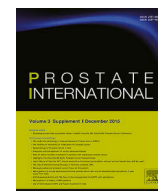




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Research Article

Holmium laser enucleation of the prostate versus transurethral resection of the prostate for benign prostatic hyperplasia: evidence from a Korean retrospective analysis using the Common Data Model

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ABSTRACT

Background: The aim of this study was to evaluate and compare the efficacy and safety of transurethral resection of the prostate (TURP) and holmium laser enucleation of the prostate (HoLEP) for treating benign prostatic hyperplasia using standardized multicenter data.

Materials and methods: We retrospectively collected data from six Korean hospitals using the Common Data Model and performed a meta-analysis. Patients were categorized into TURP (control) and HoLEP (experimental) groups, and risk ratios were calculated to compare postoperative outcomes and complications. Sensitivity analyses were conducted by sequentially excluding each hospital's data to assess the robustness of the findings.

Results: HoLEP was associated with significantly lower reoperation and transfusion rates, as well as reduced postoperative use of medications (including alpha-blockers and 5-alpha reductase inhibitors), compared to TURP. Conversely, beta-3 agonist usage was notably higher in the HoLEP group, suggesting the need for further investigation in this area. Sensitivity analyses confirmed that the overall results remained robust across individual hospital exclusions.

Conclusions: The meta-analysis demonstrates that HoLEP offers superior efficacy and safety over TURP for benign prostatic hyperplasia treatment, particularly by reducing reoperation and transfusion rates and lowering long-term medication dependency. These findings support the clinical adoption of HoLEP as a viable alternative to TURP, although the increased beta-3 agonist usage in the early postoperative period merits further study.

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1. Introduction

Benign prostatic hyperplasia (BPH) is a common urological condition in men aged over 50 years.¹ It is characterized by stromal

and epithelial cell hyperplasia in the transitional zone of the prostate, leading to gland enlargement and the onset of lower urinary tract symptoms. These symptoms notably impair quality of life and impose a substantial economic burden on healthcare systems worldwide.² As the global population ages, the prevalence of BPH is expected to increase.²

When conservative management strategies fail to alleviate symptoms, surgical intervention becomes necessary. For several decades, transurethral resection of the prostate (TURP) has been the gold standard surgical treatment for small- to medium-sized prostates (30–80 mL).^{3,4} However, its limitations have prompted the development of alternative surgical techniques.^{5,6} Among these, holmium laser enucleation of the prostate (HoLEP) uses a

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laser to remove obstructive prostate tissue and is associated with a lower risk of bleeding, shorter hospital stays, and the capacity to effectively treat larger prostates.⁷ Nonetheless, comparative studies on the efficacy of these procedures remain limited. Many studies lack broad applicability due to small sample sizes or single-center designs, restricting generalizability. A comprehensive multicenter investigation is therefore warranted to provide robust data on their comparative effectiveness.

The Observational Medical Outcomes Partnership Common Data Model (OMOP CDM) facilitates large-scale analyses of medical records while preserving patient privacy. Data management is conducted using the Observational Health Data Sciences and Informatics Atlas tool. In this study, we aimed to compare the efficacy and safety of TURP and HoLEP in BPH treatment using a CDM database of multicenter data. To clarify the study design and data analysis approach, the schematic diagram as shown in Fig. 1 outlines the selection criteria, treatment groups, and key outcomes assessed.

2. Materials and methods

The OMOP CDM used in this study is a standardized relational data model designed for large-scale analyses of nonexperimental observational data. The CDM incorporates diverse medical information across multiple domains, including demographics, observation periods, drug exposures, condition occurrences, procedures, visits, and clinical observations. By integrating multiple terminologies, such as ICD-9, CPT-4, RxNorm, and systematized nomenclature of medicine clinical terms (SNOMED CT), the CDM harmonizes data from various sources, including GE Centricity, MarketScan, and Humana, into a unified format. This standardization facilitates consistent results across disparate databases by enabling the application of uniform analytical methods within a

single framework. Consequently, the OMOP CDM provides a robust foundation for large-scale, multidatabase studies.⁸ This multicenter, retrospective cohort analysis included six hospitals in South Korea, and the patient data are summarized in Table 1.

