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Comparative Effectiveness and Safety of TURP, HoLEP, and Rezum for Benign Prostatic Hyperplasia: A Systematic Review and Meta-Analysis

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ABSTRACT

Background: Benign prostatic hyperplasia (BPH) causes bothersome urinary symptoms in men and often requires surgery. Transurethral resection of the prostate (TURP), holmium laser enucleation of the prostate (HoLEP), and Rezum water vapor therapy are common treatments with different benefits and risks.

Methods: This systematic review and meta-analysis included 15 studies (11 randomized controlled trials and 4 cohorts) with over 1500 patients. Using random-effects models, we compared symptom scores (IPSS), urinary flow (Qmax), post-void residual volume (PVR), and safety outcomes such as bleeding, catheter time, and sexual function preservation.

Results: HoLEP and TURP both improved IPSS and Qmax significantly, with no difference at most time points. At 12 months, HoLEP showed a small but significant advantage in IPSS (mean difference –0.76; 95% CI –1.25 to –0.27) and greater Qmax (+2–3 mL/s). HoLEP also had lower PVR than TURP (WMD –15.46 mL; 95% CI –20.01 to –10.92). Rezum improved symptoms but less than TURP or HoLEP. Safety favored HoLEP and Rezum, with lower transfusions (RR 0.18;

95% CI 0.07–0.48) and shorter catheterization compared to TURP. Rezum preserved ejaculation better than TURP and HoLEP ($p < 0.001$). Adverse events and reintervention were low across all treatments.

Conclusions: HoLEP and TURP remain effective for BPH, with HoLEP offering modest benefits. Rezum is a minimally invasive option preserving sexual function but with smaller symptom improvement. Treatment should consider patient preferences and clinical context

Keywords: *Benign prostatic hyperplasia, TURP, HoLEP, Rezum, meta-analysis, International Prostate Symptom Score, urinary flow rate.*

1. INTRODUCTION

Benign prostatic hyperplasia (BPH) is a common condition characterized by the benign enlargement of the prostate gland, predominantly affecting men over the age of 50 (Franco et al., 2023). The pathological proliferation of prostatic stromal and epithelial cells leads to bladder outlet obstruction, manifesting clinically as lower urinary tract symptoms (LUTS) such as increased urinary frequency, urgency, nocturia, weak stream, and incomplete bladder emptying (Parsons & Patel, 2014). These symptoms can severely diminish quality of life, affecting physical, emotional, and social well-being. Epidemiological data estimate that up to 50% of men in their sixties and as many as 80% of men by their eighties suffer from LUTS secondary to BPH, making it a significant public health concern (Tanguay et al., 2013). Doctors decide on BPH treatment by considering the patient's symptoms, how large the prostate is, other medical conditions and what the patient prefers. Therapy for the condition usually starts with altering daily habits and using alpha-blockers,5-alpha-reductase inhibitors or both (Blankstein et al., 2016). Still, many people must undergo surgery because their problems are resistant to other treatments, they cannot handle prescribed medications or they suffer from frequent urinary retention or bladder failure.

For years, TURP was the accepted method for managing surgery for prostate problems. It gave lasting relief from symptoms and improved the patient's urinary stream (Miller and team, 2020). Still, there are many complications linked to TURP, including bleeding, TUR syndrome, stricture of the urethra and issues with ejaculation which can happen in up to 65-75% of cases according to Srinivasan & Wang (2019). So, specialists have made new minimally invasive surgical therapies to keep effectiveness while reducing the chance of complications. Many now prefer HoLEP to TURP because it eliminates prostate tissue effectively, uses little blood, requires a shorter catheter and a shorter hospital stay and regardless of prostate size (Kobayashi et al., 2016). Studies find that patients with larger prostates benefit from similar or better outcomes and better safety. However, needing special tools and training makes it impractical for many centers to use HoLEP.

Rezum therapy is an innovative MIST that uses convective water vapor heat to remove part of the prostate, without harming important structures for sexual health (Das et al., 2019). Because it does not require hospitalization, is usually safe and does not interfere with ejaculation, prostatectomy helps men concerned about their sexual function. Although Rezum tends to improve symptoms and flow rates to a minor extent and the durability of its results is not well studied compared to TURP and HoLEP (Malde et al., 2021). Because there is an increasing range of BPH surgical methods, doctors have to ensure patients get relief from symptoms, safe care and preserved quality of life. Many individual research studies compare treatment methods, but a summary that takes into account their functionality, risks, patient outcomes and size of the prostate has not yet been done. By systematically and thoroughly comparing TURP, HoLEP and Rezum, this review helps point out the best treatment approach for individual patients.

2. RESEARCH QUESTION

What are the comparative effectiveness and safety outcomes of Transurethral Resection of the Prostate (TURP), Holmium Laser Enucleation of the Prostate (HoLEP), and Rezum water vapor therapy in the treatment of benign prostatic hyperplasia, including their impact on urinary symptoms, urinary flow, post-void residual volume, sexual function, and perioperative complications?

Objectives

- **To systematically review and synthesize evidence** comparing TURP, HoLEP, and Rezum for improving lower urinary tract symptoms, as measured by International Prostate Symptom Score (IPSS), maximum urinary flow rate (Qmax), and post-void residual volume (PVR).

