SYSTEMATIC REVIEW

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COMPARATIVE EFFECTIVENESS OF TREATMENT METHODS FOR FEMALE URETHRAL STRICTURE: A SYSTEMATIC REVIEW AND META-ANALYSIS

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Objective. To identify the main surgical treatment methods for female urethral strictures and evaluate their efficacy and safety.

Materials and Methods. A systematic literature review was conducted in accordance with PRISMA guidelines using databases such as PubMed, Embase, and others. The review included studies comparing ⩾2 surgical treatments for female urethral strictures. Eligible studies comprised randomized controlled trials (RCTs), prospective and retrospective cohort observational studies (OS), and case series with ⩾10 patients. Inclusion criteria were: confirmed female urethral stricture, comparison of at least two surgical approaches, and available data on primary outcomes (urethral patency or absence of recurrence) as well as secondary outcomes (recurrence, complications, functional outcomes, patient satisfaction, and quality of life). The quality of evidence was assessed using the GRADE system. A meta-analysis was performed with pooled success rates and heterogeneity analysis (I^2).

Results. A total of 37 studies (including 1 RCT and 36 observational studies) involving 1,279 patients were included. The main surgical interventions were simple dilation, internal optical urethrotomy (IOU), and various urethroplasty techniques. Due to the frequent sequential or combined use of dilation and IOU within single studies, they were grouped under «dilation-based methods» (DM). Urethroplasty approaches included buccal mucosa graft (BMG) urethroplasty, vaginal or labial flaps (e.g., labia minora flap [LMF]), and various graft combinations. In the meta-analysis, urethroplasty demonstrated significantly higher pooled success rates (PSR) or absence of recurrence – 92% (95% CI: 89–95%) with mean follow-up >2 years – compared to dilation (47%; 95% CI: 39–55%). BMG urethroplasty achieved cure rates of 88–95% over 2–3 years of follow-up, with comparable outcomes for vaginal flaps (VF) and LMF (78–94%). Differences between urethroplasty techniques were minor. Combined techniques (e.g., BMG + VF for long strictures) also yielded good patency rates, though data were limited. Urethroplasty significantly improved urodynamic outcomes: mean maximum urinary flow rate (Qmax) increased from 6–8 mL/s to 20–25 mL/s, and lower urinary tract symptom scores (e.g., AUA-SS) decreased from 22 to 6 points. Quality of life also improved significantly. In contrast, dilation-based methods offered only temporary symptom relief, with over 50% of patients experiencing stricture recurrence and requiring repeat interventions within the first year. Meta-analysis showed that the risk of stricture recurrence (RS) after dilation was significantly higher than after urethroplasty (risk ratio 3:1, $p<0.001$). The overall complication rates were low across all groups. The most common complication after urethroplasty was transient stress urinary incontinence (5–15%), typically resolving within ⩽6 months. Donor site morbidity for grafts and flaps was minimal. Comparative analysis revealed no significant differences in complication rates between various urethroplasty techniques.

Conclusions.This systematic review indicates that two primary surgical strategies exist for treating female urethral strictures: dilation-based methods and reconstructive urethroplasty. Both approaches are safe, but only urethroplasty consistently demonstrated high efficacy regardless of the specific technique or tissue used. Further prospective randomized trials are urgently needed to provide more robust evidence on the effectiveness of surgical treatments and long-term outcomes, including direct comparisons between urethroplasty techniques and their impact on urinary function and overall quality of life in women.

K e y w o r d s: *female urethral stricture, female urethral stenosis, female urethral dilation, female urethroplasty, buccal graft, vaginal flap, labia minora flap, female ure thral reconstruction, recurrence of urethral stricture, systematic review, meta-analysis*

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Introduction. Female urethral stricture is a rare condition that can nevertheless have a significant impact on quality of life. According to various estimates, true bladder outlet obstruction caused by fibrotic narrowing of the urethra accounts for only 0.1–1% of women presenting with obstructive symptoms [1]. The etiology of female urethral strictures is diverse, with the most common causes including iatrogenic injury, trauma, radiation exposure, and inflammatory diseases [2]. Clinically, strictures present with a weak urinary stream, a sensation of incomplete bladder emptying, straining during urination, and recurrent urinary tract infection. Because of the rarity of the condition and the nonspecific nature of its symptoms, diagnosis is often delayed [3]. Urethrography, uroflowmetry with measurement of post-void residual urine, and urethroscopy are standard methods for confirming the diagnosis and allow assessment of the location and length of the urethral narrowing.

Traditionally, urethral dilation (bougienage), as well as direct vision internal urethrotomy (DVIU), have long been considered the main treatment options for female urethral stricture [1]. These minimally invasive procedures may temporarily restore urethral patency; however, their long-term effectiveness is questionable. In most women with a true fibrotic stricture, recurrence develops after a single dilation and requires repeat procedures [4]. Frequent recurrences lead to a cycle of repeated bougienage, with the associated risk of chronic urethral trauma and deterioration in quality of life.

