Original Article

Male sling versus artificial urinary sphincter for the treatment of incontinence after prostate surgery: a systematic review with meta-analysis

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Background: Urinary incontinence following prostate treatment (IPT) represents a significant complication that detrimentally impacts the quality of life for patients who have undergone prostate surgery. Presently, there is a scarcity of evidence regarding the preferred surgical techniques for IPT. We conducted a meta-analysis to compare the outcomes of the male sling and artificial urinary sphincter (AUS) in the treatment of IPT.

Methods: Data were extracted through electronic literature searches on PubMed, Web of Science, and Embase databases until September 2023. Eligible studies included patients who underwent AUS or male sling procedures for IPT and had a follow-up duration exceeding 12 months. The primary end point was the success rate, with the secondary outcome focusing on complication rates. A fixed-effects or random-effects models were used to calculate the pooled estimate and its 95% confidence interval (CI). The publication bias was assessed using funnel plots and Egger's regression test.

Results: The meta-analysis included nine studies, involving a total of 1,350 participants. No statistically significant difference in success rates was found between AUS and male sling [odds ratio (OR): 0.96, 95% CI: 0.91–1.01]. In terms of the complication rate, there was no significant disparity between the two procedures (OR: 0.87, 95% CI: 0.86–1.12).

Conclusions: The findings from this study indicated that male sling surgery yielded success and complication rates comparable to those of AUS. This suggests that male sling could serve as a viable alternative surgical option in the treatment of IPT.

Keywords: Incontinence; sling; systematic review; urinary sphincter

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Introduction

Urinary incontinence (UI) is a frequent postoperative complication following radical prostatectomy (RP), affecting approximately 5–6% of male patients persistently, thus significantly influencing their overall quality of life (1). Additionally, a minority of patients may experience iatrogenic incontinence as a result of surgical interventions related to benign prostatic enlargement, with an incidence ranged from 0.5–3.7% (2-4).

Several therapeutic modalities have been developed for addressing incontinence following prostate treatment (IPT). These modalities encompass pelvic floor muscle exercises, pharmacotherapy, and surgical interventions.

Surgical interventions, in particular, are typically reserved for patients of persistent UI unresponsive to conservative measures. The two predominant surgical interventions employed are the artificial urinary sphincter (AUS) and the male sling (5). The male sling involves a minimally invasive procedure in which a sling is placed via a transobturator or retropubic approach to provide support to the urinary sphincter mechanism. In contrast, AUS constitutes a more intricate surgical process involving the implantation of an inflatable cuff encircling the urethra, connected to a pump and a reservoir located in the scrotum. Both the male sling and AUS have demonstrated encouraging outcomes in the management of IPT, with success rates spanning from 65–90% and 80–90%, respectively (6). Nonetheless, a consensus on the superior technique remains elusive, and the selection of procedure often hinges on surgeon preference, as well as patient-related factors such as age, comorbidities, and preoperative urinary function (7,8).

A meta-analysis undertaken by Lin *et al.* (9) encompassed five respective studies, comprising a total of 509 patients, and revealed that AUS outperformed male slings in the context of moderate UI with an acceptable complication rate. After that, several additional studies have been conducted to compare the efficacy of these two approaches. Notably, the MASTER study has conducted a randomized controlled trial (RCT) comparing AUS and male slings, finding no disparity in incontinence rates between them (10), thus emphasizing the imperative need for further research to elucidate the comparative effectiveness of these two techniques.

In this study, we have systematically synthesized the available evidence derived from pertinent studies to provide a comprehensive evaluation of the relative effectiveness of these two treatment options. We anticipate that our findings will facilitate clinicians in rendering informed decisions pertaining to the optimal management of IPT. We present this article in accordance with the PRISMA reporting checklist (available at https://tau.amegroups.com/article/view/10.21037/tau-24-107/rc).

Highlight box

Key findings

- This meta-analysis compared the outcomes of male sling and artificial urinary sphincter (AUS) for treating incontinence following prostate surgery. The study found no significant difference in success rates between the two procedures, with both showing similar efficacy in managing urinary incontinence (UI). Additionally, the complication rates were comparable, suggesting that male slings are a viable alternative to AUS.

