SYSTEMATIC REVIEW

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RECONSTRUCTION OF THE FEMALE URETHRA DURING ITS DESTRUCTION: A SYSTEMATIC REVIEW AND META-ANALYSIS

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In accordance with the PRISMA protocol, a comprehensive literature search was conducted, and based on a systematic review and meta-analysis, the effectiveness of various surgical approaches for complete or partial urethral destruction in women was evaluated. A total of 36 studies were included, encompassing more than 500 female patients with severe urethral injury. The analysis incorporated retrospective case series, cohort and comparative studies, as well as one systematic review. The primary outcomes assessed were urethral patency restoration, urinary continence, recurrence rate, complications, and the need for re-interventions. Statistical analysis included a meta-analysis of success proportions using a random-effects model; the level of evidence was evaluated according to the GRADE system.

The best outcomes were observed with urethroplasty using autologous tissues (buccal mucosa, vaginal and labial flaps), which provided long-term urethral patency (88.2%; 95% CI, 82–93%) and preservation of continence. Other urinary diversion techniques (urethroclesis, suprapubic fistula, Monti procedure) achieved continence in the majority of patients with severe comorbidities (success rate 78%), but were associated with a high incidence of complications, including infections, stone formation, and progressive renal failure. Tissue urethroplasty remains the most effective and safest method of urethral reconstruction in women. Minimally invasive procedures should be regarded as temporary measures, while diversion operations should be reserved for the most severe cases.

K e y w o r d s: *female urethra, female urethroplasty, female urethral reconstructive surgery, female urethral destruction, radiation-induced urethral injury, urinary diversion in women, Monti principle, PRISMA, meta-analysis, urethral radiation necrosis.*

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Introduction. Complete destruction (loss) of the female urethra is an extremely rare complication in which the urethral canal is absent along its entire length from the bladder neck to the external meatus. Such patients develop continuous urinary incontinence due to the absence of the urethral sphincter. Most commonly, this condition occurs as a severe form of genitourinary fistula in women after complicated childbirth: prolonged obstruction during labor may lead to ischemia and necrosis of the anterior vaginal wall, including the urethra [1, 2]. As a result, a large defect is formed with separation (detachment) of the urethra from the bladder at the level of the neck, the so-called "complete disruption of the vesicourethral segment" [3]. According to Cisse (2022), such complete disruptions account for up to 30–35% of all urogenital fistulas [3].

Another cause of complete urethral loss may be long-term bladder catheterization. Prolonged indwelling urethral catheterization in neurological patients (with spinal cord injury, multiple sclerosis and other neurological diseases) often leads to urethral pressure sores and subsequent fibrotic replacement of its wall. Andrews and Shah were the first to describe this problem in women with neurogenic bladder as the "incompetent urethra" syndrome after chronic catheterization [4, 5]. Clinically, this presents as urine leakage around the catheter, and attempts to solve the problem by increasing catheter size only aggravate urethral damage and urine leakage [4]. Ultimately, the "urethral desquamation" syndrome develops (a term introduced by Morgan et al., 1978 [6]), a condition in which the urethra is essentially

atrophic and transformed into a wide, non-continent channel.

Urethral destruction in women may also result from pelvic trauma, which is less common compared to men (for example, in road traffic accidents). A typical pattern is complete distraction injury with separation of the urethra from the bladder due to pelvic fractures. Although rare, such cases have been reported. According to the review by Solanki et al., the incidence of urethral injury in women is 6% among those with pelvic fractures [7]. In severe cases requiring life-saving emergency surgery, the female urethra is sometimes not reconstructed immediately, and definitive repair is postponed, which also leads to secondary atrophy of the urethral stump.

Regardless of etiology, patients with complete urethral loss suffer from total urinary incontinence, resulting in severe hygienic and psychological consequences. In contrast to typical fistulas, there is no "target" for direct fistula closure, since there is insufficient residual urethra that could simply be anastomosed to the bladder neck. It is therefore necessary either to create a new urethral channel from other tissues or to restore urinary drainage via an alternative route.

