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EUROPEAN UROLOGY FOCUS xxx (xxxx) xxx–xxx

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journal homepage: www.europeanurology.com/eufocus

Benign Prostatic Hyperplasia

Five-year Retreatment and Medication Restart Rates Following Benign Prostate Hyperplasia Treatments: A Nationwide Real-world Analysis Using Epic Cosmos

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Article info

Article history:
Accepted January 12, 2026

Keywords:
Benign prostatic hyperplasia
Trends
Transurethral resection of the prostate
Minimally invasive surgical treatments
Holmium laser enucleation of the prostate
Thulium laser enucleation of the prostate
Prostatic urethral lift
Aquablation
Retreatment rates
Rezūm

Abstract

Background and objective: Surgical treatments for benign prostatic hyperplasia (BPH) have expanded with the diffusion of minimally invasive surgical treatments (MISTs), but concerns persist regarding their long-term durability. This study aimed to provide a comprehensive, real-world description of current treatment trends, retreatment rates, and medication reinitiation up to 5 yr following MISTs and traditional procedures.

Methods: This observational retrospective fixed-cohort study was conducted using Epic Cosmos, including data of 6 450 295 patients and 420 611 procedures between 2014 and 2024. The primary outcome was procedural trend; the secondary outcomes were surgical retreatment and medication reinitiation. Analyses were descriptive and unadjusted for potential confounders due to the aggregated nature of the dataset.

Key findings and limitations: At 5 yr, retreatment rates were higher after prostatic urethral lift (PUL; 16%), transurethral needle ablation of the prostate (15%), transurethral microwave thermotherapy (17%), and Rezūm (14%), and lower after holmium laser enucleation of the prostate (HoLEP)/thulium laser enucleation of the prostate (ThuLEP; 4.4%) and simple prostatectomy (1.2%) when compared with transurethral resection of the prostate (TURP; 7.1%). Medication reinitiation at 5 yr was more common after MISTs (PUL: 21% α-blockers, 25% 5α-reductase inhibitors [5-ARIs], and 27% overactive bladder [OAB] drugs; all $p < 0.001$; Rezūm: 18% α-blockers, $p = 0.001$; 22% 5-ARIs, $p = 0.05$; and 23% OAB drugs, $p > 0.99$) and lower following traditional procedures, including HoLEP/ThuLEP—11% α-blockers ($p < 0.001$), 12% 5-ARIs ($p < 0.001$), and 21% OAB drugs ($p = 0.3$), and simple prostatectomy—5.4% α-blockers ($p < 0.001$), 6.5% 5-ARIs ($p < 0.001$), and 9.4% OAB drugs ($p < 0.001$), when compared with TURP (15% α-blockers, 17% 5-ARIs, and 23% OAB drugs). Limitations include the use of aggregated electronic health record data subject to coding errors and the inability to adjust for clinical variables such as prostate size and symptom severity.

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https://doi.org/10.1016/j.euf.2026.01.003

Please cite this article as: F. Carletti, F. Tamborino, A. Turcan et al., Five-year Retreatment and Medication Restart Rates Following Benign Prostate Hyperplasia Treatments: A Nationwide Real-world Analysis Using Epic Cosmos, Eur Urol Focus (2026), https://doi.org/10.1016/j.euf.2026.01.003

Conclusions and clinical implications: In this large, real-world cohort, anatomical procedures such as HoLEP, ThuLEP, and simple prostatectomy were associated with the lowest long-term rates of retreatment and medication restart, whereas higher rates were observed with MISTs, particularly PUL and Rezūm. TURP remained the most performed procedure. As the use of MISTs declines after its initial uptake, future studies should clarify which patient characteristics may underlie these observed differences.

ADVANCING PRACTICE

What does this study add?
Using the Epic Cosmos database, we analysed over 420 000 procedures performed between 2014 and 2024. Transurethral resection of the prostate remains the most common procedure, though its use is declining. Anatomical surgeries such as holmium/thulium laser enucleation and simple prostatectomy were associated with the lowest 5-yr retreatment and medication restart rates. By contrast, minimally invasive surgical treatments such as Rezūm and PUL were associated with higher rates of retreatment and medication reinitiation, and their utilisation has declined since peaking in 2021.

