Long-term patterns of surgical reintervention after various benign prostatic hyperplasia procedures in a large national database

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ABSTRACT

Introduction: The surgical management of benign prostatic hyperplasia (BPH) has expanded significantly over the past two decades with the introduction of minimally invasive techniques. As treatment options grow, understanding real-world patterns and timing of surgical retreatment is essential to inform shared surgical decision-making. This study evaluates long-term surgical reintervention rates following common surgical procedures for BPH using a live national database.
Methods: We conducted a retrospective, observational study using the TriNetX Diamond Network, which aggregates electronic health records from over 120 million patients across 73 U.S. healthcare organizations. Adult males aged 18 years or older diagnosed with BPH who underwent a first-time surgical procedure between 2005 and 2025 were included. Cumulative surgical reoperation rates were assessed at predefined intervals up to 10 years following the index procedure. Reoperation was used as a marker for

KEY MESSAGES

- Reoperation rates after BPH surgery vary widely by procedure, with enucleation and open approaches demonstrating the lowest rates of retreatment.
- Most reoperations occur early, frequently within the first year.
- TURP is the most common secondary outlet procedure following an index BPH operation.

surgical retreatment, recognizing it does not capture all forms of treatment failure. Statistical comparisons were performed using Chi-squared tests, with significance set at p<0.05.
Results: A total of 103 019 patients met inclusion criteria, of whom 7687 (7.5%) underwent a re-operation within 10 years. Open simple prostatectomy demonstrated the lowest long-term reoperation rate, followed by holmium laser enucleation of the prostate. Procedures such as robotic waterjet ablation and water vapor thermal therapy had shorter followup windows due to recent adoption. Reoperation rates differed significantly across procedures at each interval (p<0.0001). Transurethral resection of the prostate was the most common secondary procedure, except in patients initially treated with laser enucleation or prostatic artery embolization, where same-modality retreatment predominated.
Conclusions: This large, real-world study offers long-term data on reintervention patterns between various BPH procedures, and may inform patient counseling regarding the likelihood and timing of additional interventions.

INTRODUCTION

Benign prostatic hyperplasia (BPH) is among the most prevalent conditions affecting aging men, with histologic evidence of disease present in 50%–60% of men in their 60s and 80%–90% of men in their 70s and 80s[1]. United States population-based studies report that 56% of men aged 50–79 experience lower urinary tract symptoms due to BPH[2], a prevalence expected to rise as the population continues to age[3]. Surgical intervention remains relatively uncommon, with approximately 1.7% of men aged 40–64 and 2.4% of men over 64 undergoing surgical treatment for BPH-related lower urinary tract symptoms annually[4].

Surgical management of BPH has shifted dramatically with the advent of minimally invasive surgical treatments (MISTs) over the last two decades. While transurethral resection of the prostate (TURP) has long been considered the gold standard[5], several well-established alternatives have emerged, including laser photoselective vaporization (PVP) and holmium or thulium laser enucleation (HoLEP/ThuLEP), which have been in use for over 20 years. In contrast, newer technologies - such as water vapor thermal therapy (WVTT), prostatic urethral lift (PUL), robotic waterjet treatment (RWT), and prostatic artery embolization (PAE) - represent more recent additions to the surgical landscape, reflecting an ongoing shift toward outpatient and office-based interventions. Additionally, larger prostates are often managed via simple prostatectomy, performed through open or robotic-assisted laparoscopic approaches[6], or, endoscopically with prostate enucleation such as HoLEP/ThuLEP[7]. Meanwhile, older modalities such as transurethral microwave thermotherapy (TUMT) and transurethral needle ablation (TUNA) are now considered largely historical and are rarely used in contemporary practice. A critical factor influencing both patients and providers is the likelihood that additional surgical intervention will be required after an initial procedure. In real-world practice, re-treatment reflects not only intrinsic procedural efficacy but also patient preferences, providers expertise, access to specialized care, and thresholds for re-intervention. Previous studies on BPH re-operation rates may be limited by strict inclusion criteria, small sample sizes, single high volume institution data, or a lack of long-term outcomes. Furthermore, few large-scale studies have characterized both the timing of surgical re-treatment and type of secondary outlet procedures utilized following an initial BPH intervention.

