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Review Articles

Comparative Analysis of Holmium Laser Enucleation of the Prostate and Robotic-Assisted Simple Prostatectomy in Benign Prostatic Hyperplasia Management: A Systematic Review and Meta-Analysis

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Purpose: As the prevalence of benign prostatic hyperplasia (BPH) increases, the demand for surgical interventions that optimize patient outcomes while minimizing complications grows. This systematic review compares the efficacy, efficiency, and safety of holmium laser enucleation of the prostate (HoLEP) with robotic-assisted simple prostatectomy (RASP), providing insights for evidence-based surgical decision-making in BPH treatment.

Materials and Methods: Adhering to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines, the study protocol was registered with Prospero (CRD42024509627). Searches were conducted in Medline, Embase, Web of Science, Scopus, and Cumulative Index to Nursing and Allied Health Literature up to February 1, 2024, to include studies that compare HoLEP and RASP in patients with BPH. Risk of bias was evaluated using the Newcastle Ottawa Scale.

Results: HoLEP and RASP demonstrated equivalent effectiveness in treating BPH, as shown by similar functional outcomes such as maximum urinary flow rate and postvoid residual volume. However, HoLEP outperformed RASP in several operational efficiency metrics, reducing operative time by 49.48 minutes, hospitalization duration by 1.5 days, and catheterization period by 3.8 days. HoLEP also significantly reduced the risk of blood transfusions by 75%. Patients undergoing RASP were 1.87 times more at risk for grade 2 complications and 3.41 times more at risk for developing grade 3 or above complications.

Conclusions: HoLEP and RASP are effective for managing BPH. HoLEP shows advantages in recovery metrics and lower blood transfusion rates, while RASP benefits from ease of implementation in robotic-equipped facilities. Optimizing surgical outcomes will depend on reducing disparities in technique adoption, improving surgical training, and aligning with evidence-based guidelines.

Key Words: holmium laser enucleation of the prostate (HoLEP), robotic-assisted simple prostatectomy (RASP), benign prostatic hyperplasia, clinical outcomes, meta-analysis

Benign prostatic hyperplasia (BPH) remains a predominant urological condition affecting the quality of life of millions of men globally.[1] Standing as a public health concern due to increases in life expectancy,[2] BPH

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disproportionally affects men aged older than 50[3] and induces progressive lower urinary tract symptoms.[4] The management of BPH has evolved significantly, mirroring advances in medical technology and surgical technique. Within BPH management, the benchmark for endoscopic surgical intervention has traditionally been transurethral resection of the prostate (TURP).[5,6] To reduce TURP-related complications, anatomic endoscopic enucleation of the prostate (AEEP), including holmium laser enucleation of the prostate (HoLEP), has emerged as the size-independent gold standard, addressing many of the limitations associated with the older TURP approach to treating BPH.[7,8] HoLEP is performed in a transurethral fashion using a 26F high-flow endoscope and with a high-power holmium:YAG laser. The procedure involves making an incision proximal to the verumontanum into the surgical capsule, allowing for the enucleation of the adenoma. The enucleated tissue is then morcellated within the bladder for retrieval.[9] In parallel, traditional open simple prostatectomy (OSP) has been phased out by the much less invasive robotic-assisted simple prostatectomy (RASP), with less morbidity. RASP uses robotic technology to perform a transvesical approach for adenoma enucleation. The procedure begins with a cystotomy, after which the surgeon identifies the plane between the adenoma and the peripheral zone and bluntly dissects the adenoma. Hemostasis is achieved by oversewing the prostatic fossa, and the bladder mucosa is advanced to the prostatic apex to restore urinary tract continuity and minimize the risk of urinary leakage.[10-12]

HoLEP and RASP represent advancements in treating BPH. Despite their progressive integration into clinical practice, a comprehensive, quantitative comparative analysis of these techniques must be available in the existing literature. Although there has been a previous qualitative assessment of the 2 approaches,[13] a recent influx of clinical studies directly contrasting HoLEP with RASP[14-16] has made quantitative evidence synthesis possible and highly warranted. This systematic review aims to provide an in-depth meta-analysis that evaluates each method's efficacy, efficiency, and complication profile. As BPH prevalence continues to rise, there is an increasing need for such evidence synthesis to support the development of evidence-based clinical guidelines. These guidelines are essential for guiding clinical decision-making and improving patient counselling. This systematic review seeks to address this significant knowledge gap and lay the groundwork for more effective and patient-focused treatment strategies in BPH management.

METHODS

This systematic review was conducted and reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses[17] guidelines (Supplementary Material S-1, https://www.jurology.com). The study protocol and associated search strategy underwent registration in the International Prospective Register of Systematic Reviews on February 14, 2024 (CRD42024509627).

Inclusion and Exclusion Criteria

Studies were eligible for our systematic review if they included an adult sample diagnosed with BPH and a comparative analysis of HoLEP and RASP. Comparisons in efficacy, efficiency, and complication outcomes met inclusion. Considering the rapid evolution in BPH management, several study designs met the inclusion criteria. This included cluster or noncluster randomized controlled trials, controlled trials, uncontrolled trials, and cohort studies, including cross-sectional prospective and retrospective designs. Studies not solely comprised of patients with BPH, not including both HoLEP and RASP exposure, or based on single-case observations were excluded. Studies in a language other than English, French, or Spanish or using nonhuman sampling were excluded from this systematic review.

Literature Search

A search was conducted on Medline, Embase, Web of Science, Scopus, and Cumulative Index to Nursing and Allied Health Literature from inception to February 1, 2024. One of the authors (T.B.) developed the search strategy. A combination of MeSH and keywords associated with HoLEP, RASP, and BPH was used to identify publications that compared HoLEP and RASP in treating BPH. No restrictions to study design, location, language, or setting were imposed during the search. Details of the search strategy for each database are provided as Supplementary Material S-2 (https://www.jurology.com).

