REVIEW PAPER

FUNCTIONAL UROLOGY

Does miniaturisation improve holmium laser enucleation of prostate outcomes? A meta-analysis of comparative studies

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Introduction Holmium laser enucleation of the prostate (HoLEP) is a versatile treatment for benign prostatic hyperplasia (BPH), serving as an alternative to transurethral resection of the prostate (TURP) and open/robotic-assisted prostatectomy. Recent advancements have focused on evaluating the impact of smaller (22–24 Fr) vs larger (26–28 Fr) resectoscope sheaths on procedural outcomes.
The aim of this study was to assess and compare the safety, efficiency, and complication rates associated with smaller and larger resectoscope sheaths in HoLEP procedures through a meta-analysis.
Material and methods A systematic review was conducted following PRISMA guidelines. Four studies (one RCT and three retrospective) comprising 633 patients (277 with small sheaths [SR] and 356 with large sheaths [LR]) met inclusion criteria. Outcomes assessed included operative time, enucleation/morcellation efficiency, complications (urethral strictures, transient incontinence), and recovery parameters.
Results In terms of efficiency, no significant differences were observed in operative time, enucleation time, or enucleation efficiency. LR showed faster morcellation time (p = 0.03). As for complications, SR had significantly lower urethral dilation rates (8.0% vs 39.5%, p = 0.01). No significant differences in urethral stricture rates, catheterisation duration, complication rates or transfusion rates. In terms of recovery, similar hospital stay durations and incontinence rates were seen at 3 months postoperatively between groups, and SR might decrease incontinence rates at 1 month postoperatively.
Conclusions Using smaller resectoscope sheaths in HoLEP reduces urethral dilation rates without compromising procedural efficiency or safety. Larger sheaths had shorter morcellation times. The choice of sheath size should be guided by patient anatomy, surgeon expertise, and procedural requirements. Further large-scale RCTs are needed to confirm long-term outcomes.

Key Words: benign prostatic hyperplasia ‹› holmium laser enucleation of the prostate ‹› resectoscope

INTRODUCTION

Holmium laser enucleation of the prostate (HoLEP) is a size-independent treatment option for benign prostatic hyperplasia (BPH). It serves as an alternative to traditional transurethral resection of prostate (TURP) for small to medium-sized prostates and to open or robotic-assisted simple prostatectomies (RASP) for larger prostates [1, 2].
HoLEP has been found to be superior to TURP in post-operative functional outcomes during both short and long-term follow-ups [3–5]. Compared to RASP, HoLEP has similar functional outcomes but offers advantages such as earlier recovery and a better safety profile with lower blood transfusion and moderate to significant complication rates [6].
Multiple recent studies have compared outcomes of HoLEP with miniaturised smaller resectoscope sheaths compared to the traditional larger sheaths [7–10]. It was hypothesised that smaller resectoscopes may lead to lower stricture rates compared to larger scopes, which have a stricture rate

of 1.2–7.3%, due to decreased urethral trauma [11–15]. This was first hypothesised in an observational study comparing the outcomes of HoLEP with a 26 Fr vs 28 Fr resectoscope sheath, however, the rate of urethral strictures was not found to be statistically different at 3.5% vs 1.8% [16].

The objective of this meta-analysis is to consolidate current research comparing the operative outcomes of HoLEP with smaller and larger resectoscope sheaths, including the following: operative time, enucleation and morcellation efficiency, complications (urethral stricture, transient incontinence), and recovery parameters. This review aims to provide clarity regarding the impact of resectoscope size on procedural safety and efficiency, contributing to an informed choice of equipment and approach in clinical practice.

MATERIAL AND METHODS

In March 2024, with PROSPERO registration (CRD42024603851), a systematic search for a systematic review was performed following the PRISMA criteria (Figure 1). PubMed, EMBASE, and Cochrane library of systematic reviews were queried for the terms "(HoLEP) AND (resectoscope)". No restrictions on publication date were applied; only English language articles were considered. Two independent (MZUA, MH) reviewers screened returned results for inclusion and data extraction. Data conciliation was performed through consensus. This study was exempt from review by the institutional review board, and informed consent was not required because data were publicly available.

Inclusion criteria

Randomised controlled trials (RCTs) and observational studies comparing small resectoscope (SR) sheaths (22–24 Fr) to large resectoscope (LR) sheaths (26–28 Fr).

Exclusion criteria

Our exclusion criteria included conference abstracts and non-English articles.

Data extraction

Data were extracted independently by two reviewers. Data relevant to this meta-analysis besides authorship and year of publication were as follows: risk of bias assessment, cohort size, Anticholinergic use postoperatively, bladder neck contracture rates, catheterisation time, enucleation volume, enucleation time, hospitalisation duration, major complications (IIIb or higher as per Clavien Dindo classifi-

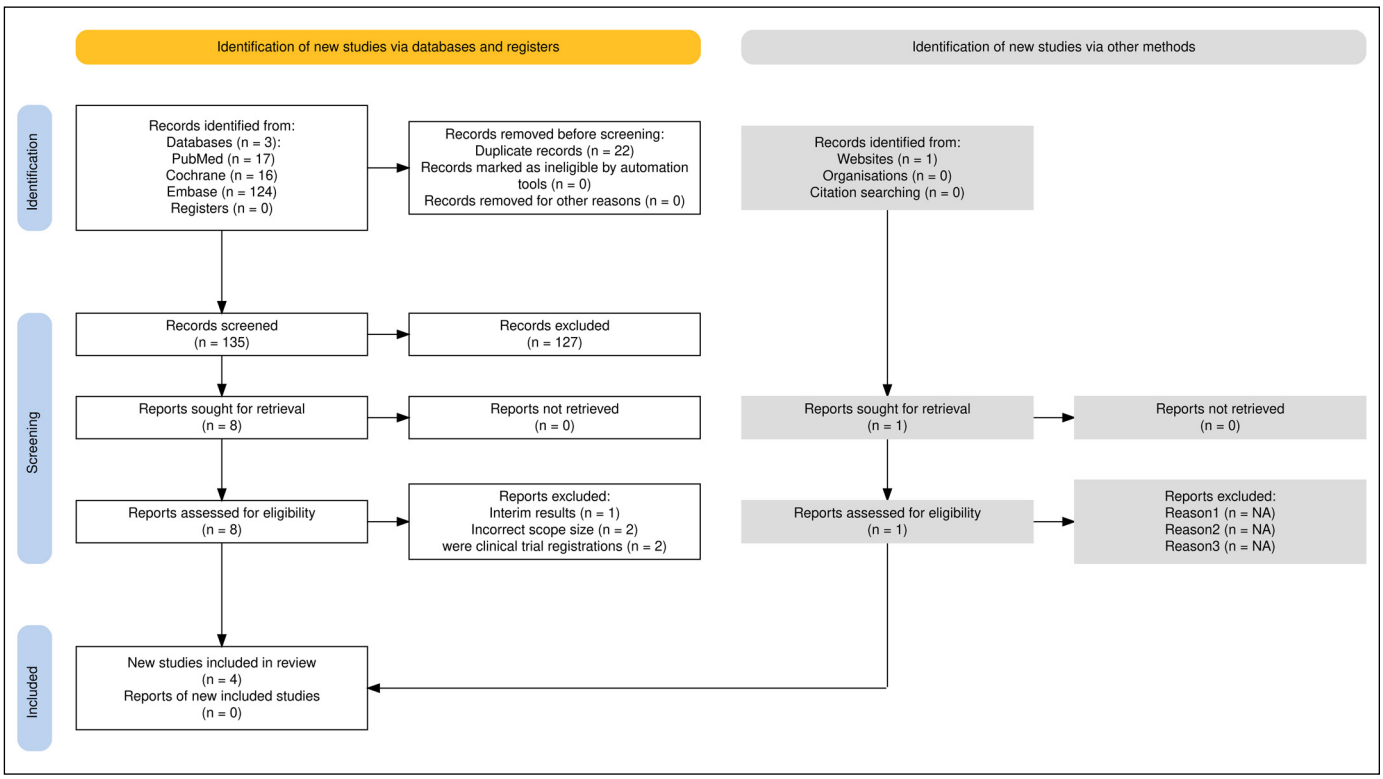


Figure 1. *PRISMA flowchart of article selection.*

cation system), morcellation efficiency, morcellation time, operative time, postoperative incontinence, total complications, transfusion rates, urethral dilation rates and urethral stenosis. Studies providing data in median and ranges were used to estimate mean and standard deviation using Wan's method [17]. Bias was assessed using Cochrane's Risk of Bias 2 tool for RCTs and the Newcastle-Ottawa Score, which is displayed in Tables 1 and 2.