To compare the efficacy and safety of TURP and HoLEP, a cohort was constructed from these six hospitals. Patients who underwent TURP were designated as the control group, whereas those who underwent HoLEP comprised the treatment group. The incidence of efficacy- and safety-related events, such as urethral strictures, was compared between the groups. Given the potential for urethral strictures to recur, patients with a history of urethral stricture treatment before BPH surgery were excluded. Reoperations were defined as subsequent BPH-related surgeries performed to address symptom recurrence or residual adenoma, including repeat TURP, HoLEP, or simple prostatectomy, regardless of the initial surgical method. Interventions for complications, such as urethral stricture, were excluded from this definition and analyzed separately. This cohort design enabled comparisons of clinically relevant outcome incidence rates in both groups.

Safety outcomes, including transfusions, emergency room visits, and inpatient admissions, were assessed within the first 30 days postoperatively to capture acute procedure-related complications. To evaluate medication usage over short- and long-term periods, postoperative follow-up was divided into three intervals: 0–3 months, 3–12 months, and 12–36 months. Usage of alpha-blockers and 5-alpha reductase inhibitors (5-ARIs) was analyzed to evaluate the efficacy of obstruction relief. Conversely, anticholinergics and beta-3 agonists were categorized under safety outcomes. While these medications are typically used for symptom management, in the absence of subjective symptom scores [e.g., the International Prostate Symptom Score (IPSS)] within the CDM, their prescription served as an objective proxy for postoperative storage complications (e.g., *de novo* urgency⁹). This methodology

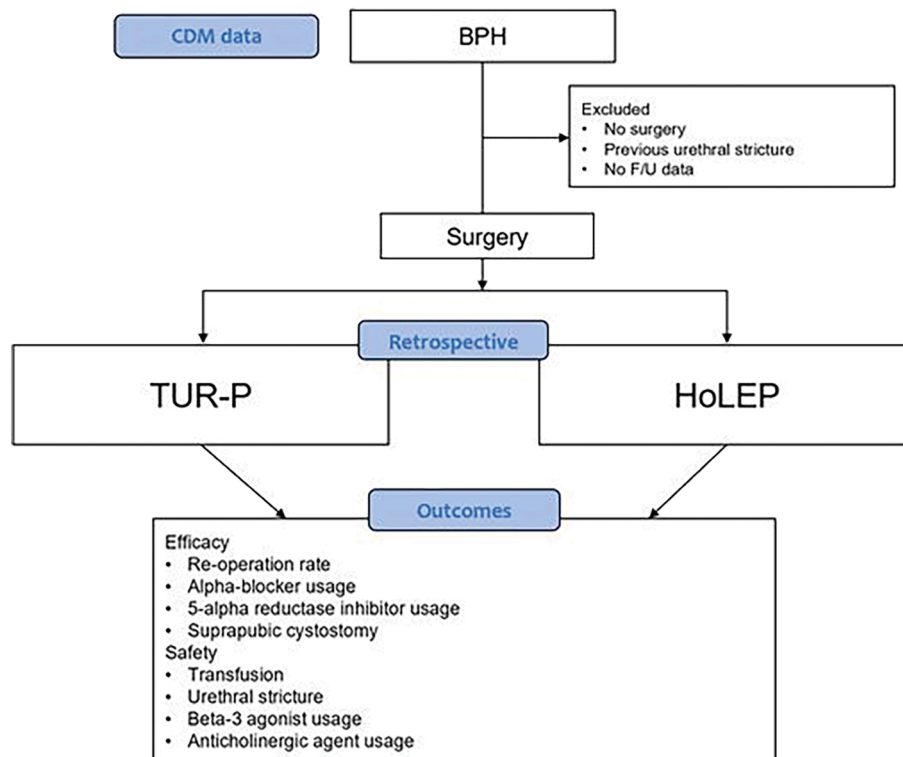


Fig. 1. Study design and outcome measures regarding BPH treatment using TURP and HoLEP.

BPH, benign prostatic hyperplasia; CDM, Common Data Model; HoLEP, holmium laser enucleation of the prostate; TURP, transurethral resection of the prostate.