Surgical management of this pathological condition has historically evolved along two parallel pathways. On the one hand, as early as the 1960s, obstetricians and gynecologists working with fistula patients (primarily in Africa) sought to restore a woman's ability to void via the natural route. The classic work of Reginald and Catherine Hamlin (Ethiopia) demonstrated the feasibility of creating a new urethra from vaginal tissues: in 1969 they reported a series of 50 patients with complete urethral loss who underwent simultaneous repair of the vesicovaginal fistula and tubular vaginal urethroplasty reinforced with the gracilis muscle [8]. This "anatomical reconstruction" approach aims to create a neourethra capable of maintaining continence, which, however, also requires restoration of a sphincter mechanism. Various anti-stress techniques have been used for this purpose, including transposition of the bulbocavernosus muscle (Ingelman–Sundberg procedure as modified by Hamlin), interposition of a vascularized fat pad (Martius flap) and others.

On the other hand, an alternative to reconstruction is urinary diversion by closure of the bladder neck with suprapubic drainage, abandoning attempts to restore the urethra. In 1994, M. B. Chancellor et al. proposed functional urethral closure with a pubic sling, with subsequent drainage of the bladder through a suprapubic cystostomy [9]. In other cases, complete closure of the bladder neck and urethra (urethroclesis) has been performed via an abdominal or vaginal approach with placement of a cystostomy tube [4, 10]. For socially active patients, a continent catheterizable stoma has been developed based on the Monti principle: a segment of small bowel is used to create a channel between the bladder and the skin (analogous to the Mitrofanoff appendicovesicostomy) [11].

These options raise several practical questions for clinicians:

– Which method offers the highest likelihood of durable urethral reconstruction and continence restoration?
– What is the true risk of complications associated with each approach?
– For the most complex patients (e.g. with neurological disorders), is it preferable to attempt urethral reconstruction or to proceed directly to urinary diversion?

Aim. To systematize the available literature on these issues.

Materials and methods. We performed a systematic review of all clinical studies reporting surgical treatment of complete or partial destruction of the female urethra, and carried out a comparative analysis of the outcomes of different strategies: tissue-based urethral reconstruction versus various forms of urinary diversion.

Systematic review design. The review was conducted in accordance with PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. Inclusion criteria were defined using the PICO framework.

Population (P): women (⩾18 years) with complete or near-complete urethral destruction, defined as anatomical absence of the urethra or non-patency over a substantial length due to trauma, iatrogenic injury, prolonged catheterization, irradiation injury, etc. Studies on female urethral strictures were eligible if it was clear from the context that the stricture was total (i.e. effectively obliterative).

Intervention (I): any therapeutic procedure for this condition, including surgical urethral reconstruction (using various techniques) or creation of alternative urinary drainage pathways (urethral occlusion, cystectomy with suprapubic cystostomy, ileocystostomy, etc.).

Comparisons between groups undergoing local tissue urethral reconstruction versus various types of urinary diversion were based on primary outcomes: (1) successful urethral reconstruction, defined as absence of need for re-intervention and sustained urethral patency [12], and (2) restoration of urinary continence. We also considered major complications (3), such as recurrent stricture/fistula and urosepsis [13].

Given the rarity of the condition, we did not restrict the types of included studies, ranging from larger case series (⩾5 patients) to comparative cohorts and meta-analyses. We excluded reports with fewer than 5 patients, purely descriptive technical notes without clinical outcome data, as well as animal studies and studies in non-relevant populations (men, children). We also excluded papers that did not meet the criteria (e.g. those focused solely on short strictures or fistulas without urethral destruction).

Literature search. A systematic search was performed in PubMed, Scopus, RSCI and Semantic Scholar (via the Semantic Scholar API interface) using the following English-language keywords: female urethral destruction, female urethral loss, urethral loss in women, female urethral reconstruction, urethral substitution in female, bladder neck closure in female, and related terms. The search covered the entire period of available publications up to May 2025. In total, 500 potentially relevant records were identified. After screening, 40 publications were retained for full-text review. Full-text articles were then assessed for eligibility; four papers were excluded (two due to lack of separate data for the female subgroup, one because the series included fewer than five patients, and one due to data duplication in a later publication). Finally, 36 studies were included in the qualitative synthesis.