Statistical analysis

Data analysis was performed in Review Manager V5.4 (Cochrane). Higgins' 12% test was employed to test heterogeneity, using 50% as a cutoff value. Random-effects models were used in place of fixed-effects for heterogeneous variables. Continuous data are reported as mean difference with 95% confidence intervals (CI). Dichotomous data, such as complications, were reported using odds ratios (OR) with 95% CI. The resulting values with associated p-values <0.05 were considered significant. Funnel plots were plotted to look for small study bias in dichotomous data.
The data analysis was rerun, excluding non-PubMed-indexed (Yildiz et al. 2022) studies in outcomes, with three studies remaining after exclusion [8].

Table 1. *Risk of bias 2 for Dean et al. 2023*

Domain	Risk of bias
1. Bias arising from the randomization process	Low
2. Bias due to deviations from intended interventions	Low
3. Bias due to missing outcome data	Low
4. Bias in measurement of the outcome	Some concerns
5. Bias in selection of the reported result	Low
Overall Bias Assessment	Some concerns

RESULTS

Four studies (one RCT and three retrospective studies) met the inclusion criteria and were analysed. This included 633 patients, 277 and 356 in the SR and LR groups, respectively. Overall characteristics of included studies are displayed in Table 3, baseline characteristics in Table 4, and outcomes analysed in each study in Table 5.

Operative time

Operative time was described in 3 studies, totalling 533 patients (237 and 296 in the SR and LR, respectively). Analysis revealed no differences between groups, with a mean difference of –0.5 minutes [–3.88, 2.87], p = 0.77, suggesting equivalent operative time with both methods. This finding is displayed in Figure 2.

Enucleation time

Enucleation time was described in 3 studies, totalling 553 patients (237 and 316 in the SR and LR, respectively). Analysis revealed no differences between groups, with a mean difference of –0.88 minutes [–3.53, 1.77], p = 0.52, suggesting equivalent enucleation time with both methods. This finding is displayed in Figure 3.

Enucleation efficiency

Enucleation efficiency was described in 3 studies, totalling 553 patients (237 and 316 in the SR and LR, respectively). Analysis revealed no differences between groups, with a mean difference of –0.07 g/min [–0.16, 0.02], p = 0.11, suggesting equivalent enucleation efficiency with both methods. This finding is displayed in Figure 4.

Table 2. *Newcastle Ottawa Score for non-randomised trials*

Study	Selection (Max 4)	Comparability (Max 2)	Outcome (Follow-up Adequacy Max 3)	Total Score (Max 9)	Limitations
Ibis et al. 2021 [10]	Representativeness: yes Non-exposed cohort: yes Exposure ascertainment: yes Baseline info: yes	Controls for BMI and prostate size: partial	Short-term follow-up (4, 12, 24 weeks)	7	Short (90-day) follow-up
Taha et al. 2023 [9]	Representativeness: yes Non-exposed cohort: yes Exposure ascertainment: yes Baseline info: yes	Propensity score matching: yes	Short-term follow-up (up to 3 months)	8	Short (24-week) follow-up and 26 Fr morcellator used following 22 Fr enucleation
Yildiz et al. 2022 [8]	Representativeness: yes Non-exposed cohort: yes Exposure ascertainment: no; Baseline info: no	Controls for age, BMI, IPSS: partial	Long-term follow--up (12 months)	6	Single surgeon performing with different endoscopes at different periods (introducing experience bias). Various sizes of instruments were used

Morcellation time

Morcellation time was described in 3 studies, totalling 553 patients (237 and 316 in the SR and LR, respectively). Analysis revealed statistically significant differences between groups with a mean difference of 0.97 minutes [0.11, 1.83], p = 0.03 in favour of LR. This suggests faster morcellation time with LR. This finding is displayed in Figure 5.

Morcellation efficiency

Morcellation efficiency was described in 3 studies, totalling 553 patients (237 and 316 in the SR and LR, respectively). Analysis revealed differences between groups with a mean difference of –0.71 g/min [–1.43, 0.02], p = 0.06, in favour of LR. However, this finding was not statistically significant. This finding is displayed in Figure 6.

Table 3. *Included studies characteristics*

Study	Study type	Journal (Impact factor)	HoLEP Technique	Resectoscope sheath sizes	Morcellator Used
Ibis et al. 2021 [10]	Observational (retrospective)	LUTS: Lower Urinary Tract Symptoms (1.5)	En-bloc HoLEP with early apical release	22F and 26F	26F nephroscope with VersaCut tissue morcellator (Lumenis)
Taha et al. 2023 [9]	Observational (prospective, propensity score-matched)	World Journal of Urology (2.8)	Mini-HoLEP (MiLEP) compared with standard HoLEP	22F (MiLEP) and 26F (HoLEP)	Wolf® Piranha
Yildiz et al. 2022 [8]	Observational (retrospective)	Haseki Medical Bulletin (0.2)	Standard three-lobe HoLEP	24F and 26F	Jena Surgical Multicut
Dean et al. 2023 [7]	Randomized controlled trial	Journal of Endourology (2.9)	Standard three-lobe/two-lobe HoLEP with early apical release	24F and 28F	24F and 28F morcellator

Table 4. *Baseline characteristics of the included studies*

Study	Baseline finding	Smaller resectoscope group	Larger resectoscope group	p
Ibis et al. 2022 [10]	Mean age [years]	66.3	67.1	0.575
	Prostate volume [ml]	63.9	66.0	0.213
	Preoperative IPSS	22.3	23.5	0.149
	Preoperative PSA	4.8	5.7	0.228
	BMI	29	30.7	0.195
Taha et al. 2023 [9]	Mean age [years]	74	74	0.200
	Prostate volume [ml]	100	100	0.940
	Chronic retention [%]	33	31	1.000
	ASA score	2	2	0.310
	Indwelling catheter use [%]	38	33	0.800
Yildiz et al. 2022 [8]	Mean age [years]	69.1	68.5	0.608
	Prostate volume [ml]	108.6	112.8	0.395
	Preoperative IPSS	26.5	27.3	0.102
	BMI	23.6	23.8	0.427
	Post void residual	151.1	150.9	0.983
Dean et al. 2023 [7]	Mean age [years]	68.6	70.1	0.218
	Prostate volume [cm³]	92.3	100.2	0.355
	Preoperative AUASS	20.6	20	0.732
	ASA score	2.3	2.3	0.288
	Indwelling catheter use [%]	22	26	0.574

ASA – American Society of Anesthesiologists; AUASS – American Urological Association symptom score; BMI – body mass index; IPSS – International Prostate Symptom Score; PSA – prostate-specific antigen