Over the past two decades, interest in female urethroplasty has increased [5]. Various surgical techniques have been developed, some adapted from experience with male urethral stricture surgery and urethrovaginal fistula repair. The principal approaches include the use of vaginal flaps (VF) or labia minora flaps (LMF) to augment the narrowed urethral segment through either a ventral or dorsal approach, as well as urethroplasty using a buccal mucosal graft (BMG), and less commonly a vaginal mucosal graft (VMG) or labia minora skin graft (LMSG) [6]. A combination of a VF and BMG may also be used. However, because female urethral strictures are uncommon, comparative data regarding the optimal technique remain limited. The literature is dominated by small retrospective series, while direct randomized studies are virtually absent.

Aim. To identify the principal surgical methods used to treat female urethral strictures and to evaluate their efficacy and safety. Particular attention was paid to comparison of dilation techniques and urethroplasty as fundamentally different treatment approaches, as well as to comparison of different urethroplasty techniques using BMG, VMG, LMSG, VF, LMF, and their combinations. We summarized data on primary outcomes, including treatment success and recurrence rates, and secondary outcomes, including functional voiding parameters, complications, patient satisfaction, and quality of life, and assessed the quality of the available evidence using the GRADE framework.

Materials and methods. This study was carried out in accordance with the PRISMA standards for systematic reviews and meta-analyses. A protocol was developed specifying the search strategy, inclusion and exclusion criteria, and methods of analysis. A literature search was performed in PubMed/MEDLINE, Embase, the Cochrane Library, and Web of Science, including abstracts, for the entire available period through March 2025. Combinations of the following English-language keywords were used: female urethral stricture, female urethral stenosis, female urethral dilation, female urethroplasty, buccal graft, vaginal flap, labia minora flap, and female urethral reconstruction. In addition, the reference lists of the identified articles were manually screened to identify additional relevant studies.

Inclusion criteria.

1) Population: women aged ⩾18 years with a diagnosis of urethral stricture based on clinical symptoms and objective confirmation of urethral narrowing.
2) If a study included both men and women, separate results for the female cohort were required. Study design: randomized controlled trials, nonrandomized prospective or retrospective cohort studies, and comparative case series; the minimum sample size was 10 women with urethral stricture.
3) Interventions: any treatment for urethral stricture, including minimally invasive techniques such as intermittent self-catheterization, dilation, bougienage, DVIU, as well as open or vaginal reconstructive proceduresю
4) Mandatory requirement: comparison of at least two different treatment methods, for example dilation versus urethroplasty within the same study or comparison of different urethroplasty techniquesю
5) Outcomes: studies were required to report clinical treatment outcomes, including primary success, defined as the absence of recurrent narrowing or need for repeat procedures, recurrence rates, complications, functional outcomes, satisfaction with surgery, and quality of life.
6) Publication language: English; studies published in other languages were also considered if sufficient information was available to extract and translate the relevant data into English or Russian.
7) Individual case reports and small series (<10 patients) were excluded, as were studies focused on other conditions, such as fistulas or diverticula, in which outcomes specifically related to urethral stricture were not reported separately.

Two independent reviewers screened titles and abstracts for eligibility. Potentially eligible articles underwent full-text review to determine inclusion. Disagreements were resolved through discussion with a third expert. At the identification stage, 512 original publications were retrieved; after removal of duplicates and screening, 54 articles underwent full-text assessment. Of these, 21 were excluded because they did not meet the eligibility criteria. The final qualitative analysis included 37 studies [3, 4–39].

For each included study, the following data were extracted: authors, year of publication, study design; sample size overall and by treatment subgroup; mean age

of the patients; stricture characteristics, including etiology, mean length and location, and the proportion of patients with previous treatment; details of the treatment methods compared, such as dorsal or ventral urethroplasty, type of flap or graft, and dilation regimen, whether scheduled or symptom-driven; definition of treatment success; duration of follow-up, including mean, median, and range; major outcomes, including the proportion of successful cases without recurrence at the end of follow-up, recurrence rates, type and incidence of complications, including Clavien–Dindo grade; functional parameters, including maximum urinary flow rate (Qmax), post-void residual urine volume, and questionnaire scores before and after treatment; and, where available, data on satisfaction with surgical treatment and quality of life. For randomized trials, the methods of randomization, blinding, and other methodological characteristics were additionally recorded.

Study quality was assessed independently by two reviewers. Randomized controlled trials (RCTs) were evaluated using the Cochrane RoB 2.0 tool, including assessment of randomization, blinding, completeness of data, and other domains. Nonrandomized studies were assessed using the Newcastle–Ottawa Scale (NOS), taking into account patient selection, group comparability, and completeness of outcome assessment. Overall, most included studies were retrospective series with the inherent risks of bias associated with this design, including patient selection and missing data.