This study aims to address these gaps by leveraging a live, national database to characterize the real-world risk, timing, and patterns of surgical re-treatment following common BPH procedures. We assess re-operation rates at defined intervals up to ten years following the index procedure and describe the average time to re-operation for each modality. We also examine patterns of secondary outlet procedures, providing insight into how re-treatment is managed in real world clinical practice. These findings contribute important data for shared decision-making and patient counseling regarding the likelihood and timing of additional surgical interventions after initial BPH surgery.

METHODS

Data source

We conducted a retrospective cohort study using electronic health records from the TriNetX Diamond Network, a database containing information on over 120 million patients across 73 U.S. healthcare organizations (HCOs). The study period spanned from February 5th, 2005, to February 5th, 2025, with the final dataset extracted on February 5th, 2025. TriNetX provides aggregated, anonymized population-level data, ensuring the exclusion of personally identifiable health information. Since the study utilized fully anonymized data with no means of individual patient identification, it was exempt from Institutional Review Board (IRB) review as it did not constitute human subjects research[8].

Cohort definitions

The study cohorts included males aged ≥18 years diagnosed with BPH who underwent an initial surgical treatment for BPH. Re-operation rates were assessed at predefined intervals: 3 months, 6 months, 1 year, 2 years, 3 years, 4 years, 5 years, 7.5 years, and 10 years following the index procedure, contingent upon data availability. Patients were included only if adequate follow-up data were available for the specified time intervals. Laparoscopic/robotic-assisted simple prostatectomy (LSP/RSP) was assigned a distinct CPT code in 2023; prior to this, it was coded identically to open simple prostatectomy (OSP)[9], limiting reliable LSP/RSP data to the past 2 years. A complete list of reintervention procedures analyzed is provided in Supplementary Table 1. Due to the novelty of procedures and changes in CPT code, results were truncated for RWT (3 years), WVTT (5 years), and LSP/RSP (2 years). At the 10-year mark—or the latest timepoint with sufficient follow-up—the types of re-operative procedures were further classified, and the average time to re-operation was calculated.

Literature review

To construct Table 1, we conducted a focused review of the most current clinical guidelines and peer-reviewed literature regarding benign prostatic hyperplasia (BPH) procedures. We systematically examined the 2023 American Urological Association (AUA) and 2022 Canadian Urological Association (CUA) guidelines to extract official recommendations, procedural indications, and complication profiles. Additionally, we reviewed key chapters from the most recent edition of *Campbell-Walsh-Wein Urology* for additional relevant information.

Statistical analysis

Descriptive variables were reported as means ± standard deviation (SD), unless otherwise specified. Differences in re-operation rates between all groups were assessed with Chi-square tests of independence at all time intervals. Re-operation-free curves (Figure 1) were constructed using fixed-interval cumulative re-operation rates. At each predefined follow-up interval (3 months, 6 months, 1 year, etc.), the cumulative proportion of patients who had undergone a secondary surgical procedure was subtracted from 100% to derive the re-operation-free rate. These values were then plotted across time for each procedure. This method does not account for censoring due to loss of follow-up or death and therefore does not represent a formal Kaplan-Meier survival analysis. As a result, long-term estimates may be biased toward greater apparent freedom from surgical re-treatment, particularly at later time intervals. For each procedure, the mean time to re-operation was calculated by identifying all patients who underwent a secondary procedure and computing the average follow-up duration (in days) from the index surgery to the date of re-operation. The results were reported as mean ± standard deviation (SD). All statistical analyses and calculations were performed in R Studio (Boston, MA) and statistical significance was set at $p < 0.05$.

RESULTS

Current BPH surgical guidelines

TURP remains the gold standard for the treatment of BPH in prostates measuring 30–80 mL. HoLEP, however, is recommended and recognized as a size-independent modality, with growing interest and adoption. In the absence of HoLEP/ThuLEP, OSP (first-line) or LSP/RSP (conditional) are considered appropriate options for managing larger prostates when the necessary expertise is available. MIST therapies are conditionally recommended, offering the advantage of preserving ejaculatory function, though further studies are needed to better define their role in the increasingly crowded BPH surgical landscape. The AUA specifically recommends against the use of TUNA. Overall, there is consensus between the AUA and CUA guidelines regarding the management of BPH.