Study Selection and Extraction

Results were exported to Rayyan[18] for screening. Screening using a double-screening approach was performed.[19] Two independent reviewers (A.S. and M.P.B.) screened the title and abstract for eligibility, and a third author (S.A.) resolved any discordance. After this, publications deemed relevant for the review were checked against our inclusion and exclusion criteria by the same 2 authors. Similarly, any conflict was resolved by a third author (T.B.).

Data extraction was completed on March 8th, 2024, by 2 authors (T.B. and M.P.B.), and all entries were further cross-validated by another reviewer (S.A.). Extraction of comprehensive points of interest from the overall included studies, including first author, author contact email, publication year, full citations, country, publication type, study design, total sample size, attrition rate, sample age, BMI, baseline prostate size, PSA, international prostate symptom score (IPSS), maximum urinary flow rate (Qmax), and postvoid residual (PVR). We further extracted a detailed set of data for both HoLEP and RASP respective groups, including age, BMI, prostate size, PSA, IPSS, Qmax, PVR, operative time, adenoma resected mass, estimated blood loss, hemoglobin and hemoglobin change, quality of life scores, length of hospital stay, catheterization time, Clavien complication grade, non-Clavien–based complication reports, and reports of hematuria, urgency, incontinence, dysuria, stricture, UTIs, sepsis, emergency department visits, intensive care admission, and transfusions. We

extracted mean, standard deviations, confidence intervals, reported effect sizes, P values, and t values for continuous data, and event frequencies, effect sizes, and P values for dichotomous variables.

Risk of Bias Assessment

We evaluated the risk of bias using the Newcastle Ottawa Scale for cross-sectional and cohort studies.[20] This scale evaluates the selection, comparability, and exposure characteristics of each study. Each study is assigned a score that ranges from 0 to 9, with higher scores indicating a lower risk of bias. Two reviewers (M.P.B. and A.S.) completed quality assessments. A third reviewer (T.B.) resolved any discrepancies.

Analysis

Comprehensive meta-analysis software (version 4) was used to conduct meta-analyses. Owing to the expected within-study and between-study variability, all analyses were performed using a random-effect modelling approach. The primary outcomes included efficacy, efficiency, and complication differences between HoLEP and RASP procedures for patients with BPH. We used Hedges g to determine the effect of using HoLEP vs RASP on continuous outcomes such as length of hospital stay, catheterization time, Qmax, PVR, prostate size, PSA, IPSS, QoL, and mass of resected tissue. All respective complications were pooled and assessed in the form of relative risk (RR). When multiple follow-ups were present, data points most proximal to the time of surgery were selected for meta-analysis. Heterogeneity was tested using the Q statistic and reported as a percentage of variation across studies (I^2).

RESULTS

Our search identified 217 studies. Following duplicate removal, 132 studies remained, of which 106 were excluded during title and abstract screening. Of the remaining 26 studies, 9 full-text publications[14-16,21-26] and 6 conference abstracts[27-32] were included in the systematic review. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses flowchart outlining the study flow is presented in Figure 1. Analyses were based on a pooled sample of 2454 patients, of which 1709 underwent HoLEP and 765 received treatment using RASP. The studies' data spanned 6 countries with sample sizes ranging from 53[16] to 632[22] patients. Average age and BMI ranged from 67.5[26] to 76[16] and 21.9[23] to 29.5,[32] respectively. The preoperative prostate size was between 91.8[25] and 220,[16] and PSA was high across studies, ranging from 5.4[24] to 9.8.[16] Study characteristics are further presented in Table 1.

Risk of Bias

The included publications were found to have a low to moderate risk of bias. The most common sources of bias were not accounting for confounding variables and using different source populations for the HoLEP and RASP groups.

Operative, Hospitalization, and Catheterization Durations

Operative time for HoLEP was 49.48 minutes shorter than RASP (g = −0.803; 95% CI, −1.436 to −0.170; P = .013; Figure 2, A). Furthermore, HoLEP notably improved postoperative recovery metrics. Specifically, patients undergoing HoLEP as opposed to RASP were discharged from the hospital 1.5 days earlier (g = −1.103; 95% CI, −1.564 to −0.641; $P < .001$; Figure 2, B) and had their urinary catheter removed 3.8 days faster than patients treated using RASP (g = −2.307; 95% CI, −3.507 to −1.108; $P < .001$; Figure 2, C).

Efficacy Assessments

RASP resulted in a 6.74-gram increase in prostate resected (g = −0.206; 95% CI, −0.392 to −0.021; P = .029; Figure 3, A). Conversely, postoperative PSA was determined to be 0.377 ng/mL lower in HoLEP patients (g = −0.295; 95% CI, −0.560 to −0.031; P = .029; Figure 3, B). No difference was found between HoLEP and RASP regarding postoperative Q-max, PVR, IPSS, and QoL ($P > .05$).

Baseline Sources of Heterogeneity

A meta-regression was not feasible because of the number of observations. As such, we assessed the differences in baseline characteristics of HoLEP and RASP samples. RASP patients were significantly older than HoLEP patients by 2 years on average (g = 0.207; 95% CI, 0.027-0.387; P = .024). RASP patients were also found to score 3.638 points higher on the IPSS (g = −0.306; 95% CI, −0.508 to −0.104; P = .003). In prostate-related measures, the baseline prostate for patients undergoing RASP was determined to be 8.35 grams larger than patients treated using HoLEP (g = −0.243; 95% CI, −0.393 to −0.092; P = .002). Similarly, PSA was 1.743 ng/mL higher at baseline for patients treated with RASP (g = −0.250; 95% CI, −0.435 to −0.066; P = .008). BMI did not differ between HoLEP and RASP patients (g = 0.033; 95% CI, −0.425 to 0.492; P = .887).