Table 1
Hospital patient data

Hospital	Total patients	Data period	TURP patients	HoLEP patients
AUMC	2.95M	Jan 1994–present	1,356	215
EUMC	1.81M	Jan 2001–present	2,121	660
PNUH	1.75M	Feb 2011–Aug 2019	42	2,155
WKUH	1.37M	Mar 1998–present	1,392	237
SCHBC	1.35M	Feb 2001–Apr 2023	543	314
CAUHS	1.13M	Jun 2022–present	138	153

AUMC, Ajou University Medical Center; CAUHS, Chung-Ang University Hospital; EUMC, Ewha Womans University Medical Center; HoLEP, holmium laser enucleation of the prostate; PNUH, Pusan National University Hospital; SCHBC, Soonchunhyang University Bucheon Hospital; TURP, transurethral resection of the prostate; WKUH, Wonkwang University Hospital.

aligns with previous studies utilizing administrative data, which have established medication retention as a valid surrogate for clinical outcomes.^{10,11} Separate cohorts were constructed for each period. The number of TURP and HoLEP procedures performed at each participating hospital is summarized in Table 1.

Because patient data from each hospital were deidentified, each hospital was treated as an independent study unit. To synthesize an overall effect from these individual units, a meta-analysis was conducted. A meta-analysis integrates effect sizes from multiple studies by weighting them according to sample size, standard error, or study quality, thereby generating a unified estimate despite differences in sample characteristics, clinical settings, and measurement methods.

An effect size is a standardized measure that facilitates comparisons across studies. Common metrics include Cohen's *d*, odds ratios, and correlation coefficients. In this study, the risk ratio (RR) was selected as it is well suited for cohort studies and provides an intuitive measure of relative risk—the ratio of the probability of an outcome occurring in the treatment group to that in the control group. Unlike odds ratios, which can overestimate risk when event rates are high, RR offers a clearer representation of relative risk.¹² The general formula for RR is

$$\text{Risk Ratio (RR)} = \frac{P_{\text{experimental}}}{P_{\text{control}}}$$

$P_{\text{experimental}}$: probability of the event occurring in the experimental group

P_{control} : probability of the event occurring in the control group

This retrospective cohort study categorized patients based on their exposure to different surgical treatments (TURP vs. HoLEP) and examined subsequent efficacy- and safety-related outcomes. Using RR allowed for a straightforward interpretation of whether a given surgical method was associated with a higher or lower likelihood of specific postoperative complications or benefits.

Before performing the meta-analysis, heterogeneity across individual studies was assessed using the I^2 statistic, with values exceeding 50% indicating substantial heterogeneity.¹³ The formula for calculating I^2 was

$$Q_w = \sum \{w_i \times (y_i - \hat{\mu})^2\}$$

$$I^2 = \frac{Q - df}{Q}$$

where w_i is the weight assigned to the i -th study, y_i is the estimated value of the i -th study, and k is the number of studies included. Depending on the level of heterogeneity, a fixed-effect model (for low heterogeneity) or a random-effect model (for high heterogeneity) was applied.

A sensitivity analysis was performed by sequentially excluding data from each hospital (a leave-one-out approach) to determine

whether the overall results were influenced by any single study. This analysis ensured that the pooled estimates remained robust and that no single hospital disproportionately affected the findings.⁴

2.1. Ethics statement

This study was approved by the institutional review board (Approval No. 2405-008-19522), and the requirement for informed consent was waived due to the retrospective nature of the study.

3. Results

3.1. Efficacy comparison

3.1.1. Reoperation rates

HoLEP significantly reduced reoperation rates, with a pooled RR of 0.38 [95% confidence interval (CI): 0.27–0.54], indicating a 62% reduction in risk. The heterogeneity was negligible ($I^2 = 0\%$), justifying the use of a fixed-effect model (Fig. 2A). The sensitivity analysis confirmed that the RR remained statistically significant even when data from individual hospitals were excluded. Although excluding data from Soonchunhyang University Bucheon Hospital (SCHBC) and Pusan National University Hospital (PNUH) slightly increased variability (as shown by a small rise in Tau^2), the overall result remained robust, indicating that no single hospital had a disproportionate impact on the outcome (Supplementary Fig. 1).