What is known and what is new?

- It is known that AUS has been considered the gold standard for treating post-prostatectomy incontinence. However, this study adds to the body of evidence by demonstrating that male slings offer comparable success rates and complication profiles, challenging the preference for AUS based on current clinical practice.

What is the implication, and what should change now?

- The implications of these findings suggest a shift towards considering male slings as a first-line surgical option for UI following prostate surgery, particularly for patients seeking less invasive procedures. This could lead to a re-evaluation of treatment guidelines and patient counseling practices. Further research, including randomized controlled trials with extended follow-up, is recommended to validate these findings and explore the long-term outcomes and cost-effectiveness of both procedures.

Methods

Study selection

A systematic literature search was performed in accordance with PRISMA guideline. The following electronic databases were searched up to September 2023: PubMed, Embase, and Web of Science. The search strategy combined relevant keywords and Medical Subject Headings (MeSH) terms, including “male sling”, “artificial urinary sphincter”, and “urinary incontinence”. No restrictions regarding language or publication date were imposed. The congress abstracts were not included in the screening process. Additionally, a manual review of the reference sections of identified literature was carried out to find potential data sources.

Inclusion and exclusion criteria

Eligibility criteria for study inclusion were defined as follows: (I) comparative investigations on the effectiveness of male slings and AUS in the management of IPT; (II) reporting of outcome measures related to urinary continence (success rates and complication rates); and (III) availability of sufficient data for quantitative analysis. Excluded from consideration were case reports, reviews, and articles with inadequate follow-up periods of less than 12 months.

Data extraction

Two independent reviewers conducted a preliminary

assessment of the titles and abstracts of the identified studies to determine their eligibility for inclusion. The full texts of selected studies were subsequently scrutinized for definitive inclusion. Data extraction was carried out using a standardized form, including information on author, publication year, country, study period, study type, sample size, inclusion criteria, definition of success, type of sling, duration of follow-up, and outcome measures (success rates and complication rates). In the event of discrepancies in data extraction, resolutions were achieved through consensus or consultation with a third reviewer.

Quality assessment

The Newcastle-Ottawa Scale (NOS) was employed to assess the quality of nonrandomized studies incorporated into the meta-analysis. This evaluation encompassed critical aspects including the representativeness of the cohort, the method of ascertaining the intervention, documentation confirming the absence of the outcome of interest at the study's commencement, comparability of cohorts based on their design or analysis, the assessment of outcomes, and the adequacy of follow-up to observe the outcomes. According to the NOS, 7–9 score studies were thought of as high-level quality, 5–6 score studies were thought as moderate level, and <5 score studies were low-level quality. Quality assessments of RCTs were performed using the Cochrane Collaboration's tool (11).

Statistical analysis

This study undertook a comparative analysis of the efficacy and safety of male sling and AUS in IPT management. The primary endpoint of the study was the success rates (a reduction of pads use ≥50%) of the two procedures, and the secondary outcome was complication rate (infection, urinary retention, groin pain, erosion, mechanical failure, explantation), with outcomes analyzed using odds ratios (ORs) and 95% confidence intervals (CIs). To assess statistical heterogeneity among the included studies, the I^2 statistic was employed. If substantial heterogeneity was observed (I^2>50%), a random-effects model was applied; otherwise, a fixed-effects model was used. The forest plots were used to display the ORs and CIs of individual studies and their summary effects. To identify any potential factors that might contribute to heterogeneity, meta-regression and subgroup analysis were performed to gather more information. A sensitivity analysis was used to test the stability of the meta-analysis results. The presence of publication bias was visually assessed using funnel plots and quantitatively through Egger's regression test. All statistical analyses were conducted using STATA 12.0 (StataCorp, College Station, TX, USA).

Results

Figure 1 provides an illustrative depiction of the screening process. A total of nine studies were included in the quantitative analysis (10,12-19). Among these nine studies, one was an RCT (10), while the remaining eight were non-randomized studies. Detailed information about the included studies is presented in *Table 1*. Tables S1,S2 display the quality assessment results.