Data extraction and quality assessment. For each study we recorded the design, sample size, patient characteristics (age, etiology of urethral destruction), details of the

intervention (type of urethroplasty or diversion), length of follow-up and the reported outcomes. Overall, the quality of most included studies was limited by their retrospective design, lack of control groups and small sample sizes. The overall strength of evidence was assessed using the GRADE system, taking into account risk of bias, indirectness, inconsistency (heterogeneity) and imprecision of effect estimates.

Data synthesis. The collected data are presented in a descriptive (narrative) form and summarized in tables and figures. For quantitative assessment, we performed a proportion meta-analysis of successful outcomes for two categories of approaches: (1) tissue-based urethral reconstruction (any type of urethroplasty using the patient's own tissues); (2) diversion procedures involving definitive exclusion of the urethra from the urinary stream (such as urethroclesis, suprapubic cystostomy, cystectomy with enterostomy, or Monti-type procedures). Proportion meta-analysis was carried out using random-effects models (DerSimonian–Laird) after Freeman–Tukey double arcsine transformation of proportions to stabilize variance. Heterogeneity was assessed with the I^2 statistic. All calculations were performed using Python (statsmodels), the R package meta (metaprop), and RevMan 5.4. Pooled estimates are presented graphically as forest plots. Interpretation of the meta-analytic findings was cautious because of the high degree of between-study variability and the heterogeneous nature of the included cases.

Characteristics of included studies. The review comprised 36 sources [1, 3, 4, 7, 9, 11, 13–42], including 30 single-arm case series (27 retrospective and three prospective), five non-randomized comparative studies, and one randomized controlled trial. The publications originated from 15 countries. The largest series were carried out in multidisciplinary urological centers in the USA, the UK, India, Africa and China. Altogether, outcomes were reported for more than 500 women (precise aggregation was difficult due to potential overlap of patient cohorts between some reports). The etiologies of urethral destruction were distributed approximately as follows: post-traumatic pelvic ring injuries account for about 15% of cases, urethral loss related to prolonged catheterization for 20%, obstetric urogenital fistulas with urethral loss for 25%, iatrogenic injury (pelvic surgery, radiation-induced injury of the urethra) for 30%, and other or unclear etiologies for 10%.The mean age of patients ranged from 18 years (in series dedicated to obstetric fistulas) to 55 years (in mixed-etiology cohorts). Duration of follow-up was frequently inappropriate: 15 studies did not report follow-up time at all or limited it to the in-hospital period. In the remaining reports, mean or median follow-up ranged from 6 weeks to 8 years; the most comprehensive follow-up (mean 8 years) was provided in the retrospective series by Husmann & Viers (2020) in neurological patients [13].

In almost all reports, the primary endpoint was the surgical outcome, defined as the absence of need for re-intervention (or absence of recurrent fistula/stricture) at the last follow-up visit. Treatment strategies can be broadly divided into two categories. (1) Urethral reconstruction using autologous tissues. This approach was used in most studies, although the specific techniques varied. Reported options included skin flaps from the labia minora (the so-called Falandry technique [27]), tubularized flaps from

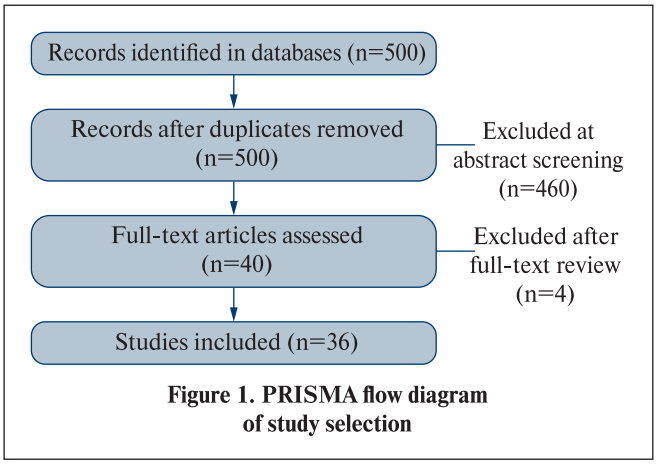


Figure 1. PRISMA flow diagram of study selection

the anterior vaginal wall, free buccal or lower lip mucosal grafts, as well as combinations of these techniques (in one series, three buccal graft techniques were compared in 8 patients [43]). In some cases, bladder tissue was used for urethral substitution, for example an inverted flap of the anterior bladder wall combined with simultaneous fistula closure. Abandonment of urethral reconstruction in favor of various urinary diversion procedures. This strategy was applied in the most complex patients, usually with concomitant bladder dysfunction. Seven studies (15% of patients) reported outcomes after definitive bladder neck closure, creation of a permanent suprapubic fistula (cystostomy), or cystectomy with ureterocutaneostomy. Finally, one study (Osman et al., 2013) was a systematic review of 221 cases of female urethral stricture disease [12]; its data were incorporated into our analysis as a pooled estimate of the efficiency of individual techniques.

