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REVIEW

Systematic review and meta-analysis of internal urethrotomy vs. open urethroplasty: Implications for management of recurrent urethral stricture

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Summary *Background: Internal urethrotomy is commonly used as the first treatment for urethral strictures but has a high recurrence rate. Open urethroplasty comes with best long-term results and decreases the risk of needing any further interventions. Until now, there are no recommendations based on evidence that compare the outcome of recurrent urethral stricture when treated with internal urethrotomy and open urethroplasty. This systematic review compared those two procedures for recurrent urethral stricture.*
Methods: We searched databases using PubMed, Scopus, and EBSCO for relevant literature published in English up to September 2024. The primary outcome was the recurrence rate at 12 months. Secondary outcomes are symptom relief, maximum urinary flow rate, adverse events and complications, and sexual function. We used Revman to compare the pooled patients.
Results: We included three studies with 454 pooled patients. Data for the recurrence rate of 12 months were included for meta-analysis. The results showed a risk ratio of 5.24 ((95% CI 2.89-9.53, $p < 0.00001$), indicating that open urethroplasty significantly has lower recurrence rate than internal urethrotomy group. Symptoms relief in urethroplasty is better than in urethrotomy but not significantly different between the two groups. Improvement of Q_{max} happened in both groups with no significant difference, although urethroplasty has better improvement than urethrotomy group. Complications during a 24 month follow up were seen in both groups with the most common complications being urinary symptoms, urinary tract infection, and erectile dysfunction. Those complications were less frequently observed in urethroplasty but there are no significant difference between the groups. Post procedure sexual function was comparable between the two procedures.
Conclusions: Our review shows that open urethroplasty has lower recurrence rates at 12 months compared to internal urethrotomy for recurrent urethral strictures. However, symptom relief, improvement in urinary flow rate, complication, and post-procedure sexual function were comparable between the two procedures. Further randomized controlled trials with larger sample sizes, multicenter designs, and longer follow-up periods are needed to confirm the results of our review.

KEY WORDS: *Recurrent urethral stricture; Internal urethrotomy; Open urethroplasty; Urethral procedure.*

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INTRODUCTION

Urethral stricture, or narrowing of the urethra, is a common condition that causes significant morbidity. It can occur in both sexes, but approximately 99% of cases are reported in males. The male urethra is divided into anterior and posterior segments. Anterior strictures account for 92.2% of cases, with the majority occurring in the bulbar urethra (46.9%). Other locations of anterior urethral stricture include the penile urethra, the panurethra (a combination of the bulbar and penile urethra), and the meatus (1).

The etiology of urethral stricture is varied and can be categorized into four causes: inflammatory, traumatic, iatrogenic, and idiopathic (1). Among these, iatrogenic and idiopathic factors are the most common (1).

Consequently, the pathophysiology of urethral strictures has yet to be fully understood. A widely accepted hypothesis is that it comes from fibrosis caused by inflammation of the mucosa and adjacent spongiosal tissue (2).

In Indonesia, 58.3% of urethral stricture cases are caused by trauma. Only 15% of cases are attributed to iatrogenic etiology (3).

The most commonly used procedures for the treatment of urethral stricture are dilatation, internal urethrotomy, and urethroplasty. Over the past few decades, treatment approaches have continued to evolve, with increasing interest in minimally invasive procedures (4). Internal urethrotomy is the most initial treatment performed, especially with bulbar and short-segment urethral stricture (2). It is preferred because it does not require specialist surgical expertise, allows early mobilization, a shorter period of urethral catheterization, faster recovery, and overall good short-term results (4, 5). However, a major drawback is the high recurrence rate, with patency rates ranging from 8% to 77% (2, 6).

Recurrence impairs a patient's quality of life and make urethral strictures more complex increasing the need for grafts during urethroplasty, particularly in patients who had undergone two or more internal urethrotomies (2, 7). Predictors of recurrence are not yet well defined, but *Zehri et al.* identified several associated factors, including idiopathic etiology, stricture length greater than 2 cm, strictures following *transurethral resection of the prostate* (TURP), and strictures located in the penile urethra (4). Additionally, diabetes mellitus and hypertension are comorbidities that increase the risk of recurrence (2).

