Clinical efficacy of prostatic apex preservation vs. the non-preserving method in the management of BPH: A systematic review and meta-analysis

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Received April 17, 2025; Accepted January 20, 2026

DOI: 10.3892/wasj.2026.437

Abstract. The present study was carried out to determine the efficacy of the apex preservation technique in the management of benign prostatic hyperplasia (BPH) complications following surgery. For this purpose, the PubMed, Embase and Cochrane Library electronic databases were widely searched for controlled trials published up to 2025. The ROBINS-I tool was used to assess the risk of bias in the included studies. Funnel plots and Egger's regression test were applied for publication bias in the present study. GRADEpro was used to assess the quality of evidence. The results revealed that the surgery duration of the preserving technique was significantly shorter [mean difference (MD), -9.82; 95% confidence interval (CI), -13.91 to -5.73; P<0.00001]. The preserving technique method was associated with a lower incontinence rate (relative risk, 0.18; 95% CI, 0.07 to 0.46; P=0.0004). Blood loss in the preserving technique group was also less (MD, -65.37; 95% CI, -121.97 to -8.77; P=0.02). On the whole, as demonstrated herein, preserving the prostatic apex is also more time-efficient, leading to a markedly lower risk of developing complications such as blood loss and quicker urinary continence recovery following catheter removal. This leads to improved patient satisfaction, while maintaining similar International Prostate Symptom Score, quality of life and peak urinary flow rate values. Therefore, further research is required in order to fully determine the clinical effects of prostatic apex preservation in BPH surgery in minimizing the rate of complications.

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Key words: prostatic apex preservation, benign prostatic hyperplasia, urinary incontinence

Introduction

For decades, transurethral resection of the prostate (TURP) has been regarded as the definitive surgical treatment for benign prostatic hyperplasia (BPH) (1,2). TURP, along with suprapubic enucleation techniques, remains the gold standard for relieving bladder outlet obstruction in clinical practice (3).

However, despite its widespread success, 5-10% of patients undergoing BPH surgery experience severe post-operative complications, most commonly urinary incontinence, followed by reoperation, recatheterization, urinary tract infections and perioperative bleeding (4,5).

Early post-operative incontinence has been reported in up to 30-40% of cases (6), underscoring a persistent challenge in optimizing functional outcomes following TURP. The pathophysiological mechanisms underlying post-TURP incontinence remain incompletely understood. It is generally accepted that conventional TURP involves the resection of the prostatic apex, a region intimately associated with the external urethral sphincter, which plays a critical role in passive urinary control (7).

The fundamental rationale for prostatic apex preservation is that maintaining a greater length of the urethral sphincter complex may protect more sphincteric muscle fibers, thereby preserving continence (8). Active continence is maintained by the levator ani muscle complex acting on the prostatic apex and membranous urethra (7), while the external urethral sphincter, located predominantly within the prostate between the apex and the verumontanum (9-11), provides essential closure function.

The preservation of the Denonvilliers' fascia, a tendinous structure extending from the prostate base to its apex, is also deemed to be vital, as it serves as a supportive fulcrum for both the prostate and the urethra (11,12). Moreover, Van der Poel *et al* (13) and Hoyland *et al* (14) demonstrated that the innervation of the prostatic apex and the urethral sphincter is intricately interconnected, suggesting that the maintenance of the prostatic urethra during surgery enhances post-operative continence outcomes.

Recently, several controlled clinical trials have investigated the efficacy of urethral mucosa preservation at the prostatic apex in the surgical management of BPH (15-18).

However, individual studies have reported inconsistent results, and to date, to the best of our knowledge, no systematic review or meta-analysis has comprehensively compared the outcomes of apex-preserving versus apex-resecting techniques.

Therefore, the present study aimed to systematically review and quantitatively synthesize the available evidence on the clinical efficacy of prostatic apex preservation during BPH surgery, with particular attention to urinary continence and perioperative outcomes.

Data and methods

Search strategy. The present systematic review and meta-analysis adhered strictly to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (19) and was prospectively registered in PROSPERO (CRD420250642661).

A comprehensive electronic search was conducted from database inception to January, 2025 across PubMed, Google Scholar and the Cochrane Library. Search terms included combinations of 'prostatic apex preservation', 'benign prostatic hyperplasia' and 'outcomes'.

Additional manual searches of reference lists and clinical trial registries were performed to identify any relevant studies not indexed in the databases. The complete search algorithm is detailed in Table SI.

Inclusion and exclusion criteria. Study selection was guided by the Population, Intervention, Comparator, Outcome, and Study Design (PICOS) framework.

The inclusion criteria were the following: i) Population: Patients diagnosed with BPH, without restriction by age or comorbidities; ii) intervention: Surgical procedures that preserved the prostatic apex; iii) comparator: Conventional surgical approaches involving prostatic apex dissection; iv) primary outcome: Post-operative urinary incontinence rate; v) secondary outcomes: Intraoperative blood loss, volume of prostate tissue resected, International Prostate Symptom Score (IPSS), quality of life (QoL), peak urinary flow rate (Qmax) and duration of the surgery; vi) study design: Randomized controlled trials (RCTs) and non-randomized controlled clinical studies.