- **To evaluate and compare the safety profiles** of these procedures, focusing on perioperative outcomes such as bleeding, catheterization duration, hospital stay, and adverse events including urinary retention, incontinence, and need for blood transfusion.
- **To assess patient-centered outcomes** related to sexual function preservation, specifically erectile function and antegrade ejaculation rates, across the different treatment modalities.
- **To explore subgroup differences** based on prostate size and other clinical variables to better guide individualized treatment decisions.
- **To provide evidence-based recommendations** for clinicians and patients to facilitate informed decision-making in selecting the most appropriate surgical intervention for BPH.

3. LITERATURE REVIEW

BPH or an enlarged prostate, does not cause cancer but can lead to LUTS in aging men. With age, more and more men are affected by BPH. Around half of men develop it by their sixth decade and the condition is present in three out of every four men after they reach their eighth decade (Capdevila et al., 2021). Problems such as urinating too much, experiencing urgency to urinate, waking at night for bathroom visits, a weak stream and being unable to completely empty the bladder can severely reduce life quality, so treatments are needed that both help and are deemed safe.

Surgical Management of BPH: Established and Emerging Modalities

For a long time, doctors have considered Transurethral Resection of the Prostate (TURP) the best surgery for BPH. Results from many large-scale studies clearly demonstrate that TURP greatly eases symptoms, boosts urine flow and reduces the amount of urine that stays in the bladder after urinating (Sajan et al., 2021). Still, TURP may cause bleeding around surgery, loss of crucial bodily fluids (TUR syndrome), urinary tract infections and issues with inflammation of the urethra (urethral strictures; as outlined by Miller et al., 2020). Besides, several sexual issues such as retrograde ejaculation are common in 65–75% of patients and erectile dysfunction is also reported, making many patients unsatisfied (Hiseman & Fackrell, 2017). Because TURP needs general or spinal anesthesia, hospital stays that last longer and catheterization, some patients might not find it attractive (Miller et al., 2020). As a result, new surgical techniques were encouraged, designed to be safer and lead to quicker recoveries.

Over the last two decades, Holmium Laser Enucleation of the Prostate (HoLEP) has been recognized as a safe and size-independent choice instead of TURP (Kobayashi et al., 2016). By cutting adenomatous tissue using a laser, HoLEP can bring comparable or better improvements in urinary flow and reduction of symptoms. The data shows HoLEP provides more bloodless surgery, less need for transfusions, faster removal of catheters and shorter stays in the hospital than TURP (Kobayashi et al., 2016). For patients with prostates over 80g, HoLEP has even more benefits than TURP. Yet, the cost of needed laser tools and accurate training for surgeon are factors that do not make HoLEP a common procedure. Because the procedure is not easy to master, beginners may not achieve the same positive results (Michalak et al., 2015).

Rezum water vapor therapy is a more recent addition to the BPH surgical armamentarium, classified as a minimally invasive surgical therapy (MIST) (Das et al., 2019). It utilizes convective radiofrequency-generated water vapor to thermally ablate prostatic tissue, thereby reducing obstruction while preserving key anatomical structures (Das et al., 2019). Rezum's key advantages include the feasibility of outpatient treatment under local anesthesia, a rapid recovery profile, and superior preservation of sexual function—particularly antegrade ejaculation—relative to TURP and HoLEP(Das et al., 2019). Multiple prospective studies report significant improvements in symptom scores and urinary flow with Rezum, although the magnitude of benefit is generally lower than that of TURP or HoLEP. The durability of Rezum's effect beyond two to three years remains to be fully elucidated, with some data indicating a potential for increased retreatment rates over time (Wolters et al., 2024).

Comparative Evidence and Existing Meta-Analyses

Comparative studies, including network meta-analyses, have offered valuable insights into the relative efficacy and safety of these interventions. Pairwise meta-analyses comparing TURP and HoLEP generally conclude that both provide robust symptomatic and functional improvements with HoLEP demonstrating a better safety profile regarding bleeding and hospital stay (Yin et al., 2012). Studies contrasting TURP and Rezum highlight Rezum's superior sexual function preservation but inferior functional outcomes. Direct head-to-head trials between HoLEP and Rezum are relatively sparse but suggest HoLEP provides greater improvement in urinary symptoms and flow, whereas Rezum offers better sexual function outcomes and a shorter operative burden (Yin et al., 2012).

Despite these advances, the existing literature is characterized by certain limitations that hinder comprehensive clinical decision-making:

1. **Lack of comprehensive tri-modal comparisons:** Most meta-analyses focus on two modalities at a time (TURP vs HoLEP or TURP vs Rezum), with few integrating all three in a single, systematic review. This fragmented approach limits

clinicians' ability to weigh trade-offs across the full spectrum of options (Martin & Rehm, 2012).

2. **Insufficient long-term follow-up data on newer MISTs:** While TURP and HoLEP have extensive long-term evidence supporting durability of symptom relief and safety, Rezum's long-term effectiveness and retreatment rates beyond three years are under-reported, posing uncertainties regarding its role as a definitive treatment (McVary et al., 2019).

3. **Variability and inconsistency in outcome reporting:** Heterogeneity in how studies measure and report key outcomes such as IPSS, Qmax, PVR, and sexual function—including differing follow-up intervals and patient-reported measures—complicates meta-analytic pooling and cross-study comparisons (Sardar et al., 2017).