Surgical success (restoration of urethral patency). The pooled analysis demonstrated a clear advantage of tissue-based urethroplasty over alternative approaches in achieving a durable anatomical result. Among patients who underwent urethral reconstruction, the pooled success rate was 88% (95% CI 82–93%), although variability between studies was substantial. Figure 2 shows individual success rates for the key urethroplasty series. For example, in the cohort described by Gaur et al. (2024), 65 of 73 women (89%) who underwent buccal mucosal urethroplasty had no recurrence and required no further intervention at a median follow-up of 24 months [35]. In the study by Kore and Martins (2022), use of a dorsal flap (either buccal or vaginal mucosa) allowed to restore urethral patency in 30 of 32 patients (94%) with a mean follow-up of 26 months [21]. Earlier reports provide somewhat less optimistic figures. Falandry (1997) achieved anatomical success in only 24 of 35 women (69%) treated on for obstetric fistulas with complete urethral loss in an African population [27], and Hamlin (1969) similarly reported a success rate of 70% for complete fistula healing in comparable pathology [8].

Nevertheless, in all recent series in which reconstruction was performed by experienced surgeons using well-vascularized tissue flaps or mucosal grafts, the rates of secondary stricture or anastomotic failure were very low, typically 0–10% [35, 43].

Other urinary diversion strategies used as definitive treatment effectively avoided stricture-related complications since the urethra is excluded from the urinary stream. However, for these procedures, the definition of "success"

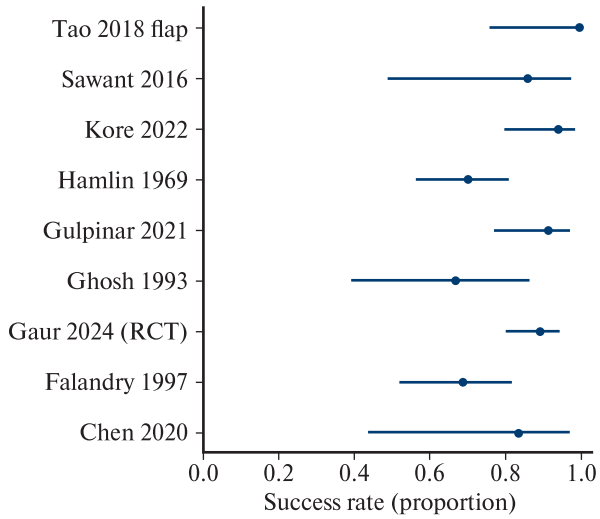


Figure 2. Forest plot showing success rates of tissue-based urethral reconstruction methods. Points represent success estimates for each study; horizontal lines indicate 95% confidence intervals

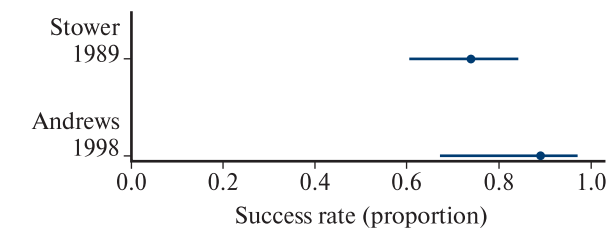


Figure 3. Forest plot of outcomes for urinary diversion/urethral occlusion procedures (achievement of continence)

relates to continence rather than anatomical restoration. In the classic series by Stower et al. (1989), 50 women with catheter-related urethral destruction underwent surgical urethral closure and suprapubic cystostomy; after the first procedure, 37 patients (74%) became completely dry, while the remaining 13 required additional interventions [23]. Andrews and Shah (1998) reported that among 18 neurological patients who underwent various forms of urethral closure, continence was achieved in 16 (89%) [5]. These data are summarized in Figure 3. The pooled continence rate for diversion procedures was 80% (95% CI 65–91%). Thus, tissue-based urethroplasty appears to be the most effective method overall, with urethral occlusion and diversion reserved as secondary options.