The exclusion criteria included the following: Studies not involving BPH or human participants, non-interventional or observational studies (e.g., reviews, editorials and case reports), non-English publications and studies for which full-text data were unavailable. The full PICOS schema used for eligibility assessment is summarized in Table SII.

Data extraction. Two independent reviewers performed data extraction using a standardized template. Discrepancies were resolved through discussion and consensus. The following data were extracted from each eligible study: First author, publication year and journal, study design and sample size, mean age of the participants, post-operative urinary incontinence rate, intraoperative blood loss, Qmax, IPSS, QoL score and prostate volume resected. When necessary, corresponding authors were contacted to clarify incomplete or ambiguous data.

Risk of bias assessment. The methodological quality of the included non-RCTs was evaluated using the Risk of Bias in Non-randomized Studies of Interventions (ROBINS-I) tool (20). In total, four studies met the inclusion criteria and were assessed in detail (15-18). The results of the ROBINS-I assessment are presented in Fig. 1.

Overall, studies demonstrated a low-to-moderate to moderate-to-severe risk of bias, primarily due to missing outcome data and selective reporting.Specifically, Liu and Yang (15) and Fujisaki *et al* (17) exhibited a low-to-moderate risk, Liang *et al* (16) had a moderate-to-severe risk due to incomplete data and selective outcome reporting, while Irani *et al* (18) was rated low-to-moderate.

Statistical analysis. All statistical analyses were conducted using Review Manager (RevMan) version 5.4 (21). For continuous variables, outcomes are expressed as the mean difference (MD) with 95% confidence intervals (CIs). For dichotomous outcomes, the relative risk (RR) with 95% CI was calculated. Heterogeneity was evaluated using the Chi-squared (χ^2) test and quantified by the I^2 statistic. An I^2 value >50% indicated substantial heterogeneity, and a P-value <0.05 was considered to indicate a statistically significant difference. The random effects model was used for the present study as a small number of studies and clinical heterogeneity are expected (21,22).

Results

Study selection and characteristics. A total of 4,141 studies were identified via the databases. A total of 641 duplicate studies were detected. Following deduplication, 3,500 records were filtered. Subsequently, 3,442 were removed as they were not related to apex preservation. No automation tools were used in the screening part. The remaining 58 studies were refiltered for retrieval. A total of two studies were not retrieved for full text, and out of the 56 studies that were retrieved, 41 studies were excluded as they were not controlled trials, four studies were not related to the inclusion criteria, and seven studies did not cover the complication. Thus, four studies were included (15-18). Of these four studies, 638 participants were identified. The PRISMA flow chart (23) reflects the identification of studies via the databases and registers, rescreening and reassessment of the qualified studies (Fig. 2).

Of the total 638 participants, 452 were in the prostatic apex preservation group and 186 were in the apex dissection group. The characteristics of the studies included in the present systematic review are presented in Table I.

The characteristics of outcomes from each study, such as the duration of surgery, incontinence rate, intraoperative blood loss, prostate volume excised, IPSS, QoL and Qmax are presented in Table II.

Quality of evidence. The Grading of Assessment, Development, and Evaluation (GRADE) approach was used to assess the overall evidence concerning individual outcomes. The GRADEpro tool was applied to evaluate the certainty of the evidence (26,27). The summary assessment, development and evaluation of the findings according to the GRADE guidelines for the included studies (outcomes on urine incontinence and other outcomes that are moderate-quality evidence) are presented in Table III.

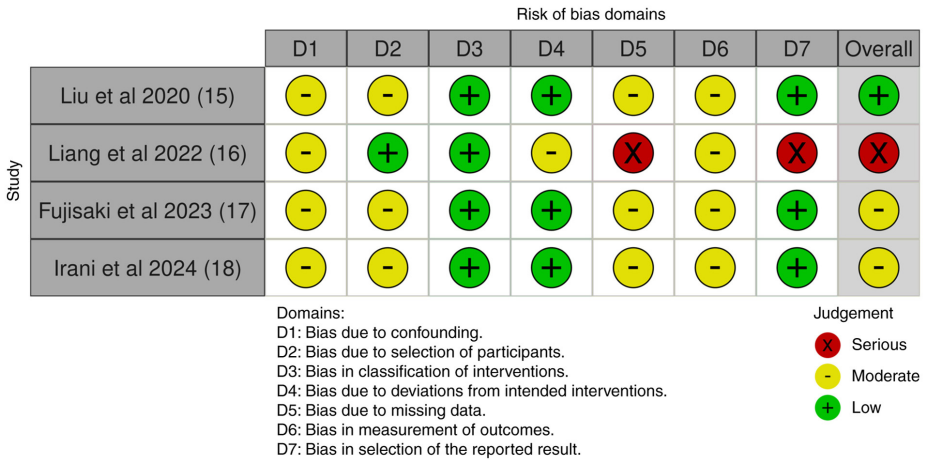

Figure 1. Risk-of-bias assessment using the ROBINS-I tool for included non-randomized studies. The domains evaluated include confounding, selection of participants, classification of interventions, deviations from intended interventions, missing data, measurement of outcomes, and selection of reported results. ROBINS, Risk of Bias in Non-randomized Studies of Interventions.