Complications

Critically, HoLEP was associated with a 75% reduction in the risk of needing a blood transfusion (RR = 0.249; 95% CI, 0.108-0.575; P = .001; Figure 4, A). Patients treated with RASP were found to be 1.8 times more at risk for postoperative complications when compared with patients treated with HoLEP (RR = 0.566; 95% CI, 0.388-0.825; P = .003; Figure 4, B). When evaluated using the Clavien-Dindo reporting standard, no differences between grade 1 outcomes were present. However, patients treated with RASP were 1.87 times more at risk for grade 2 complications (RR = 0.534; 95% CI, 0.334-0.854; P = .009; Figure 4, C) and, notably,

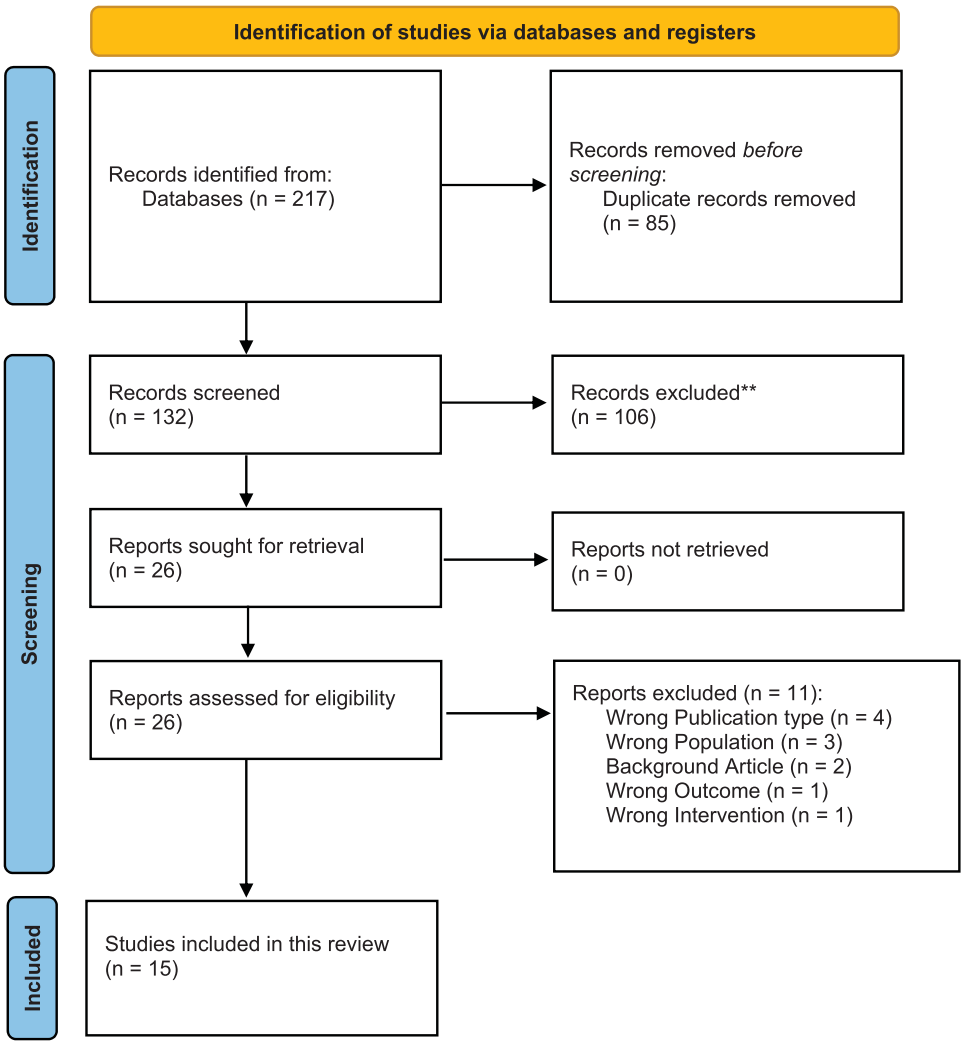


Figure 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses flowchart.

3.41 times more at risk for developing a grade 3 or above complication (RR = 0.293; 95% CI, 0.134-0.639; P = .002; Figure 4, D).

RASP was associated with a 4.48 times greater risk of developing a UTI than HoLEP (RR = 0.223; 95% CI, 0.057-0.871; P = .031). Similarly, HoLEP patients had a higher chance of passing the trial of void than RASP (RR = 0.566; 95% CI, 0.388-0.825; P = .003). There were no statistically significant differences between the 2 surgical interventions concerning stricture rate, urgency, hematuria, stress urinary incontinence, or urge incontinence. Supplementary Material S-3 (https://www.jurology.com) contains findings related to stricture and stress incontinence. Specific outcomes were only reported once within the literature and thus were unsuitable for meta-analysis. Zhang et al[22] reported that 1 and 4 patients of the 600 treated with HoLEP experienced septic shock and ICU admission, respectively. Of the 32 patients treated with RASP, 1 had a small-bowel perforation requiring exploratory laparotomy. In addition, Lee et al[14] observed comparable readmission rates with the emergency department between groups.

DISCUSSION

With the prevalence of BPH escalating from 51.1 million cases in 2000 to 94 million in 2019,[1] optimizing management strategies is essential. To the best of our knowledge, this represents the first meta-analysis specifically focusing on comparing HoLEP and RASP within the context of BPH management. Our findings show that HoLEP and RASP had comparable outcomes, with HoLEP having fewer complications, mainly fewer blood transfusions, and earlier urinary catheter removal. However, RASP and HoLEP had similar outcomes for postoperative PVR, Q-max, IPSS, and QoL.