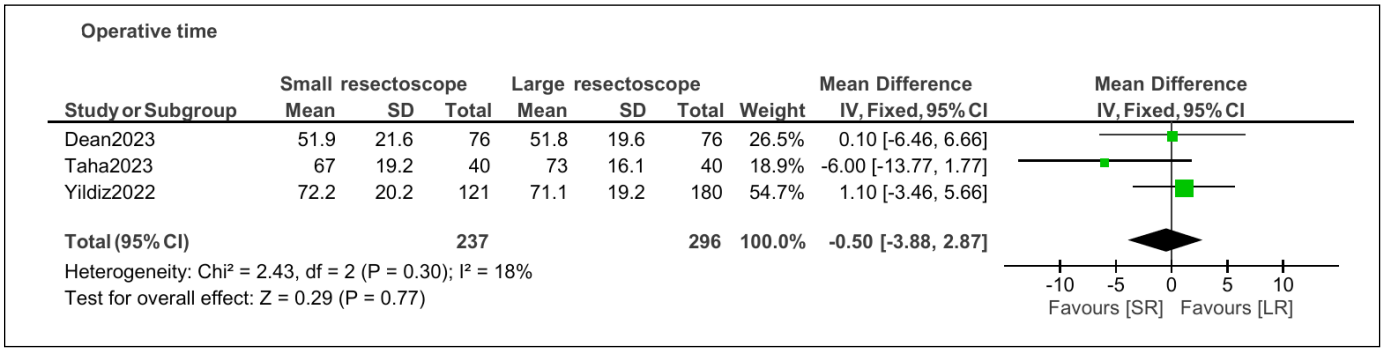


Figure 2. *Forest plot for operative time.*

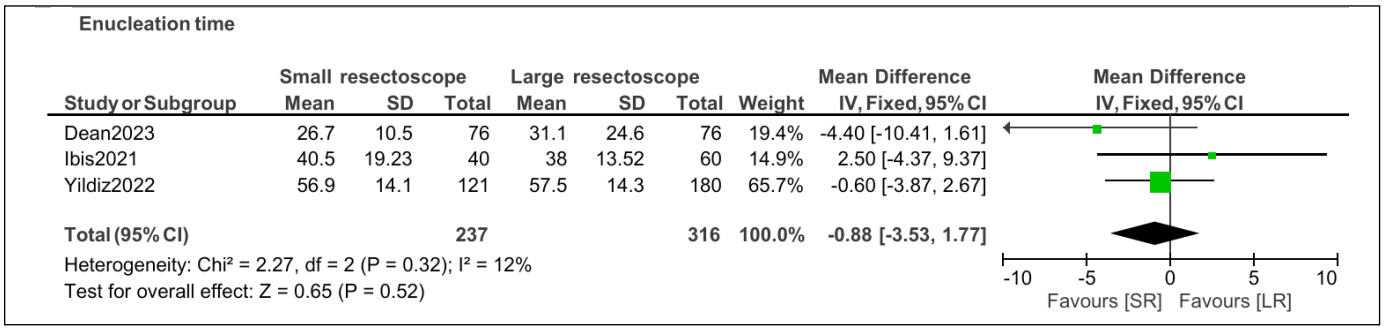


Figure 3. *Forest plot for enucleation time.*

Table 5. *Outcomes analysed*

Outcomes	Findings			
	Ibis et al. 2021 [10]	Taha et al. [9] 2023	Yildiz et al. 2022 [8]	Dean et al. 2023 [7]
Operative time	NR	NSD	NSD	NSD
Enucleation time	NSD	NR	NSD	NSD
Enucleation efficiency	NSD	NR	NSD	NSD
Morcellation time	NSD	NR	Lower in smaller resectoscope group	NSD
Morcellation efficiency	NSD	NR	Lower in smaller resectoscope group	NSD
Specimen weight	NSD	NR	NSD	NSD
Urethral dilation rates	NSD	Lower in smaller resectoscope group	Lower in smaller resectoscope group	NSD
Catheterisation duration	NSD	NR	NSD	NR, (Higher same day successful trial of void in larger resectoscope group)
Transfusion rates	NR	NR	NSD	NSD
Hospitalisation duration	NR	NSD	NSD	Lower in larger resectoscope group
Complication rates	NR	NSD	NSD	NSD
Urethral stricture rates	NR	NR	NSD	NSD
Bladder neck contracture	NR	NR	NSD	NSD
Urinary incontinence at one month	Lower incontinence in the smaller resectoscope group	Lower incontinence in the smaller resectoscope group	NSD	NSD
Urinary incontinence at three months	NSD	NSD	NR	NSD