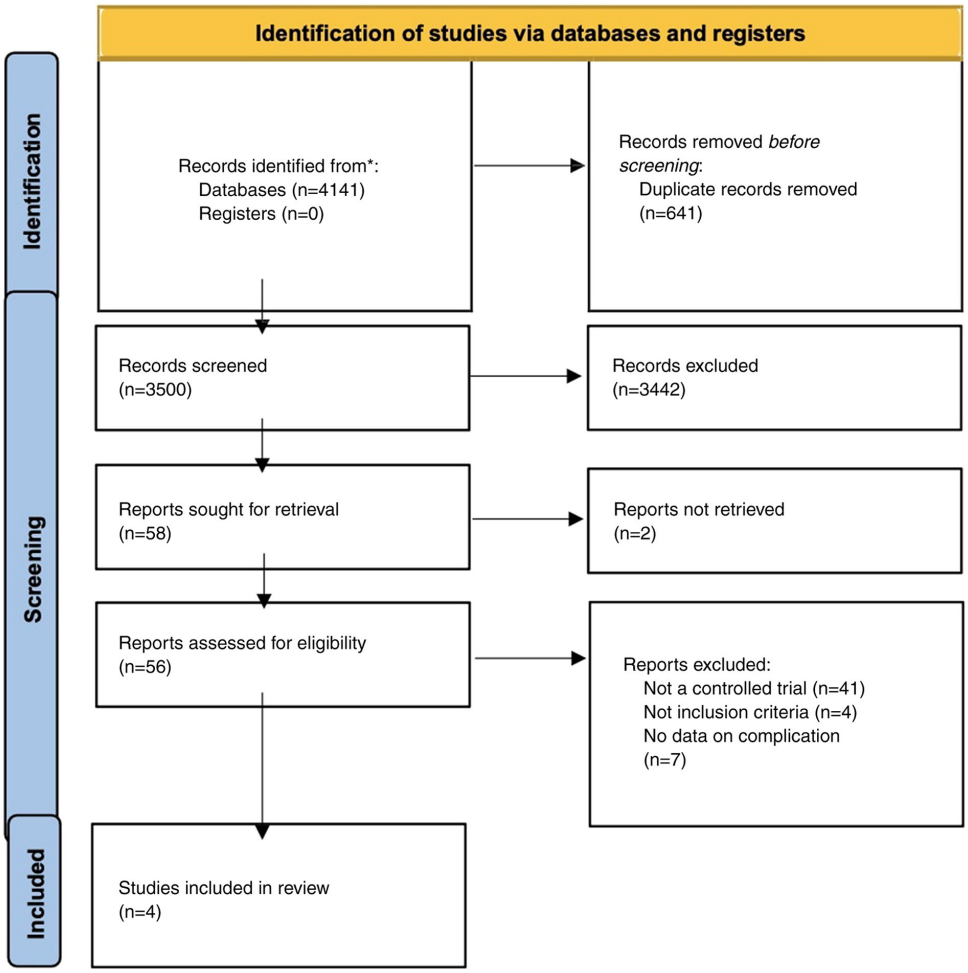

Figure 2. PRISMA flow diagram of the study selection process. The diagram depicts the identification, screening, eligibility assessment and inclusion of studies for the systematic review and meta-analysis.

The duration of surgery between the two groups. All studies analyzed the duration of surgery, involving 638 participants (452 in the prostatic apex preservation group and 186 in the apex dissection group). Random effects were used, and the results revealed that the surgery duration of the preserving technique was significantly shorter than that of the non-preserving technique (MD, -9.82; 95% CI, -13.91 to -5.73; P<0.00001) (Fig. 3).

Urinary incontinence. All studies analyzed incontinence post-operatively, involving 638 participants (452 in the prostatic

Table I. Characteristics of the studies included in the present systematic review and meta-analysis.

Authors, year of publication	Study	No. of participants	Country	Study period	Study design	Outcome and follow-up	(Refs.)
Liu and Yang, 2020	Comparison of the transurethral resection of the prostate by traditional versus preserved urethral mucosa of the prostatic apex	40 (preserved group) 40 (dissection group)	China	2015-2016	Single center prospective trial with mean age were 73 years for the APUMP and 75 years for no-APUMP group	Urinary function with 1 month of follow-up and surgical indicator (surgery time, intraoperative blood loss, gram of excised prostate, and incontinence rate)	(15)
Liang *et al*, 2022	Clinical study on the application of preserved urethral mucosa at the prostatic apex in transurethral plasma kinetic resection of the prostate	45 (preserved group) 45 (dissection group)	China	2018-2021	Single center prospective study with mean age were 69.3 years for the APUMP and 68.6 years for no-APUMP group	Urinary function with 1 and 3 months of follow-up and surgical indicator (surgery time, intraoperative blood loss, gram of excised prostate, and incontinence rate)	(16)
Fujisaki *et al*, 2023	Use of the anterior prostatic mucosa preservation technique during holmium laser enucleation of the prostate can reduce postoperative stress urinary incontinence	340 (preserved group) 75 (dissection group)	Japan	2018	Single center retrospective study performed by two surgeons with mean age were 75 years for the APUMP and 73 years for no-APUMP group	Urinary function with 1 month of follow-up and surgical indicator (enucleation time, incontinence rate, and gram of excised prostate)	(17)
Irani *et al*, 2024	The impact of urethral mucosa preservation of prostatic apex during monopolar transurethral resection of the prostate on postoperative function outcomes: a retrospective comparative study	27 (preserved group) 26 (dissection group)	Iran	2018-2020	Single center retrospective cross sectional study mean age were 69 years for the APUMP and 67 years for no-APUMP group	Urinary function with 6 months of follow-up and surgical indicator (surgery time, intraoperative blood loss, gram of excised prostate, and incontinence rate)	(18)

Table II. Outcomes of the included studies.