Compared to internal urethrotomy, open urethroplasty provides superior long-term outcomes and reduces the likelihood of requiring further interventions. However, it is more invasive, requires specialist surgical expertise, and involves a longer period of urethral catheterization and recovery (5). Open urethroplasty is typically performed in patients who have previously undergone endoscopic procedures and it is preferred in recurrent cases, as after repeated endoscopic treatments, including internal urethrotomy which have a failure rate exceeding 80% (6, 7). Current guideline recommendations are largely based on expert opinion and consensus. The *American Urological Association* (AUA) recommends urethroplasty for recurrent strictures (7). Meanwhile, the *Société Internationale d'Urologie* (SIU) recommends either endoscopic treatment or urethroplasty after a symptomatic recurrence following three months. However, there are no evidence-based recommendations that directly compare the outcomes of internal urethrotomy and open urethroplasty in cases of recurrent urethral stricture.
Therefore, this systematic review and meta-analysis was conducted to determine which approach provides more favourable outcomes for patients with recurrent urethral stricture.

Methods

Literature search strategy
We conducted a comprehensive literature search using PubMed, Scopus, and EBSCO, with a cutoff date of September 2024. The following keywords were applied: "*urethral stricture*," "*internal urethrotomy*," and "*urethroplasty*." MeSH terms and manual searches were also utilized to ensure no relevant articles were missed.

Inclusion and exclusion criteria
PICOS (*Patient, Intervention, Comparison, Outcome, Study Type*) was used for creating inclusion criteria. P: Male patient with recurrent urethral stricture after at least one previous intervention. I: Internal urethrotomy. C: Control group consisting in patients treated with open urethroplasty. O: Outcome of the studies including 1-year recurrence. S: *Randomized controlled trials* (RCTs), retrospective studies, or prospective studies. Exclusion criteria included unpublished or non-comparative studies, as well as studies that were inaccessible or lacked extractable analytical data.

Study screening and selection
Data searching, screening, and selection were conducted independently by two researchers. The titles and abstracts of all studies were initially reviewed, followed by full-text screening of articles that met the inclusion criteria. Data from the included studies were then extracted and analysed independently by both researchers. Any discrepancies were resolved through consultation with a third researcher.

Data items
The data we extracted are studies with the outcome of recurrence rate.

Bias risk assessment
Due to different designs of studies included in our review, we used different methods to assess the risk of bias. RCTs were assessed with ROB-I (*Risk of Bias-I*) and non-randomized study assessed with *Non-Randomized Studies-of Interventions* (ROBINS-I).

Statistical analysis
Statistical analysis was performed using RevMan software. For studies that reported data as ranges, medians, or quartiles, values were converted into means (MD) and *standard deviations* (SD). Heterogeneity was assessed using the I^2 statistic. An I^2 value of less than 50% indicated low heterogeneity, for which a fixed-effects model was used; an I^2 value greater than 50% indicated meaningful heterogeneity, warranting the use of a random-effects model. The interpretation of I^2 values was as follows: 0%-40% indicated low heterogeneity; 40%-60% moderate heterogeneity; 60%-90% substantial heterogeneity; and 90%-100% considerable heterogeneity.

Publication bias
We performed publication bias analysis if the number of included studies is equal or more than 10 studies.

Results

Study selection
A systematic review was conducted following the *Preferred Reporting Items for Systematic Reviews and Meta-analyses* (PRISMA) guidelines. This review was registered with PROSPERO (ID: CRD420251141685). In our initial search, we identified 1.585 articles. No additional results were found through manual searching. Article selection was conducted by two authors based on titles and abstracts. Studies that met the inclusion criteria were then assessed through full-text review. One study was excluded due to being in a non-English language, and four studies were excluded as they referred to the same trial. After the selection process, three studies were included: *Bandini et al.* (8), *Mariyanovski et al.* (9), and *Goulao et al.* (10).

Study characteristics
The included studies consist of a randomized controlled trial (*Goulao B et al.*), a retrospective study (*Bandini M et al.*), and a prospective study (*Mariyanovski V et al.*). Only studies that directly compared DVIU (*direct vision internal urethrotomy*) and open urethroplasty were included. The characteristics of the included studies are summarized in Table 1.

Assessment of Risk of Bias
ROB-2 was used to assess *Gaulao B et al.* while ROBIN-I was used to assess *Bandini M et al.* and *Maroyanovski V*. Risk of bias in each study can be seen in Table 2 and 3.