In the overall analysis, no statistically significant difference in success rates was identified between AUS and the male sling (OR: 0.96, 95% CI: 0.91–1.01, *Figure 2A*). The overall analysis exhibited significant heterogeneity (I^2=51.9%, P=0.03). Notably, the results of the Egger's test (t=–0.54, P=0.61), Begg's test (Z=–0.63, P=0.60), and funnel plot (*Figure 2B*) indicated an absence of significant publication bias.

Further sensitivity analysis confirmed the stability of the overall synthesis (*Figure 2C*). In the meta-regression and subgroup analysis (*Table 2*), no difference in success rates was observed between the two techniques, neither within RCT studies nor among non-randomized studies (P=0.057). Similarly, there was no significant difference in success rates when comparing adjustable and non-adjustable slings (P=0.11). The pooling of studies by publication year, sample size, and UI severity revealed no significant differences in success rates. Detailed subgroup analysis information can be obtained in the *Table 2*.

In the analysis of complication rates, no statistically significant difference in post-operative complications was found (OR: 0.87, 95% CI: 0.86–1.12, *Figure 3A*). Heterogeneity in the overall synthesis was non-significant (I^2=0%, P=0.63). Assessment for publication bias yielded negative results based on the Egger's test (t=–0.37, P=0.73), Begg's test (Z=0.25, P=0.81), and funnel plot (*Figure 3B*). Furthermore, sensitivity analysis affirmed the stability of the overall post-operative complication synthesis (*Figure 3C*).

Discussion

The implantation of AUS has long been regarded as the gold standard for addressing IPT in most cases (20).

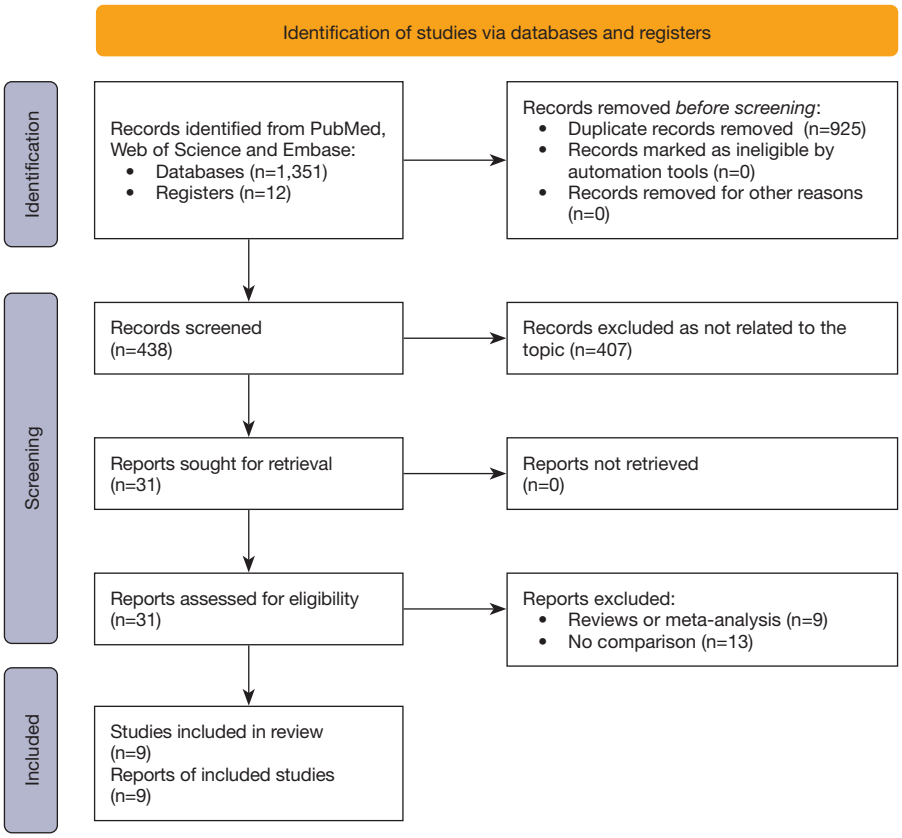

Figure 1 PRISMA 2020 flow diagram for new systematic reviews which included searches of databases, registers and other sources.