In contrast to expectations, our analysis revealed that HoLEP resulted in greater reductions in PSA levels despite RASP being associated with larger

Table 1. *Summary of Study Characteristics and Risk of Bias Assessments*

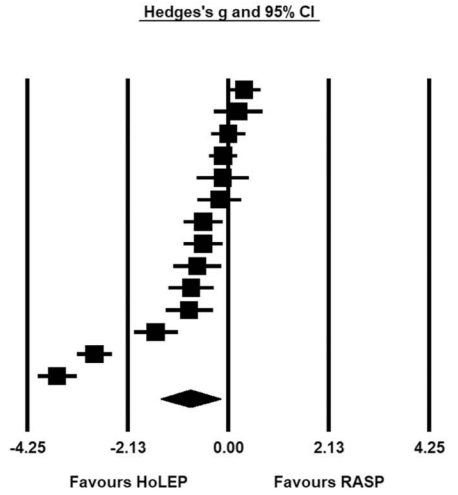
Authors	Year	Publication type	Country	Age	BMI	Prostate size	PSA	Preoperative IPSS	Postoperative IPSS	Temporal outcomes	Efficacy outcomes	Complications	Risk of bias
Umari et al[21]	2017	Article	Italy	71	26	—	7.55	24	3.71	Hospitalization time, catheterization time	Postoperative prostate size, PSA, Qmax, PVR, IPSS	Complications (Clavien), transfusion, stricture, incontinence (combined)	Low
Zhang et al[22]	2017	Article	United States	71	—	—	—	—	—	Operative time, hospitalization time, catheterization time	Postoperative prostate size	Complications (Clavien), transfusion, septic shock, ICU admission	Moderate
Fuschi et al[23]	2021	Article	Italy	36.96	21.88	145.85	5.43	24.23	8.19	Operative time, hospitalization time, catheterization time	Prostate, removed/resected, Qmax, PVR, IPSS	Complications (Clavien), stricture	Moderate
Bove et al[24]	2021	Article	Italy	70	26	102	5.1	20	5.56	Operative time, hospitalization time, catheterization time	PSA, Qmax, IPSS, QoL	Complications (Clavien), incontinence (stress), incontinence (combined)	Moderate
Kim and Byun[25]	2022	Article	Korea	69.29	—	91.82	6.06	—	10.24	Operative time, hospitalization time, catheterization time	Prostate, removed/resected	Complications (Clavien), transfusion, urinary retention, stricture, hematuria, incontinence (stress, urge, and combined), urgency	Low
Grosso et al[26]	2023	Article	Italy	67.52	26	128.52	7.22	19.99	5.51	Operative time, hospitalization time, catheterization time	Qmax, IPSS, QoL	Complications (non-Clavien), stricture, incontinence (stress, urge, and combined)	Moderate
Lee et al[14]	2023	Article	United States	71.24	27.56	149.26	7.48	—	4.71	Operative time, hospitalization time, catheterization time	Prostate, removed/resected PSA, IPSS	Complications (Clavien), transfusion, UTI, ED admission	Moderate
Palacios et al[15]	2023	Article	United States	—	—	—	—	—	—	Operative time, hospitalization time, catheterization time	Prostate removed/resected, PVR	Complications (Clavien)	Low
Van der Jeugt et al[16]	2023	Article	Belgium	76	26.6	220	9.8	18	6.83	Operative time, hospitalization time, catheterization time	Postoperative prostate size, PSA, Qmax, PVR, IPSS, QoL	Complications (Clavien), incontinence (stress, urge, and combined), urgency	Low
Bhat et al[27]	2021	Abstract	United States	68.67	—	149.33	7.43	21.33	3.67	Operative time, hospitalization time, catheterization time	PSA, IPSS	Transfusion, UTI, stricture, hematuria, incontinence (combined)	N/A
Vignot et al[28]	2022	Abstract	France	—	—	—	—	—	—	Operative time, hospitalization time, catheterization time	Prostate removed/resected	Complications (Clavien)	N/A
Angelo et al[29]	2023	Abstract	Belgium	—	—	—	—	—	—	Operative time, hospitalization time, catheterization time	NR	NR	N/A
Ceraolo et al[30]	2023	Abstract	United States	70.43	—	132.82	5.79	—	—	Operative time, hospitalization time, catheterization time	PSA	Urinary retention, hematuria	N/A
Cochetti et al[31]	2023	Abstract	France	—	—	—	—	—	—	Operative time, hospitalization time, catheterization time	PSA, Qmax	Complications (non-Clavien)	N/A
Herrmann et al[32]	2023	Abstract	Germany	70.8	29.45	—	—	—	—	Operative time, hospitalization time, catheterization time	NR	Complications (non-Clavien), transfusion	N/A

Abbreviations: ED, emergency department; IPSS, International Prostate Symptom Score; N/A, not applicable; NR, not reported; PVR, postvoid residual; Qmax, maximum urinary flow rate; QoL, quality of life.

A

Study name	Outcome	Hedges's g	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
Palacios et al.	Operative Time	0.333	0.177	0.031	-0.013	0.679	1.884	0.060
Kim et al.	Operative Time	0.208	0.259	0.067	-0.301	0.716	0.801	0.423
Umari et al.	Operative Time	0.000	0.185	0.034	-0.362	0.362	0.000	1.000
Vignot et al.	Operative Time	-0.112	0.147	0.022	-0.401	0.177	-0.759	0.448
Van der Jeugt et al.	Operative Time	-0.120	0.275	0.076	-0.658	0.419	-0.435	0.663
Fuschi et al.	Operative Time	-0.192	0.233	0.054	-0.648	0.264	-0.824	0.410
Bove et al.	Operative Time	-0.533	0.206	0.043	-0.937	-0.129	-2.583	0.010
Grosso et al.	Operative Time	-0.535	0.207	0.043	-0.941	-0.129	-2.583	0.010
Ceraolo et al.	Operative Time	-0.657	0.255	0.065	-1.156	-0.159	-2.583	0.010
Herrmann et al.	Operative Time	-0.789	0.239	0.057	-1.258	-0.321	-3.302	0.001
Bhat et al.	Operative Time	-0.831	0.252	0.063	-1.325	-0.338	-3.302	0.001
Cochetti et al.	Operative Time	-1.537	0.233	0.054	-1.995	-1.080	-6.589	0.000
Lee et al.	Operative Time	-2.833	0.186	0.035	-3.199	-2.468	-15.209	0.000
Zhang et al.	Operative Time	-3.626	0.208	0.043	-4.034	-3.219	-17.438	0.000
Pooled		-0.803	0.323	0.104	-1.436	-0.170	-2.488	0.013
Prediction Interval		-0.803			-3.485	1.878		