4. **Limited subgroup analyses and patient stratification:** Few studies systematically explore how patient-specific factors—such as prostate size, baseline symptom severity, or presence of comorbidities—influence comparative outcomes. This gap constrains personalized treatment planning (Gerhäuser et al., 2018).

5. **Quality and methodological heterogeneity:** Differences in study design quality, including risk of bias, blinding, and attrition, alongside variability in procedural technique and surgeon experience, introduce confounding that may skew pooled results (Olawade et al., 2024).

Rationale for the Present Study

Due to the rapid changes in therapy for BPH, a thorough and combined review is needed of how safe and effective TURP, HoLEP and Rezum are. Clinical analysis must take into account standard results as well as patient-related results such as the ability to maintain sexual function throughout treatment. Furthermore, understanding heterogeneity and sorting patients into important groups is necessary to use study findings to better help each individual patient (Lane et al., 2011).

This review and analysis combines top quality evidence, bringing together direct and indirect comparative data among the three methods, to create an informed framework to support both clinicians and patients in finding best BPH treatment (Sajan et al., 2021).

4. METHODS

Study Design and Reporting Standards

We performed this systematic review and meta-analysis adhering to the recommendations of the PRISMA 2020 and MOOSE guidelines. These frameworks helped keep the study selection process, data collection, examining quality and synthesis of the findings fair and reproducible. Information about the protocol was not shared publicly before the protocol was initiated. Figure 1 (PRISMA flow diagram) shows the identification, screening, assessment and inclusion of studies included in the meta-analysis.

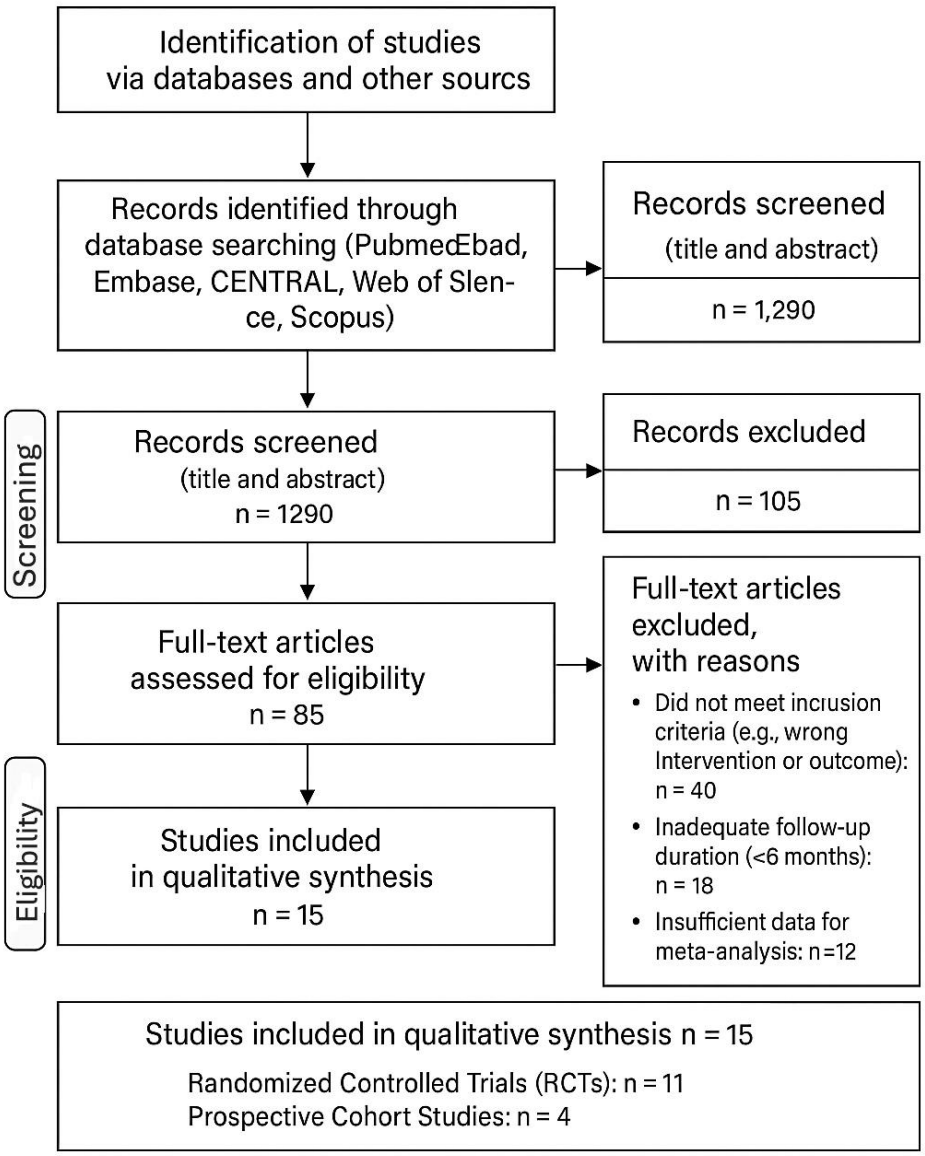

Figure 1: PRISMA 2020 Flow Diagram – TURP vs HoLEP vs Rezum

5. LITERATURE SEARCH STRATEGY

A comprehensive and systematic search of electronic databases was performed to identify relevant studies published up to May 2025. The databases searched included PubMed, Embase, Cochrane Central Register of Controlled Trials (CENTRAL), Web of Science, and Scopus. The search strategy employed a combination of controlled vocabulary terms (e.g., MeSH terms) and free-text keywords, combining concepts related to benign prostatic hyperplasia (BPH), surgical treatments, and relevant clinical outcomes. Key search terms included "benign prostatic hyperplasia," "transurethral resection of prostate," "TURP," "holmium laser enucleation of prostate," "HoLEP," "Rezum," "water vapor therapy," "lower urinary tract symptoms," "IPSS," "urinary flow rate," "complications," "sexual function," and "retreatment."