Demographics

103,019 individuals with a diagnosis of BPH who underwent a primary surgical procedure and had completed the predefined follow-up for 10 years were identified (Table 2). Of these, 7,687

(7.5%) underwent a re-operation within the study period. Mean age at the time of first intervention was 69.7 years. Most patients were listed as Caucasian with most from the Southern United States. The most common elements of past medical history were urinary retention, hematuria, and history of urinary tract infection. The prevalence of pre-index urinary retention varied across procedural cohorts (Supplemental Table 2). Demographics and relevant comorbidities are summarized in Table 2 and Supplemental Table 2.

Reoperation rates

Figure 1 illustrates the re-operation-free rates over time for each procedure. At 10 years, OSP and HoLEP/ThuLEP had the lowest re-operation rates at 0.9% and 2.4%, respectively. TURP showed a 10-year re-operation rate of 6.1%. LSP/RSP demonstrated the lowest rate overall (0.4%), though data were available only up to 2 years. RWT, with 3 years of data available, had a re-operation rate of 2.8%. Among procedures with 10-year follow-up, PAE showed the highest re-intervention rate overall at 23.4%. Detailed re-operation rates for each procedure across all time intervals are presented in Table 3. The mean time to re-operation was calculated for each procedure and is summarized in Table 3.

Early retreatment was defined descriptively as occurring within the first year following the index procedure. Most re-intervention events occurred within the first few years following the initial procedure. Of note, PAE, RWT and OSP re-treatments largely occurred in the first year with 80%, 75% and 66% of secondary interventions occurring during that time, respectively. Chi-square analysis revealed significant differences in re-operation rates between procedures at each interval ($p < 0.0001$).

Rates of secondary outlet procedures were calculated at the maximum follow-up interval (Figure 2). TURP was the most commonly performed secondary outlet procedure overall, except in patients who initially underwent HoLEP/ThuLEP, PAE, or LSP/RSP. For HoLEP/ThuLEP and PAE, the most common secondary procedure was a repeat of the initial procedure. In patients who initially underwent LSP/RSP, the most common secondary procedure was PAE. Discussion

TURP was the most frequently performed procedure amongst over 100,000 men studied in this population. This is in keeping with American and Canadian guidelines presenting TURP as the gold standard and the great comparator for all other BPH surgical treatments. In men who underwent BPH surgery we identified three major findings regarding the risk, timing, and patterns of BPH surgical re-interventions. First, re-operation rates varied substantially across procedures, with OSP and HoLEP/ThuLEP demonstrating the lowest cumulative re-treatment rates and PAE showing the highest by 10 years. Second, most re-operations occurred within the first few years post-intervention with majority taking place in the first year (table 3). Third, secondary procedures tended to reflect either provider familiarity or procedural accessibility, with TURP remaining the most frequently performed re-intervention overall. Importantly, these findings reflect real-world practice in a likely heterogenous patient and practioner environment rather than intrinsic procedural durability or overall clinical success, and should be interpreted in that context.

These patterns likely reflect differences in surgical technique, patient selection, and provider expertise. For example, the low re-operation rate for HoLEP may be influenced by its association with high-volume, experienced centers. Conversely, elevated re-operation rates following WVTT and PAE could reflect their relative novelty and broader application across provider skill levels or incorrect patient selection. The clustering of re-treatment events within the first year suggests that early re-intervention is common across several modalities. However, the reasons for early re-treatment cannot be determined based on claims-based data alone and may include a heterogenous mix of complications (e.g. stricture of bladder neck contracture), staged management (PAE for management of recalcitrant hematuria prior to outlet management), re-treatment preferences, or true lack of efficacy. Casual attribution to technical failure or patient selection is therefore not possible. Additionally, baseline disease severity and treatment indication differed across procedural cohorts, for example the prevalence of pre-index urinary retention varied substantially across cohorts (Supplemental Table 2), although this diagnosis cannot distinguish between acute and chronic retention or confirm catheter dependence.

