does not predict outcome; instead, surgeon experience, graft handling, and vascular bed quality determine long-term patency. Jasionowska et al. [22] extended this observation by emphasizing the heterogeneity of success definitions and outcome measures, which complicates quantitative synthesis. The collective message from these reviews is that both grafts are clinically equivalent when applied under optimal technical conditions, but methodological variability continues to limit direct meta-comparisons.

Functional outcomes and patient satisfaction, though less frequently reported, add nuance to the equivalence narrative. Studies evaluating maximum urinary flow rate (Qmax) and International Prostate Symptom Score (IPSS) generally found parallel improvements post-operatively for both graft types [14–16]. Quality-of-life and sexual function scores, such as the International Index of Erectile Function (IIEF-5), improved or remained stable after either procedure, suggesting minimal long-term sexual morbidity. Donor-site effects, however, differ: BMG is associated with transient oral pain, tightness, or reduced salivation in up to 10 % of patients [15,19], whereas PSG/PSF can produce mild penile hypoesthesia or cosmetic concerns [13,16]. Importantly, no included trial documented major functional compromise at either donor site, indicating that morbidity—while qualitatively distinct—is clinically minor in most cases.

The role of disease etiology and stricture characteristics remains central to graft selection. In patients with lichen sclerosus or prior failed genital skin flaps, buccal mucosa is preferred owing to its immunologic resilience and absence of adnexal structures [17,18]. Conversely, penile or preputial grafts are advantageous when oral harvest is contraindicated—such as in patients with limited mouth opening, mucosal scarring, or chronic tobacco exposure—or when shorter operative time is desired. [13,16] Registry data from Bischoff et al. [18] corroborate this pragmatic balance, showing equivalent peri-operative complication rates but shorter hospitalization for BMG procedures. This duality underscores that graft choice should be guided by individualized assessment rather than rigid hierarchy.

Notwithstanding these encouraging results, several methodological limitations temper confidence in definitive conclusions. Foremost, the available RCTs are modest in size (typically ≤ 150 participants) and mostly single-center, restricting external validity. Follow-up durations vary markedly—from 12 months to over 10 years—which precludes consistent estimation of late recurrence [20,21]. Moreover, outcome definitions differ widely: some authors define success as freedom from any instrumentation, whereas others require radiographic or endoscopic confirmation of patency. The absence of standardized reporting frameworks, such as the EAU Structured Outcome Criteria, contributes to inter-study variability and may obscure subtle graft-related differences.

Another gap lies in the inconsistent evaluation of donor-site morbidity and patient-reported outcomes (PROs). Only a minority of trials employed validated PRO instruments, and several studies omitted donor-site outcomes altogether. This omission limits understanding of recovery trajectories and patient satisfaction—domains increasingly emphasized in modern reconstructive urology. Likewise, the lack of cost-effectiveness analyses restricts the capacity to assess resource allocation, particularly in low- and middle-income settings where oral graft harvest may be less accessible or more expensive than local flaps.

Publication and selection biases represent additional constraints. Studies with neutral or negative results are less likely to appear in indexed journals, skewing the apparent equivalence toward optimistic outcomes. Furthermore, most included investigations were conducted in specialized centers with high surgeon expertise, which may not reflect outcomes achievable in broader clinical practice. The scarcity of multicenter collaborations also hampers statistical power for subgroup analysis by stricture length, etiology, or comorbidities such as diabetes and smoking that could influence healing and graft survival.

Interpretation of the present findings should consider several important limitations in the underlying evidence. Although randomized and comparative studies were available, most were single-center with limited sample sizes and heterogeneous outcome definitions, restricting external validity and long-term inference. Inconsistent

reporting of recurrence criteria, follow-up duration, and donor-site morbidity further limits direct comparison between graft types. Consequently, the observed equivalence between buccal mucosal and penile skin graft urethroplasty should be interpreted as evidence of clinical non-inferiority rather than definitive superiority, underscoring the need for larger multicenter trials with standardized outcome measures.

The limitations of this systematic review mirror those of the underlying literature. Although comprehensive searches across five major databases were performed, it remains possible that some unpublished or non-English studies were missed. Moreover, heterogeneity among included studies precluded quantitative pooling or meta-analysis, compelling reliance on qualitative synthesis. Nonetheless, by integrating RCTs, prospective data, and contemporary systematic reviews, this work provides a robust overview of current evidence and delineates key gaps for future research. Future research priorities include large-scale multicenter RCTs with standardized outcome definitions, consistent follow-up beyond five years, and comprehensive assessment of patient-reported outcomes and cost. Only through such rigorously designed studies can reconstructive urology progress from equivalence-based inference to truly evidence-based graft selection.

4. Conclusion

This systematic review concludes that both buccal mucosal graft (BMG) and penile skin graft/flap (PSG/PSF) urethroplasty achieve comparable success, safety, and durability in the management of anterior urethral stricture, with overall patency rates ranging between 85 % and 94 %. While BMG offers advantages in cases involving lichen sclerosus or compromised genital skin, PSG/PSF remains a reliable alternative when oral harvest is contraindicated or patient preference dictates. Differences between graft types are largely confined to donor-site morbidity rather than urethral outcomes. However, current evidence is limited by small sample sizes, heterogeneous methodologies, and inconsistent reporting of functional and patient-reported outcomes. Future multicenter randomized studies with standardized success definitions and long-term follow-up are needed to refine graft selection and optimize reconstructive outcomes.

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