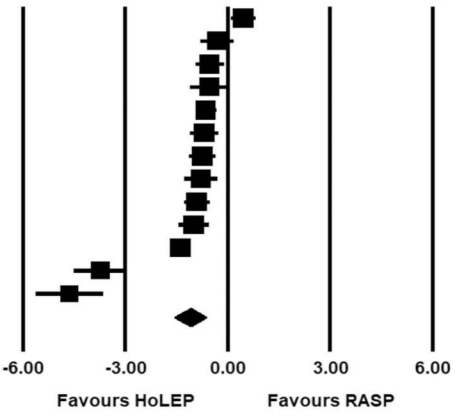
$k = 14$, $I^2 = 96.96\%$



B

Study name	Outcome	Hedges's g	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
Palacios et al.	LOS	0.458	0.178	0.032	0.110	0.806	2.581	0.010
Bhat et al.	LOS	-0.304	0.244	0.059	-0.782	0.174	-1.247	0.212
Bove et al.	LOS	-0.533	0.206	0.043	-0.937	-0.129	-2.583	0.010
Van der Jeugt et al.	LOS	-0.546	0.280	0.078	-1.095	0.002	-1.954	0.051
Vignot et al.	LOS	-0.647	0.149	0.022	-0.939	-0.356	-4.349	0.000
Grosso et al.	LOS	-0.692	0.210	0.044	-1.103	-0.281	-3.299	0.001
Umari et al.	LOS	-0.743	0.191	0.036	-1.117	-0.369	-3.898	0.000
Herrmann et al.	LOS	-0.789	0.239	0.057	-1.258	-0.321	-3.302	0.001
Zhang et al.	LOS	-0.908	0.183	0.033	-1.266	-0.549	-4.959	0.000
Cochetti et al.	LOS	-0.997	0.217	0.047	-1.423	-0.572	-4.593	0.000
Lee et al.	LOS	-1.392	0.154	0.024	-1.693	-1.091	-9.064	0.000
Fuschi et al.	LOS	-3.740	0.385	0.148	-4.495	-2.985	-9.707	0.000
Kim et al.	LOS	-4.633	0.499	0.249	-5.611	-3.655	-9.287	0.000
Pooled		-1.103	0.236	0.055	-1.564	-0.641	-4.682	0.000
Prediction Interval		-1.103			-2.962	0.757		

$k = 13$, $I^2 = 93.74\%$



C

Study name	Outcome	Hedges's g	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
Bove et al.	Catheter	0.533	0.206	0.043	0.129	0.937	2.583	0.010
Van der Jeugt et al.	Catheter	-0.096	0.275	0.076	-0.635	0.442	-0.351	0.726
Palacios et al.	Catheter	-0.458	0.178	0.032	-0.806	-0.110	-2.581	0.010
Umari et al.	Catheter	-0.528	0.188	0.035	-0.896	-0.160	-2.813	0.005
Ceraolo et al.	Catheter	-0.657	0.255	0.065	-1.156	-0.159	-2.583	0.010
Grosso et al.	Catheter	-0.692	0.210	0.044	-1.103	-0.281	-3.299	0.001
Herrmann et al.	Catheter	-0.789	0.239	0.057	-1.258	-0.321	-3.302	0.001
Bhat et al.	Catheter	-0.831	0.252	0.063	-1.325	-0.338	-3.302	0.001
Cochetti et al.	Catheter	-1.684	0.239	0.057	-2.152	-1.216	-7.057	0.000
Vignot et al.	Catheter	-2.391	0.190	0.036	-2.764	-2.019	-12.574	0.000
Fuschi et al.	Catheter	-2.508	0.310	0.096	-3.116	-1.899	-8.077	0.000
Lee et al.	Catheter	-3.980	0.221	0.049	-4.414	-3.546	-17.986	0.000
Kim et al.	Catheter	-6.329	0.637	0.406	-7.578	-5.079	-9.928	0.000
Zhang et al.	Catheter	-12.343	0.392	0.153	-13.111	-11.575	-31.518	0.000
Pooled		-2.307	0.612	0.375	-3.507	-1.108	-3.769	0.000
Prediction Interval		-2.307			-7.434	2.819		

$k = 14$, $I^2 = 98.92\%$

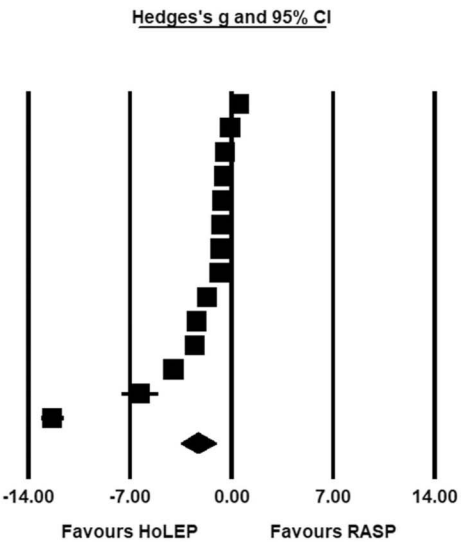


Figure 2. A, Operative time difference between holmium laser enucleation of the prostate (HoLEP) and robotic-assisted simple prostatectomy (RASP) for benign prostatic hyperplasia management. B, Length of stay (LOS) differences between HoLEP and RASP for benign prostatic hyperplasia management. C, Catheterization time difference between HoLEP and RASP for benign prostatic hyperplasia management.