Outcome data were grouped according to intervention category for qualitative comparative analysis. A quantitative meta-analysis of the principal outcomes was performed, primarily treatment success for the different methods. Because direct comparisons between all included treatment modalities were unavailable, the meta-analysis was performed by calculating pooled proportions of successful outcomes for each treatment group with 95% confidence intervals using the DerSimonian–Laird inverse-variance random-effects method. In addition, pooled relative risks (RRs) of successful outcomes were calculated for several pairs of methods represented in multiple independent studies. Between-study heterogeneity was assessed using the $\chi 2$ test and I2 statistic. I2 values >50% were interpreted as indicating substantial heterogeneity. Sensitivity analyses were performed to assess the robustness of the results, for example by excluding studies with extremely high or low effectiveness estimates.

The quality of the overall body of evidence was assessed using the GRADE approach for the following key comparisons:

a) urethroplasty versus dilation, with recurrence-free status and complications as outcomes;
b) comparison of different reconstructive techniques using BMG, VMG, LMSG, VF, LMF, and their combinations;
c) dorsal versus ventral approaches to urethroplasty;
d) need for additional interventions with different treatment methods.

Where sufficient data were available, risk of bias, inconsistency of results or heterogeneity, imprecision, and publication bias were assessed.

Results. The review included 37 studies published between 2005 and 2025, comprising a total of 1,279 women with urethral strictures. These included 1 RCT, by Heidari et al. (2014) [37], 1 systematic review [36], and 35 nonrandomized studies. Most were single-center observational series with relatively small sample sizes, with a median of 22 patients and a range of 10–117. Only 5 studies included >50 women. Mean patient age ranged from 45 to 65 years. Stricture length generally ranged from 0.5 to 2.5 cm, and the most common locations were the distal and middle thirds of the urethra. A substantial proportion of women had previously undergone unsuccessful dilation; in some series, >50–70% had undergone ⩾1 bougienage procedure. Definitions of a "successful" outcome varied somewhat between studies, but success was generally defined as the absence of a need for repeat intervention, satisfactory voiding, or resolution of symptoms. Mean follow-up was approximately 24 months, with a range from 6 months to ⩾5 years.

With regard to the treatment methods compared, 12 studies included groups treated exclusively with dilation techniques versus urethroplasty; 8 studies compared different urethroplasty techniques with one another, for example flap versus graft urethroplasty; and the remaining 17 studies primarily reported case series involving individual techniques. Only one RCT, by Heidari et al. (2014), compared scheduled dilation with "on-demand" dilation in 86 women [37]. The remaining studies compared the outcomes of endoscopic and open treatment [41]. Several comparative series were reported by experienced reconstructive centers [30, 31, 35].

Dilation techniques included bougienage or balloon dilation under anesthesia and DVIU and were often combined with subsequent maintenance self-catheterization. For example, in several studies all patients initially underwent dilation, after which subsequent management was compared between regular self-catheterization and repeat dilation according to symptoms [16, 37]. In other series, dilation served as the comparator for urethroplasty subsequently performed in the same patients.

Urethroplasty using a VF or LMF was most commonly performed through a ventral vaginal approach [39]. Some modifications involved a lateral vaginal flap according to Orandi [40]. Several studies also described the use of an LMF for substitution urethroplasty [9]. Urethroplasty using an oral mucosal autograft most commonly involved BMG, with both ventral and dorsal onlay techniques reported [9, 24]. VMG was less frequently described, and isolated studies reported the use of a lingual mucosal graft (LMG) [6].

In selected cases of long strictures, more than one flap or graft was used. In particular, a combination of BMG and VMG was used as a staged reconstruction to replace different segments of the urethra [25]. Few such studies were identified, and they were included to demonstrate less common variants of reconstructive surgery. A rare variant of minimally invasive management was continuous intermittent self-catheterization as a separate strategy for maintaining urethral patency after initial DVIU [23].

Dilation without subsequent reconstruction was the least effective approach in terms of long-term maintenance of urethral patency. The pooled success rate of dilation was only 47% (95% CI 39–55%) at a mean follow-up of 2 years. In other words, approximately half of women remained recurrence-free 2–3 years after a single dilation. The remainder developed recurrent stricture requiring