Recurrence rate of 12 months
Recurrence rate at 12 months was evaluated in all the included studies (Figure 2). The analysis showed a risk ratio of 5.24 (95% CI 2.89-9.53, $p < 0.00001$) indicating that open urethroplasty significantly has lower recurrence rate than internal urethrotomy group.

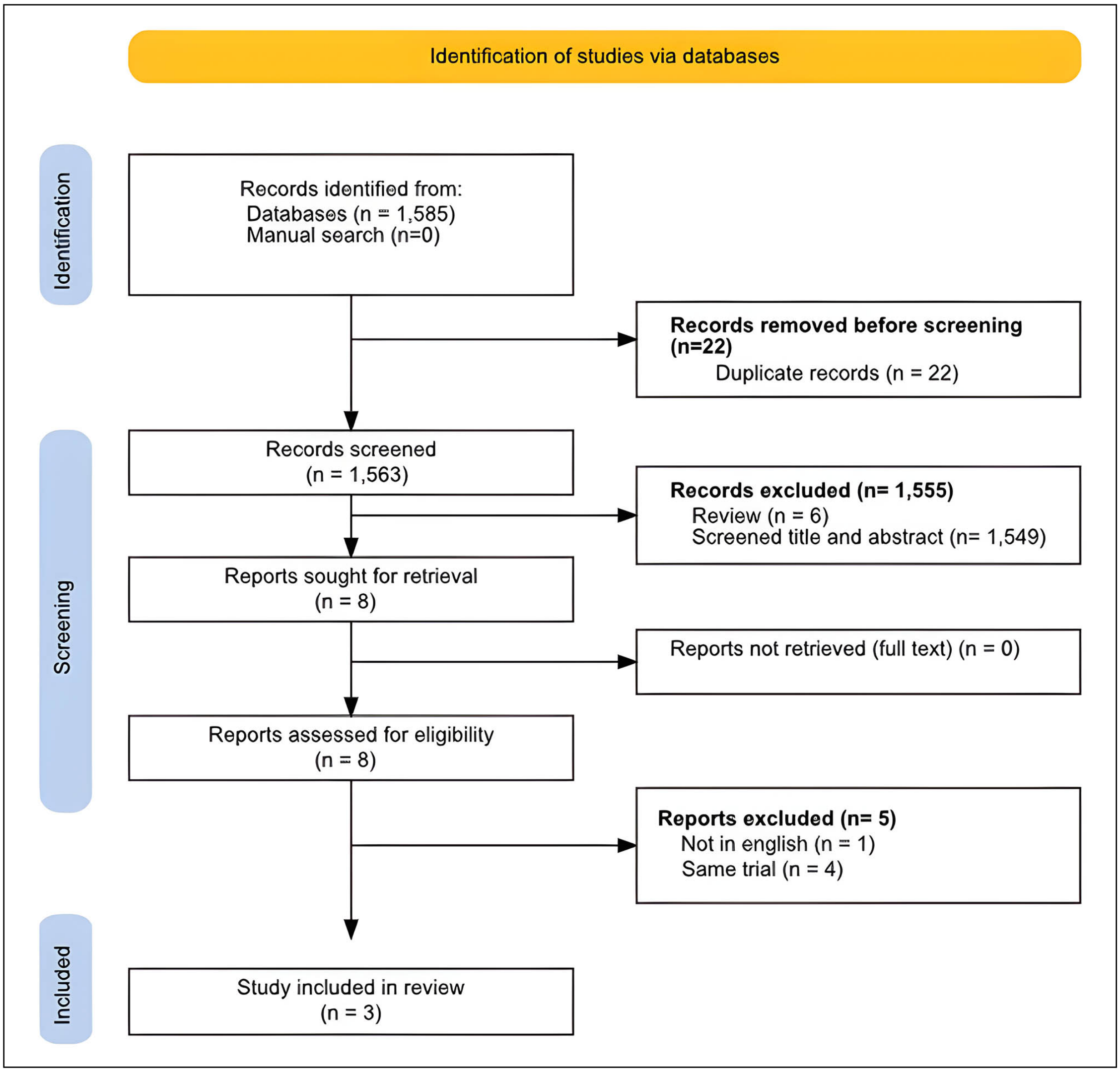


Figure 1.
Systematic review PRISMA diagram.