Restoration of urinary continence. Given that a substantial proportion of patients were incontinent before treatment, therapeutic success was also evaluated from a functional perspective, namely whether urinary continence could be achieved. In women undergoing urethroplasty with autologous tissues and without pre-existing sphincter damage, complete continence was generally preserved. In a large review by Osman (2013), no cases of de novo stress urinary incontinence were reported among 221 female urethroplasties analyzed [12]. With careful handling of the bladder neck, postoperative incontinence usually does not occur [21].

However, in the setting of total urethral loss, sphincter insufficiency is frequently present, and therefore even a technically perfect urethroplasty does not guarantee continence. Blaivas et al. (2008) reported that after single-stage vaginal urethroplasty, complete continence was achieved in only 60% of patients, and half of the remainder subsequently required a sling insertion [1]. Current practice tends to favor prophylactic sling placement at the time of urethral substitution. In the series by Sawant et al. (2016), all seven patients with complete urethral loss underwent simultaneous creation of a neourethra from the anterior vaginal wall and implantation of an autologous fascial sling [33]. As a result, six of seven women (85.7%) became completely continent, and only one had persistent mild stress incontinence. These findings are consistent with the broader review data, where continence rates of up to 87% are reported when urethroplasty is combined with sling surgery.

Urinary diversion and urethral closure almost invariably provide socially acceptable continence, as uncontrolled leakage of urine is eliminated. For example, after transvaginal urethral closure with suprapubic cystostomy (urethroclesis), nearly all neurological patients were dry between performing intermittent self-catheterization or change of cystostomy drainage [5]. However, in some patients a fistula developed (in four of eight women, urethral closure proved insufficient, although two were successfully re-treated). In addition, a subset continued to experience incontinence due to overflow or leakage around the cystostomy tube, particularly in the setting of catheter obstruction [13]. Overall, diversion procedures tend to resolve the problem of incontinence more reliably than attempts to preserve a severely damaged urethra.

It is important to mention negative consequences. In 15–20% of women who undergo reconstructive urethroplasty after prior pelvic radiotherapy, de novo stress urinary incontinence develops even when urethral continuity is restored. In the systematic review by Sapienza et al. (2021), urethroplasty for irradiation-induced strictures was associated with stress urinary incontinence in 19% of patients (95% CI 10–31%) despite an 80% success rate of the reconstruction itself [26]. This reflects prior sphincter damage caused by ionizing radiation and illustrates that anatomical integrity of the urethra does not always mean functional recovery.

Urodynamic parameters. Reports on voiding parameters are scarce, but some investigators performed uroflowmetry and measured postvoid residual volume. In the above-mentioned study by Gaur et al. (2024), the median (or mean) maximum flow rate (Qmax) increased from 7 to 22.5 mL/s after urethroplasty, while the mean postvoid residual volume decreased from 185 to 17 mL [35]. There were no significant differences between dorsal and ventral urethroplasty approaches, as both techniques yielded comparable improvements in urethral patency. Gülpınar et al. (2021) likewise demonstrated an increase in mean Qmax from 7 to 25 mL/s at 12 months after reconstruction, with no differences between three variants of buccal mucosal urethroplasty [43].

Complications and adverse outcomes. Across the available data, the most frequent adverse outcome was recurrent urethral obstruction (or fistula breakdown), that is, failure of surgical treatment requiring reoperation. Other notable complications included urinary tract infections. Their frequency was generally not well defined,

as many patients experienced intermittent infections both before and after treatment. However, when comparing management strategies, a clear difference emerged in neurologic patients: those with a chronic cystostomy or ileovesicostomy experienced substantially higher rates of pyelonephritis and urosepsis than patients who underwent orthotopic reconstruction. Husmann and Viers (2020) provide a striking example: 82% of patients with an ileovesicostomy had at least one episode of severe urosepsis, whereas this proportion was 50% among patients after cystectomy with conduit diversion or simple cystostomy [13].