Clinical Relevance
As minimally invasive surgical treatments (MIST) for benign prostatic hyperplasia have proliferated, questions regarding their long-term durability have become increasingly central to patient counseling and health-system planning. Leveraging a nationwide electronic health record network, this study provides the largest real-world comparison to date of retreatment and medication restart rates across contemporary BPH procedures. Anatomical debulking approaches—particularly HoLEP/ThuLEP and simple prostatectomy—were consistently associated with the lowest five-year rates of surgical retreatment and postoperative medication use, suggesting superior durability at a population level. In contrast, higher retreatment and medication reinitiation rates following MIST, notably prostatic urethral lift and Rezūm, raise concerns about the long-term adequacy of obstruction relief in routine practice. Importantly, these findings reflect associations rather than causal effects, as patient selection, prostate size, surgeon expertise, and symptom burden could not be accounted for in this aggregated dataset. Nevertheless, retreatment and medication restart serve as pragmatic markers of treatment failure that resonate with patients and payers alike. These data reinforce the need to align procedural selection with patient priorities, anatomy, and expectations regarding durability, while underscoring the importance of longer-term comparative effectiveness studies with granular clinical detail. Associate Editor: Dean Elterman.

Patient Summary
These results suggest that while minimally invasive surgical treatments are often selected for their favourable short-term recovery and perioperative safety, these were associated with higher long-term retreatment rates than to anatomical surgeries that completely remove the obstructing prostate tissue. Patients undergoing holmium laser enucleation of the prostate, thulium laser enucleation of the prostate, and simple prostatectomy experienced the lowest rates of repeat surgery and medication restart. These differences may reflect patient selection and practice-level factors.

1. Introduction

Benign prostatic hyperplasia (BPH) is the most common cause of lower urinary tract symptoms (LUTS) in older men [1]. The initial management of LUTS typically involves α-blockers and 5α-reductase inhibitors (5-ARIs) [2]. When medical therapy fails, surgery is required. Established techniques include holmium laser enucleation of the prostate (HoLEP), thulium laser enucleation of the prostate (ThuLEP), robotic waterjet ablation (Aquablation), photoselective vapourisation of the prostate (PVP), transurethral incision of the prostate (TUIP), and the transurethral resection of the prostate (TURP). In the past decade minimally invasive surgical treatments (MISTs) have been introduced, promising reduced sexual dysfunction and improved perioperative outcomes [3].

However, their long-term durability remains uncertain, and real-world evidence to compare the long-term outcomes of different procedures is needed to improve shared decision-making and health care planning.

We conducted an observational retrospective fixed-cohort study using Epic Cosmos, an extensive deidentified electronic health record database. As this is an observational study using aggregated data without adjustment for potential confounders, our aim is to describe real-world associations between procedure types and subsequent outcomes, rather than to establish causal efficacy.

2. Patients and methods

2.1. Data source

This observational retrospective fixed-cohort study utilised data extracted from Epic Cosmos [4,5], a data aggregation platform managed directly by the developer of the Epic electronic health record system (Epic, Verona, WI, USA). It functions as a multicentric repository that continuously retrieves, harmonises, and collates deidentified health records from these participating organisations. As of our data extraction (May 2025), the database comprised records from over 300 million patients across >1748 hospitals and 40 000 clinics in the USA. To ensure data uniformity across different institutions, the platform uses standardised terminologies. Institutional review board approval was not required as data were aggregated, deidentified, and restricted to population-level queries, preventing patient identification. Consequently, as individual-level data were not accessible, adjustment for potential confounders was not feasible. Patients were identified using International Classification of Diseases, 10th revision [6] codes and Current Procedural Terminology (CPT) codes.

2.2. Study population and procedures

We included men aged ≥18 yr with at least one documented health care encounter and a recorded diagnosis of BPH (ICD-10 codes N40.0-N40.3) between January 1, 2014 and December 31, 2024.

Baseline variables included age at the time of the procedure, body mass index (BMI; kg/m^2), ethnicity, insurance coverage, and comorbidities. Potential confounders that could influence retreatment rates include prostate volume, patient age, surgeon volume/expertise, and baseline symptom severity. Owing to the aggregated nature of the data, these could not be included as covariates.