Authors, year of publication	Outcome								(Refs.)
	Age, years	Duration of surgery	Urine incontinence	Intra operative blood loss	Gram of prostate excised	IPSS	QoL	Qmax	
Liu and Yang, 2020	A: 75±8.3 B: 73±1 0.5	A: 65±185 B: 50±16.5	A: 9 (7 recovered in 1 week and 2 cases recovered in 3 weeks) B: 0	A: 280±33 B: 190±35	-	A: 5±1.2 B: 4.9± 1.1	A: 1.3±0.9 B: 1.1±5	A :22.1±5 B: 21.8±4.5	(15)
Liang *et al*, 2022	A: 68.6 ±8.22 B: 69.27±6.15	A: 53.87±17.48 B: 4.11±14.18	A: 7 (4 cases recovered in 1 week and 4 cases recovered in 3 weeks) B: 0	A: 85.2 7±34.0 B: 68.78±27.05	A: 46.56±18.44 B: 47.62±18.38	A: 6.51±1.04 B: 6.18±1.24	A: 1.56±0.55 B: 1.51±0.51	A: 19.92 ±1.3 B: 20.08±1.17	(16)
Fujisaki *et al*, 2023	A: 73±11.25 B: 75±8.25	A: 46.5±43.25 B: 33±31.5	A: 11/75(14.7%) B: 14/340 (4.1%)	-	A: 35±4.25 B: 34.5±57	-	-	A: 9.9±10.1 B: 10.5±14	(17)
Irani *et al*, 2024	A: 67.7±9.12 B: 69.8±8.47	A: 40.59±5.2 B: 33.84±4.44	A: 6 (4 were healed within 1 week and two within 3 months) B: 0	A: 305±63.4 B: 212. 5±65	-	A: 7.59±3.23 B: 9.44±3.71	-	A: 18.3±7.99 B: 16.37±3.96	(18)

A, control group (apex dissection); B, experimental group (apex preservation).

Table III. Summary of the findings according to the GRADE guidelines for included studies.

Certainty assessment							No. of patients		Effect			
No. of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	Preserved urethral mucosa method	Non-preserved urethral mucosa method	Relative (95% CI)	Absolute (95% CI)	Certainty	Importance
Surgery time												
4	Non-randomized studies	Serious[a]	Not serious	Not serious	Serious[b]	None	452	186	-	MD 8.14 lower (10.39 lower to 5.88 lower)	⊕⊕◯◯ Low[a,b]	Important
Urine incontinence												
4	Non-randomized studies	Serious[a]	Not serious	Not serious	Serious[b]	None	14/452 (3.1%)	33/186 (17.7%)	RR 0.16 (0.08 to 0.33)	149 fewer 1,000 per (from 163 fewer to 119 fewer)	⊕⊕◯◯ Low[a,b]	Critical
Intra operative blood loss												
3	Non-randomized studies	Serious[a]	Not serious	Not serious	Serious[b]	None	112	111	-	MD 50.7 lower (60.01 lower to 41.39 lower)	⊕⊕ ◯◯ Low[a,b]	Important
IPSS												
3	Non-randomized studies	Serious[a]	Not serious	Not serious	Serious[b]	None	112	111	-	MD 0.15 lower (0.49 lower to 0.19 higher)	⊕⊕◯◯ Low[a,b]	Important

Table III. Continued.

Certainty assessment							No. of patients		Effect			
No. of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	Preserved urethral mucosa method	Non-preserved urethral mucosa method	Relative (95% CI)	Absolute (95% CI)	Certainty	Importance
QoL												
2	Non-randomized studies	Serious[a]	Not serious	Not serious	Serious[b]	None	85	85	-	MD 0.3 lower (0.5 lower to 0.11 lower)	⊕⊕◯◯ Low[a,b]	Not important
Qmax												
4	Non-randomized studies	Serious[a]	Not serious	Not serious	Serious[b]	None	452	186	-	MD 0.11 higher (0.38 lower to 0.59 higher)	⊕⊕◯◯ Low[a,b]	Critical

[a]Non-randomized trial; [b]small to moderate population and short follow-up. CI, confidence interval; MD, mean difference; RR, risk ratio; IPSS, International Prostate Symptom Score; QoL, quality of life; Qmax, peak urinary flow rate.