Our observed re-operation rates generally aligned with the existing literature for several commonly performed BPH procedures (Figure 1, Table 1-2), though notable divergences were identified. At five years, re-operation rates for TURP (5.4%), PVP (7.5%), PUL (12.2%), and PAE (23.8%) closely mirrored previously published estimates[10-12]. Similarly, our 3-year re-operation rate for RWT (2.8%) was consistent with prior reports[10]. In contrast, re-operation rates following HoLEP and ThuLEP were substantially lower in our study—2.1% at five years—compared to literature-reported rates of 6.6% for HoLEP and 8.4% for ThuLEP[10]. On the other hand, our findings were more aligned with outcomes from high-volume centers, such as El-Hilali et al., who reported a 1.4% re-operation rate at 18 years[13]. These discrepancies likely reflect the influence of surgeon and institutional experience. HoLEP has a well-documented learning curve, with technical proficiency requiring at least 50–60 cases and optimal outcomes typically achieved by high-volume operators. Our findings may reflect data from centers or surgeons with greater experience, while the higher rates in the literature may include early adopters or lower-volume institutions. As surgeon-level data were not available in our dataset, we were unable to directly assess the impact of operator experience on re-operation risk. WVTT, on the other hand, demonstrated a higher re-operation rate in our cohort (8.5% at five years) than the 4.4% reported in earlier studies[14]. Several factors may account for this discrepancy. First, our study reflects real-world patterns across a broad range of institutions, whereas published rates are often derived from industry-sponsored trials or select centers with early procedural expertise. Additionally, patient selection may differ; in clinical practice, WVTT may be offered to patients with larger prostates or more advanced symptoms than in trial populations, potentially increasing the likelihood of requiring re-intervention. Finally, as a relatively new therapy, variation in technique and limited operator experience may contribute to higher failure rates in general practice. TUNA and TUMT re-operation rates were lower than literature estimates, but these are now considered legacy technologies. OSP also showed a very low re-operation rate in our analysis (0.8% at five years). Notably, long-term re-operation data for LSP/RSP remain scarce.

Patterns of secondary procedures appeared to reflect provider familiarity, institutional resources, and procedural availability rather than evidence-based salvage superiority. For example, same-modality re-treatment predominated after HoLEP/ThuLEP and PAE, suggesting that highly specialized providers may preferentially offer modalities with which they have greater experience. However, despite celebrating its 100th birthday in 2026, TURP remains the most common procedure in secondary intervention space for BPH. This likely reflects its ubiquity in urologists' skillset, patient familiarity, and easy access to needed equipment across a wide array of health systems.

Limitations

This study has several important limitations. First, re-operation captures only one dimension of long-term treatment failure and does not reflect symptom recurrence managed medically, catheter dependence, or patient choice to avoid further surgery. Second, the use of CPT and ICD codes may introduce coding inaccuracies. CPT-based re-intervention may capture staged procedures, management of complications (e.g. bladder neck contracture of stricture), or miscoding, in addition to true treatment failure. Third, important clinical variables such as prostate volume, symptom severity, frailty, anticoagulation status, surgeon experience, and uroflowmetry and urodynamic data were unavailable and may introduce confounding. Fourth, follow-up was assessed using fixed intervals rather than censoring, which may bias long-term estimates toward greater apparent durability. However, this was done to mitigate data loss and excluded patients lacking interval follow-up to reduce the risk of underestimating re-operation rates due to loss of follow-up. Additionally, PAE may be used for refractory prostatic bleeding or as a temporizing bridge to definitive surgery, which cannot be distinguished from primary BPH treatment based on coding alone. Another limitation was absence of data on re-initiation of medical therapy and patterns of score changes on standard patient questionnaires such as IPSS which requires a detailed look and should be explored in future studies. As large database become more readily available the incorporation of patient related quality of life parameters and clinical surveys becomes ever more important. This incorporation will allow clinicians to meaningfully understand patient outcomes and treatment failures in real world clinical practice.