We used the following CPT codes to identify surgical interventions for BPH: TURP (CPT: 52601), repeated TURP (reTURP; CPT: 52630), interstitial laser coagulation (ILC; CPT: 52647), PVP (CPT: 52648), holmium laser enucleation (HoLEP) and thulium laser enucleation (ThuLEP) of the prostate (CPT: 52649), prostatic urethral lift (PUL; CPT: 52441 and 52442), water vapour thermal therapy (Rezūm; CPT: 53854), transurethral needle ablation of the prostate (TUNA; CPT: 3852); transurethral microwave thermotherapy (TUMT; CPT: 53850), simple prostatectomy (open, laparoscopic, and robotic; CPT: 55821, 55831, and 55867), TUIP (CPT: 52450), and Aquablation (CPT: 0421T). Procedures without specific CPT codes, such as temporarily implanted nitinol device (iTIND) or prostatic artery embolisation (PAE), were excluded.

To ensure adequate follow-up and account for varying observation times in the absence of patient-level time-to-event data, we utilised a fixed-cohort design to calculate cumulative incidence. Retreatment and medication reinitiation rates were calculated at 1, 3, and 5 yr by restricting index procedures to only those performed between January 1, 2014 and May 30 of 2024, 2022, and 2020, respectively. This ensured that every patient included in the analysis had the full temporal opportunity to experience the event. Surgical retreatment was defined as any repeated BPH-related surgical intervention occurring ≥30 d after the index procedure. Medication restart was defined as reinitiation of any of the following therapies: α-blockers (tamsulosin, alfuzosin, doxazosin, terazosin, or silodosin), 5-ARIs (finasteride or dutasteride), or overactive bladder (OAB) drugs (solifenacin, tolterodine, or mirabegron); each was evaluated within 1–12, 1–36, and 1–60 mo after the index procedure.

2.3. Outcomes

The primary outcome was the distribution of procedures from 2014 to 2024. The secondary outcomes were retreatment and medication restart rate at 1-, 3-, and 5-yr follow-up.

2.4. Statistical analysis

Statistical analyses were conducted using R software 4.0 (R Foundation for Statistical Computing, Vienna, Austria). Categorical variables were presented as absolute frequencies and percentages, continuous variables as medians with interquartile ranges (IQRs). Fisher's exact test compared procedures against TURP, providing odds ratios with 95% confidence intervals and p values. Owing to the aggregated nature of the data, which precluded access to individual censorship times, survival analyses were not feasible. Instead, fixed-cohort cumulative incidence rates were compared using Fisher's exact test.

3. Results

3.1. Cohort characteristics

Between January 2014 and December 2024, 6 450 295 patients were diagnosed with BPH (median age 73 yr; IQR: 66–80). Most diagnoses occurred in men aged 70–79 yr (34%), followed by those aged 60–69 yr (26%), 80–89 yr (20%), and ≥90 yr (6.5%; Fig. 1).

Prevalence (Fig. 2) increased with age, peaking at 29% in the 80–89-yr age group.

3.2. Temporal trends of procedures

Table 1 and Fig. 3 show the distribution of BPH procedures from 2015 to 2024. The use of TURP decreased from 54% in 2014 to 43% in 2024, while that of HoLEP/ThuLEP increased from 5.2% to 15%. PVP use peaked at 34% in 2015 but declined to 13% by 2024. The use of Aquablation, introduced in 2020, rose to 11% in 2024. PUL usage rate increased from 0.6% in 2015 to 8% in 2024, and Rezūm from 2.8% in 2019 to 3.3% in 2024.

The rate of traditional procedures decreased from 98% to 88%, while that of MISTs increased from 2% to 13% (Table 2).

3.3. Demographics

Complete demographics are presented in Supplementary Table 1. Median ages were 71–72 yr for TURP, HoLEP/ThuLEP, and PVP, and younger for TUIP (66 yr) and Rezūm (69 yr). Patients undergoing reTURP were older (75 yr). BMI was 27–28 kg/m^2 across groups. Most patients had Medicare coverage (71–92%).

White patients represented between 74% (simple prostatectomy) and 87% (PVP). African American patients ranged from 7.5% undergoing PVP to 16% undergoing simple prostatectomy. Other racial groups were represented in smaller proportions across all procedures.