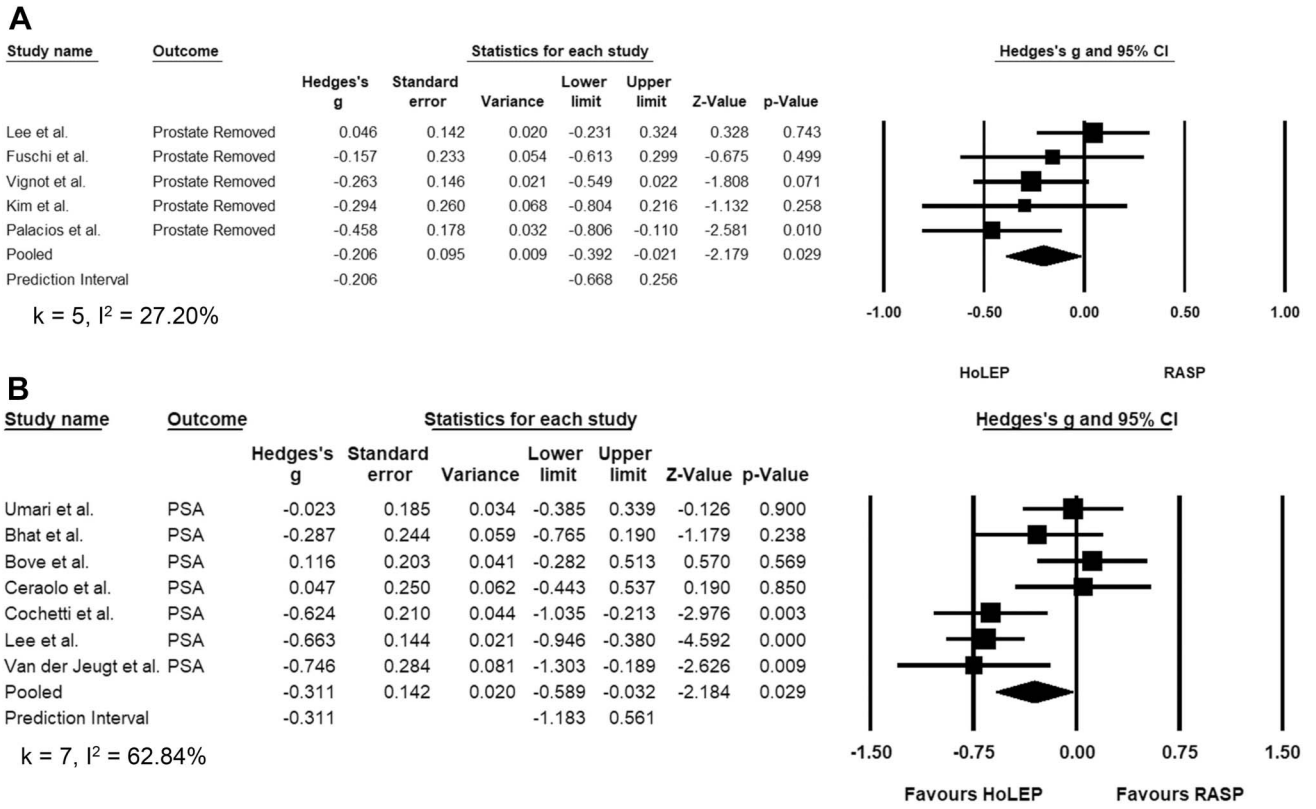


Figure 3. A, Difference in prostate-resected amount between holmium laser enucleation of the prostate (HoLEP) and robotic-assisted simple prostatectomy (RASP) for benign prostatic hyperplasia management. B, PSA differences between HoLEP and RASP for the management of benign prostatic hyperplasia.

volumes of resected prostate tissue. This apparent inconsistency is likely due to baseline differences between the patient groups rather than inherent differences in the surgical techniques. Specifically, patients undergoing RASP tended to have higher baseline PSA levels, were generally older, and exhibited worse preoperative International Prostate Symptom Scores (IPSS) compared with those undergoing HoLEP. These factors suggest that RASP patients had more advanced BPH or greater baseline morbidity. Higher baseline PSA levels in RASP patients likely resulted in a less pronounced proportional decrease postoperatively, even when larger volumes of prostate tissue are removed. The AUA guidelines recommend the use of HoLEP, thulium laser vapoenucleation of the prostate for all prostate sizes, and simple prostatectomy, which includes RASP, for treating larger prostates[33] However, the European Association of Urology guidelines only list HoLEP, bipolar enucleation, and OSP as first-line treatments for a larger prostate.[34] Similarly, Canadian Urological Association guidelines recommend AEEP, including HoLEP as the first line for treatment modalities of choice for prostates larger than 80 cc and OSP if AEEP is unavailable.[35]

Moreover, HoLEP has emerged over the past 20 years as the gold standard intervention independent of prostate size, with robust evidence confirming its efficacy and safety profile for managing larger prostates.[36-40] This role is based on solid evidence; the divergence may reflect regional variations in clinical practice and the adoption of surgical technologies. Considering that 9 of our included 15 studies are based in Europe, this points to the potential presence of challenges in implementing and accessing HoLEP within the field. Previous evidence has suggested that RASP is more frequently used in nonmetropolitan areas than HoLEP.[41] As such, it remains reasonable to infer that lack of access translates into underutilizing HoLEP for large prostates in which surgeons choose RASP over alternatives suggested by guidelines such as OSP due to less morbidity and easier access to robotic surgery.

When looking at efficacy, both HoLEP and RASP produce very similar efficacy outcomes. For instance, both shared comparable Qmax, PVR, and IPSS outcomes postoperatively. This matches previous qualitative comparisons of these 2 modalities in which they were equally effective in treating prostatic adenomas.[13] However, HoLEP had a more significant reduction in PSA. This difference may be reflective of baseline differences between the samples in which RASP was associated with more prostate tissue resected because of a larger baseline prostate size.