In this context, the complications observed after reconstructive urethroplasty appear comparatively modest. Most series reported no major infections or upper tract deterioration. Only isolated instances of fistula formation were described. For example, in the study by Sawant (2016), two of seven patients developed transient fistulous tracts, all of which were successfully closed using local tissues [33]. In the series by Ghosh (1993), four of 12 women developed vesicovaginal fistulas after bladder flap urethroplasty [17]. These cases are essentially failures of the reconstructive procedure.

Recurrence-free survival. The mean follow-up duration across included studies was approximately two years, which limits conclusions about truly long-term outcomes (5-10 years). Nevertheless, some insights can be drawn from older reports. In the study by Stower (1989), outcomes of urethrocleisis were followed for up to 10 years [23]. The authors noted that although no major late complications requiring hospitalization occurred, minor complications (Clavien-Dindo grade I-II) were observed in 66% (33 of 50) of patients. In other words, most women with a cystostomy eventually required at least one repeat intervention (for example, bladder stone removal or fistula revision). Similarly, Husmann (2020) showed that after a mean follow-up of eight years, 88% of patients with an ileovesicostomy underwent at least one additional operation (excluding routine stoma changes) [13].

By contrast, in the orthotopic reconstruction group, although data on women remain limited, repeat interventions were less common. Disease progression over time must also be considered. For example, neurologic patients with a closed urethra may gradually develop upper urinary tract deterioration (nephrosclerosis was found in 41% over an eight-year period). In contrast, in irradiated patients, delayed continence problems are more common after urethroplasty (as noted earlier [26], 20% developed incontinence at four years).

A positive observation is that when urethroplasty success is maintained during the first 1-2 years, the outcome is generally stable thereafter. This suggests that if no restenosis occurs within two years after surgery, the urethra is likely to remain patent in the long term, provided no new adverse factors arise.

Meta-analysis

Despite the high heterogeneity of the studies (I2 > 80% for comparisons between methods), we attempted to quantitatively summarize the differences in efficiency between approaches. Pooled data yielded the following mean estimates: success of reconstruction using local tissues was 88.2% (95% CI 82.4–93.0%); success of diversion procedures was 77.9% (95% CI 65.0–89.0%). Thus, reconstructive surgery demonstrates a higher likelihood of favorable outcome compared with bougienage (odds ratio approximately 7:1). Diversion procedures are inferior to urethroplasty in terms of anatomical outcome (as the urethra is not restored), but they are often the only option to achieve continence in very complex patients. The differences between techniques are visually illustrated in the previously presented forest plots (Figures 2–3).

The methodology of the meta-analysis is limited by the near-complete absence of direct randomized comparisons between different treatment modalities; consequently, the observed differences should be interpreted as descriptive. Urethroplasty outperforms urinary diversion in terms of achieving the desired state (no further procedures required), although in the latter group this comparison is indirect (through continence as the main endpoint). The I2 value was 79% for reconstructions using autologous tissue, which reflects the heterogeneity of the included cases (different etiologies), variable study quality, and the evolution of surgical techniques over the past 50 years. We did not identify clear evidence of publication bias (studies spanned a broad spectrum of outcomes from poor to excellent, including both older series with suboptimal results and contemporary reports with very good outcomes).

Confounding is possible. For example, the most severe cases were more likely to undergo diversion, whereas less complex cases were more likely to receive reconstruction. This may artificially increase the apparent success of reconstruction. However, the reverse bias is unlikely, since it is rare for an obviously straightforward case to be treated with diversion; from a surgeon's ethical standpoint, the default is to attempt reconstruction rather than to choose the technically simpler option of urinary diversion. Therefore, our conclusion regarding the superiority of reconstructive surgery appears to be reasonably well supported, even though it is not based on prospective comparative trials.

Quality of evidence (GRADE). Taken together, the reliability of the available data is rated as low. This is primarily due to the fact that most information comes from uncontrolled, retrospective studies (downgrading for study design), there is substantial heterogeneity between studies (downgrading for inconsistency and imprecision), and sample sizes are often small.

On the other hand, the treatment effect of urethral reconstruction is sufficiently pronounced (approximately a two- to fourfold increase in the odds of success) that, according to GRADE, confidence that reconstruction is superior to dilatation can be upgraded to some extent (there is a "dose-response" or "intensity-effect" gradient: the more radical the procedure, the higher the likelihood of cure). Nevertheless, the overall quality of evidence remains low: future, better-designed studies are very likely to change the current estimates of effect. The certainty of evidence for specific outcomes such as quality of life is very low, as these data are scarse and based on isolated series.