NSD – no statistical difference; NR – not reported

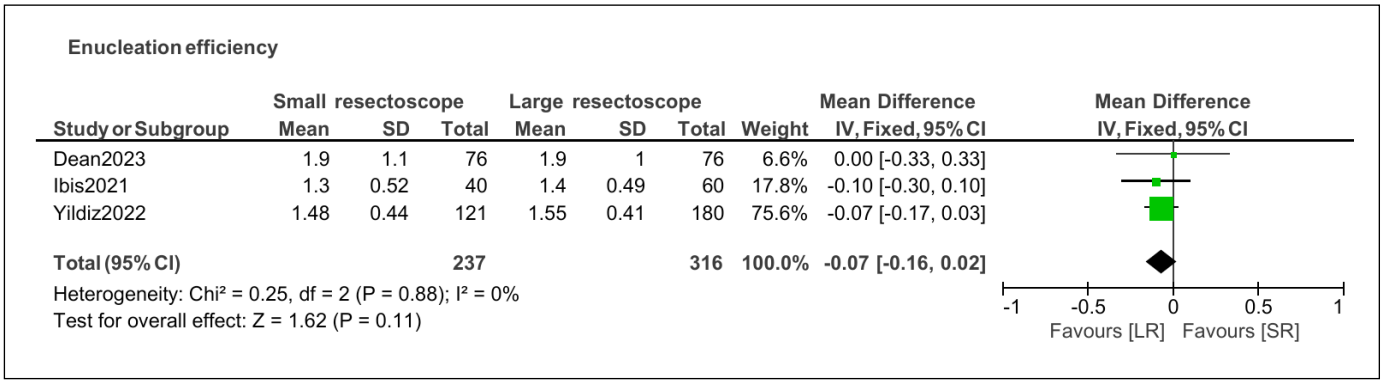


Figure 4. *Forest plot for enucleation efficiency.*

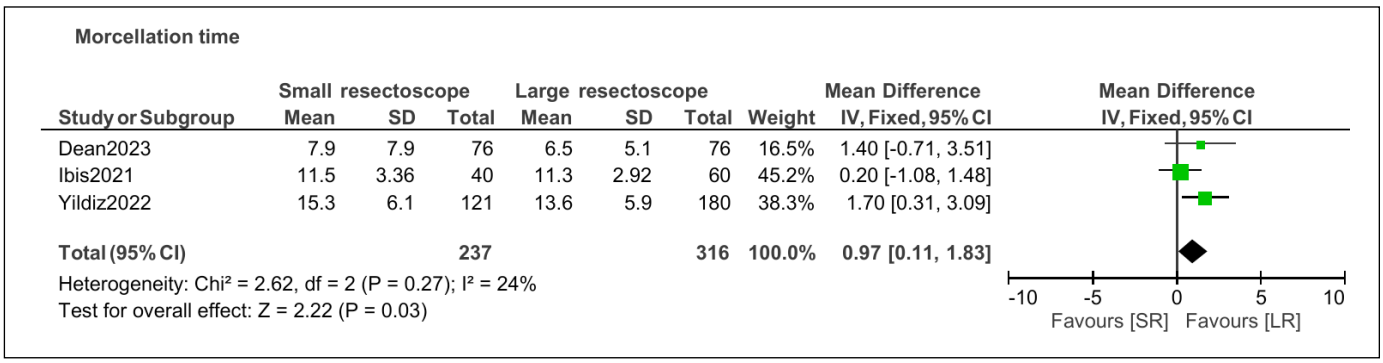


Figure 5. *Forest plot for morcellation time.*

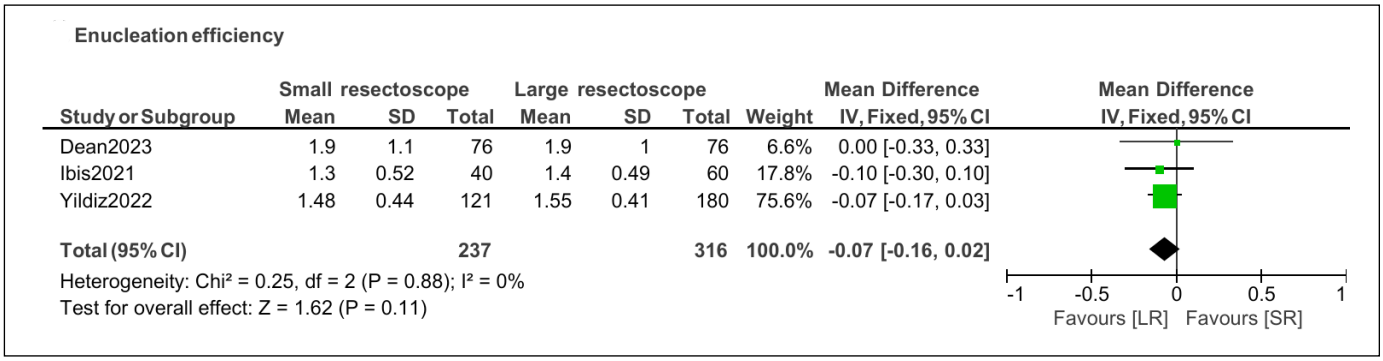


Figure 6. *Forest plot for morcellation efficiency.*

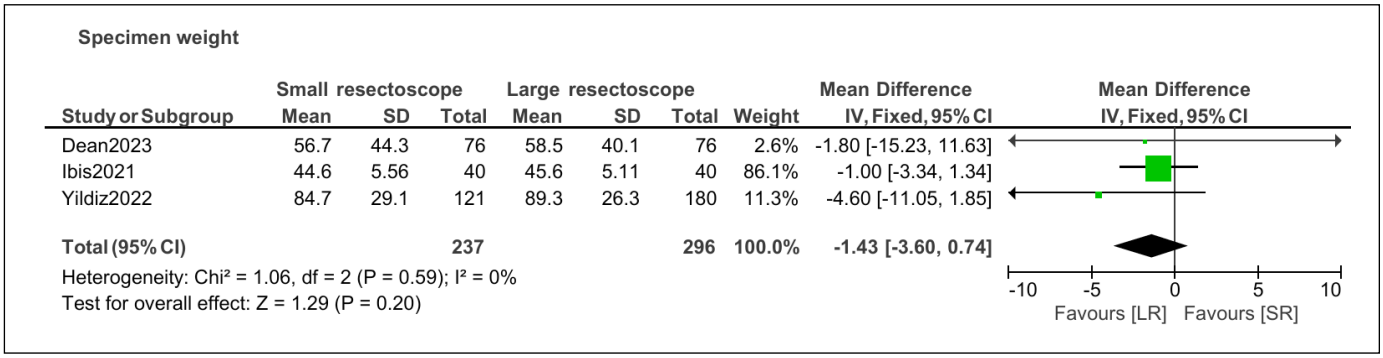


Figure 7. *Forest plot for specimen weight.*

Specimen weight

Specimen weight was described in 3 studies, totalling 533 patients (237 and 296 in the SR and LR, respectively). Analysis revealed no differences between groups with a mean difference of –1.43 g [–3.60, 0.74], p = 0.20, suggestive of equivalent enucleation volume with both methods. This finding is displayed in Figure 7.

Urethral dilation rates

Urethral dilation rates were described in 3 studies, totalling 533 patients (237 and 296 in the SR and LR groups, respectively). Urethral dilation rates for patients in the SR group were 8.0% as compared with 39.5% for LR. This finding was statistically significant with an associated OR of 0.17 [0.04, 0.69], p = 0.01. The funnel plot is included in the supplemental material. This finding is displayed in Figure 8.

Catheterisation duration

Catheterisation duration was described in 2 studies, totalling 401 patients (161 and 240 in the SR and LR, respectively). Analysis revealed no differences between groups, with a mean difference of 0.93 hours [–0.49, 2.35], p = 0.20, suggesting of equivalent catheterisation duration with both methods. This finding is displayed in Figure 9.

Transfusion rates

Transfusion rates were described in 2 studies, totalling 453 patients (197 and 256 patients in the SR and LR groups, respectively). Of these, SR reported 0 (0%) transfusions and LR 1 (0.4%) transfusion. This difference was not statistically significant OR = 0.49 [0.02, 12.19], p = 0.67. The funnel plot is included in the supplemental material. This finding is displayed in Figure 10.

Hospitalisation duration

Hospitalisation duration was described in 3 studies, totalling 533 patients (237 and 296 in the SR and LR, respectively). Analysis revealed no differences between groups with a mean difference of 1.35 hours [–2.88, 5.59], p = 0.53, suggestive of equivalent hospitalisation duration with both methods. This finding is displayed in Figure 11.