CONCLUSIONS

In conclusion, this national real-world analysis demonstrates substantial variation in the risk and timing of surgical re-intervention following different BPH procedures. These findings describe real world re-treatment patterns in clinical practice and can help inform discussions with patients and families regarding expectations and likelihood for additional intervention. Future studies should incorporate baseline patient characteristics such as prostate size, medication use, functional outcomes, and patient-reported measures, including quality-of-life and symptom burden, to complement re-operation rates. Continued analyses leveraging live, national databases will be essential as newer therapies mature, our application of established therapies adapt and long-term outcomes evolve.

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FIGURES AND TABLES

Figure 1. 10-year reoperation-free rates for common BPH procedures. Each procedure is color-coded and listed in the legend in descending order of re-operation-free rates. LSP, RWT, and WVTT did not have 10 years of data due to insufficient followup. Reoperation-free rates were calculated as 100% minus the reoperation rate. BPH: benign prostatic hyperplasia; LSP: laparoscopic simple prostatectomy; RWT: robotic waterjet treatment; WVTT: water vapor thermal therapy.

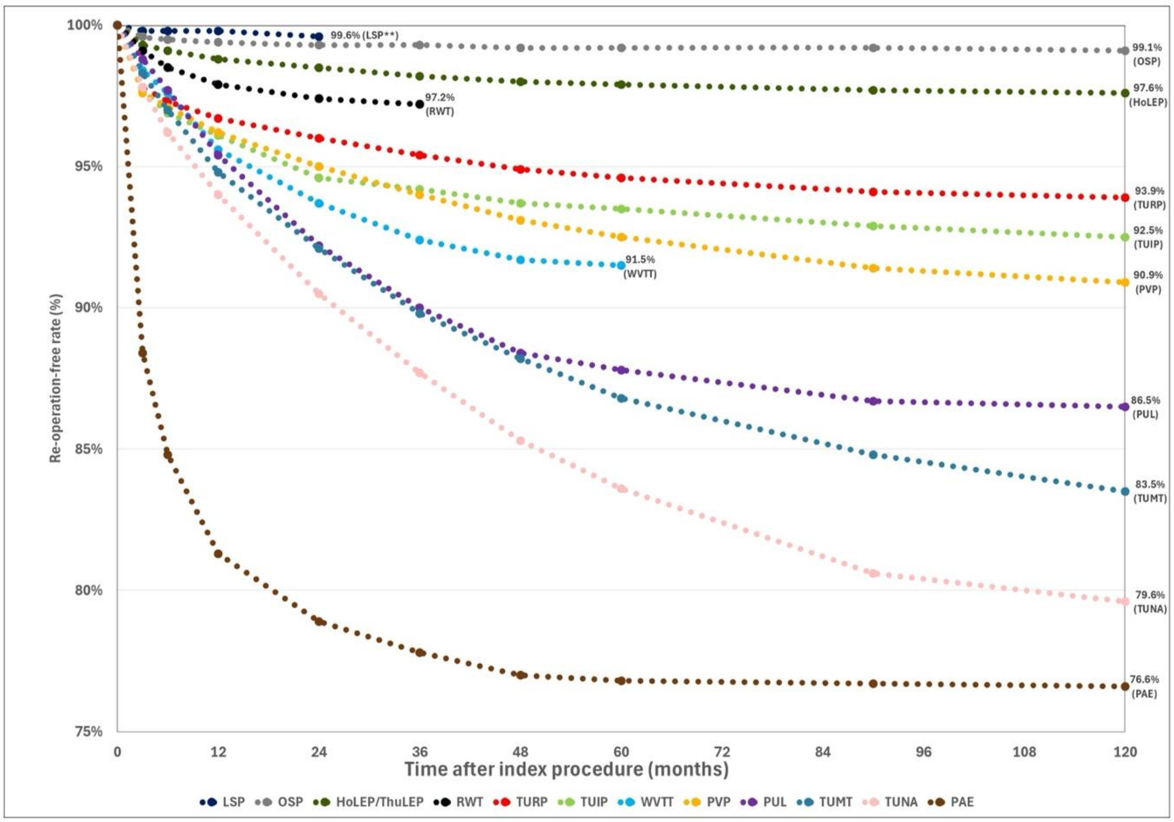

Figure 2. Types of secondary outlet procedures at maximum time interval. Each bar represents the total reoperation rate, with color-coded segments corresponding to the type of secondary procedure performed. Reoperative procedure rates and types are reported at the 10-year interval unless otherwise specified. *Indicates 5 years, **3 years, and ***2 years.