A previous meta-analysis reported a noteworthy 88% improvement in continence following AUS implantation, with 73% of patients achieving complete continence (21). However, in recent years, male sling has gained increased popularity due to their surgical simplicity, favorable functional outcomes, and low complication rates. Reported success rates for treatment with male slings range from 56% to 90% in long-term follow-up studies (22,23).

Several comparative studies have investigated the efficacy of these two techniques, but most published data stem from individual experiences at a limited number of surgical centers, with only a single head-to-head comparison from an RCT (10). This study conducted a meta-analysis to directly compare the efficacy of male slings and AUS in the treatment of IPT. The results of our analysis indicate that both treatment modalities are effective surgical options and demonstrate similar efficacy in improving UI. These findings contrast with a previous meta-analysis by Lin *et al.* (9), which reported that AUS outperform slings for the treatment of moderate male IPT. Notably, our study employed STATA 12.0 for statistical analysis, while Lin *et al.* (9) utilized RevMan 5.3.

In addition to the primary outcomes, our analysis also assessed complication rates. Both techniques presented unique (*de novo* emergency, urethral atrophy, mechanical failure) and common complications (perineal/groin pain). As some studies did not provide detailed information about complications, we could only compare overall complication rates, revealing that male slings exhibited a comparable rate of adverse events in comparison to AUS. However, it is worth noting that most complications in the male sling group were minimal and self-limited, while high-grade complications, such as urethral atrophy, urethral erosion, and mechanical failure, were more frequently observed in the AUS group.

Despite the similarity in overall success and complication rates, the choice between these two interventions should be personalized, taking into consideration patient factors and surgeon preferences. Patient preference should not be underestimated, as some studies have shown that patients

Table 1 Characteristics of studies included in the meta-analysis

Author	Publication year	Country	Study period	Study type	Inclusion criteria	Success definition	Sling type	Cases for slings	Cases for AUS	Follow-up duration (months)
Hoy (12)	2014	Canada	2004–2013	Respective	Mild to moderate IPT (≤5 pad/d)	0–1 pad/d	AdVance	76	48	Sling: 24; AUS: 42
Lim (13)	2014	Korea	2009–2013	Respective	Moderate IPT (2–4 pad/d)	0–1 pad/d	Argus	20	13	Sling: 24.7±11.8; AUS: 29.8±14.9
Kim (14)	2018	Korea	2001–2016	Respective	All patients with IPT	0–1 pad/d	Argus-T	50	53	31.0±21.4
Grabbert (15)	2019	Germany and Austria	2010–2012	Respective	All patients with IPT	Completely dry and improvement	Argus and Argus-T and ATMOS	82	220	16.7
Khouri (16)	2020	USA	2008–2019	Respective	Moderate IPT (MSIGS scores of 2–3)	0–1 pad/d	AdVance and AdVance XP	114	65	20.1
Sacco (17)	2021	Italy	2011–2017	Respective	Moderate IPT (3–5 pad/d)	0–1 pad/d	TiLOOP	35	35	Sling: 47.2; AUS: 51.2
Abrams (10)	2021	UK	2014–2017	RCT	All patients with IPT	Urine leakage "less than once a week" or "a small amount"	Advance	190	190	12
Esquinas (18)	2021	Spain	2014–2019	Prospective non-randomized study	All patients with IPT	No pads or using a safety pad with <10 mL in the pad test	ATOMS	102	27	34.9±15.9
Geretto (19)	2023	Italy	1995–2022	Respective	All patients with IPT	<10 mL in the pad test	ATOMS	49	49	43±35

AUS, artificial urinary sphincter; IPT, incontinence after prostate treatment; d, day; ATOMS, adjustable transobturator male system; RCT, randomized controlled trial; MSIGS, Male Stress Incontinence Grading Scale.

overwhelmingly choose male sling over AUS when provided with the choice between the two procedures (7). Male slings are less invasive and may be preferred by patients seeking a more conservative approach. In contrast, AUS implantation involves a more complex surgery, making it more suitable for patients with severe incontinence or those who have failed previous treatments (24).