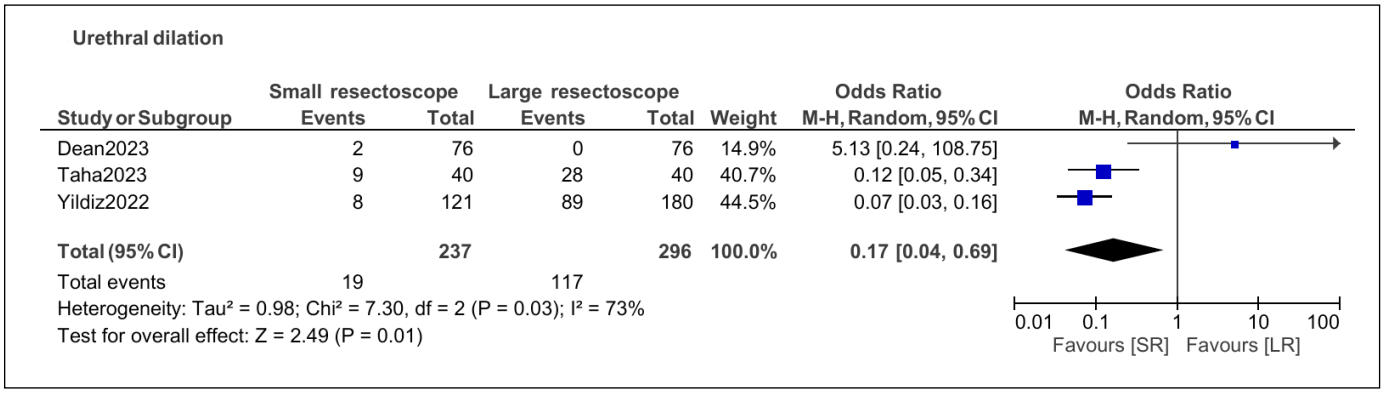


Figure 8. *Forest plot for urethral dilation rates.*

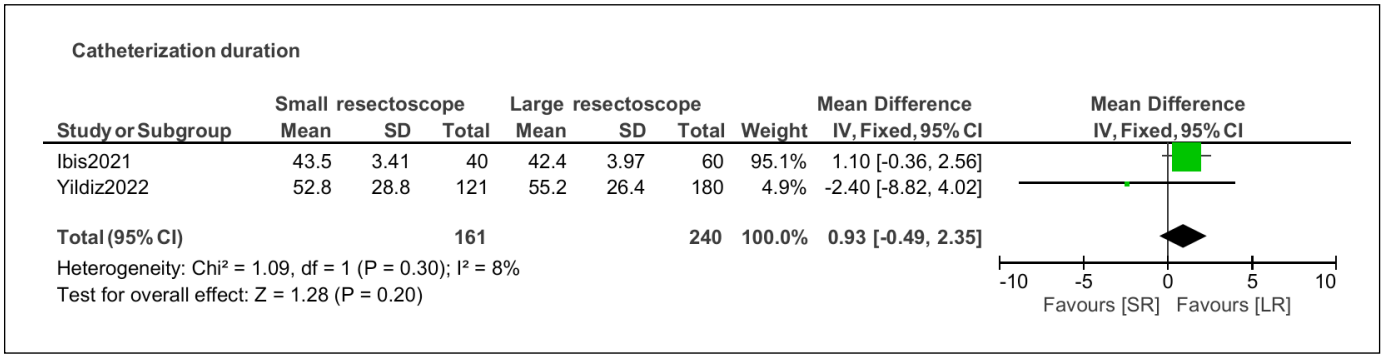


Figure 9. *Forest plot for catheterisation duration.*

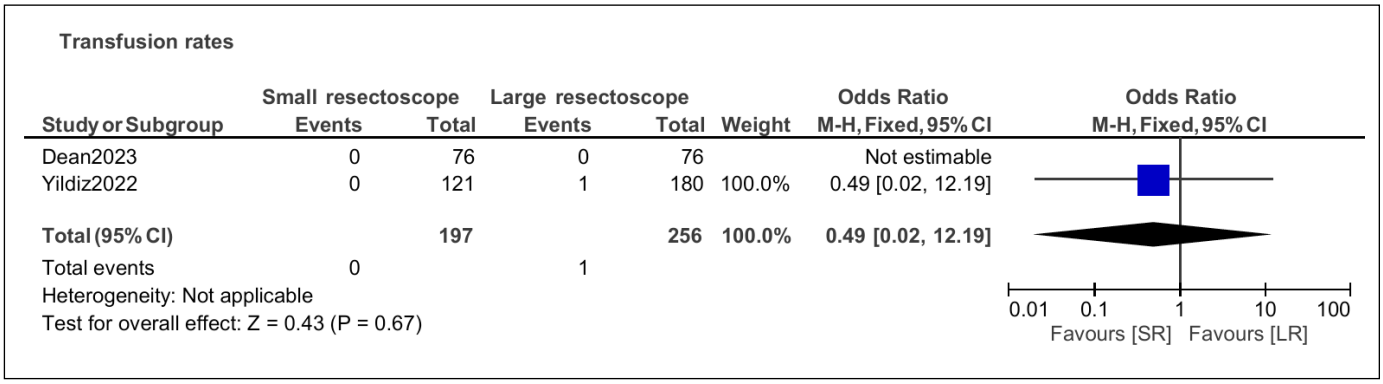


Figure 10. *Forest plot for transfusion rates.*

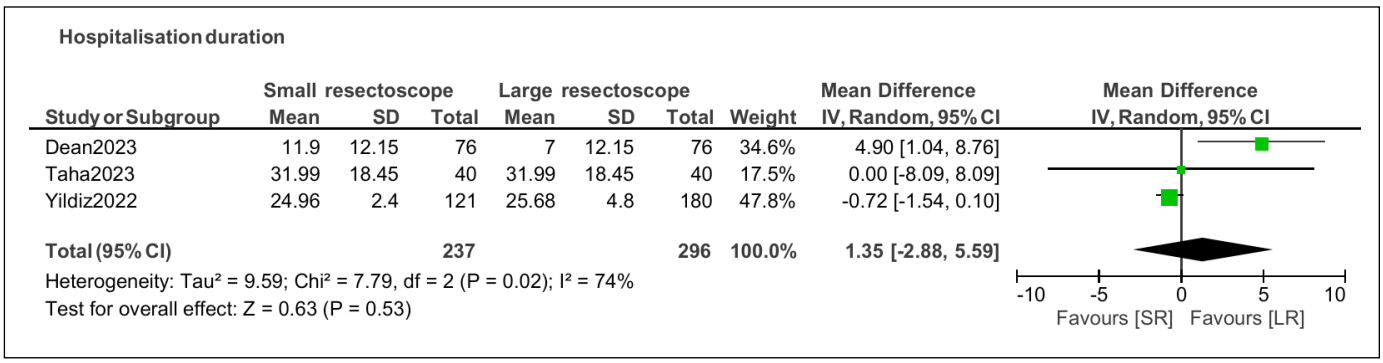


Figure 11. *Forest plot for hospitalisation duration.*

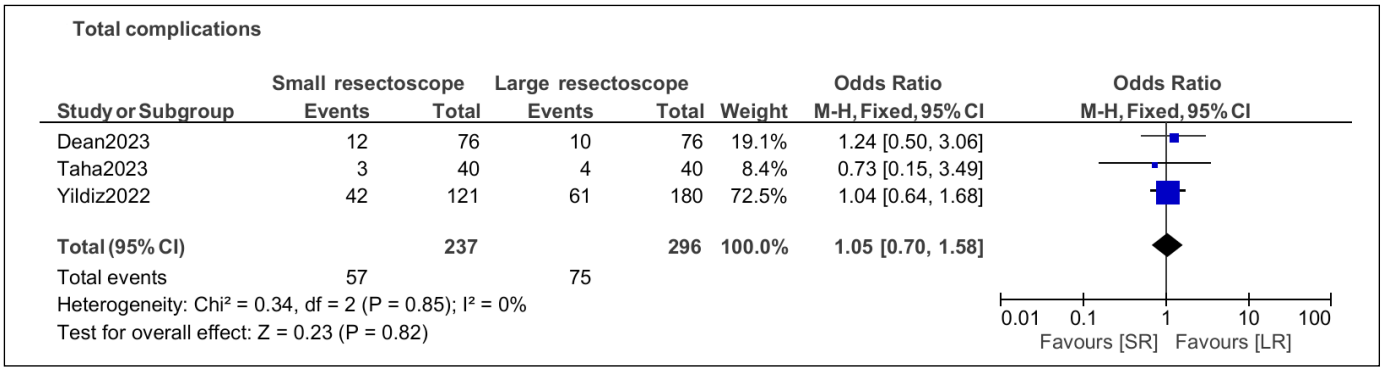


Figure 12. *Forest plot for total complications.*

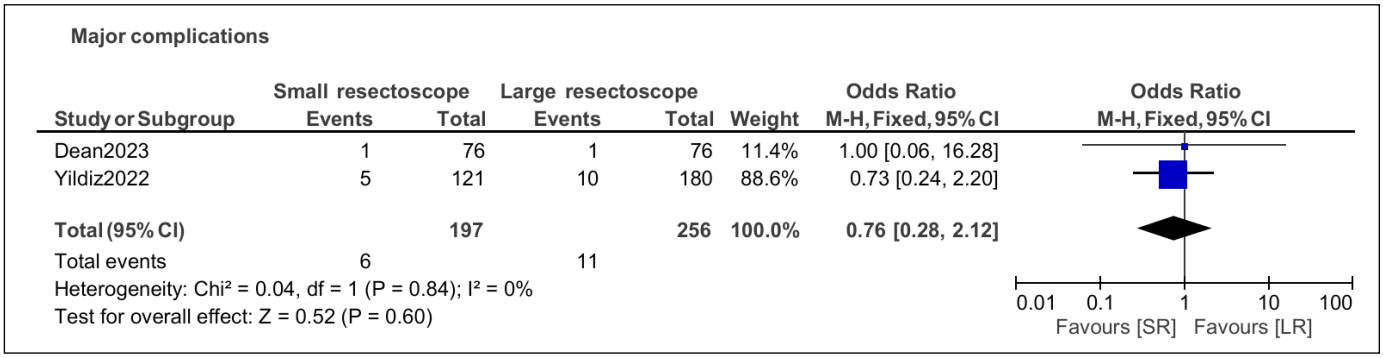


Figure 13. *Forest plot for major complications.*

Complication rates

Complication rates were described in 3 studies, totalling 237 patients in the SR group and 296 in the LR group. Significant complications were defined as complications of Clavien-Dindo classification grade ≥IIIb. The overall complication rates for SR and LR were 24.05% vs 25.34% (p = 0.82), with a moderate/severe complication rate of 3.05% vs 4.3% (p = 0.60), respectively. Odds of total complications between groups were OR = 1.05 [0.70, 1.58], p = 0.82; the odds of moderate to significant complications were OR = 0.76 [0.28, 2.12], p = 0.60. Funnel plots are included in the supplemental material. This finding is displayed in Figures 12 and 13.

Urethral stricture rates

Urethral stricture rates were described in 3 studies, totalling 545 patients (233 and 312 patients in the SR and LR groups, respectively). Of these, SR and LR reported a stricture rate of 4 (1.72%) and 10 (3.21%), respectively. This difference was not statistically significant OR = 0.59 [0.18, 1.90], p = 0.37. The funnel plot is included in the supplemental material. This finding is displayed in Figure 14.

Bladder neck contracture rates

Bladder neck contracture (BNC) rates were described in 2 studies, totalling 453 patients (197 and 256 patients in the SR and LR groups, respectively). Of these, SR reported 1 (0.51%) BNC and LR 2 (0.78%) BNC. This difference was not statistically significant, OR = 0.74 [0.07, 8.27], p = 0.81. The funnel plot is included in the supplemental material. This finding is displayed in Figure 15.