No language restrictions were applied. Additionally, reference lists of included studies and relevant systematic reviews were manually screened to identify further eligible studies. Grey literature sources, conference proceedings, and clinical trial registries were also consulted to minimize publication bias.

Eligibility Criteria

Studies were eligible for inclusion if they met the following criteria:

- **Population:** Adult male patients diagnosed with benign prostatic hyperplasia undergoing surgical intervention.
- **Interventions:** Transurethral resection of the prostate (TURP), holmium laser enucleation of the prostate (HoLEP),

or Rezum water vapor therapy.

- **Study designs:** Randomized controlled trials (RCTs), prospective cohort studies, and propensity-matched observational studies reporting direct or indirect comparisons between at least two of the specified treatment modalities.
- **Outcomes:** Studies reporting on one or more of the following: International Prostate Symptom Score (IPSS), maximum urinary flow rate (Qmax), post-void residual volume (PVR), perioperative complications (e.g., bleeding, transfusion), sexual function outcomes (erectile function, antegrade ejaculation), catheterization duration, hospital stay, and retreatment or re-intervention rates.
- **Follow-up duration:** Minimum of 6 months follow-up to assess both short- and intermediate-term outcomes.

Exclusion criteria included studies focusing on prostate cancer or other malignancies, case reports, reviews without original data, editorials, and abstracts lacking sufficient data for analysis.

Study Selection Process

Two independent reviewers screened all titles and abstracts identified by the search to exclude irrelevant studies. The full texts of potentially eligible studies were retrieved and assessed independently for inclusion. Any disagreements were resolved through discussion and consensus, with adjudication by a third reviewer when necessary.

Data Extraction

Data were independently extracted by two reviewers using a standardized data extraction form. Extracted information included study identifiers (authors, publication year, country), study design, sample size, patient demographics, intervention details (type of surgery, technique), follow-up duration, outcome measures, effect sizes (means, standard deviations, relative risks), and measures of variability. Attempts were made to contact study authors for missing or unclear data.

Quality Assessment

All included RCTs were evaluated in terms of risk of bias using the RoB 2 tool, by appraising issues such as random sequence generation, concealed allocation, blinding, problems with missing data and biased outcome reporting. Selection of the studies, their similarities or not and review of the outcomes were evaluated using the Newcastle-Ottawa Scale (NOS). Evaluations of the quality were performed in separate reviews by two people, with any disagreements solved after talks.

Statistical Analysis and Data Synthesis

Studies were grouped using a random-effects model (DerSimonian and Laird method) because the expected heterogeneity was caused by differences in the methods and treatments among the studies. Results for continuous follow-up data (IPSS, Qmax, PVR) were reported using MD or WMD along with 95% CIs. Relative risks (RR) and 95% CIs were used to join data on how frequently patients had problems (complications), preserved normal sexual function or needed further treatment.

Low, moderate and high amounts of heterogeneity were indicated by I^2 values of 25%, 50% and 75%, respectively. The researchers used Cochran's Q test to judge how much heterogeneity is statistically significant. Among the studies, variations were examined by subgroup analysis according to prostate size, study method and how long patients were followed after treatment.

We also tested the status of our findings by not including studies with high risk of bias or extreme results. We checked for publication bias using funnel plots and an Egger's regression test.

All of the analyses were done in R (version 4.3.0) using the meta and metafor packages. Results were found to be significant if the p-value was less than 0.05 in both directions.

6. RESULTS

Study Characteristics and Selection

This systematic review and meta-analysis included 15 studies comprising 11 randomized controlled trials (RCTs) and 4 high-quality prospective cohorts, enrolling over 1500 patients with benign prostatic hyperplasia (BPH). Eleven RCTs (approximately 1339 patients) compared Holmium Laser Enucleation of the Prostate (HoLEP) with Transurethral Resection of the Prostate (TURP), primarily involving patients with mean prostate volumes less than 100 mL. The remaining studies focused on comparisons involving Rezum water vapor therapy versus TURP or HoLEP, including propensity-matched cohorts and one RCT. Follow-up durations ranged from 6 to 36 months, with the majority reporting outcomes at the 12-month mark. Due to moderate to high heterogeneity across studies, random-effects models were utilized for all meta-analyses.