Discussion

Main findings. In this systematic review, we summarized the outcomes of treatment for one of the most challenging conditions in urology, which is destruction (loss) of the female urethra. Despite the small number of studies

and patients, the overall pattern is clear: reconstructive procedures of the urethra using autologous tissues provides substantially better anatomical and functional outcomes than palliative interventions. Successful urethral reconstruction restores continuity of the urethra, enables voiding via the natural route, obviates the need for permanent catheters (or intermittent self-catheterization), and markedly improves quality of life [32]. In the vast majority of cases, reconstruction does not worsen continence [12], particularly when modern techniques with concomitant pelvic floor support are used [33].

In contrast, simple dilatation (bougienage) or urethrotomy in the setting of obliteration are inherently temporary measures: more than half of women experience recurrence of obstruction, as demonstrated both in clinical series and in the meta-analysis by Osman [12]. The low efficacy of urethral dilatation in women is explained by the fact that female urethral strictures are usually secondary to fibrosis or scarring of the mucosa after trauma or infection, rather than idiopathic, as they often are in men [26]. A possible exception may be extremely frail patients who are unfit for anesthesia, in whom dilatation can provide a short period of relief. However, in many of these cases it may be more reasonable to proceed directly to suprapubic cystostomy, avoiding further trauma to the remaining urethra.

Urethral diversion (urethral closure) represents a fundamentally different strategy: instead of restoring normal anatomy, it adapts the urinary tract to new conditions. We showed that such procedures are quite effective in preventing uncontrolled urine leakage, with continence rates of up to 80–90% [5]. Diversion remains indispensable in patients in whom urethral reconstruction is not feasible, for example in the presence of total radiation-induced fibrosis or severe comorbidities that preclude major reconstructive surgery. However, this effectiveness comes at the cost of lifelong dependence on catheters or external collection devices, along with a broad spectrum of complications, including infections, stone formation, and stoma-related problems. Even the proponents of these methods describe them as a last resort [5].

Thus, the clinical relevance of our review lies in reinforcing the principle that, whenever technically feasible and not contraindicated, surgeons should strive to reconstruct the native urethra in women. Naturally, success depends on the amount of residual tissue available for reconstruction and on the surgeon's expertise.

Choice of strategy must be individualized, taking into account the patient's overall condition and physiological reserves. Autologous tissue urethroplasty is often a complex, multi-hour procedure requiring general anesthesia; it may be associated with blood loss (on average about 200 mL according to Sawant et al. [33]) and usually necessitates postoperative catheterization for 2–3 weeks. The efficiency of urethroplasty is not guaranteed, and if reconstruction fails, the patient may return to her baseline condition or even worse, if additional scarring develops. Nevertheless, the risk of serious complications from these procedures is low and comparable to that of other reconstructive procedures.

Diversion and occlusive procedures are generally technically simpler and shorter, and are often performed under regional anesthesia. However, they lead to a marked reduction in quality of life, particularly in young and socially active women. For example, in the study by Rosen et al., cited by Husmann [13], it is emphasized that although suprapubic cystostomy solves the problem of incontinence, it is highly undesirable in women of reproductive age because of its impact on sexual function and reproduction. Moreover, catheter-related complications (stones, infections) mean that a permanent suprapubic tube is far from the "minor issue" it is sometimes perceived to be.

One of the principal conclusions drawn by Husmann & Viers is succinctly captured in their statement, "we abandoned ileovesicostomy" [13], a reflection of the procedure's high complication burden. Their findings demonstrate that the ostensibly more radical option, namely cystectomy with ileal conduit, proved, in the long term, to be safer than the seemingly more conservative ileovesicostomy. This highlights an important principle: a "smaller" operation is not inherently better than a "larger" one, and long-term outcomes must be weighed carefully.