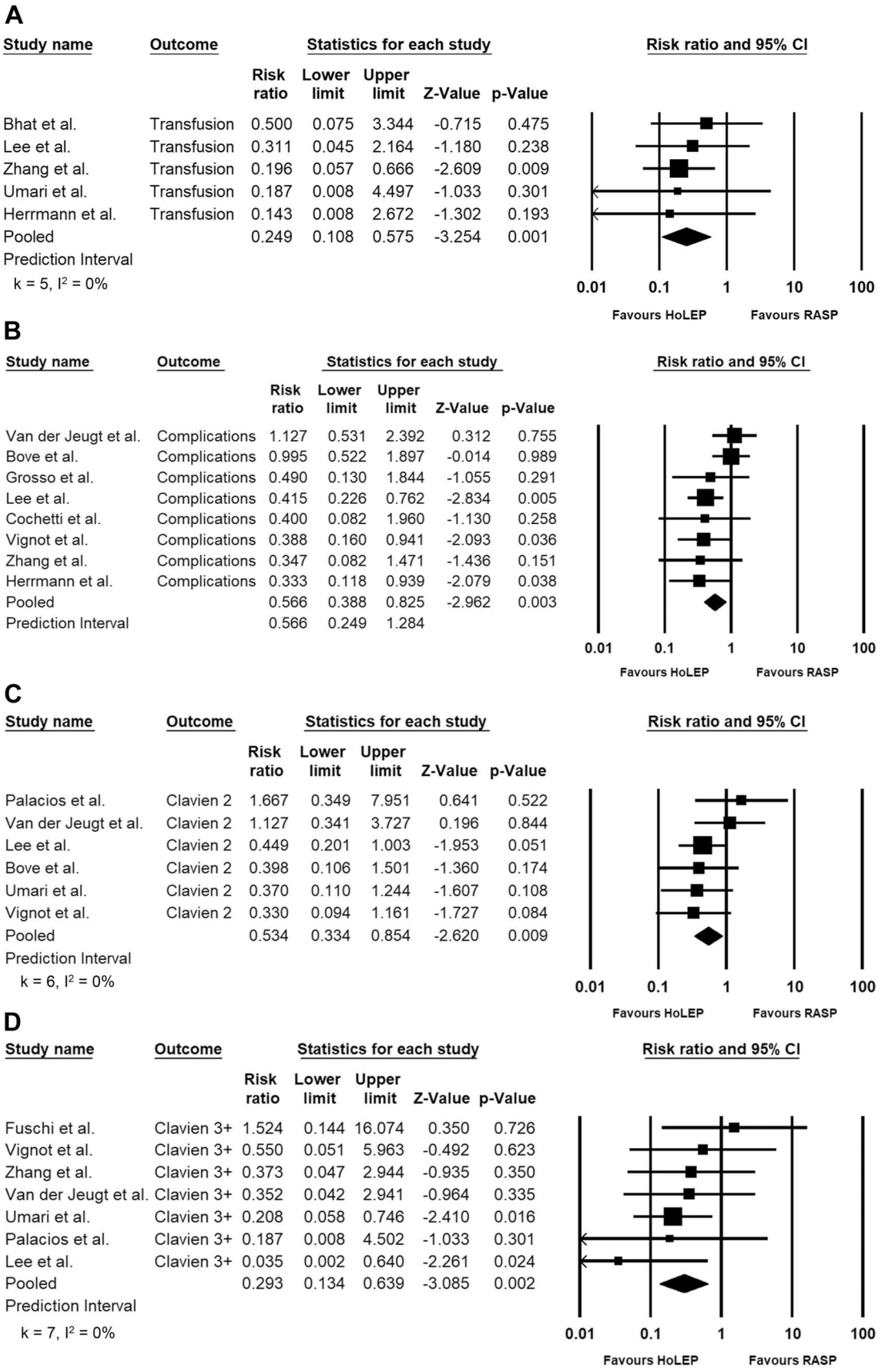


Figure 4. A, Transfusion risk between holmium laser enucleation of the prostate (HoLEP) and robotic-assisted simple prostatectomy (RASP). B, Differences in the risk of postoperative complications between HoLEP and RASP. C, Relative risk differences in Clavien 2 complications between HoLEP and RASP. D, Relative risk differences in Clavien 3 or above between HoLEP and RASP.

Similarly, lower PSA outcomes in HoLEP may reflect a lower PSA level at baseline in its patient sample. As such, this observed difference should be interpreted considering baseline confounders.

HoLEP demonstrated a significant advantage in our analyses in operative efficiency, with a shorter operative time and hospitalization. This outcome implies a potential decrease in intraoperative risks and anesthesia exposure and signifies an essential consideration for health care resource utilization. Furthermore, the enhanced postoperative recovery associated with HoLEP, as evidenced by shorter hospital stays and quicker catheter removal times, directly contributes to improved patient experiences and reduced health care costs. These findings highlight the potential of HoLEP to not only streamline patient care pathways but also to contribute to the broader objectives of health care systems in enhancing efficiency and patient throughput. Zhang et al[22] evaluated the length of hospitalization. They identified the need for continuous bladder irrigation as a significant source of longer hospitalization time in RASP patients in which 50% were reported requiring continuous bladder irrigation for a full day. Although these findings fit within our analyses, our evaluation identified a difference in stay that was, on average, greater than 1 day, suggesting other factors, such as complication rates, are likely further influencing hospitalization length.