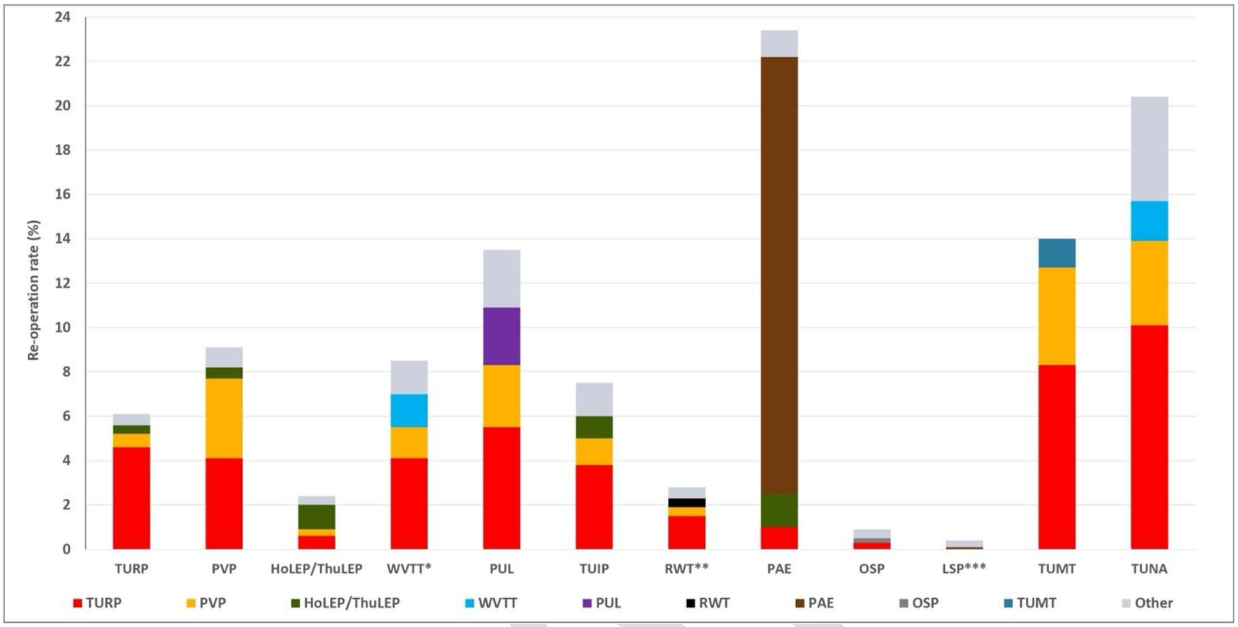

Table 1. Current literature on common BPH procedures.