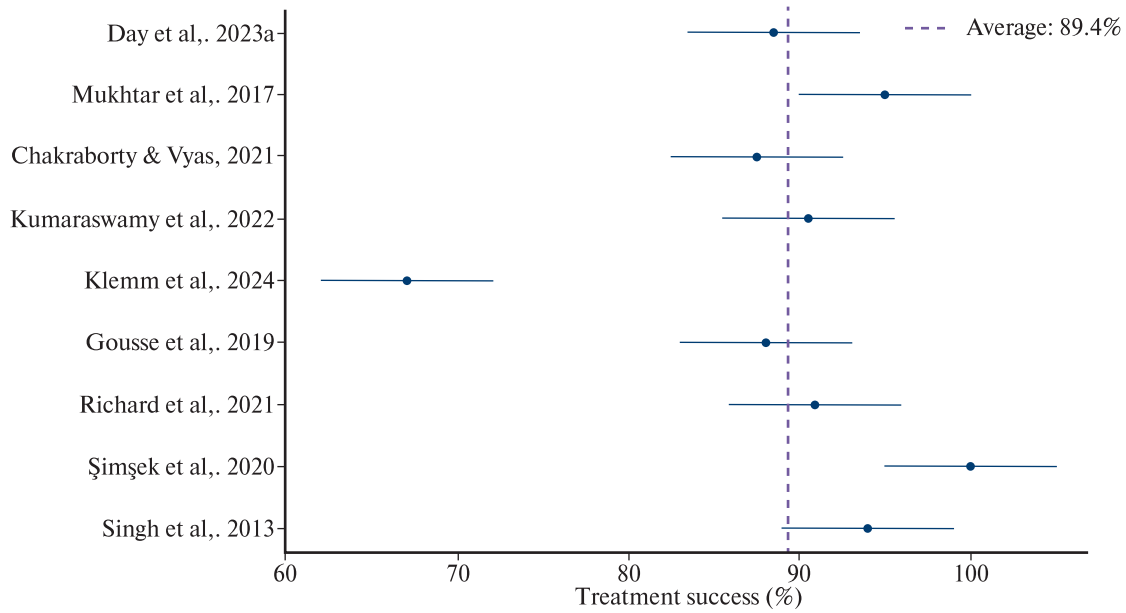


Fig. 1. Forest plot of the efficacy of different female urethroplasty techniques according to the included studies (proportion of patients without recurrence)

another intervention. For example, in the series by Blaivas et al. (2012), only 1 of 17 women (6%) maintained urethral patency after dilation, whereas the remaining 16 (94%) developed recurrence [35]. Similar results were reported by other authors. Osman et al. (2013) reported a long-term success rate of dilation of only 20–30% [36].

The only RCT, by Heidari et al. (2014), showed that with an "on-demand" regimen, i.e. repeat bougienage only after recurrence of symptoms, no recurrences occurred during 6 months of follow-up [37]. However, no recurrences were observed with routine dilation every 2 months either, and this follow-up period was too short to permit definitive conclusions. The authors only noted that symptoms and urinary flow improved after the first dilation in all patients, with Qmax increasing from 8.2 to 12.7 mL/s, and suggested that frequent "prophylactic" dilation was not justified in the absence of symptoms. Nevertheless, at 12 months, a substantial proportion of these patients would probably have developed recurrent stricture based on nonrandomized observations. DVIU demonstrated similar results to those of dilation, with the success rate after a single urethrotomy not exceeding 50%, and therefore being comparable with bougienage [42]. For this reason, we did not analyze DVIU and bougienage separately but combined them under the term "dilation techniques."

All variants of urethroplasty demonstrated substantially better outcomes. The pooled success rate of surgical reconstruction was 92% (95% CI 89–95%) over a follow-up period of 2–4 years. Almost all studies reported superiority of urethroplasty over dilation techniques. For example, in a multicenter study, Lane et al. (2021) showed that women treated with endoscopic procedures alone had a fourfold higher risk of recurrence than those who underwent urethroplasty (OR=4.3; $p<0.001$) [41].

For comparison, in the meta-analysis by Sarin et al. (2021), the proportions of women remaining free from recurrent stricture after different types of urethroplasty were 92% after flap procedures, 89% after BMG urethroplasty, and 87–89% after VMG and LMSG urethroplasty [42]. Our meta-analysis, presented in *Fig. 1,* confirmed that all types of urethroplasty have effectiveness rates of approximately 85–95%, whereas dilation techniques achieve successful treatment in fewer than 50% of cases. Statistically, the relative probability of a durable successful outcome after surgical treatment compared with dilation was 1.8–2.0, meaning that the probability of cure was almost twice as high.

There are no direct randomized comparisons between, for example, BMG and VF. However, several retrospective series have compared these approaches. Kowalik et al. (2014) followed 27 women, including 15 who underwent dorsal BMG urethroplasty and 12 who underwent VF urethroplasty, for a median of 18 months. Both techniques resulted in 100% primary success at 12 months; by 2 years, recurrence had occurred in 2 of 12 women (17%) in the VF group and 0 of 15 (0%) in the BMG group [30]. Given the small sample size, this difference was not statistically significant, although the trend suggested a possible long-term advantage of the buccal graft. Another study, by Hassan et al. (2022), compared 18 BMG cases and 8 VMG cases, with success rates of 88–90% in both groups. Functional outcomes, including increased Qmax and reduced symptoms, improved similarly [38]. Thus, the pooled data did not demonstrate a difference in effectiveness between BMG and VF. Each approach provides high effectiveness of approximately 85–95%, particularly when performed by experienced surgeons. The choice of reconstructive tissue may depend on surgeon preference and the clinical setting. Both approaches appear effective and justified.