We determined the presence of distinct safety profiles between the 2 modalities. HoLEP was associated with fewer blood transfusions, a critical concern within the context of surgical interventions.[42] This finding is paramount because it directly correlates with a diminished risk of transfusion-related acute injuries and complications, such as venous thromboembolism,[43] immunological reactions,[44] and lung injury.[45] Such reductions not only facilitate patient recovery but further promote a decreased duration of hospital stay.[46] Moreover, HoLEP was associated with a considerable decrease in the frequency of overall patient complications. This reduction extended to moderate and severe complications rigorously defined using the Clavien Dindo grading approach. HoLEP and RASP produced comparable stricture, urgency, hematuria, and incontinence rates. However, there was a nearly fivefold decrease in UTI outcomes and a 44% reduced risk of urinary retention with HoLEP compared with RASP. This may reflect more effective management of urinary flow and bladder function postoperatively. Although we determined that there was no difference in Qmax and PVR, the advantages of HoLEP may extend beyond immediate mechanical outcomes and reflect more precise removal of prostatic tissue, leading to better preservation of the natural anatomy and thus reducing the risk of postoperative swelling and irritation, both of which can predispose patients to UTI and urinary retention.[47]

Similarly, evidence has shown that less catheterization time, as observed in HoLEP, is associated with lower rates of UTI.[48] The absence of significant differences in Qmax and PVR indicates that HoLEP and RASP effectively address the obstruction. Still, the superior outcomes regarding UTIs and urinary retention with HoLEP suggest benefits likely related to the procedural specifics and postoperative course. However, future research is needed to identify these factors and their implications.

The involvement of surgeon experience in these outcomes remains unknown. Although HoLEP is praised for its efficacy and safety profile, the assertion that its successful deployment is contingent on a steep learning curve warrants a closer examination. Conversely, RASP is purported to have a more forgiving learning trajectory, potentially influencing its broader adoption despite the superior outcomes associated with HoLEP. The difference in the learning curves between these surgical techniques (ie, approximately 50 cases for HoLEP proficiency[40] as opposed to 5-10 cases for RASP[49]) raises critical questions about the impact of surgical expertise on patient outcomes. Within the context of our analyses, higher learning curves may have resulted in higher surgical skills in surgeons performing HoLEP, which would translate into lower rates of complications. With the widespread availability of robotic surgery mainly for oncological indication, RASP can be implemented to treat BPH, especially for those surgeons already accomplished on the robot with excellent patient outcomes having gone through the learning curve already.

Moreover, the reluctance to engage with the rigorous training demands of HoLEP might contribute to its underutilization despite its established status as the gold standard intervention for treating large prostates. The implications of such underutilization are multifaceted, encompassing missed opportunities for optimizing patient care and broader impacts on health care systems striving for efficiency and excellence in surgical outcomes. However, a recent systematic review has reported that implementing simulation training and a mentorship program would reduce the learning curve from 50 to 25 cases for HoLEP efficiency,[50] suggesting that proper training program optimizations may lead to greater adoption of HoLEP.

Future studies should analyze the influence of procedural-specific experiences on patient outcomes. This includes comparative studies between HoLEP and RASP and broader analyses encompassing the spectrum of surgical modalities available for BPH treatment. Furthermore, meta-analyses comparing HoLEP learning curves with other modalities of BPH treatment could offer valuable insights into the

relative accessibility and adaptability of these techniques within the urological community.

Limitations

A substantial limitation of our meta-analysis is our exposure group's lack of randomized allocation. This meta-analysis, based heavily on cohort studies, reflects the need for RCT evidence to compare both approaches. Furthermore, we identified divergence in data being reported within studies, with some studies not reporting known urological complications and fundamental assessments, including but not limited to stricture rates, stress incontinence, PVR, IPSS, and PSA. This limited our ability to include all studies throughout all our evaluations. Future studies should aim to converge reporting, even if presented as Supplementary Material (https://www.jurology.com). Moreover, our analyses focused on immediate and relatively short-term outcomes. Future studies looking at long-term patient experiences, such as reoperation needs, because this would contribute to our understanding of differences between both surgical approaches. Heterogeneity was high in our operative, hospitalization, and catheterization time assessment. Future meta-analyses on the topic should include meta-regressions to help identify sources of variability once the sample of studies on the topic reaches a number that provides the necessary statistical power for evaluation.

Application to Clinical Practice

This meta-analysis presents an unprecedented comparison between HoLEP and RASP within the scope of BPH management. Our findings demonstrate both HoLEP and RASP as practical approaches for larger prostates. HoLEP has pronounced reductions in blood transfusions, operative time, length of stay, and recovery metrics. RASP can be easier to implement in a setting where surgeons are experienced with robotic surgery and with excellent outcomes.

Furthermore, our analysis highlights the critical need for surgical practices to be aligned with evidence-based guidelines. The observed regional discrepancies in the utilization of HoLEP in addressing large prostates, despite its proven effectiveness, suggest underlying challenges in its implementation and accessibility. These challenges may stem from various factors, including the availability of resources. In response to these findings, the health care community needs to engage in concerted efforts to address these barriers. This includes enhancing surgical education and training to broaden the pool of clinicians proficient in HoLEP and introduce RASP as an option to already trained robotic surgeons.

However, the differences in preoperative patient profiles for HoLEP and RASP highlight the importance of a tailored approach to surgical selection. RASP's frequent application in patients with larger prostates, elevated PSA levels, and advanced age—factors often accompanied by higher baseline morbidity—emphasizes the complexity of adhering to a one-size-fits-all guideline. Such disparities necessitate integrating individualized clinical judgment, anchored in the most current and comprehensive evidence, to determine the optimal surgical intervention on a case-by-case basis.

CONCLUSION

Our meta-analysis compares HoLEP and RASP, which equally effectively treat BPH in larger prostates. HoLEP had superior recovery parameters and lower blood transfusion rates. RASP's easy accessibility and adaptability make it more widely available. Addressing the disparities in the adoption and accessibility of both techniques is essential for leveraging their full potential. Future efforts should focus on enhancing training, harmonizing clinical guidelines, and improving access, guided by ongoing research and a commitment to evidence-based care.

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