Table 1.
Characteristics of included studies.

Study (n)	Study Type	Age, years (range)	Etiology of stricture	Location of stricture	Intervention	Follow-up (months)	Recurrence rate (12 months)
Bandini M, et al., 2023 (n = 103)	Retrospective study	40 (30-53)	Idiopathic (62) Catheter induced (15) Hypospadias-related (3) Iatrogenic (14) Trauma (4) Other (10)	Anterior urethra	DVIU (91) Open urethroplasty (12)	12, 24, 36, 48 Open urethroplasty (1, 8.3%)	DVIU (31, 33.7%)
Mariyanovski V, et al., 2021 (n = 129)	Prospective study	59.3 (24-78)	Iatrogenic (9) Perineal trauma (8) Transurethral surgery (15) Hypospadia repair (9) Infection (12) Linchen sclerosus (6) Unknown (8)	Anterior urethra	IUT (62) Open urethroplasty (67)	12	IUT (36, 58.06%) Open urethroplasty (8, 11.94%)
Goulao B, et al., 2020 (222)	RCT	48.95	Unknown (76+81) Trauma (22) Infection (11) Other (19) Missing (11)	Bulbar urethra	Urethrotomy (104) Urethroplasty (93)	12, 24	Urethrotomy (17, 16.34%) Urethroplasty (2, 2.1%)

Table 2.
Results of quality assessment in individual study (ROB-2).

	Goulao B, et al. (n = 222)
Bias arising from the randomization process	Low risk
Bias due to deviations from intended interventions	Some concern
Bias due to missing outcome data	Low risk
Bias in measurement of the outcome	Low risk
Bias in selection of the reported result	Some concern
Overall risk of bias	Some concern

Table 3.
Results of quality assessment in individual studies (ROBINS-I).

	Bandini M, et al. (n = 103)	Mariyanovski V, et al. (n = 129)
Bias due to confounding	Low risk	Moderate risk
Bias in classification of interventions	Low risk	Low risk
Bias in selection of participants into the study	Moderate Risk	Moderate Risk
Bias due to deviations from intended interventions	Moderate Risk	Moderate Risk
Bias due to missing data	Low risk	Low risk
Bias arising from measurement of the outcome	Moderate risk	Low risk
Bias in selection of the reported results	Low risk	Moderate risk
Overall risk of bias	High risk	High risk

improvement, with an odds ratio of 2.64 (95% CI: 1.14-6.15; p = 0.024).

Adverse event and complication

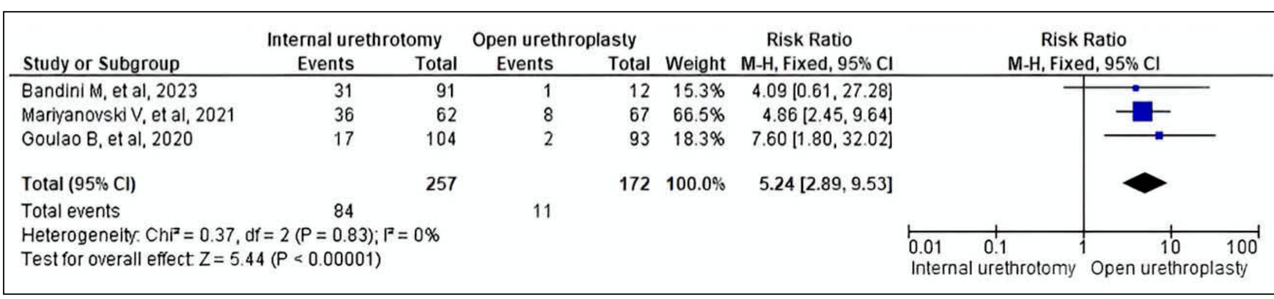
Adverse events were reported in the study of *Goulao B et al.*, involving 80 patients. The most common perioperative adverse event prior to reintervention was mouth pain, reported in 12 patients from the urethroplasty group due to buccal mucosal graft harvesting. Other reported events included bladder spasms, urinary tract infections, and initial failed trials without catheter.

Over a 24-month follow-up period, the most common complication was presence of persistent urinary symptoms, observed in 7 patients in the urethroplasty group and 6 in the urethrotomy group. Additional complications included urinary tract infections (5 patients in the urethroplasty group vs. 6 patients in the urethrotomy group) and erectile dysfunction (4 patients vs. 3 patients, respectively).