3.4. Retreatment rates

At 1 yr, the retreatment rate for patients undergoing TURP was 2.8% (Table 3 and Fig. 4). Significantly higher odds of retreatment were observed following TUMT (7.9%), TUNA (5%), Rezūm (4.5%), and PUL (4.4%; all $p < 0.001$). Conversely, patients treated with HoLEP/ThuLEP (1.5%) and simple prostatectomy (0.8%) had significantly lower retreatment odds ($p < 0.001$). PVP (2.6%) and Aquablation (2.7%) did not differ significantly from TURP.

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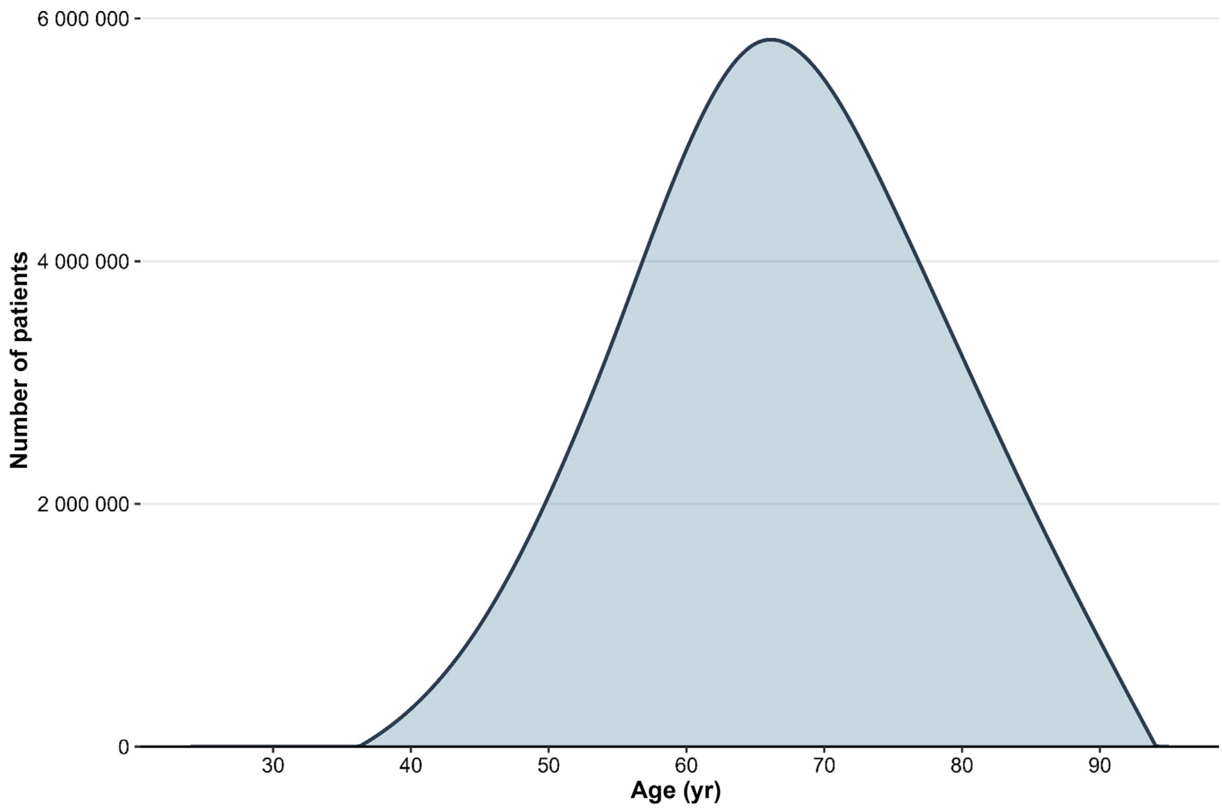

Fig. 1 – Age distribution of patients diagnosed with benign prostatic hyperplasia in the USA, from January 2014 to December 2024.