Procedure	Ideal prostate size	Advantages	Disadvantages	Notable complications	Guidelines & recommend-ations	1-year reop rate (%)	2-year reop rate (%)	3-year reop rate (%)	5-year reop rate (%)	References
TURP	30–80 cc	Gold standard; durable	Retrograde ejaculation (65%); bleeding (2–9%); TUR syndrome (0.8%)	TUR syndrome; sepsis; bladder neck contracture	First-line per AUA (Grade A) & CUA	4.0% (3.0–5.1%)[10]/5.3 %[11]	5.0% (3.5–6.6%)[10]	6.0% (4.4–7.7%)[10]	5.8%[12]/7.7 % (5.8–9.8%)[10]/ 7.0%[11]	5,15,16
PVP	30–80 cc (including anticoagulated)	Less bleeding; suitable for AC/AP	Possible incomplete resection in large glands	Mild irritative LUTS; low transfusion need	Alternative per AUA (B) & CUA	3.3% (1.8–5.2%)[10]	4.1% (2.9–5.6%)[10]	6.7% (4.3–9.5%)[10]	7.1% (5.1–9.4%)[10]/ 8.9%[11]	5,15-17
HoLEP/ThuLEP	>30 cc	Durable; effective in large prostates	Steep learning curve; transient incontinence	Bleeding; incontinence; ejaculatory dysfunction	Strong per AUA (Grade B), excellent per CUA (Grade A)	HoLEP: 2.4% (1.1–4.1%)[10] ThuLEP: 3.7% (2.2-5.5%)[10]	HoLEP: 3.3% (0.1–17.2%)[10]	HoLEP: 5.4% (3.7–7.2%)[10]	HoLEP: 6.6% (4.2–9.5%)[10] ThuLEP: 8.4% (6.1–11.2%)[10]	5,15,16
WVTT (Rezum)	<80 cc	Office-based; preserves sexual function	Limited data in large glands; durability still under review	Hematuria; dysuria; urgency	Conditional (AUA C, CUA C)	6.2%[11]	–	–	4.4% [14]	5,14-16
PUL (UroLift)	≤80 cc (no median lobe preferred)	Quick recovery; preserves	Not for median lobes; relatively	Dysuria, hematuria, pelvic pain	Conditional (AUA C, CUA C)	5.9%[11]	–	–	11.6%[11]	5,15,16,18

		sexual function	higher reop rates							
TUIP	≤30 cc (no median lobe)	Low risk of retrograde ejaculation; short op time	High reop rates in larger glands; not for big prostates	Retrograde ejaculation (18%)	Strong (AUA B, CUA B)	–	–	–	13.4% (6.9–21.5%)[10]	5,15,16,19
RWT (Aquablation)	<150 cc	Robotic precision; low ejaculatory dysfunction	Limited long-term data; device cost	Mild hematuria; irritative LUTS	Conditional (AUA C, CUA C)	2.6% (0.5-7.4%)[10]	3.1% (1.1–6.0%)[10]	3.0% (0.6–8.4%)[10]	4.1% (1.7–7.2%)[10] / 3.7%[20]	15,16,21-23
PAE	>80 cc	No anesthesia; minimally invasive	Lower efficacy; ischemia risk; high reop	Non-target embolism; ureter/bladder ischemia	Conditional (AUA CUA C)	12.2% (2.4–27.8%)[10]	20.0% (8.9–34.1%)[10]	26.4% (18.9–35.0%)[10]	23.8% (21.4–26.3%)[10]	5,15,16,24,25
OSP	>80 cc, large glands	Durable; effective for large prostates	Invasive; longer hospital stay; transfusion risk	Transfusion (7–14%); incontinence (8–10%)	First-line if enucleation not available	1.3% (0.3–2.8%)[10]	–	–	4.4% (1.5–8.7%)[10]	5,15,16,26,27
LSP/RSP	>80–100 cc	Less blood loss vs open; durable	High cost; requires expertise	Reduced EBL; similar to open complications	Conditional (experienced centers)	–	–	–	–	5,15,16,26,27
TUMT	Non-surgical patients	Office-based; minimal peri-op risk	Poor long-term durability	Urinary retention; irritative LUTS	Alternative in select elderly (AUA C, CUA C)	9.9% (7.0–13.3%)[10]	19.9% (15.0–25.7%)[10]	23.3% (16.3–31.2%)[10]	31.2% (25.5–37.2%)[10]	5,15,16

TUNA	Non-surgical patients	Low risk of major complications	High retreatment; outdated	Encrustation; urinary symptoms	Not recommended (AUA)	**	**	**	**	5,15,16

Reoperation rates listed as mean ± SD, when applicable. **TUNA demonstrated a re-operation rate of 19.1% (18.7%-39.7%);[28] however, the followup timeframe was not specified as it was part of a meta-analysis.

Table 2. Cohort demographics and comorbidities.