Urinary incontinence at one month

Urinary incontinence at one-month (UI@1) rates were described in 4 studies, totalling 633 patients (277 and 356 patients in the SR and LR groups, respectively). Of these, SR reported 27 (9.75%) UI@1 and LR 56 (15.73%) UI@1. This difference was not statistically significant (OR = 0.53 [0.25, 1.11], p = 0.09). The funnel plot is included in the supplemental material. This finding is displayed in Figure 16A.
On exclusion of Yildiz et al. [8], urinary incontinence at one-month (UI@1) rates were described in three

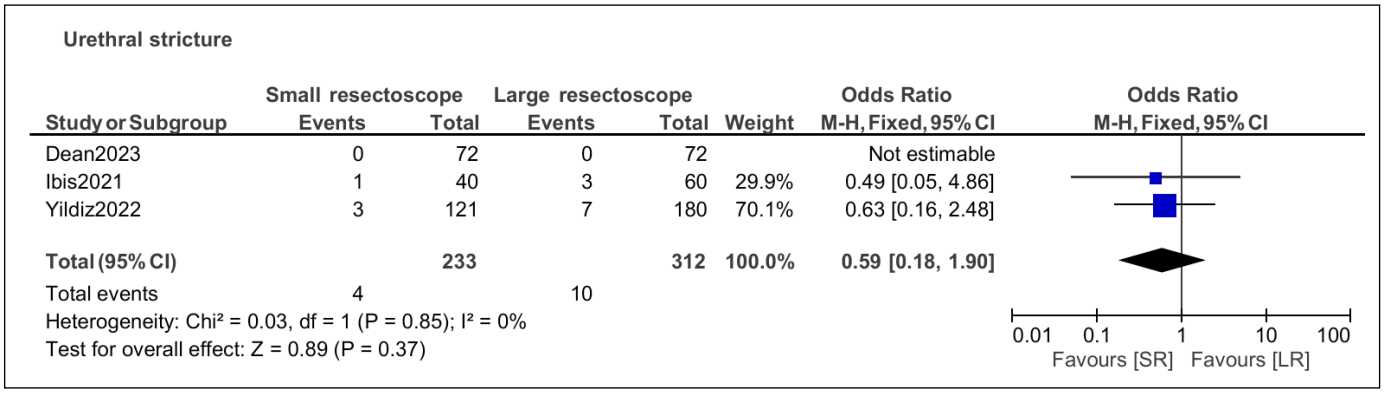


Figure 14. *Forest plot for urethral stricture.*

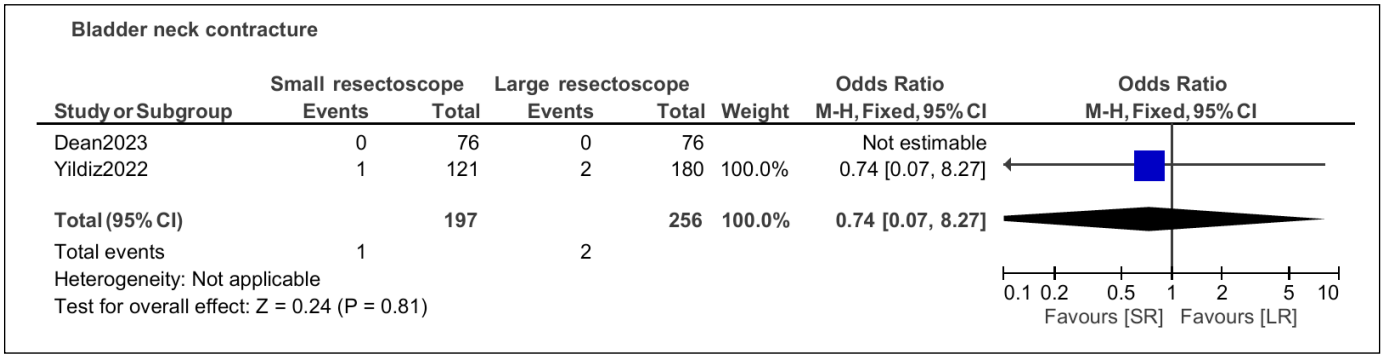


Figure 15. *Forest plot for bladder neck contracture.*

studies, totalling 332 patients (156 and 176 patients in the SR and LR groups, respectively). Of these, SR reported 19 (12.18%) UI@1 and LR 46 (26.14%) UI@1. This difference was statistically significant: OR = 0.40 [0.22, 0.72], p = 0.002. This is displayed in Figure 16B.

Urinary incontinence at three months

Urinary incontinence at 3-month (UI@3) rates were described in 3 studies, totalling 332 patients (156 and 176 patients in the SR and LR groups, respectively). Of these, SR reported 12 (7.69%) UI@3 and LR 18 (10.23%) UI@3. This difference was not statistically significant, OR = 0.75 [0.35, 1.62], p = 0.47. The funnel plot is included in the supplemental material. This finding is displayed in Figure 17.

DISCUSSION

The findings of this meta-analysis, which included one RCT and three retrospective studies encompassing 633 patients, shed light on key aspects

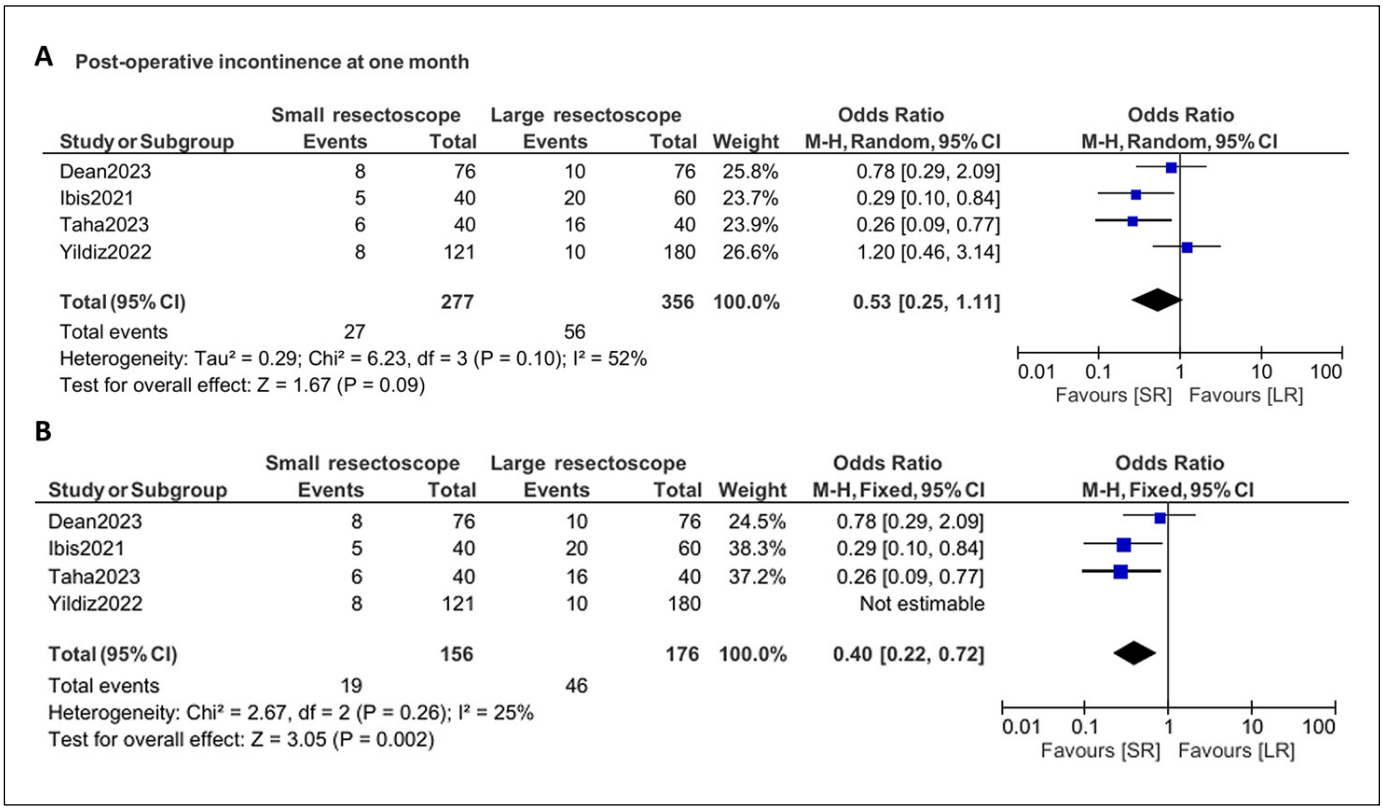


Figure 16. A) *Forest plot for urinary incontinence at one month.* **B)** *Forest plot for urinary incontinence at one month (excluding non-PubMed-indexed articles).*