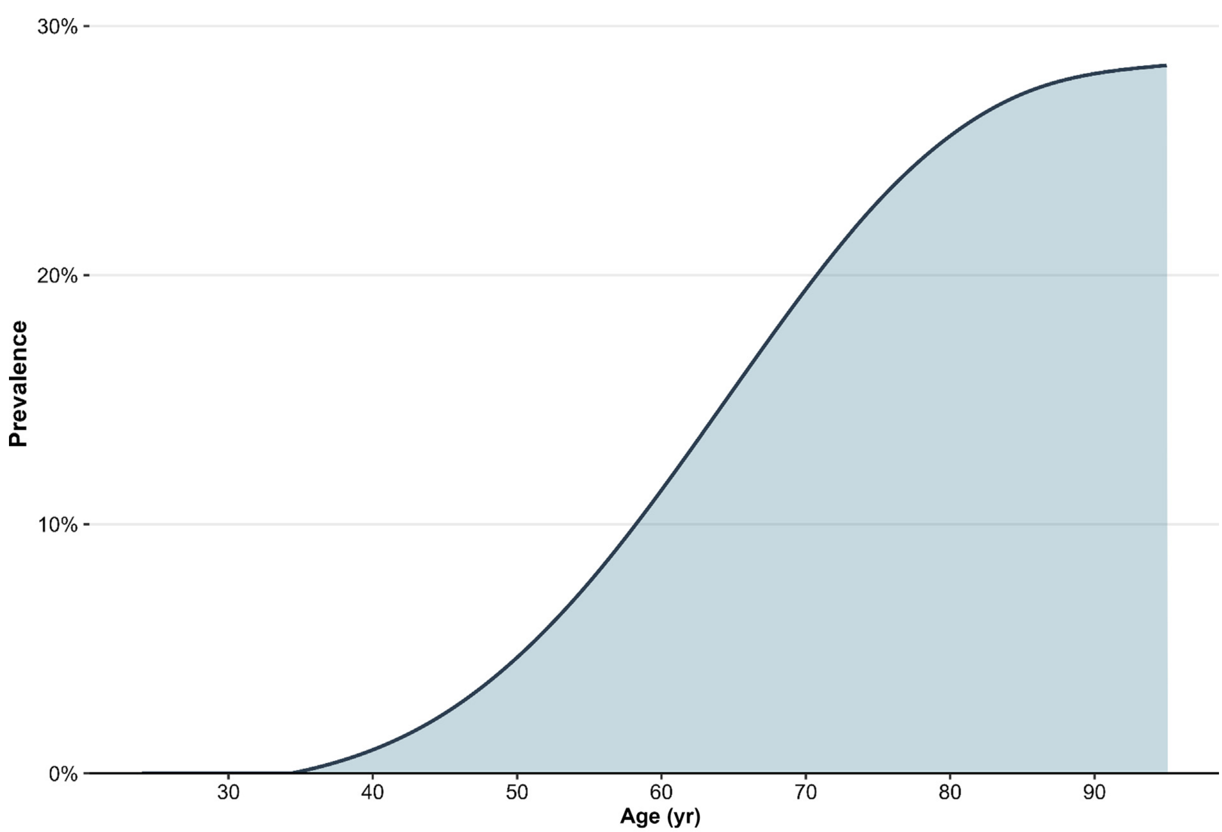

Fig. 2 – Age-stratified prevalence of benign prostatic hyperplasia among male patients aged ≥18 yr in the USA, from January 2014 to December 2024.

Table 1 – Annual trends in BPH surgical procedures in the USA (January 2014 to December 2024)