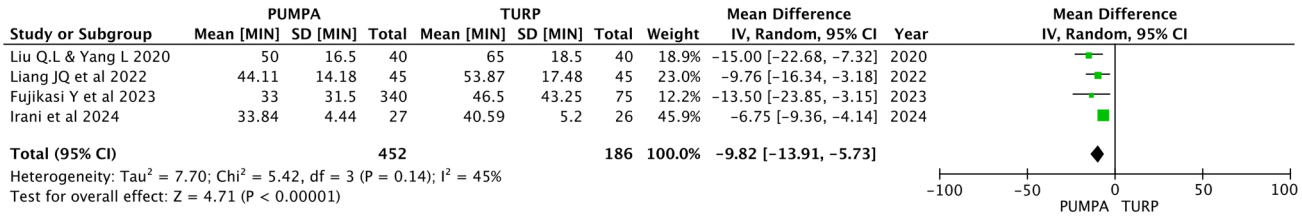

Figure 3. Forest plot comparing duration of surgery between apex-preserving and apex-dissection techniques. Apex preservation was associated with a significantly shorter duration of surgery (MD, -9.82 min; 95% CI, -13.91 to -5.73). The studies shown are the following: Liu and Yang (15), Liang *et al* (16), Fujisaki *et al* (17) and Irani *et al* (18). PUMPA, preserved urethral mucosa at the prostatic apex; TURP, transurethral resection of the prostate; MD, mean difference; CI, confidence interval.

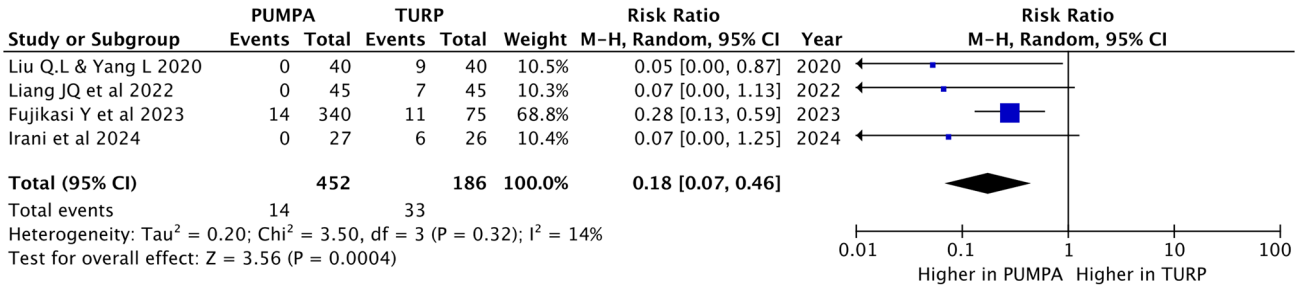

Figure 4. Forest plot of post-operative urinary incontinence comparing preservation vs. non-preservation groups. The apex-preservation group demonstrated significantly lower rates of early postoperative incontinence (RR, 0.18; 95% CI, 0.07-0.46). The studies shown are the following: Liu and Yang (15), Liang *et al* (16), Fujisaki *et al* (17) and Irani *et al* (18). PUMPA, preserved urethral mucosa at the prostatic apex; TURP, transurethral resection of the prostate; RR, relative risk; CI, confidence interval.

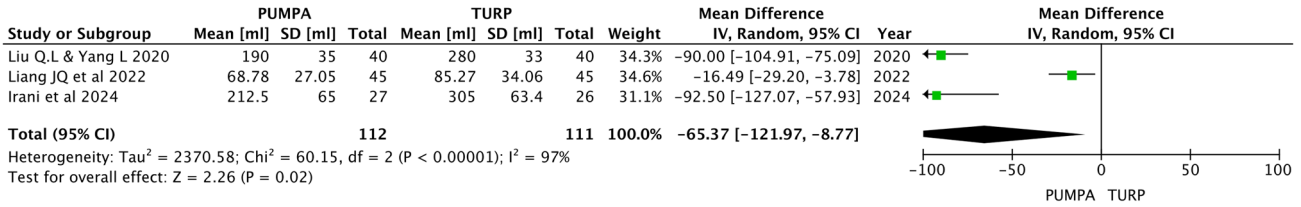

Figure 5. Forest plot of intraoperative blood loss. Apex-preserving procedures showed reduced blood loss compared with conventional dissection (MD, -65.37 ml; 95% CI, -121.97 to -8.77). The studies shown are the following: Liu and Yang (15), Liang *et al* (16) and Irani *et al* (18). PUMPA, preserved urethral mucosa at the prostatic apex; TURP, transurethral resection of the prostate; MD, mean difference; CI, confidence interval.

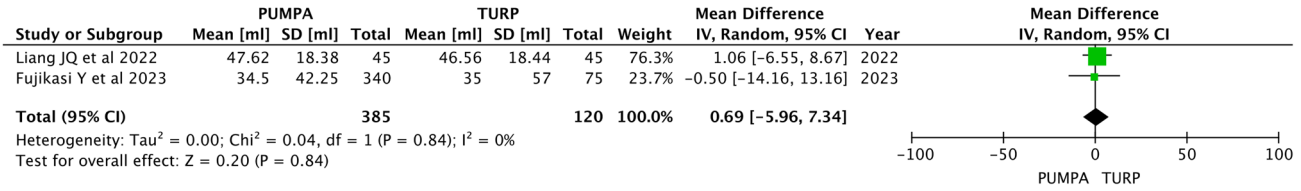

Figure 6. Forest plot comparing prostate tissue volume excised. No significant difference in resected prostate volume was observed between the groups (MD, 0.69 g; 95% CI, -5.96 to 7.34). The studies shown are the following: Liang *et al* (16) and Fujisaki *et al* (17). PUMPA, preserved urethral mucosa at the prostatic apex; TURP, transurethral resection of the prostate; MD, mean difference; CI, confidence interval.

apex preservation group and 186 in the apex dissection group). Random effects were used, and the results revealed that the preserving group had a lower incontinence rate compared to the non-preserving group (RR, 0.18; 95% CI, 0.07 to 0.46; P=0.0004) (Fig. 4).