Total n	**Age at index**	**Race**						**Ethnicity**			**Comorbidities**										**Geographic distribution**				
		White	Black or African	Asian	Other Race	Unknown Race	American Indian or	Not Hispanic or	Unknown ethnicity	Hispanic or Latino	COPD	CAD	DM	History of UTI	Urinary retention	Hematuria	OSA	Obesity	Prostate cancer	Bladder cancer	Northeast	Midwest	Southeast	West	Unknown
103019	69.7	75.5 %	8.6 %	5.6 %	3.5 %	6.6 %	0.2 %	74.1 %	8.6 %	17.3 %	11.5 %	34.0 %	31.9 %	39.2 %	61.3 %	45.2 %	21.2 %	30.5 %	15.9 %	5.7 %	28.1 %	16.3 %	38.2 %	16.1 %	1.3 %

Weighted average of cohort demographics and comorbidities. Data include total number of patients who underwent a primary procedure, the prevalence of key comorbidities, and geographic distribution based on U.S. census regions. Percentages are weighted by procedure volume to calculate overall averages. Notably, the TriNetX database includes a disproportionate number of institutions located in the Southern U.S., which may influence regional representation.

Table 3. Average time to re-operation and cumulative re-operation rates for up to 10-years following primary procedure.											
	3 months	**6 months**	**1 year**	**2 years**	**3 years**	**4 years**	**5 years**	**7.5 years**	**10 years**	**Average time to reoperation**	**% of repeat procedures occurring in first year**
TURP (n=44179)	2.2% (986)	2.7% (1185)	3.3% (1465)	4.0% (1778)	4.6% (2049)	5.1% (2229)	5.4% (2382)	5.9% (2600)	6.1% (2697)	665.4±829.5	54%
PVP (n=2028)	2.4% (489)	2.9% (588)	3.8% (768)	5.0% (1022)	6.0% (1222)	6.9% (1390)	7.5% (1517)	8.6% (1618)	9.1% (1841)	878.8±920.2	42%
HoLEP/ThuLEP (n=13123)	0.7% (94)	0.9% (120)	1.2% (156)	1.5% (200)	1.8% (236)	2.0% (261)	2.1% (278)	2.3% (305)	2.4% (313)	692.0±801.6	50%
WVTT (n=3415)	1.6% (53)	2.4% (83)	4.4% (150)	6.3% (215)	7.6% (261)	8.3% (284)	8.5% (289)	-	-	475.1±400.8*	52%
PUL (n=6538)	1.2% (81)	2.3% (147)	4.6% (301)	7.8% (507)	10.0% (653)	11.6% (755)	12.2% (797)	13.3% (868)	13.5% (883)	730.7±593.5	34%
TUIP (n=978)	2.3% (22)	3.1% (30)	3.9% (38)	5.4% (53)	5.8% (57)	6.3% (62)	6.5% (64)	7.1% (69)	7.5% (73)	667.1±874.5	52%
RWT (n=3562)	0.9% (32)	1.5% (54)	2.1% (75)	2.6% (92)	2.8% (100)	–	–	–	–	256.5±265.5**	75%
PAE (n=4855)	11.6% (565)	15.2% (737)	18.7% (906)	21.1% (1025)	22.2% (1078)	23.0% (1115)	23.2% (1126)	23.3% (1132)	23.4% (1135)	250.3±416.4	80%
OSP (n=2120)	0.4% (9)	0.5% (11)	0.6% (12)	0.7% (15)	0.7% (15)	0.8% (16)	0.8% (16)	0.8% (17)	0.9% (18)	537.6±951.3	66%
LSP/RSP (n=1936)	0.2% (3)	0.2% (4)	0.2% (4)	0.4% (7)	–	–	–	–	–	255.1±261.4***	57%

TUMT (n=637)	1.7% (11)	3.0% (19)	5.2% (33)	7.9% (50)	10.2% (65)	11.8% (75)	13.2% (84)	15.2% (97)	16.5% (105)	1034.7±935.8	31%
TUNA (n=1110)	2.2% (24)	3.8% (42)	6.0% (66)	9.5% (105)	12.3% (137)	14.7% (163)	16.4% (182)	19.4% (215)	20.4% (226)	1013.4±838.5	29%

Average time to reoperation are summarized at the 10-year interval unless otherwise specified. *5 years, **3 years, and ***2 years. Reported as mean ± SD (days). Cumulative reoperation rates for each procedure are displayed at each time point.