Procedure, *N* (%)	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	Total procedures (2014–2024)
TURP	934 (54)	4868 (49)	8047 (53)	12 114 (52)	16 286 (50)	19 500 (48)	18 828 (48)	23 691 (46)	27 676 (46)	32 152 (45)	34 192 (43)	198 288
HoLEP/ThuLEP	90 (5.2)	537 (5.5)	876 (5.8)	1333 (5.8)	2154 (6.6)	2778 (6.9)	3514 (9)	5131 (10)	6717 (11)	9680 (13)	12 186 (15)	44 996
PVP	542 (31)	3382 (34)	4570 (30)	6247 (27)	7544 (23)	8215 (20)	7450 (19)	9230 (18)	9635 (16)	10 135 (14)	10 530 (13)	77 480
Aquablation	0	0	0	0	13 (0.04)	18 (0.04)	60 (0.1)	610 (1.2)	1704 (2.9)	4723 (6.7)	8646 (11)	15 774
PUL	0	52 (0.5)	186 (1.2)	1024 (4.5)	3020 (9.3)	5193 (13)	5042 (13)	6923 (13)	7372 (12)	7415 (10)	6282 (8)	42 509
ReTURP	95 (5.5)	686 (7)	939 (6.2)	1408 (6.1)	1769 (5.5)	1902 (4.7)	1752 (4.5)	2122 (4.1)	2175 (3.7)	2520 (3.6)	2738 (3.5)	18 106
Rezūm	0	0	0	0	0	1139 (2.8)	1248 (3.2)	2255 (4.4)	2551 (4.3)	2738 (3.9)	2544 (3.2)	12 475
TUIP	19 (1.1)	111 (1.1)	211 (1.4)	285 (1.2)	372 (1.1)	456 (1.1)	388 (1)	564 (1.1)	602 (1)	661 (0.9)	717 (0.9)	4386
TUMT	21 (1.2)	55 (0.6)	82 (0.5)	78 (0.3)	39 (0.1)	16 (0.04)	34 (0.1)	32 (0.06)	77 (0.1)	55 (0.1)	66 (0.1)	555
ILC	17 (1)	100 (1)	90 (0.6)	85 (0.4)	91 (0.3)	84 (0.2)	78 (0.2)	128 (0.2)	78 (0.1)	83 (0.1)	70 (0.1)	904
Simple prostatectomy	0	14 (0.1)	29 (0.2)	124 (0.5)	276 (0.8)	440 (1.1)	370 (0.9)	472 (0.9)	527 (0.9)	359 (0.5)	398 (0.5)	3009
TUNA	0	26 (0.3)	77 (0.5)	262 (1.1)	790 (2.4)	307 (0.8)	152 (0.4)	158 (0.3)	108 (0.2)	138 (0.2)	111 (0.1)	2129
Total procedure year	1718	9831	15 107	22 960	32 354	40 048	38 916	51 316	59 222	70 659	78 480	420 611

HoLEP = holmium laser enucleation of the prostate; ILC = intraprostatic laser coagulation; PUL = prostatic urethral lift; PVP = photoselective vapourisation of the prostate; Rezūm = water vapour therapy; reTURP = repeated transurethral resection of the prostate; simple prostatectomy = open/laparoscopic/robot-assisted simple prostatectomy; ThuLEP = thulium laser enucleation of the prostate; TUIP = transurethral incision of the prostate; TUMT = transurethral microwave thermotherapy; TUNA = transurethral needle ablation; TURP = transurethral resection of the prostate.

By 5 yr, the retreatment rate following TURP rose to 7.1%. TUMT (7.9%), TUNA (5%), Rezūm (4.5%), PUL (4.4%), TUIP (3%), and PVP (2.6%) maintained significantly higher rates ($p \leq 0.05$; Table 3). The lowest rates were observed following HoLEP/ThuLEP (1.5%) and simple prostatectomy (0.8%; $p < 0.001$).