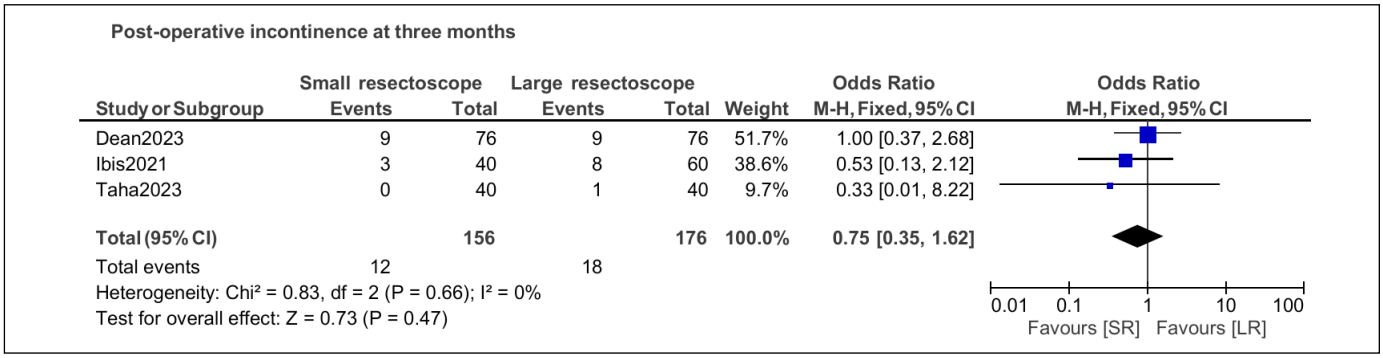


Figure 17. *Forest plot for urinary incontinence at three months.*

of using different resectoscope sheath sizes in HoLEP procedures and revealed several critical outcomes.

Both smaller (SR) and larger resectoscope sheath (LR) groups showed no significant differences in operative and enucleation times. This suggests that miniaturising the scope does not substantially impact the efficacy of the procedure, despite the reduced flow which is associated with a small scope. It could be argued that this might be due to relatively smaller prostate volume in included studies, as seen in Dean et al. [7], which excluded prostates above 200 ml. However, the average pre-operative prostate size was 90 ml or higher in three out of the four studies [7–10], which is similar to average pre-operative HoLEP prostate volumes as seen in the literature [14]. This indicates that surgeons can opt for either size based on comfort and institutional preference without compromising enucleation efficiency.

A significant finding was that the LR group demonstrated lower morcellation time. This may be attributed to the improved irrigation flow, which helps prevent bladder collapse and reduces the risk of bladder perforation requiring bladder repair. In a cohort of 1,476 patients, the rate of bladder injury during morcellation was 1.4% (20 patients), with 0.07% (1 patient) requiring open repair. Among the included studies, Dean et al. used 24 Fr and 28 Fr morcelloscopes. However, they switched the 24 Fr morcellator to a 28 Fr morcellator in 6 cases (8%) [7]. Alternatively, Yildiz et al. [8] and Ibis et al. [10] used a single-size Multicut morcellator system (Jena Surgical) and 26 F nephroscope with VersaCut tissue morcellator (Lumenis,) respectively, in all the cases. We believe this is currently the greatest challenge of miniaturised HoLEP. Using either a larger morcelloscope during morcellation or starting with a smaller scope but switching to the larger scope in cases of difficulties are acceptable strategies.

One of the most notable outcomes was the significantly lower urethral dilation rates observed in the SR group compared to LR (8.0% vs 39.5%, p = 0.01). This finding along with the hypothesis that smaller resectoscopes are associated with reduced urethral manipulation, potentially decreasing the risk of subsequent stricture formation might make SR HoLEP more attractive. However, in a RCT pre-operative dilation with Otis urethrotomy decreased the urethral stricture rates in patients undergoing HoLEP [11]. Thereby, it is possible to prevent the traditionally common complication associated with larger resectoscopes of urethral strictures by elective pre-operative dilation.

Although the rates of urethral strictures differed, it was not statistically significant at 1.7% with SR and 3.21% in LR, very similar rates were found in a retrospective cohort study of 502 patients undergoing HoLEP with urethral stricture rates of 1.8% vs 3.5% in 26 Fr and 28 Fr groups respectively (p = 0.405) [16]. Similarly, Gunes et al. [18], evaluating TURP resectoscope size, found a statistically significant increased urethral stricture rate with the larger resectoscope. Future adequately powered studies with a longer follow-up duration might show a statistically significant difference. This is likely the major advantage of miniaturised HoLEP.

The duration of catheterisation and hospitalization did not significantly differ between the SR and LR groups. Similarly, the total and significant complication rates, as well as transfusion rates, were comparable between the groups. These finding highlights that despite the reduced flow smaller sheath size had a similar safety profile as the large resectoscope. The improved urinary incontinence on exclusion of non-PubMed-indexed studies, suggest that SR HoLEP might lead to early sphincteric recovery. Notably, the similar rates of urinary incontinence at three months postoperatively suggest that both techniques have eventual improvement of sphincteric dysfunction in a majority of patients. It is possible that the true benefit might be greater with complete SR HoLEP as some studies used larger morcelloscope's during morcellation. Moreover, other techniques have been studied to decrease incontinence rates, including early apical release, pre-operative pelvic floor exercises and botulinum toxin administration during HoLEP, all of which have shown promising results [19–22].

The limitations of this study include the inclusion of non-randomised retrospective studies; however, they did not differ in pre-operative characteristics as seen in Table 4. The means of certain variables were estimated from the median and ranges via the Wans method [17]. Outcomes such as BNC and urethral stricture might be inadequately assessed due to the limited follow-up duration in the studies. Further large-scale RCTs are warranted to strengthen the evidence base, particularly regarding long-term outcomes such as stricture formation and functional recovery. Functional outcomes such as post-operative International Prostate Symptom Score (IPSS) and uroflowmetry were not analysed due to heterogeneous reporting, and it is unlikely to be different based on the resectoscope sheath size. Moreover, there was no difference in the post-operative American Urological Association symptom score (AUASS), IPSS and uroflowmetry between the groups in the included studies [7–10].

CONCLUSIONS

This meta-analysis indicates that using a smaller resectoscope sheath (22–24 Fr) during HoLEP lower urethral dilation rates and may decrease early incontinence rates without compromising operative time, enucleation efficiency, or complication rates. While larger sheaths (26–28 Fr) showed faster morcellation times. The choice of sheath size should be tailored to the surgeon's expertise, patient anatomy, and desired outcomes.

Overall, this review demonstrates that smaller resectoscopes are safe and efficacious in HoLEP.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

FUNDING

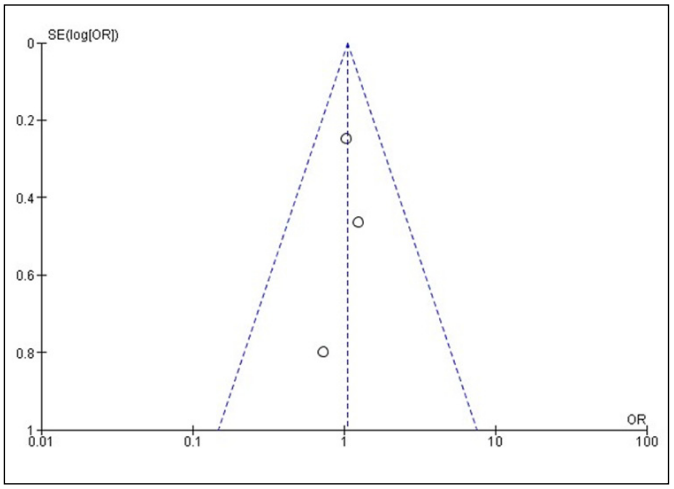
This research received no external funding.