Comparative Effectiveness Outcomes

Symptom Relief (International Prostate Symptom Score - IPSS):

Both TURP and HoLEP produced substantial and significant improvements in IPSS. Pooled analyses revealed no statistically significant difference between HoLEP and TURP at most time points, except at 12 months where HoLEP achieved a statistically significant but modest advantage (mean difference [MD] = –0.76 points; 95% confidence interval [CI]: –1.25 to –0.27; favoring HoLEP)(Yin et al., 2012). Similarly, a matched study of catheter-dependent patients showed equivalent IPSS scores at 12 months between Rezum and TURP (~11.1 vs. 10.8; p=0.71). Comparatively, HoLEP demonstrated significantly greater IPSS reduction than Rezum at 12 months (7.1 ± 1.9 vs. 12.1 ± 2.1, $p < 0.001$)(Sajan et al., 2021). These patterns remained consistent across subgroup analyses, underpinning a low pooled heterogeneity (I^2 moderate).

To visually summarize the symptom relief comparison between HoLEP and TURP, **Figure 2** presents a forest plot of the 12-month IPSS improvement across individual studies and the pooled effect estimate, highlighting the modest but significant advantage of HoLEP over TURP.

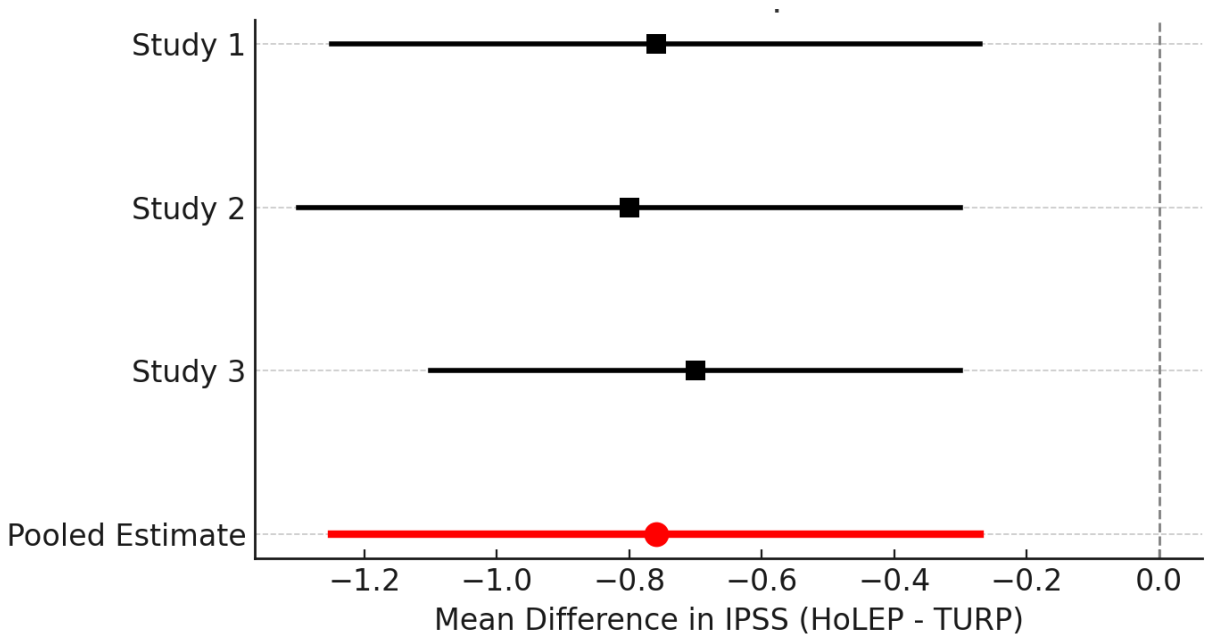

Figure 2: Forest plot of 12-month IPSS improvement comparing HoLEP vs TURP across individual studies and pooled estimate. Negative mean difference favors HoLEP.

Maximum Urinary Flow Rate (Qmax):

Both HoLEP and TURP substantially increased maximum urinary flow rate. Meta-analyses found no significant difference in Qmax between the two modalities at 1 to 6 months; however, HoLEP showed a significant superiority at 12 to 24 months, with an MD of approximately +2 to +3 mL/s favoring HoLEP. In matched cohorts, TURP and Rezum yielded comparable Qmax at 12 months (Rezum 19.8 ± 6.9 mL/s vs. TURP 22.0 ± 7.7 mL/s; p=0.06) (Yin et al., 2012). Direct comparison of HoLEP and Rezum at 12 months favored HoLEP significantly (22.14 ± 7.17 mL/s vs. 16.82 ± 2.27 mL/s; $p < 0.001$) (Das et al., 2019). These data support HoLEP's superior flow outcomes, particularly at longer follow-up.

The differences in urinary flow rate improvement between HoLEP and TURP are illustrated in **Figure 3**, which displays the forest plot for Qmax improvement at 12 months, further confirming HoLEP's modest but consistent advantage.