Additional survival analysis showed clear differences in the long-term durability of outcomes between treatment modalities. Urethroplasty demonstrated the highest recurrence-free survival rate, confirming that, when properly performed, this technique provides stable restoration of urethral continuity. Interestingly, diversion procedures offered only temporary stability: during the first 2–3 years their results were comparable to urethroplasty, but over time the proportion of stable patients declined substantially, reflecting the incidence of late complications. These findings underscore the need to consider urethroplasty as the first-line option in eligible patients, as well as the importance of long-term follow-up after diversion procedures.

Limitations and potential sources of bias. This review is limited by the quality of the included studies. As noted above, most of the available data are of low evidence level and derived from retrospective series. Selection bias is possible: individual centers may have accumulated either predominantly milder or, conversely, particularly severe cases, so their results may not fully reflect the broader clinical spectrum. Publication bias cannot be excluded either, since successful reconstructive cases are more likely to be reported than failures. We attempted to mitigate this by including historical series with poor outcomes, but there are likely unpublished cohorts in which attempts at urethral reconstruction "failed" and are not reported.

Our proportion meta-analysis should therefore be interpreted with caution, since its results were heavily influenced by a few large series (Osman, Husmann, etc.), while small studies contributed disproportionately little to the pooled estimates. Despite this, across all reasonable assumptions (including those that attribute less favorable outcomes to reconstructive approaches), the difference compared with conservative management persists.

Another limitation is population heterogeneity. We combined different clinical entities, such as trauma, fistulas, erosions and irradiation injury of the urethra. From a strictly methodological standpoint this is imperfect, as these conditions differ in pathogenesis. However, from a practical perspective, the common anatomical problem (absence of a functioning urethra) justifies analyzing them together when assessing treatment strategies.

A further concern is the definition of "successful outcome". Some studies defined success as "no need for reoperation" [12], others as "absence of restenosis on urethrography," and still others as "patient-reported satisfaction." We primarily relied on objective criteria (absence of repeat intervention and recurrence). It is debatable whether a patient with a patent urethra who still requires pads because of incontinence should be classified as a success or a failure. We categorized such cases as partial success (anatomical success, functional failure). In the quantitative synthesis they were counted as successes (the urethra was restored), but the text explicitly discusses these nuances.

Differences in postoperative management may also have influenced outcomes. For example, protocols for catheterization duration, stricture prevention, or the use of topical estrogens in postmenopausal women. These aspects were rarely described in sufficient detail in the included studies, making it impossible to analyze their impact systematically.

Future directions. Given the overall low quality of currently available evidence, there is a clear need for new studies in this field. A randomized controlled trial comparing, for example, urethroplasty versus diversion would hardly be ethical, given the fundamentally different prognoses and goals of these approaches. However, prospective registries and comparative studies of different reconstructive techniques are both feasible and necessary.

For instance, the question of which type of tissue reconstruction is optimal remains unanswered. Some authors advocate the use of labial/buccal mucosa, reporting success rates of up to 94% [12], whereas others demonstrate that vaginal flaps yield comparable outcomes with minimal complication rates [21]. Direct comparative studies with larger patient cohorts are required, ideally within a multicenter observational design in which each center applies its preferred technique and the pooled results are subsequently analyzed.

There is also a paucity of data on postoperative rehabilitation and conservative management, including the role of pelvic floor physiotherapy, estrogen support for the urethral mucosa, and standardized catheterization protocols. These questions could be addressed in relatively small cohorts. Another important area is health-related quality of life and long-term psychosocial outcomes. While such aspects have been studied in the context of obstetric fistulas, they are poorly reported in urological literature.

Finally, emerging technologies such as regenerative medicine and tissue engineering open up prospects for the creation of a neourethra from biomaterials. Attempts have already been made to use cell-seeded matrices in women with scar-related strictures [44]. Although these approaches remain experimental, they may, in the future, improve outcomes in complex cases where native tissues are insufficient.

Conclusion

Autologous tissue urethroplasty is the most effective treatment for complete or extensive destruction of the female urethra, providing urethral patency and preserving continence in the majority of patients. Minimally invasive procedures are associated with high recurrence rates and are suitable only as a temporary solution in cases of partial destruction. Diversion procedures are indicated when reconstruction is not feasible but are accompanied by a significant risk of complications and a reduction in quality of life.

Whenever technically possible, reconstructive surgery with individualized selection of technique should be preferred. To strengthen the evidence base and improve guideline quality, multicenter prospective studies are urgently needed.

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