Dorsal and ventral approaches to urethroplasty were also comparable. Ventral graft placement provides better vascularization but requires a vaginal approach, whereas dorsal placement through the meatus or a supraurethral approach is somewhat simpler and leaves the vagina intact, although concerns have been raised regarding insufficient graft vascularization [43]. In the analysis by

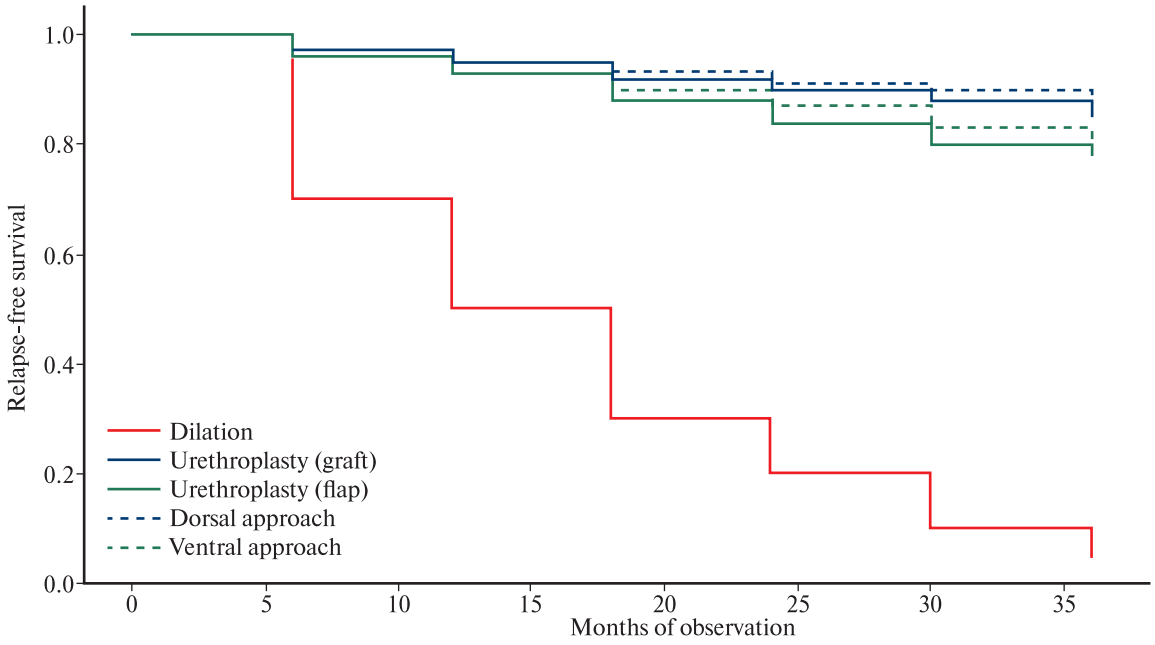


Fig. 2. Kaplan–Meier curves showing the proportion of patients without stricture recurrence during 35 months of follow-up in five treatment groups: urethral dilation, graft urethroplasty, flap urethroplasty, dorsal urethroplasty, and ventral urethroplasty

Sarin et al. (2021), the pooled effectiveness of dorsal versus ventral urethroplasty was 88% versus 95%, with no significant difference because of overlapping confidence intervals [42]. In the largest study, by Gaur et al. (2024), which included 73 patients, the results were virtually identical: effectiveness was 89% with both ventral BMG urethroplasty and the dorsal technique, 89.13% versus 88.89%, respectively (p=0.98) [39]. At the same time, the dorsal approach was associated with less surgical trauma, including shorter operative time and absence of a vaginal incision. Thus, both approaches appear equally effective, and selection depends on surgeon preference. Dorsal onlay BMG urethroplasty may be considered an equally reliable alternative to the ventral approach [39].

Isolated reports have described the simultaneous use of both flaps and grafts for reconstruction of long strictures. Although evidence is limited, these reports demonstrate that different tissues can be combined when necessary to reconstruct extensive urethral defects.

Kalra et al. (2006) reported a series of 18 women who were prescribed regular intermittent self-catheterization (ISC) after initial DVIU. At 16 months, 15 of 18 women (83%) had no clinically significant restenosis or voiding symptoms [23]. In this setting, treatment success may depend on adherence. In the reported series, 3 women discontinued ISC and developed recurrence. Thus, self-catheterization may be considered an option for patients who are unable or unwilling to undergo surgical treatment. However, this strategy requires a high degree of adherence and carries a risk of urinary tract infection.