It is essential to recognize that our analysis identified significant heterogeneity among the included studies, possibly due to variations in patient populations, surgical techniques, and outcome assessments. Five studies encompassed patients with moderate UI, while the other four studies did not specify restrictions. Moreover, five studies explored the comparison between adjustable slings and AUS, whereas four studies focused on non-adjustable slings. Most importantly, a lack of a standardized definition of treatment success between studies may account for the major heterogeneity in the meta-analysis (*Table 1*). To account for this heterogeneity, we employed random-effects models, which consider both within-study and between-study variability. Sensitivity analyses were conducted, and the results remained consistent across various subgroup analyses.

While this study focused on the clinical outcomes of male slings and AUS for treating IPT, the cost-effectiveness of these procedures is an essential factor for healthcare decision-making. The initial acquisition cost of AUS is generally higher than that of male slings. However, AUS implantation may require a longer operative time and potentially lead to more complex postoperative complications, which could translate to higher overall healthcare costs. Conversely, male slings, despite their lower upfront cost, might necessitate repeat procedures due to potential durability concerns.

While our meta-analysis included nine studies selected based on their relevance, quality, and robust methodologies, there are important limitations to consider. First, only one RCT was included, with the majority of studies being non-

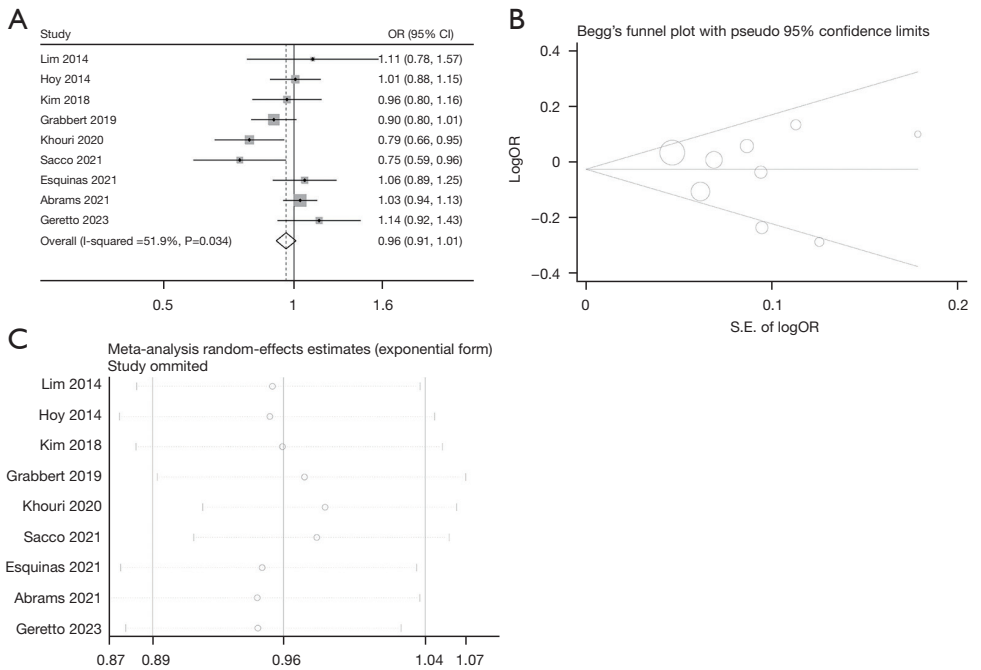

Figure 2 Success rate comparison between male sling and artificial urinary sphincter. (A) Forest plot of meta-analysis; (B) funnel plot for publication bias detection; (C) sensitivity analysis. OR, odds ratio; CI, confidence interval; S.E., standard error.