Intraoperative blood loss. Liu and Yang (15), Liang *et al* (16), and Irani *et al* (17) analyzed the blood loss during surgery, involving 223 participants (112 in the prostatic apex preservation group and 111 in the apex dissection group). Random effects were used, and the results revealed that blood loss in the preserving group was also less than that in the non-preserving group (MD, -65.37; 95% CI, -121.97 to -8.77; P=0.02; Fig. 5).

Prostate excised volume. Liang *et al* (16) and Fujisaki *et al* (17) analyzed the excised prostate volume, involving 505 participants (385 in the prostatic apex preservation group and 120

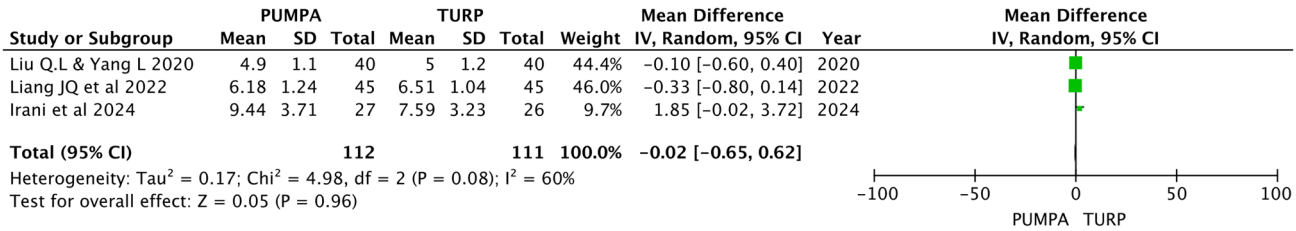

Figure 7. Forest plot of IPSS following surgery. Postoperative IPSS values were comparable between apex-preserving and apex-dissection groups (MD, -0.02; 95% CI, -0.65 to 0.62). The studies shown are the following: Liu and Yang (15), Liang *et al* (16) and Irani *et al* (18). IPSS, International Prostate Symptom Score; PUMPA, preserved urethral mucosa at the prostatic apex; TURP, transurethral resection of the prostate; MD, mean difference; CI, confidence interval.

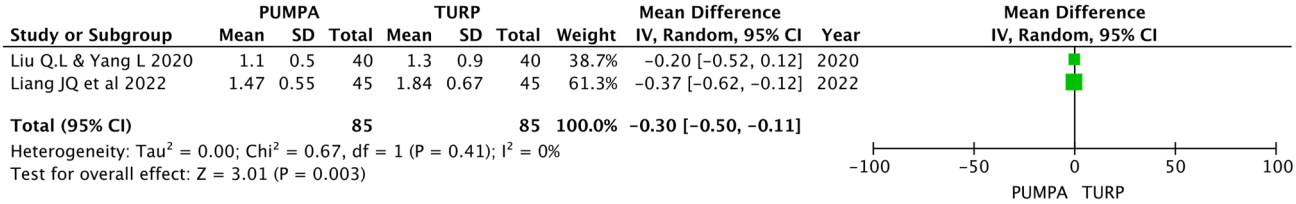

Figure 8. Forest plot of postoperative QoL scores. QoL outcomes did not differ significantly between groups (MD, -0.30; 95% CI, -0.50 to -0.11). The studies shown are the following: Liu and Yang (15) and Liang *et al* (16). QoL, quality-of-life; PUMPA, preserved urethral mucosa at the prostatic apex; TURP, transurethral resection of the prostate; MD, mean difference; CI, confidence interval.

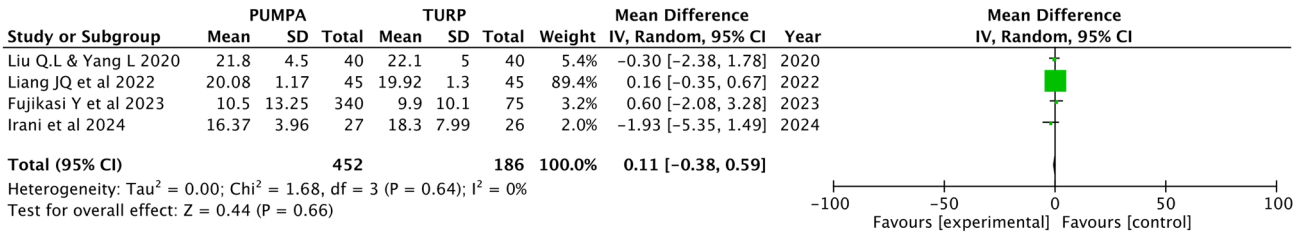

Figure 9. Forest plot of post-operative Qmax. Qmax outcomes were similar between the two surgical techniques (MD, 0.11 ml/sec; 95% CI, -0.38 to 0.59). The studies shown are the following: Liu and Yang (15), Liang *et al* (16), Fujisaki *et al* (17) and Irani *et al* (18). Qmax, peak urinary flow rate; PUMPA, preserved urethral mucosa at the prostatic apex; TURP, transurethral resection of the prostate; MD, mean difference; CI, confidence interval.

in the apex dissection group). Random effects models were used, and the results revealed similar volumes of excised tissue between the two groups (MD, 0.69; 95% CI, -5.96 to 7.34; P=0.84) (Fig. 6).