3.1.2. Suprapubic cystostomy

The evaluation of suprapubic cystostomy (SPC) procedures demonstrated that the HoLEP group had a significantly lower incidence than the TURP group. The pooled RR was 0.39 (95% CI:

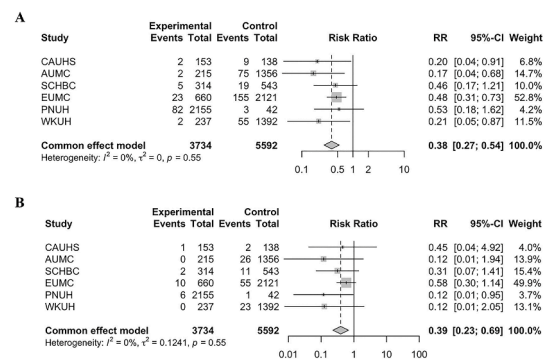


Fig. 2. Results of the meta-analysis of the (A) reoperation rates and (B) suprapubic cystostomy. CI, confidence interval; RR, risk ratio.

0.23–0.69), corresponding to a 61% reduction in risk. With an I^2 value of 0%, a fixed-effect model was deemed appropriate (Fig. 2B). A sensitivity analysis confirmed the robustness of these findings. However, the exclusion of EUMC led to a lower pooled RR (0.21, 95% CI: 0.07–0.58), suggesting that EUMC data influenced the effect size to some extent, though the overall trend remained consistent (Supplementary Fig. 2).

3.1.3. Alpha-blocker usage

Alpha-blocker usage was analyzed across three postoperative intervals: 0–3 months, 3–12 months, and 12–36 months. During the 0- to 3-month interval, the HoLEP group exhibited lower usage than the TURP group (pooled RR = 0.71, 95% CI: 0.45–1.11), though the difference was not statistically significant. High heterogeneity ($I^2 = 94\%$) necessitated the use of a random-effect model. Between 3 and 12 months, heterogeneity decreased to 69%, and the pooled RR was 0.37 (95% CI: 0.26–0.52), indicating a significant reduction in alpha-blocker usage among HoLEP patients. In the 12- to 36-month interval, the pooled RR further decreased to 0.44 (95% CI: 0.30–0.64), with an I^2 value of 68%, reflecting significantly higher usage in the TURP group (Fig. 3).

Sensitivity analyses revealed that excluding individual studies did not substantially affect the pooled RR, although certain exclusions (e.g., WKUH) influenced heterogeneity to some extent. This finding underscored that while individual studies contributed to variability, the overall trend was robust (Supplementary Fig. 3).

3.1.4. 5-Alpha reductase inhibitor usage

For 5-ARI usage, results varied by time interval. In the first 3 months, the HoLEP group tended toward lower usage (pooled RR = 0.66, 95% CI: 0.32–1.36), but this was not statistically significant due to high heterogeneity ($I^2 = 93\%$). Between 3 and 12 months, heterogeneity was moderate ($I^2 = 65\%$), and the pooled RR dropped to 0.32 (95% CI: 0.18–0.57), representing a statistically significant reduction. During the 12- to 36-month interval, the pooled RR decreased further to 0.25 (95% CI: 0.17–0.38; $I^2 = 49\%$), supporting the use of a fixed-effect model (Fig. 4). Sensitivity analyses confirmed the stability of these results, with minimal changes in RR observed when individual hospitals were excluded (Supplementary Fig. 4).

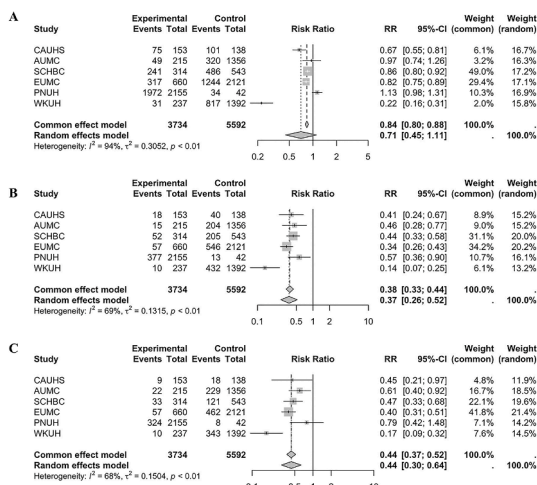


Fig. 3. Results of the meta-analysis of the alpha-blocker usage rates at (A) 0–3 months, (B) 3–12 months, and (C) 12–36 months after surgery. CI, confidence interval; RR, risk ratio.