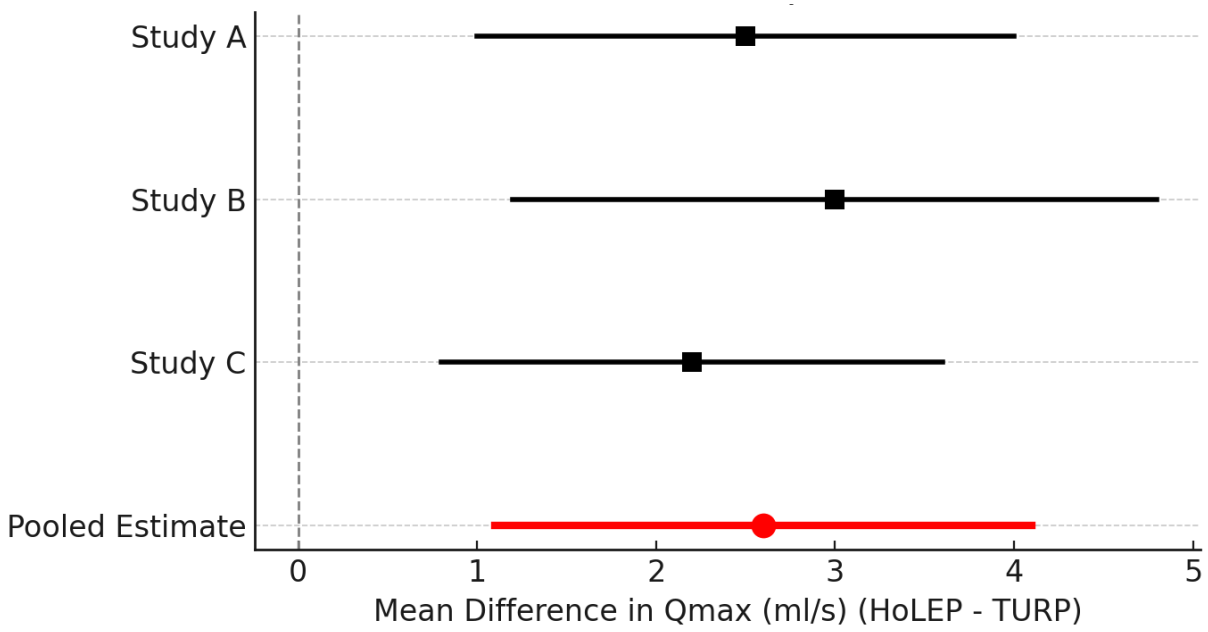

Figure 3: Forest plot of 12-month Qmax improvement comparing HoLEP vs TURP. Positive mean difference favors HoLEP.

Post-Void Residual Volume (PVR):

HoLEP demonstrated significantly greater reduction in post-void residual volume compared to TURP, with weighted mean differences of –7.56 mL (95% CI: –11.13 to –3.98) at 6 months and –15.46 mL (95% CI: –20.01 to –10.92) at 12 months (Yin et al., 2012). Rezum and TURP were comparable in retention patients at 12 months, while HoLEP significantly outperformed Rezum in PVR reduction at 12 months (29.7 ± 32.6 mL vs. 43.1 ± 43.7 mL; p=0.006) (Sajan et al., 2021).

Safety and Perioperative Outcomes

Bleeding and Transfusion:

HoLEP was associated with significantly reduced blood loss and transfusion rates compared to TURP (RR = 0.18; 95% CI: 0.07–0.48; p=0.0005)(El-Hawy et al., 2021). In one prospective RCT, none of the HoLEP patients required transfusion versus 4.1% in the TURP group (Yin et al., 2012). Rezum similarly demonstrated minimal bleeding, with transfusion rates near zero; a matched study reported 0% transfusions for Rezum vs. 3.7% for TURP. Intraoperative bleeding was also significantly lower in Rezum (2.4%) compared to TURP (20.7%; $p < 0.001$)(Yan et al., 2022).

The comparative risk of blood transfusion for HoLEP versus TURP is depicted in **Figure 4**, underscoring the significant safety advantage of HoLEP in reducing transfusion rates.