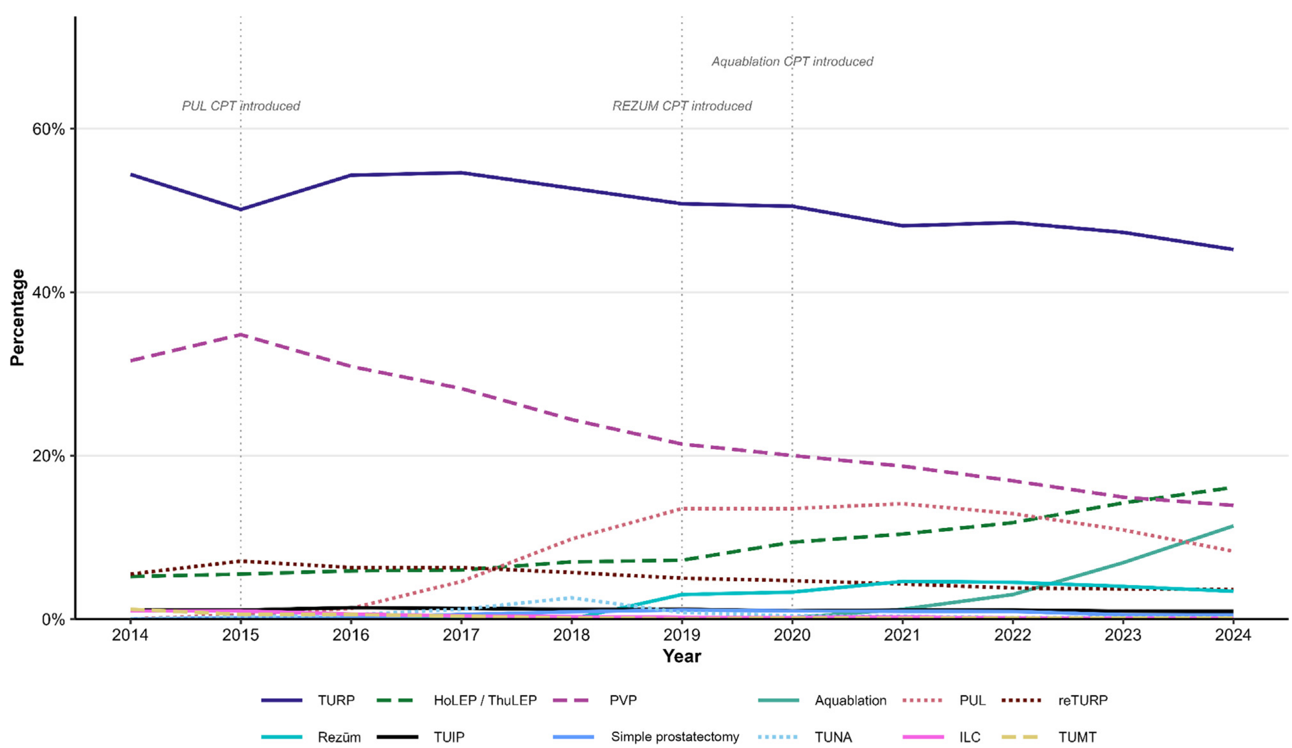

Fig. 3 – *Trends in BPH surgical procedures in the USA (2014–2024).* BPH = benign prostatic hyperplasia; CPT = Current Procedural Terminology; HoLEP = holmium laser enucleation of the prostate; ILC = intraprostatic laser coagulation; PUL = prostatic urethral lift; PVP = photoselective vapourisation of the prostate; reTURP = repeat transurethral resection of the prostate; Simple prostatectomy = open/laparoscopic/robot-assisted simple prostatectomy; Rezūm = water vapour therapy; ThuLEP = thulium laser enucleation of the prostate; TUIP = transurethral incision of the prostate; TUMT = transurethral microwave thermotherapy; TUNA = transurethral needle ablation; TURP = transurethral resection of the prostate.

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Table 2 – US trends in traditional versus MIST procedures (2014–2024) [a]

Procedure, *n* (%)	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Traditional	1680 (98)	9598 (98)	14 672 (97)	21 511 (94)	28 414 (88)	33 309 (83)	32 362 (83)	41 820 (81)	49 036 (83)	60 230 (85)	69 407 (88)
MIST	38 (2)	233 (2)	435 (3)	1449 (6)	3940 (12)	6739 (17)	6554 (17)	9496 (19)	10 186 (17)	10 429 (15)	9073 (13)
Total	1717	9722	14 811	22 180	30 910	38 373	37 278	49 227	57 040	68 022	75 650

ILC = intraprostatic laser coagulation; MIST = minimally invasive surgical treatment; PUL = prostatic urethral lift; TUMT = transurethral microwave thermotherapy; TUNA = transurethral needle ablation.
[a] MIST: Rezūm (water vapour therapy), PUL (prostatic urethral lift), TUMT (transurethral microwave thermotherapy), ILC (intraprostatic laser coagulation), TUNA (transurethral needle ablation).

Table 3 – Cumulative 1-, 3-, and 5-yr retreatment rates for individual BPH procedures