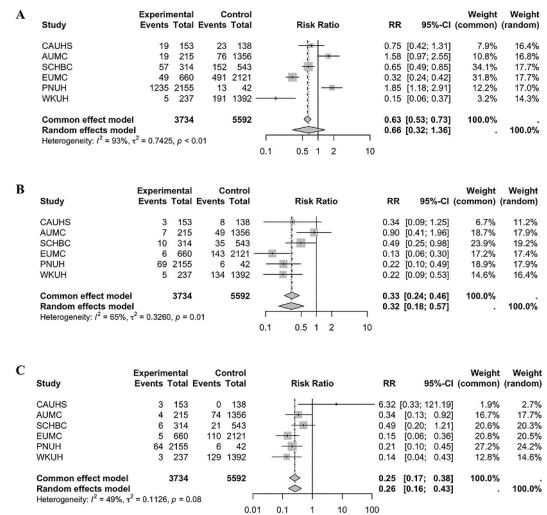


Fig. 4. Results of the meta-analysis of the 5-ARI usage rates at (A) 0–3 months, (B) 3–12 months, and (C) 12–36 months after surgery. 5-ARI, 5-alpha reductase inhibitor. CI, confidence interval; RR, risk ratio.

3.2. Safety comparison

3.2.1. Urethral stricture

HoLEP was associated with a significantly lower risk of urethral stricture surgery than TURP. The pooled RR was 0.77 (95% CI: 0.64–0.92), indicating a 23% reduction in risk, with negligible heterogeneity ($I^2 = 0\%$) (Fig. 5A). The sensitivity analysis confirmed the consistency of results across most exclusions; however, excluding EUMC data increased the P value to 0.06, suggesting that EUMC data contributed to maintaining overall statistical significance (Supplementary Fig. 5).

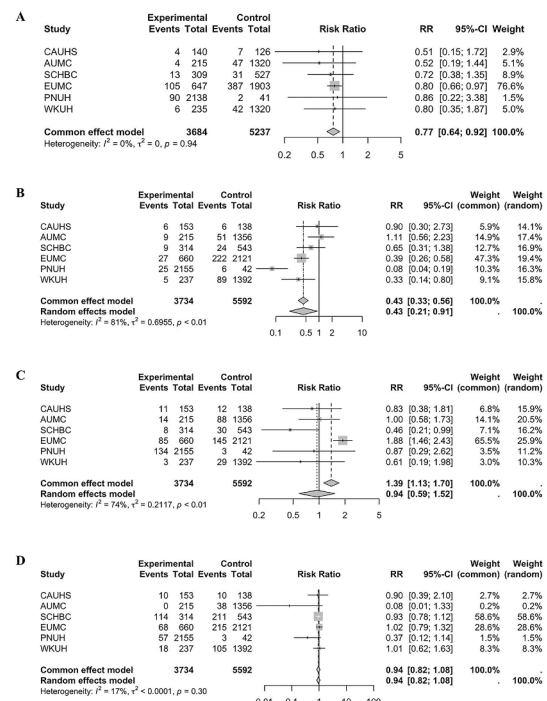


Fig. 5. Results of the meta-analysis of the (A) urethral stricture treatment rates, (B) transfusion, (C) emergency room visits, and (D) inpatient visits. CI, confidence interval; RR, risk ratio.

3.2.2. Transfusion

The HoLEP group had a significantly lower likelihood of requiring transfusions than the TURP group. Using a random-effect model, the pooled RR was 0.43 (95% CI: 0.21–0.91), reflecting a 57% reduction in risk (Fig. 5B). Despite substantial heterogeneity ($I^2 = 81\%$), the sensitivity analysis demonstrated that statistical significance was preserved across most scenarios, underscoring the robustness of the findings (Supplementary Fig. 6).