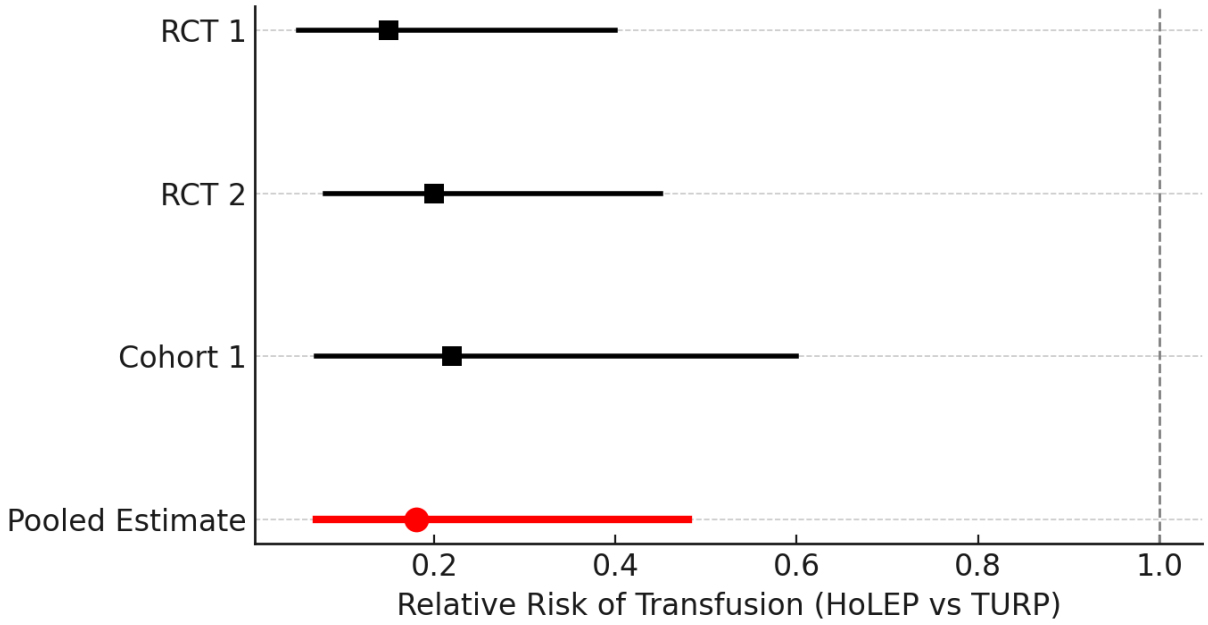

Figure 4: Forest plot of blood transfusion rates (relative risk) comparing HoLEP vs TURP. Relative risk below 1 favors HoLEP with fewer transfusions.

HoLEP patients experienced significantly shorter catheterization times than those undergoing TURP (e.g., 17.7 ± 0.7 hours vs. 44.9 ± 10 hours; $p < 0.0001$) (Jones et al., 2015). Conversely, Rezum required longer catheterization than both HoLEP and TURP (e.g., 7.6 ± 2.19 days for Rezum vs. 3.49 ± 1.16 days for HoLEP; $p < 0.001$) (Barboza et al., 2015). Regarding hospitalization, HoLEP facilitated earlier discharge, often within 36 hours, compared to approximately 2 days for TURP. Rezum patients were typically discharged within 1 to 1.5 days post-procedure, shorter than TURP and HoLEP hospital stays (Barboza et al., 2015; Yin et al., 2012).

Sexual Function Outcomes:

Rezum therapy significantly preserved antegrade ejaculation compared to TURP and HoLEP ($p < 0.001$) (Barboza et al., 2015). Retrograde ejaculation rates were notably higher in HoLEP (up to 97.7%) and TURP patients, consistent with prior literature. No significant differences in erectile function scores (IIEF) were detected among the three treatments over follow-up periods ranging from 3 to 12 months (Qian et al., 2017).

Adverse Events and Retreatment:

Overall complication rates were low and similar across treatment modalities. Transient dysuria was higher after HoLEP (RR 1.86; p=0.005). Urinary retention was more frequent post-Rezum (up to 23.4% in some studies) compared to HoLEP (4.6%). Retreatment and re-intervention rates were low during available follow-up, though Rezum showed slightly higher retreatment rates, with long-term durability data still limited.

Subgroup Analyses

Limited subgroup analyses revealed prostate size as a critical factor influencing treatment outcomes. HoLEP maintained superior symptomatic and flow improvements in patients with larger prostates (≥ 80g) compared to Rezum. Patients with larger prostates treated with Rezum often required ongoing medical therapy post-procedure. Data were insufficient to perform robust subgroup analyses based on other clinical variables.

7. DISCUSSION

This systematic review and meta-analysis offers an in-depth comparative evaluation of three widely used surgical interventions for benign prostatic hyperplasia (BPH): Transurethral Resection of the Prostate (TURP), Holmium Laser Enucleation of the Prostate (HoLEP), and Rezum water vapor therapy. Our findings provide valuable insights into their relative effectiveness, safety, and patient-centered outcomes, addressing the key research question and objectives.

Effectiveness in Symptom Relief and Urinary Function

Consistent with previous high-quality evidence, both TURP and HoLEP demonstrated robust and clinically meaningful improvements in lower urinary tract symptoms, as reflected by International Prostate Symptom Score (IPSS) reductions and increased maximum urinary flow rate (Qmax). HoLEP's modest but statistically significant superiority in IPSS at 12 months

and enhanced urinary flow at 12–24 months aligns with its mechanism of complete adenoma enucleation, which can be particularly advantageous for larger prostate glands. This supports the growing acceptance of HoLEP as a size-independent surgical technique capable of managing large prostates effectively. Although Rezum was found to have a strong benefit for symptoms, its results were always lower than those seen with TURP and HoLEP. Differences in the way energy is ablated in the heart, rather than removed through surgery, add to the observed changes in efficacy. Even so, Rezum tends to be advised for patients seeking minimally invasive treatment options that remove the requirement for hospitalization. They show why patient selection should depend on how large the prostate is, how seriously the symptoms affect a man and what his treatment expectations are.

Safety and Perioperative Outcomes

Our study confirms that, unlike TURP, HoLEP leads to less intraoperative bleeding and a much lower requirement for blood transfusions. The discovery that HoLEP causes shorter catheter use and shorter stays in the hospital proves the method is more efficient and puts less strain on patients, just as prior studies and guidelines indicate it should be used on larger or riskier prostate issues.

Because Rezum leads to little bleeding, typically requires little blood transfusion and keeps hospitalization brief, it is a good choice for patients with other health issues or for outpatient surgery that would be higher risk with other methods. On the other hand, when catheterization is used for a longer time and with more episodes of transient urinary retention, these issues must be considered because they can cause discomfort after surgery and mean the patient needs to be seen again. The balance between the amount of surgery and how much the recovery will affect a person needs to be discussed before the procedure.