ETHICS APPROVAL STATEMENT

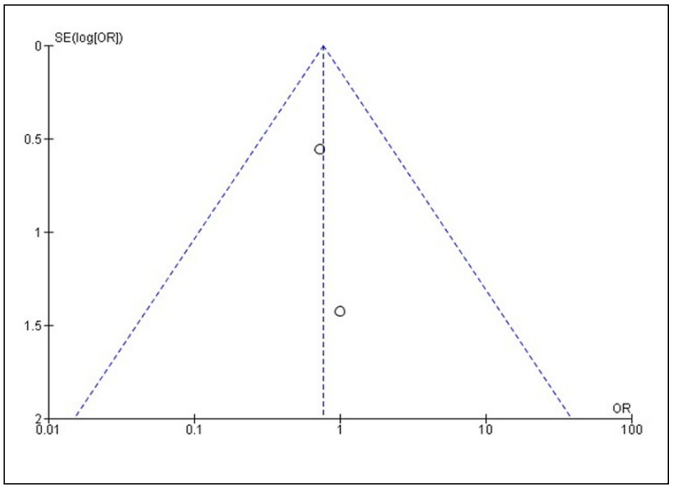
The ethical approval was not required.

SUPPLEMENTARY MATERIALS

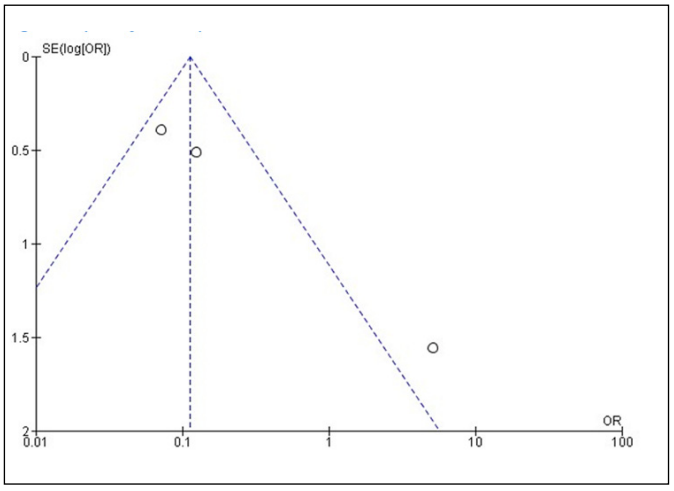
Funnel plots



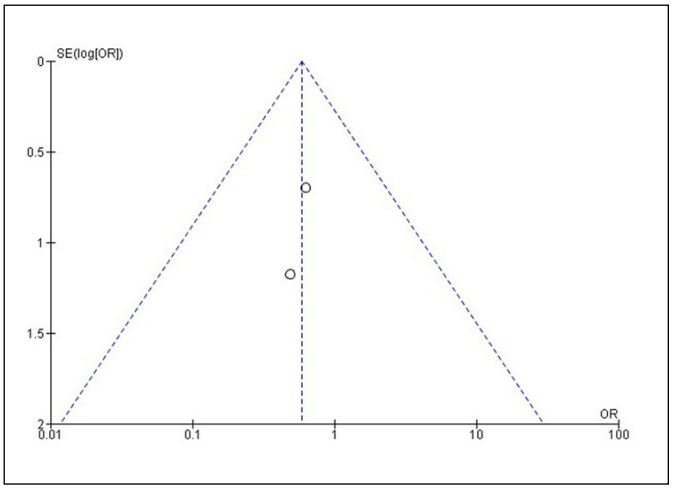
Suppl. Figure 1. *Total complications.*



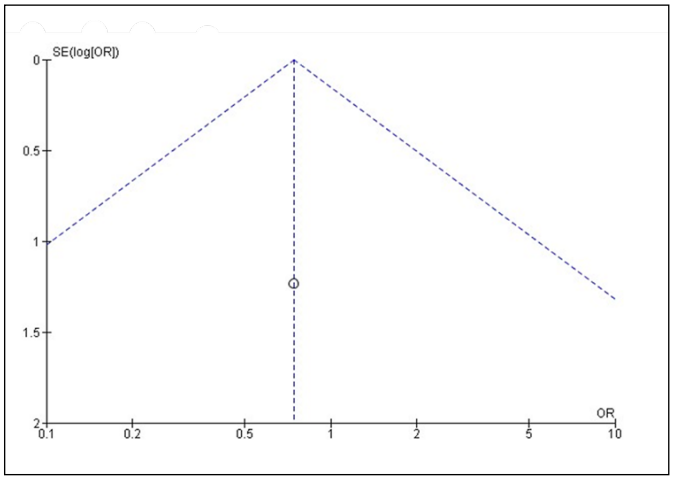
Suppl. Figure 2. *Major complications.*



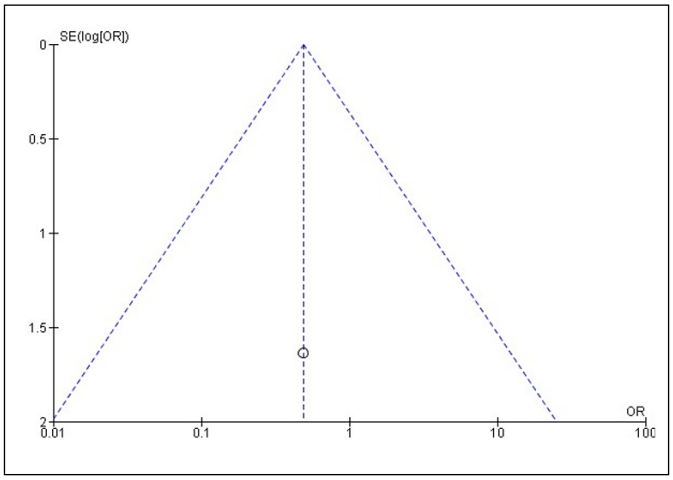
Suppl. Figure 3. *Urethral dilation.*



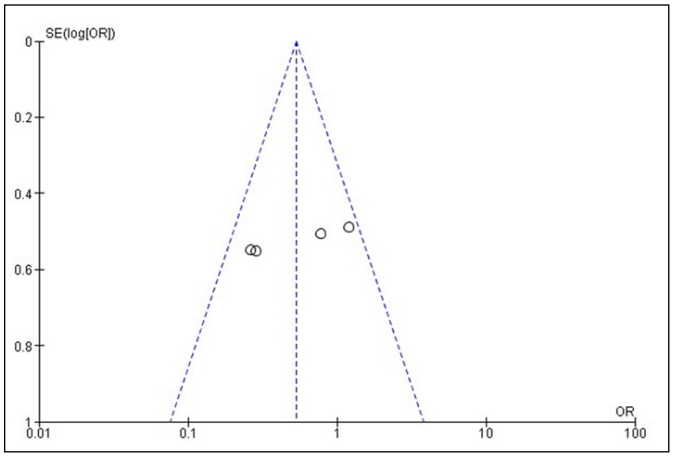
Suppl. Figure 4. *Urethral stricture.*



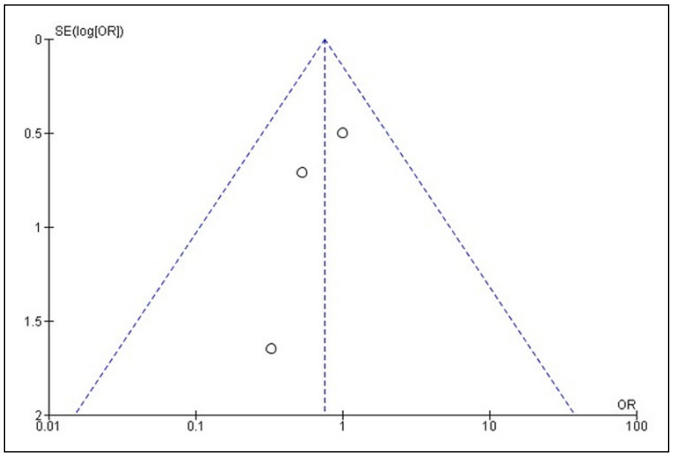
Suppl. Figure 5. *Bladder neck contracture.*



Suppl. Figure 6. *Transfusions.*



Suppl. Figure 7. *Post-operative incontinence at 1 month.*



Suppl. Figure 8. *Post-operative incontinence at 3 months.*

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