Sexual function

In the study by *Mariyanovski V et al.*, mild sexual dysfunction was observed in both groups: 7 patients (11.3%) in the internal urethrotomy group and 12 patients (17.9%) in the open urethroplasty group (p = 0.289). Reported dysfunctions included cold glans, dribbling ejaculation, and penile hyposensitivity. Sexual function was also assessed as a patient-reported outcome in the study by *Goulao B et al.*, at 24 months of follow-up. A satisfaction scale was used, ranging from 1 (very satisfied) to 5 (very dissatisfied). The mean scores were 2.9 (SD 1.2) in the urethroplasty group and 2.5 (SD 1.2) in the urethrotomy group. The adjusted mean difference was 0.35 (95% CI: -0.06 to 0.75; p = 0.09).

Figure 2.
Forest plot and meta-analysis of recurrence rate at 12 months.



Symptoms relief

In the study by *Goulao B et al.*, voiding symptoms before and after the intervention in both groups were assessed using the *Patient-Reported Outcome Measure* (PROM) score measured at baseline and 24 months after randomization. The PROM score ranges from 0 (no symptoms) to 24 (worst symptoms). The mean PROM score in the urethroplasty group was 7.4 (SD 3.8), while in the urethrotomy group was 7.8 (SD 4.2). The reported mean difference (95% CI) was -0.36 (-1.74 to 1.02; p = 0.6).

Flow rate

Maximum urinary flow rate (Q_{max}) was reported in the study by *Mariyanovski V et al.* At 12 months of follow-up, Q_{max} > 15 mL/sec was achieved in 30 patients (48.39%) in the internal urethrotomy group and in 59 patients (88%) in the open urethroplasty group.

Goulao B et al. analysed Q_{max} improvement, defined as an increase in flow rate of at least 10 mL/sec. In their findings, 18 patients (19%) in the urethroplasty group and 13 patients (13%) in the urethrotomy group achieved this

Discussion

Urethral stricture is prone to recur because no known procedure can completely eradicate the scar tissue or inhibit its growth (11). The reported incidence of urethral stricture varies in the literature, estimated to be between 0.6% and 1.2% (12). Recurrence of urethral stricture causes significant morbidity and presents challenges in both diagnosis and treatment (12). The definition of recurrence differs across studies. The most commonly accepted definition is the need for reoperation. However, many patients with recurrence avoid surgery, so this defi-