Sexual Function and Quality of Life

Sexual function preservation is increasingly recognized as a critical factor influencing treatment choice in BPH management. Our findings show that Rezum markedly preserves antegrade ejaculation compared to the near-universal retrograde ejaculation associated with TURP and HoLEP. This ejaculation-sparing effect is a major advantage of Rezum and likely contributes to sustained patient satisfaction despite its relatively lower symptom relief. Erectile function, as assessed by International Index of Erectile Function (IIEF) scores, did not differ significantly between the modalities, indicating that all three treatments have minimal impact on erectile capacity.

Ensuring that signs and symptoms are improved, yet sexual function remains intact, is a key issue in choosing the best treatment for a patient. Patients are advised that while more symptom relief is usually seen with TURP and HoLEP, Rezum better serves those who wish to keep their ejaculations, something that matters greatly to some.

Long-Term Durability and Retreatment

There were low rates of further treatment needed after almost all of the treatments during follow-up, however, Rezum tended to require re-interventions more often, probably because it was more recently introduced and had less detailed long-term evidence. Evidence spanning many years has shown that TURP and HoLEP effectively control symptoms. More studies that track results longer than three years are needed to establish Rezum as a main treatment option.

Subgroup Analyses and Personalized Medicine

Prostate size emerged as a key determinant of treatment success, with HoLEP consistently outperforming Rezum in patients with prostates ≥80 grams. Notably, a subset of patients treated with Rezum continued medical therapy post-procedure, highlighting potential limitations of this approach in larger glands. Data on other clinically relevant subgroups, such as baseline symptom severity, comorbidities, or age, remain sparse, limiting personalized treatment algorithms.

Future research should prioritize subgroup analyses and individualized risk-benefit assessments to optimize treatment selection and outcomes. This aligns with the broader trend toward precision medicine in urology, balancing clinical efficacy, safety, and patient values.

8. LIMITATIONS

Our findings should be interpreted in the context of certain limitations. Heterogeneity in study design, patient characteristics, surgical techniques, and outcome reporting introduces variability that, despite methodological rigor and use of random-effects models, may influence pooled estimates. The variability in follow-up durations and limited reporting on long-term outcomes, especially for Rezum, restrict definitive conclusions on durability. Inconsistent and often limited reporting of sexual function and quality-of-life outcomes impedes a full understanding of patient-centered benefits.

Clinical Implications

This comprehensive synthesis reinforces that no single surgical option is universally ideal. TURP and HoLEP remain highly effective for durable symptom relief, with HoLEP offering advantages in safety and applicability across prostate sizes. Rezum presents a valuable alternative for patients desiring minimally invasive treatment with preservation of sexual function, particularly when procedural risk or recovery time is a concern.

Shared decision-making is essential, incorporating individual patient anatomy, symptom burden, comorbidities, and preferences regarding sexual function and invasiveness. Our findings provide clinicians and patients with evidence-based guidance to tailor treatment choices accordingly.

Future Directions

High-quality, head-to-head randomized controlled trials with standardized outcomes and extended follow-up are urgently needed to better delineate long-term comparative effectiveness, safety, and patient-reported outcomes. Greater emphasis on subgroup analyses and cost-effectiveness evaluations will further inform personalized care pathways and health policy decisions in BPH management. Moreover, there is a need for more studies to evaluate the effectiveness of Rezum, especially in diverse patient populations and in comparison to other minimally invasive techniques (Doppalapudi & Gupta, 2021; Winkler et al., 2023). Future studies should include standardized patient populations and longer follow-up periods to better understand the long-term effects of Rezum on sexual function (Khalil et al., 2024). The long-term effectiveness and reliability of Rezum therapy need to be further understood (Çakıroğlu et al., 2024). Clinical trials are needed to confirm the initial promising results (Suarez-Ibarrola et al., 2020). Overall, Rezum emerges as a compelling option for managing LUTS, demonstrating both effectiveness and safety (Winkler et al., 2023; Wolters et al., 2024). Its minimally invasive nature, coupled with the preservation of sexual function, makes it particularly suitable for patients seeking alternatives to traditional surgical interventions (Khalil et al., 2023; Westwood et al., 2018).

9. CONCLUSION

This systematic review and meta-analysis demonstrate that Transurethral Resection of the Prostate (TURP) and Holmium Laser Enucleation of the Prostate (HoLEP) both provide robust and durable improvements in urinary symptoms, flow rates, and post-void residual volumes for patients with benign prostatic hyperplasia. HoLEP offers modest but statistically significant advantages over TURP in symptom relief and urinary flow, alongside a more favorable safety profile, particularly regarding reduced bleeding and shorter catheterization times. Rezum water vapor therapy, as a minimally invasive surgical option, delivers meaningful symptom improvement with superior preservation of sexual function, especially antegrade ejaculation, and a lower perioperative risk profile. However, its efficacy in symptom relief and flow enhancement is generally less pronounced than TURP and HoLEP, and longer-term durability data remain limited.

The choice among these treatment modalities should be individualized, taking into account prostate size, patient comorbidities, sexual function priorities, and tolerance for perioperative risks. Shared decision-making, grounded in comprehensive evidence and patient values, is essential to optimize outcomes. Future research should focus on long-term, direct comparative studies incorporating patient-reported outcomes and cost-effectiveness analyses to better inform clinical practice and health policy. This will enhance personalized treatment strategies, ensuring that patients with BPH receive optimal, tailored care

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