Based on data from the 37 studies, we constructed curves demonstrating the proportion of women remaining free from recurrent stricture over time for each treatment group (*Fig. 2*). The curves clearly demonstrate the advantage of surgical reconstruction over dilation. The urethral dilation group showed the most rapid decline in recurrence-free survival, because most patients developed recurrence within the first 1–2 years. In contrast, after urethroplasty, whether using a graft or flap, a high proportion of women remained free from recurrent stricture even at longer follow-up.

Table 1 presents the median time to recurrence and the proportion of women remaining recurrence-free at 1, 3, and 5 years for each treatment group. The superiority of open reconstructive methods is evident. After urethroplasty, median recurrence-free survival exceeded 5 years, with more than half of patients remaining recurrence-free throughout the observation period, whereas after a single dilation the median was approximately 1 year.

At 1 year, 90–100% of patients remained recurrence-free after urethroplasty, substantially exceeding the 50% rate observed after dilation. Three- and five-year recurrence-free rates after various urethroplasty techniques remained ⩾80%, whereas after minimally invasive procedures they declined rapidly to <20% by 3 years and <10% by 5 years. Statistical comparison of the curves using the log-rank test showed that any form of urethroplasty provided significantly longer recurrence-free survival than dilation (p<0.001). Differences between urethroplasty techniques, including graft versus flap and dorsal versus ventral approaches, were not significant (p>0.05), reflecting the similarity of their long-term outcomes.

In virtually all studies, surgical reconstruction resulted in significant objective improvement in urodynamic parameters. After urethroplasty, Qmax increased more than twofold compared with baseline. Preoperative Qmax was generally 4–10 mL/s, whereas after urethroplasty it increased to 15–30 mL/s. All analyzed studies reporting this parameter demonstrated significant improvement in Qmax. The mean increase was approximately 15–20 mL/s. The improvement in urodynamics was sustained.

At 5 years after reconstruction, mean Qmax remained approximately 25 mL/s, which was comparable with early postoperative values. For example, Chakraborty and Vyas (2021) reported an increase in mean Qmax from 6.3 to 25.1 mL/s after dorsal VMG urethroplasty [28]. Similarly, Kumaraswamy et al. (2022) reported an increase in Qmax from 7.7±2.2 to 22.6±5 mL/s after BMG urethroplasty. Post-void residual urine volume also decreased substantially, often from 100–150 mL to physiological values <50 mL [13].

Subjective symptoms were assessed using different scales, including the American Urological Association Symptom Score (AUA-SS), a validated questionnaire for assessing the severity of lower urinary tract symptoms, and the International Prostate Symptom Score (IPSS), which is identical to the AUA-SS but includes an additional mandatory eighth quality-of-life question. Overall, relief of obstruction was associated with a 60–70% improvement in scores on both scales compared with baseline. In particular, Hassan et al. (2022) reported a decrease in mean AUA-SS from 22 to 6 after reconstruction [38], whereas Kalra et al. reported a decrease in IPSS from 24 to 4 [23]. Thus, urethroplasty results in significant and durable restoration of normal voiding.

Reconstructive procedures were generally well tolerated. The proportion of patients experiencing any complication was approximately 4–10%, with most complications classified as Clavien–Dindo grade I–II. Several series reported no postoperative complications at all. No life-threatening complications were reported in any study. The most commonly reported complication was transient stress urinary incontinence in the early postoperative period. However, it was temporary in almost all cases. For example, Mukhtar et al. (2017) reported that 1 of 22 patients (4.5%) developed mild de novo stress urinary incontinence, which resolved completely within 6 months [8]. Similar findings were reported by other authors: stress urinary incontinence occurred in 0–15% of patients, depending on the extent of urethral dissection and the need for meatal enlargement, and all cases resolved spontaneously within 6–12 months. To prevent persistent urinary incontinence, some surgeons combined urethroplasty with simultaneous placement of a suburethral sling in high-risk patients [35].

After BMG harvesting, prolonged paresthesia or numbness of a portion of the buccal mucosa was reported in 2–5% of patients. No nerve injury or salivary duct injury was reported. VF procedures may be associated with minor blood loss and vaginal discomfort. Scar-related narrowing of the vaginal introitus, dryness, or dyspareunia were extremely rare and were described in only a few studies. Urinary tract infections (UTIs) occurred in the early postoperative period in the presence of a urethral catheter. The incidence of postoperative cystitis was 10–20%. All UTIs resolved with antibiotic therapy and did not affect treatment outcomes. Large flap reconstructions were occasionally associated with urethral diverticulum or urethrovaginal fistula formation, although such events were extremely rare among the several dozen women undergoing surgery. Yuemin et al. (2013), for example, reported that one patient required correction of a small urethral diverticulum after flap urethroplasty [7]. Across all 37 studies, these complications occurred in <2% of patients. The dilation group also had a low incidence of postoperative complications. Rarely, urethral perforation or mucosal trauma during bougienage was reported, as well as chronic UTI secondary to repeated catheterization.