Post-operative IPSS. Liu and Yang (15) and Liang *et al* (16) analyzed the IPSS at 1 month post-operatively, while Irani *et al* (18) analyzed the IPSS at 6 months post-operatively, involving 223 participants (112 in the prostatic apex preservation group and 111 in the apex dissection group). Random effects were used, and the results revealed similar IPSS between the two groups (MD, -0.02; 95% CI, -0.65 to 0.62; P=0.96) (Fig. 7).

QoL score post-operatively. Liu and Yang (15) and Liang *et al* (16) analyzed the QoL post-operatively, involving 170 participants (85 in the prostatic apex preservation group and 85 in the apex dissection group). Random effects were used, and the results revealed similar QoL scores between the two groups (MD, -0.30; 95% CI, -0.50 to 0.11; P=0.003; Fig. 8).

Qmax post-operatively. Liu and Yang (15), Liang *et al* (16) and Fujisaki *et al* (17) analyzed the Qmax at 1 month post-operatively, while Irani *et al* (18) analyzed the Qmax at 6 months post-operatively, involving 638 participants (452 in the prostatic apex preservation group and 186 in the apex dissection group). Random effects were used, and the results revealed a similar Qmax score between the two groups (MD, 0.11; 95% CI, -0.38 to 0.59; P=0.66) (Fig. 9).

Leave-one-out analysis. Leave-one-out analysis is a method used to evaluate the robustness of pooled estimation by individually excluding one study at a time and reanalyzing the data. In the present study, moderate to high heterogeneity was observed when pooling the effect sizes for urinary incontinence (I^2=14% and P=0.32). The analysis revealed that the study by Fujisaki *et al* (17) had a significant influence on the pooled effect of the urinary incontinence results. When excluding the study by Fujisaki *et al* (17), the pooled urinary incontinence rate across all studies was 0.06 (I^2=0%, P=0.99), as illustrated in the forest plot in Fig. 10. The forest plot, the study by Fujisaki *et al* (17), indicates that the urinary incontinence rate was 0.06 (95% CI, 0.01 to 0.33), which was lower than the first pooled rate of 0.18 (95% CI, 0.07 to 0.46), although not statistically significant. This result proposed that this meta-analysis is generally consistent.

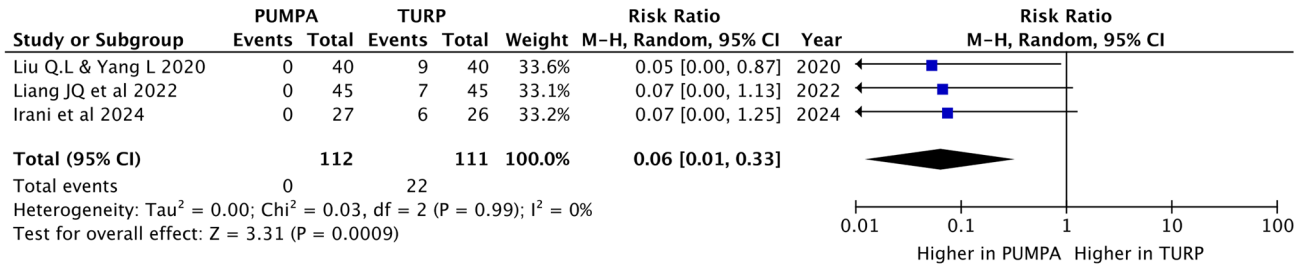

Figure 10. Leave-one-out sensitivity analysis for post-operative urinary incontinence. The studies included are the following: Liu and Yang (15), Liang *et al* (16) and Irani *et al* (18). Excluding the study by Fujisaki *et al* (17) reduced heterogeneity and yielded a pooled incontinence estimate of 0.06 (95% CI, 0.01 to 0.33), confirming robustness.

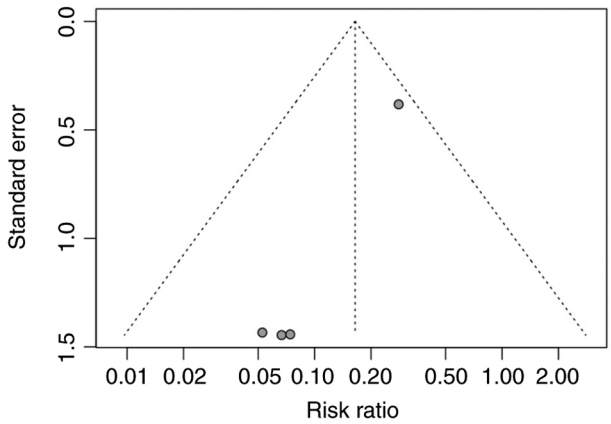

Figure 11. Funnel plot assessing publication bias for urinary incontinence outcomes. Demonstrates mild asymmetry suggestive of small-study effects, although interpretation is limited by the small number of included studies.