Table 2 Meta-regression and subgroup analyses of success rate

Subgroup	No. of studies	Meta-regression				Pooled OR (95% CI)	Heterogeneity	
		Coefficient	Standard error	*t* value	P value		I^2, %	P value
Study type		–	–	–	–			
RCT	1					1.03 (0.94–1.13)	–	–
Non-randomized	8					0.95 (0.87–1.04)	51.0	0.03
Recent 5 years study		0.77	0.78	−2.57	0.08			
Yes	6					0.94 (0.84–1.06)	68.3	0.007
No	3					1.00 (0.90–1.11)	0	0.79
Sample size >200		0.83	0.08	−2.08	0.13			
Yes	2					0.97 (0.84–1.11)	70	0.07
No	7					0.96 (0.86–1.07)	54.4	0.04
Sling type		0.87	0.07	−1.81	0.17			
Adjustable	5					0.99 (0.91–1.09)	21.5	0.28
Non-adjustable	4					0.91 (0.78–1.06)	74.7	0.008
Region		0.88	0.12	−0.94	0.42			
Asia	2					0.99 (0.84–1.17)	0	0.50
Western countries	7					0.96 (0.87–1.05)	62.9	0.01
UI severity		1.62	0.21	3.75	0.03			
Moderate	5					0.91 (0.79–1.04)	54.3	0.07
Not specified	4					1.01 (0.92–1.11)	43.5	0.15

OR, odds ratio; CI, confidence interval; RCT, randomized controlled trial; UI, urinary incontinence.

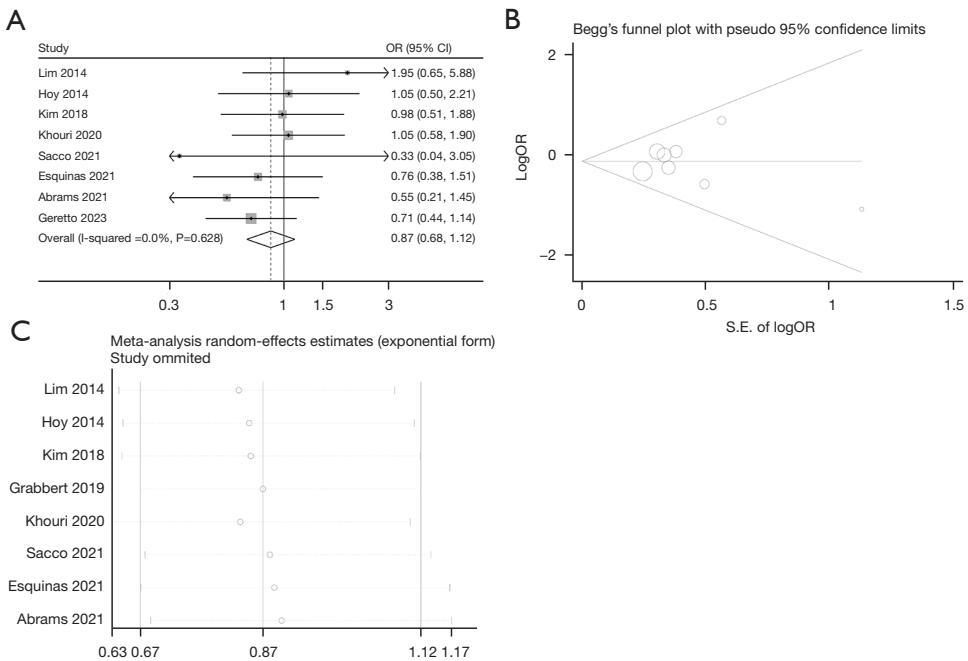

Figure 3 Complication rate comparison between male sling and artificial urinary sphincter. (A) Forest plot of meta-analysis; (B) funnel plot for publication bias detection; (C) sensitivity analysis. OR, odds ratio; CI, confidence interval; S.E., standard error.

randomized and respective, introducing the potential for selection bias and confounding. Second, the sample sizes of the included studies were relatively small, underscoring the need for larger RCTs to validate our findings and provide more definitive evidence. Third, the quality of the included studies varied, with some having a high risk of bias. Fourth, the severity of incontinence is a crucial factor in the choice between a male sling and AUS, however, the comparison between the two surgical techniques according to the severity of incontinence was not performed.

Conclusions

In conclusion, our meta-analysis suggests that male sling can be a viable alternative to AUS for treating IPT. This may offer patients a less invasive surgical option with comparable effectiveness and complication rates. Further research, including well-designed RCTs with extended follow-up durations, is warranted.

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Footnote

Reporting Checklist: The authors have completed the PRISMA reporting checklist. Available at https://tau.amegroups.com/article/view/10.21037/tau-24-107/rc

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Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://tau.amegroups.com/article/view/10.21037/tau-24-107/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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