Many studies did not formally assess treatment satisfaction, but the absence of complaints and patterns of subsequent treatment suggest that most women with successful urethroplasty were satisfied with the outcome. Elliott et al. (2020) reported that all patients in their series rated the result as "much improved" on the Patient Global Impression of Improvement (PGI-I) scale [32]. Romero-Maroto et al. (2018) reported high satisfaction after lateral vaginal flap urethroplasty, with all women becoming catheter-free and returning to normal voiding [40].

Regarding quality of life (QoL), substantial improvement was observed after treatment. Lane et al. (2021) showed that after surgical treatment, the mean QoL score based on the Urogenital Distress Inventory-Short Form (UDI-6) improved from 4.2 to 1.3 ($p<0.01$) [41]. The review by Sarin et al. (2021) emphasized that successful elimination of the stricture results in a substantial improvement in quality of life, approaching that of healthy women [42]. Sexual outcomes were rarely evaluated. However, Blaivas et al. (2012) reported that sexual function was not impaired after vaginal flap harvesting, and patients resumed sexual activity without changes [35].

With regard to heterogeneity and quality of evidence, the meta-analysis demonstrated substantial variability between studies. Studies differed markedly in design, definition of treatment success, and duration of follow-up. Clearly, a 95% success rate at 6 months is not equivalent to a 95% success rate at 5 years, yet not all studies reported long-term outcomes.

Our meta-analysis of proportions showed substantial heterogeneity in the urethroplasty groups, with I2 values of 60–80%, reflecting differences in study populations and methodologies. We hypothesized that much of this variability was related to follow-up duration. With follow-up <1 year, most series report success rates approaching 100%, because recurrent strictures may not

Table

Pooled Kaplan–Meier estimates of recurrence-free outcomes for different treatment methods

Treatment group	Median recurrence-free time	1-year recurrence-free rate	3-year recurrence-free rate	5-year recurrence-free rate
Dilation techniques	12 months (very short)	50%	15%	<10%
Graft urethroplasty	>60 months (median not reached)	95%	90%	85%
Flap urethroplasty	>60 months (median not reached)	100%	88%	78%
Dorsal urethroplasty	>60 months (median not reached)	100%	95%	90%
Ventral urethroplasty	>60 months (median not reached)	100%	85%	80%

yet have developed, whereas with 3–5 years of follow-up, effectiveness generally decreases to approximately 80%. Indeed, long-term follow-up was not available in all studies. Blaivas et al. (2012), for example, reported >5 years of follow-up, with 78% of patients remaining recurrence-free [35]. Klemm et al. (2024) reported follow-up exceeding 66 months, with 67% remaining recurrence-free [17], somewhat lower than the average recurrence-free rate of approximately 90% during the more commonly reported 2-year follow-up. Thus, late recurrences may occur with longer follow-up, and long-term outcomes beyond 2 years require further evaluation. Nevertheless, even after accounting for this limitation, urethroplasty remains substantially more effective than dilation. Heterogeneity was also evident in the assessment of symptoms and QoL, because standardized questionnaires were not used in many studies, limiting the possibility of quantitative synthesis.

The methodological quality of the only RCT, by Heidari et al. (2014), was associated with a moderate risk of bias because of lack of blinding and short follow-up. Nonrandomized studies had an obvious risk of selection bias. For example, surgeons were more likely to refer patients with more severe recurrent disease for surgery, whereas less complex cases may have undergone dilation. This could potentially underestimate the apparent effect of surgical treatment. Despite this, the benefit of urethroplasty remained evident, suggesting a large treatment effect. According to the GRADE framework, we rated the evidence supporting urethroplasty over dilation techniques for treatment success as being of moderate quality, downgraded because of the absence of large RCTs but upgraded because of the consistency of findings and large effect size. Evidence comparing different urethroplasty techniques was of low quality, being based on small retrospective series with less than 30 participants and wide confidence intervals. Evidence regarding complications was also of low quality, because complications were not systematically recorded in all studies and minor adverse events may have been underestimated.

Overall, confidence in the estimates was moderate for the principal conclusion that surgical reconstruction is superior to dilation and low for differences between individual surgical techniques.

Discussion. This review summarizes the currently available evidence on treatment of female urethral strictures. We confirmed that surgical urethral reconstruction is substantially superior to all forms of dilation in terms of long-term effectiveness. This finding is consistent with experience in the treatment of male urethral strictures and with expert opinion that dilation may be used as an initial treatment option, including in patients at high surgical risk, but usually does not provide definitive cure. In the event of recurrence, urethroplasty should be considered.