Publication of bias. The publication bias in urinary incontinence was assessed, as illustrated in the funnel plot in Fig. 11. The plot demonstrates the standard error and relative risk of urinary incontinence for each study. While it is hoped that a symmetrical distribution is achieved in the absence of publication bias, the funnel plot revealed some asymmetry, focusing on small studies in the left side, indicating a low prevalence due to the lack of data. Although the funnel plot visually revealed a potential risk of publication bias, Egger's regression test indicated potential small-study effects (bias estimate=-1.40; SE=0.11; P=0.0061). Due to the small number of studies (k=4), the results should be interpreted with caution, as Egger's regression test does not provide much value if the number of studies is <10.

Discussion

Previous studies have highlighted the value of preserving the prostatic apex in reducing post-operative complications, particularly urinary incontinence following BPH surgery (15-18). Partin *et al* (7) suggested that the resection of the prostatic apex, which houses the external urethral sphincter responsible for passive urinary control, can compromise continence mechanisms and predispose patients to post-operative incontinence. Similarly, Zinner *et al* (24) emphasized the critical role of the urethral mucosa in maintaining urinary continence.

The surgical principle of preserving or reconstructing the urethral mucosa at the prostatic apex is to extend the mucosal length and create additional mucosal folds adjacent to the external urethral sphincter. This configuration provides a 'sealing pad' effect, improving urethral closure pressure and facilitating early post-operative continence (16).

In early research, transient urinary incontinence was reported in 4 of 15 patients (26.7%) undergoing conventional TURP, with all cases resolving within 6 months (25). Late incontinence has been linked to post-operative urinary tract infection, further reinforcing the importance of mucosal integrity in preserving urinary control (18).

Across studies, apex-preserving techniques have consistently achieved higher rates of immediate continence compared to conventional dissection (15-18). In the study by Irani *et al* (18), 6 patients (23%) in the control group developed immediate post-operative urge incontinence (4 cases recovered within 1 week and 2 cases within 3 months), whereas no cases occurred in the preservation group.

Liang *et al* (16) reported a similar pattern: In total, 7 patients (15%) in the control group experienced immediate incontinence (4 patients recovered in 1 week and 3 patients in 3 weeks); again there were no cases in the intervention group. Liu and Yang (15) observed 9 cases (22.5%) of transient incontinence in the control group, all resolving within 3 months, while the preservation group demonstrated 100% immediate continence. Fujisaki *et al* (17) documented an incontinence rate of 4.1% in the preservation group vs. 14.7% in controls immediately following catheter removal.

Across the included studies, the duration of the surgery was shorter in the apex-preservation group (15-18), and intraoperative blood loss was reduced in the majority of studies (15,16,18). In total, two studies reported comparable prostate resection volumes between the two approaches (16,17), and IPSS values at 3 months were similar across all cohorts (15,16,18).

QoL metrics, assessed in two studies, exhibited promising improvements in both groups with Qol scores comparable to each other (16,17), while Qmax, an indicator of functional recovery, was consistently satisfactory in all reports (15,16,18).

To the best of our knowledge, although several meta-analyses have examined ejaculatory function following prostatic apex preservation, the present study is the first to focus primarily on urinary functional outcomes. The findings presented herein indicate that preserving the prostatic apex during BPH surgery provides a clinically meaningful

advantage in terms of early urinary continence, shorter operative duration and reduced intraoperative blood loss, without compromising long-term voiding efficacy.

Nevertheless, the present study has a few limitations which should be acknowledged. First, high heterogeneity was observed in outcomes, such as intraoperative blood loss (I^2=97%) and IPSS (I^2=60%), partly due to incomplete outcome reporting across studies. Second, surgical expertise and patient characteristics likely contributed to variability in results. Third, due to limited data availability, not all functional and perioperative parameters could be included in the pooled analysis. Fourth, the impact of ethnicity, lifestyle factors and patient comorbidities could not be evaluated. Lastly, reoperation outcomes could not be evaluated in the present meta-analysis as the included randomized controlled trials did not report reoperation data in a consistent, standardized, or extractable format. Finally, the majority of the included studies were small, single-center trials, emphasizing the need for larger, multicenter randomized studies with longer follow-up.

In conclusion, preserving the prostatic apex during BPH surgery appears to provide tangible benefits, including the earlier recovery of urinary continence, reduced intraoperative bleeding and a shorter surgery duration, while maintaining comparable postoperative urinary function. However, future large-scale, high-quality randomized trials with extended follow-up are warranted to validate these findings and establish the clinical superiority and safety of apex-preserving techniques in contemporary BPH management.

Acknowledgements

The authors would like to express their sincere gratitude to Professor Syah Mirsya Warli and Dr Bungaran Sihombing from Rumah Sakit Haji Adam Malik Medan City for the invaluable feedback and clinical support for this study. The present systematic review and meta-analysis has been registered in Prospero with the registration no. CRD420250642661.

Funding

No funding was received.

Availability of data and materials

The data generated in the present study may be requested from the corresponding author.

Authors' contributions

All authors (DDK, BT and KAWY) contributed to the conception and design of the study. Material preparation, data collection and analysis were performed by DDK, BT and KAWY. The first draft of the manuscript was written by KAWY and BT, and all authors commented on previous versions of the manuscript. DDK, KAWY and BT confirm the authenticity of all the raw data. All authors (DDK, BT and KAWY) have read and approved the final manuscript.

Ethics approval and consent to participate

Not applicable.

Patient consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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