3.2.3. Emergency room and inpatient visits

For emergency department visits, the pooled RR under a random-effect model was 0.94 (95% CI: 0.59–1.52) with moderate heterogeneity ($I^2 = 74\%$), indicating no significant difference between the groups (Fig. 5C). The sensitivity analysis yielded RR estimates ranging from 0.78 to 1.12, suggesting minimal impact from individual hospital data despite some variability in CIs (Supplementary Fig. 7). Inpatient visits exhibited similar findings. The pooled RR was 0.94 (95% CI: 0.82–1.08) under a fixed-effect model, with low heterogeneity ($I^2 = 17\%$) (Fig. 5D). The sensitivity analysis confirmed that excluding any individual hospital had negligible impact on the overall results (Supplementary Fig. 8).

3.2.4. Anticholinergic usage

Across all examined time intervals, there were no statistically significant differences in anticholinergic use between the HoLEP and TURP groups. In the 0- to 3-month interval, the pooled RR was 1.29 (95% CI: 0.86–1.93) with substantial heterogeneity ($I^2 = 94\%$). In the 3- to 12-month interval, the pooled RR was 1.08 (95% CI: 0.62–1.89; $I^2 = 92\%$). In the 12- to 36-month interval, the pooled RR was 0.90 (95% CI: 0.55–1.47; $I^2 = 74\%$) (Fig. 6). Sensitivity analyses confirmed that the overall lack of significant difference persisted regardless of individual hospital data exclusions (Supplementary Fig. 9).

3.2.5. Beta-3 agonist usage

Beta-3 agonist usage was significantly higher in the HoLEP group during the first 3 months (pooled RR = 2.40, 95% CI: 1.35–4.28; $I^2 = 97\%$). For the 3- to 12-month interval, the pooled RR was 1.77 (95% CI: 0.97–3.23; $I^2 = 93\%$). For the 12- to 36-month interval, the pooled RR decreased to 1.23 (95% CI: 0.74–2.03;

$I^2 = 73\%$). In the latter two intervals, the differences were not statistically significant (Fig. 7). Sensitivity analyses indicated that although individual studies influenced the effect size, the overall trend remained stable (Supplementary Fig. 10).

4. Discussion

To our knowledge, this is the first multicenter study to use the CDM database to evaluate the efficacy and safety of TURP and HoLEP. This meta-analysis demonstrates that HoLEP is associated with superior efficacy and safety compared to TURP, with significantly lower reoperation rates; reduced reliance on alpha-blockers and 5-ARIs; and decreased risks of urethral stricture, SPC, and transfusion. However, no significant differences were observed in anticholinergic use, beta-3 agonist use beyond the early post-operative period, emergency room visits, or inpatient admissions between the two groups.

TURP remains one of the most commonly performed surgical procedures for BPH worldwide and is still considered the gold standard.¹⁴ However, there has been an ongoing need for procedures associated with fewer complications and shorter hospital stays. HoLEP was first introduced for BPH surgery by Gilling et al. in 1994,¹⁵ and advancements in surgical techniques have since demonstrated its efficacy in numerous studies.¹⁶ A meta-analysis of 18 randomized controlled trials (RCTs) comparing TURP and HoLEP showed that HoLEP was associated with shorter catheterization times and reduced hospital stays.¹⁷ Although parameters such as maximum urinary flow rate, postvoid residual volume, and IPSS were occasionally better in the HoLEP group, these outcomes exhibited considerable heterogeneity.¹⁷ Moreover, most RCTs included relatively small sample sizes, and only a few studies demonstrated clear superiority of HoLEP in terms of efficacy.^{18,19} The disadvantages of HoLEP have been reported as longer operative times and a steep learning curve. Unlike previous RCTs and retrospective studies, this study utilized a CDM database, which precluded the use of conventional objective efficacy measures and subjective indices. Instead, efficacy was evaluated based on reoperation or SPC rates after the initial BPH surgery and the use of BPH-related medications. Findings revealed that the reoperation and SPC rates were significantly lower in the HoLEP group than in the TURP group and that the usage rates of alpha-blockers and 5-ARIs were