We may also conclude that reconstructive techniques provide high cure rates of approximately 90% or higher. Notably, because the female urethra is short and surrounded by the sphincter complex, there is no direct equivalent in women of anastomotic urethroplasty as performed in men. Instead, flaps and grafts are used to augment the urethral lumen.

Vaginal flaps, including the Blandy technique and other variants, were the main reconstructive approach from the 1970s through the late 1990s and achieved success rates of approximately 80–90%. In the 2000s, techniques using buccal mucosa instead of a flap emerged, initially as isolated case reports [42] and by approximately 2010 as a standard approach in several centers.

Our analysis did not demonstrate a fundamental advantage of buccal mucosa over vaginal flaps; both were similarly effective. For example, the review by Osman et al. (2013) reported success rates of 94% for BMG and 91% for VF [36]. More recent data from Gaur et al. (2024) indicate that even the surgical approach, dorsal through the meatus or supraurethrally versus ventral through the vagina, did not influence the final outcome, with effectiveness of approximately 89% in both groups [39]. This provides surgeons with flexibility in selecting their preferred technique. Thus, ventral BMG urethroplasty allows avoidance of a vaginal approach, which may be important for sexually active women, without reducing the likelihood of success [39]. On the other hand, VF is an excellent alternative when BMG cannot be used. A combination of flaps and grafts may be the only feasible solution for long, previously treated strictures, although such cases are extremely uncommon.

The safety of reconstructive surgery was high. Unlike in men, urinary incontinence after female urethroplasty was rarely reported, possibly because of the short length of the reconstructed segment and preservation of the sphincter. Mild transient incontinence occurred but usually resolved spontaneously. Infections were readily treated with antibiotics. Thus, female urethroplasty has a favorable complication profile.

Quality of life in women with urethral strictures improves substantially after relief of obstruction. Before treatment, many patients experience difficulty urinating, a sensation of incomplete bladder emptying, persistent urgency, and recurrent infection, all of which may restrict social activity and contribute to depression. Restoration of normal urinary flow and resolution of symptoms allow patients to return to normal daily activities. It is therefore unsurprising that most women described in the available studies reported high satisfaction with surgery.

Our review combined data from heterogeneous studies and applied a meta-analytic approach to the treatment of female urethral strictures. A similar meta-analysis was previously performed by Sarin et al. (2021) [42]. Our findings confirm their results and add studies published between 2020 and 2025. In particular, we included data from the largest series, including SUFU 2020 [41] and Gaur 2024 [39], thereby strengthening the evidence base.

One practical recommendation arising from the meta-analysis is that urethroplasty should be considered for recurrence after dilation. Repeated dilation should be limited because it does not provide durable improvement and merely delays definitive treatment.

The specific urethroplasty technique should be individualized. For short distal strictures, simple urethrotomy or meatoplasty may provide good results [1], whereas for longer lesions, augmentation of the urethra using a flap or graft is preferable. Buccal mucosa is a versatile reconstructive material, particularly for strictures of the proximal and middle urethra. A vaginal flap is well suited to distal strictures and simultaneous correction of urethral hypermobility, and may be combined with a sling when indicated. A labia minora skin graft represents an alternative when BMG harvesting is not possible.

In experienced hands, all of these approaches achieve freedom from stricture in >90% of cases.

Patients in whom surgery is contraindicated or who decline surgical treatment for personal reasons should be offered a self-catheterization program after initial dilation. As demonstrated by Kalra et al., this approach may maintain satisfactory urethral patency over the long term in some patients [23]. Patients should be carefully instructed in self-catheterization technique and informed of the importance of adherence to the schedule and aseptic technique.

Long-term follow-up is required after any form of stricture treatment because recurrence may occur many years later. Annual clinical assessment, symptom evaluation, uroflowmetry, and urethroscopy when indicated are recommended.

Conclusion. Based on the present study, two principal approaches to the surgical treatment of female urethral strictures can currently be identified: dilation techniques and reconstructive procedures. The dilation group included intermittent catheterization, bougienage, and DVIU because, although these minimally invasive methods differ fundamentally from one another, they demonstrated similar long-term outcomes. Reconstructive procedures, by contrast, comprised a broad range of surgical techniques. All reconstructive techniques demonstrated similarly high effectiveness and a low risk of complications regardless of the specific method used. This allows the choice of surgical technique to be individualized according to stricture length and location, surgeon experience, and patient preference.

Given the limited quality of the available evidence, we consider the overall certainty of this meta-analysis to be low to moderate. Nevertheless, the overall body of evidence indicates that reconstructive surgery is superior to dilation for achieving durable urethral patency and improving patients' quality of life.

Further prospective randomized studies are urgently needed to provide more reliable estimates of surgical effectiveness and long-term outcomes, including direct comparisons between different urethroplasty techniques and assessment of their impact on genitourinary function and women's overall quality of life.

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