nition may underestimate the true recurrence rate (12).
This study compares two common procedures for recurrent urethral stricture: internal urethrotomy and open urethroplasty. Other procedures, such as drug-coated balloon dilation, are not included due to limited availability in Indonesia. Internal urethrotomy involves a transurethral incision to release the stricture. It is commonly used as a first-line treatment for short strictures and is preferred because it is quick, simple, and involves a shorter recovery period (11). However, stricture recurrence following this procedure may occur sooner, as healthy tissue adjacent to the stricture is also incised (1).
In open urethroplasty, the stricture is either opened or resected and then reconstructed with direct anastomosis, with or without the use of graft material or a flap (1).
In this study, we included three studies for a meta-analysis of the 12-month recurrence rates of the two procedures. The analysis concluded that internal urethrotomy has a higher recurrence rate than open urethroplasty, with a pooled risk ratio of 5.24 (95% CI: 2.89-9.53, $p < 0.01$). In one study, *Goulao et al.* reported recurrence rates at the end of a four-year follow-up. Recurrence occurred in 39 subjects in the urethrotomy group, compared to 19 in the urethroplasty group, yielding a hazard ratio of 0.45 (95% CI: 0.29-0.72, $p = 0.001$) (10). The most plausible explanation is that internal urethrotomy typically incises the stricture without completely removing the fibrotic tissue (11). Additionally, one study found that outcomes decline with repeated internal urethrotomies in recurrent urethral stricture cases (13).
For voiding symptoms, *Goulao et al.* found no significant difference between the two groups ($p = 0.6$). However, a study by *Johnson et al.* on urethroplasty reported significant improvements in patient-reported outcomes when comparing pre- and post-operative scores. The study utilized the *American Urological Association Symptom Index* (AUASI) and the *Incontinence Symptom Index* (ISI) (14). Urethroplasty showed a 7-point improvement in AUASI scores ($p < 0.001$), though the ISI score did not show a significant change. In contrast, one study on urethrotomy found an improvement in *International Prostate Symptom Score* (IPSS) following the intervention (15).
Improvement in Q_{max} was significantly better in the urethroplasty group than in the urethrotomy group, as observed by *Goulao et al.*, with an OR of 2.64 (10). *Mariyanovski et al.* found that, after 12 months of follow-up, a significantly higher number of subjects in the urethroplasty group achieved a Q_{max} > 15 mL/sec compared to the urethrotomy group. These findings suggest that urethroplasty provides a more stable and wider urethral lumen (16).
The adverse events were lower in urethrotomy according to *Goulao et al.* The finding is understandable due to the minimally invasive nature of the procedure. In *Goulao et al.* study, the most common adverse event in the urethroplasty group was mouth pain from the buccal mucosal graft harvest (10). According to *Wood et al.* the long-term side effects from harvesting buccal mucosal graft for urethroplasty are numbness at the perioral region, difficulty to open the mouth, and salivary dysfunction (17). Other adverse effects, such as bladder spasm, are especially associated with urethroplasty. Bladder spasm can present as cramps or pain in the abdominal or perineal region or urgency symptom. The risk of bladder spasms is higher in patients undergoing procedures lasting more than 25 minutes or requiring postoperative catheterization. Since both urethroplasty and urethrotomy typically last more than 25 minutes and require catheter use, the risk applies to both procedures (18). Complication during a 24 month follow up was seen in both group with the most common complications beng urinary symptoms, urinary tract infection, and erectile dysfunction. Those complication seem to be lower in urethroplasty but there is no significant difference.
In *Goulao et al.* and *Mariyanovski et al.* the sexual function after both procedures was not significantly different (95% CI -0.06 to 0.75; $p = 0.09$). We found a systematic review that describes erectile dysfunction as a complication of urethroplasty (9,10,19). The complication can be caused by several mechanisms because mobilization and transection during the procedure can injure the bulbar arteries or cavernosal-spongiosal branches, and can cause injury of cavernous nerve which are located near bulbar urethra at 1 and 11 o'clock, or injury of perineal nerves and perineal nerves and penile dorsal nerve interaction. Another cause for short-term sexual dysfunction is a psychosomatic factor due to the appearance of penile image change (19). On the other hand, the study of sexual function in urethrotomy is limited. *Graversen et al.* suggested that erectile dysfunction following urethrotomy may result from injury to the cavernous nerves, direct tissue trauma, or extravasation of fluids disrupting the balance between venous outflow and arterial inflow (20). Another study found no significant difference in erectile dysfunction scores before and after urethrotomy (21).

Study limitations

Our systematic review comes with several limitations that need to be acknowledged. First, we only included one RCT. The difference in the study design may impact the

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Availability of data and material: *Not applicable.*

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quality of the outcome. Also, limited number of studies resulted in a small sample size that can affect the statistical power of this meta-analysis. Second, we don't include data on the location and length of the urethral stricture. Those characteristics are important factors to compare because they affect the difference in the outcome between studies. Third, because of insufficient data on long-term recurrence rates beyond 12 months, we limited our meta-analysis to studies reporting recurrence rates at the 12-month follow-up. Fourth, we do not include cost-effectiveness outcomes as there were not enough data. These limitations suggest we still can't draw firm conclusion of the better procedure, and we need long-term and high-quality studies that can be used for the basis of a guideline. We don't include the cost-effectiveness in our outcome because of the limited study that compares the two procedures. However, cost-effectiveness analysis is important to decide whether we should follow the current guidelines. It should be analysed locally because of the differences in the healthcare system in each country. The only RCT that we found was conducted in the UK National Health Service by *Shen et al.* (5). The cost was measured in pounds sterling and effectiveness was measured by *quality-adjusted life years* (QALYs). The results showed us that urethroplasty is significantly more expensive than urethrotomy while average numbers of QALYs were similar (5).

Conclusions

Our review shows that open urethroplasty has lower recurrence rates at 12 months compared to internal urethrotomy for recurrent urethral strictures. However, symptom relief, improvement in urinary flow rate, complication, and post-procedure sexual function were comparable between the two procedures. Further randomized controlled trials with larger sample sizes, multicenter designs, and longer follow-up periods are needed to confirm our review.

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