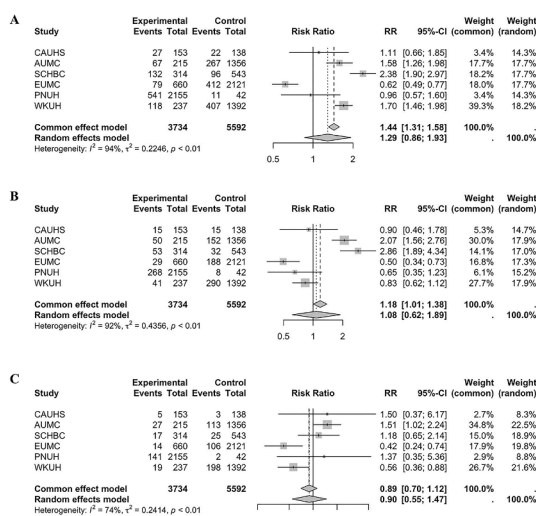


Fig. 6. Results of the meta-analysis of the anticholinergic usage rates at (A) 0–3 months, (B) 3–12 months, and (C) 12–36 months after surgery. CI, confidence interval; RR, risk ratio.

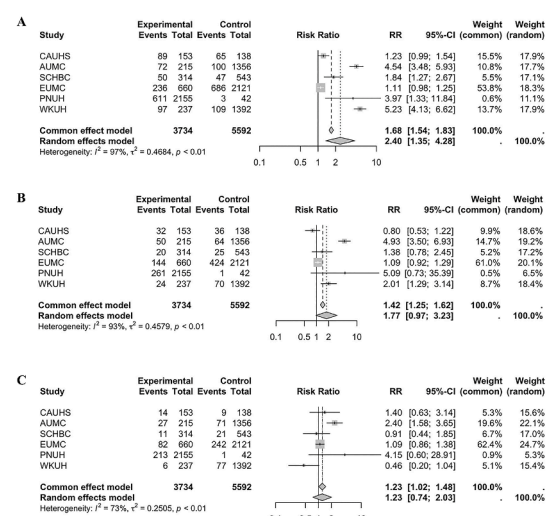


Fig. 7. Results of the meta-analysis of the beta-3 agonist usage rates at (A) 0–3 months, (B) 3–12 months, and (C) 12–36 months after surgery. CI, confidence interval; RR, risk ratio.

significantly reduced at 3 months postoperatively. While heterogeneity in reoperation and SPC rates was negligible, moderate to substantial heterogeneity was observed in medication usage outcomes, which may be attributed to differences in postoperative management practices across hospitals or among surgeons.

One advantage of HoLEP is its reduced risk of bleeding, which has been consistently reported in previous studies. HoLEP has been associated with smaller reductions in postoperative hemoglobin levels and lower transfusion rates than TURP.^{17,20} This study also confirmed a significantly lower transfusion rate in the HoLEP group. This can be attributed to the surgical technique as HoLEP enucleates the adenoma along its natural plane rather than resecting prostate tissue, resulting in fewer vascular injuries. Theoretically, while a single vessel may be transected only once during HoLEP, the same vessel could be cut multiple times during TURP, increasing the risk of persistent bleeding if hemostasis is not achieved at all points of vascular exposure.²¹ Additionally, the hemostatic properties of the holmium laser, which induces tissue coagulation at a depth of approximately 3–4 mm, contribute to superior bleeding control during HoLEP.¹⁵ This enhanced hemostatic capability allows HoLEP to be performed relatively safely, even in patients at a higher risk of bleeding.²²

Regarding urethral stricture, reported incidence rates range from 1.7% to 11.7% for TURP and 0.6% to 5.4% for HoLEP.²³ In this study, the incidence of urethral stricture was significantly lower in the HoLEP group. However, some reports suggest comparable rates of urethral stricture between TURP and HoLEP.²³ Risk factors for urethral stricture include the use of larger-diameter endoscopic instruments, larger prostate size, repeated catheterization, and a history of chronic inflammation.²⁴ The higher reoperation rate observed after TURP in this study may have contributed to an increased risk of urethral stricture, potentially due to repeated catheterization and urethral mucosal tearing during the reintervention process.

Postoperative urinary incontinence (UI) after HoLEP has been reported in 1.4% to 43% of cases.^{25,26} A nationwide study has suggested that the incidence of UI is higher following HoLEP than that following TURP.²⁷ Although postoperative UI is relatively common, it can be a significant source of distress for patients and surgeons as it negatively affects hygiene, social activities, and overall quality of life. However, the majority of cases (78.9%) are transient and resolve within 3 months post surgery.²⁸ Older patients may have a weakened urethral sphincter, making it more susceptible to intraoperative mechanical stress and potential tissue damage.²⁸ Conservative management can be beneficial for stress UI.²⁹ Additionally, the use of energy-based devices during surgery may contribute to tissue recovery issues around the surgical site, leading to the development of urgency UI.²⁵ Detrusor overactivity after BPH surgery has been reported in approximately 50% of patients, which may reflect pre-existing, subclinical overactivity that becomes symptomatic postoperatively.³⁰ For cases of urgency UI or mixed-type incontinence, anticholinergics or beta-3 agonists can be used as treatment options.³⁰ In this study, a higher prescription rate of beta-3 agonists was observed within 3 months after HoLEP; however, notable heterogeneity was present, which may be attributed to differences in surgeons' operative experience and prescribing patterns.

Our study had some limitations. First, as a retrospective study, there was an inherent risk of selection bias. The choice of surgical method was likely influenced by the preferences of surgeons and the clinical conditions of patients. Additionally, due to the inability to perform chart reviews, detailed information regarding patients' clinical status and the specific purposes of the surgeries could not be obtained. Second, despite conducting sensitivity analyses, considerable heterogeneity was observed, likely due to the

inclusion of data from multiple centers with various surgeons performing the procedures at each site. To mitigate the impact of heterogeneity, a random-effect model was used for the analysis. Third, important variables that could potentially influence study outcomes, such as prostate size and operative time, were not available. Moreover, key efficacy outcomes, including maximum urinary flow rate and IPSS, could not be assessed. These limitations are inherent to the CDM, which ensures patient data privacy. Fourth, the lack of detailed clinical granularity is a limitation of administrative data analyses. Specifically, safety outcomes such as emergency room visits and inpatient admissions were identified based on diagnostic codes and timeframes (within 30 days) rather than individual chart reviews. Consequently, we could not definitively exclude admissions unrelated to the procedure (e.g., trauma or nonurological conditions), leading to potential outcome misclassification. However, it is reasonable to assume that such random events would be distributed evenly between the two groups. Despite these limitations, while previous RCTs were often small in scale with short follow-up periods, the key strength of this study lies in its large-scale analysis of over 9,000 patients with long-term outcomes extending beyond one year.

5. Conclusions

This meta-analysis compared the efficacy and safety of TURP and HoLEP for BPH using standardized data from six Korean hospitals through the CDM. HoLEP was associated with lower transfusion and reoperation rates and reduced use of BPH-related medications beyond 1 year post surgery. Although HoLEP offers several advantages over TURP, challenges remain before it can be established as the standard procedure for BPH surgery. This study was limited by heterogeneity, highlighting the need for well-designed, large-scale prospective RCTs to provide higher-level evidence.

Author contribution

Conception and design: Se Young Choi and Changwon Lim.

Acquisition of data: Kwanghyun Kim, Seungchol Park, Daesung Cho, Woongbin Kim, Byeong Jin Kang, and Se Young Choi.

Analysis and interpretation of data: Yunseo Lee, Changwon Lim, and Se Young Choi.

Drafting of the manuscript: Yunseo Lee, Changwon Lim, and Se Young Choi.

Critical revision of the manuscript: Kwanghyun Kim, Seungchol Park, Daesung Cho, Woongbin Kim, and Byeong Jin Kang.

Obtaining funding: Se Young Choi.

Supervision: Se Young Choi and Changwon Lim.

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Conflicts of interest

The authors declare no conflicts of interest.

Acknowledgments

There are none to declare.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.pnrl.2025.12.007>.

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