Procedure	Follow-up (yr)	Retreatments, *n* (%)	Total procedures, *n*	Odds ratio (95% CI)	*p* value
TURP	1	4929 (2.8)	178 299	1 (reference)	–
	3	6054 (5.2)	115 797	1 (reference)	–
	5	4901 (7.1)	69 052	1 (reference)	–
TUMT	1	41 (7.9)	515	3.04 (2.15–4.2)	**<0.001**
	3	60 (15)	380	3.4 (2.53–4.5)	**<0.001**
	5	54 (17)	304	2.83 (2.06–3.81)	**<0.001**
TUIP	1	123 (3)	4012	1.11 (0.92–1.33)	0.2
	3	165 (6)	2687	1.19 (1.00–1.39)	**0.04**
	5	141 (8.7)	1620	1.25 (1.04–1.49)	**0.01**
Rezūm	1	504 (4.5)	11 191	1.66 (1.51–1.82)	**<0.001**
	3	568 (9.7)	5847	1.95 (1.78–2.14)	**<0.001**
	5	234 (14)	1589	2.26 (1.95–2.61)	**<0.001**
TUNA	1	105 (5)	2080	1.87 (1.52–2.28)	**<0.001**
	3	196 (10)	1840	2.16 (1.85–2.51)	**<0.001**
	5	241 (15)	1526	2.45 (2.12–2.83)	**<0.001**
PUL	1	1709 (4.4)	38 934	1.61 (1.53–1.71)	**<0.001**
	3	2732 (11)	24 734	2.25 (2.15–2.36)	**<0.001**
	5	1898 (16)	11 345	2.63 (2.48–2.79)	**<0.001**
ILC	1	36 (4.1)	881	1.50 (1.04–2.09)	**0.02**
	3	48 (6.6)	729	1.28 (0.93–1.72)	0.11
	5	44 (8.8)	501	1.26 (0.90–1.72)	0.16
PVP	1	1893 (2.6)	71 850	0.95 (0.90–1)	0.07
	3	2980 (5.8)	51 672	1.11 (1.06–1.16)	**<0.001**
	5	2680 (8)	33 572	1.14 (1.08–1.19)	**<0.001**
Aquablation	1	304 (2.7)	11 325	0.97 (0.86–1.09)	0.6
	3	79 (5.8)	1352	1.12 (0.88–1.41)	0.3
	5	NA	NA		
HoLEP/ThuLEP	1	577 (1.5)	38 781	0.53 (0.49–0.58)	**<0.001**
	3	578 (3)	19 433	0.56 (0.51–0.61)	**<0.001**
	5	401 (4.4)	9129	0.6 (0.54–0.67)	**<0.001**
Simple prostatectomy	1	23 (0.8)	2756	0.3 (0.19–0.45)	**<0.001**
	3	17 (0.9)	1973	0.16 (0.09–0.25)	**<0.001**
	5	13 (1.2)	1058	0.16 (0.09–0.28)	**<0.001**

BPH = benign prostatic hyperplasia; CI = confidence interval; HoLEP = holmium laser enucleation of the prostate; ILC = intraprostatic laser coagulation; NA = not available; PUL = prostatic urethral lift; PVP = photoselective vapourisation of the prostate; Rezūm = water vapour therapy; simple prostatectomy = open/laparoscopic/robot-assisted simple prostatectomy; ThuLEP = thulium laser enucleation of the prostate; TUIP = transurethral incision of the prostate; TUMT = transurethral microwave thermotherapy; TUNA = transurethral needle ablation; TURP = transurethral resection of the prostate.

3.5. *Postoperative medication*

Reinitiation rates of α-blockers, 5-ARIs, and OAB medications following surgery are reported at 5-yr follow-up in Table 4, at 1- and 3-yr follow-up in Supplementary Table 2.

3.5.1. *Reinitiation rate of α-blockers*

Among patients undergoing TURP, the α-blocker reinitiation rate increased progressively to 15% at 5 yr. Rates were significantly higher for PUL (21%), reTURP (18%), Rezūm (17%), PVP (17%), and TUIP (16%) compared with TURP (all $p < 0.05$). TUMT (16%), ILC (17%), and TUNA (15%) also showed higher rates while Aquablation demonstrated a comparable rate at 3 yr (12%). HoLEP/ThuLEP (11%) and simple prostatectomy (5.4%) had significantly lower reinitiation rates ($p < 0.001$).

3.5.2. *Reinitiation rate of 5-ARIs*

At 5 yr, patients treated with TURP showed a 17% reinitiation rate of 5-ARIs. Significantly higher rates were observed for PUL (25%), reTURP (21%), and PVP (20%; all $p < 0.05$). Rezūm also showed a higher 5-yr rate (22%; $p = 0.05$), TUIP (22%), TUMT (21%), ILC (19%), and TUNA (18%) demonstrated numerically elevated rates, though not statistically

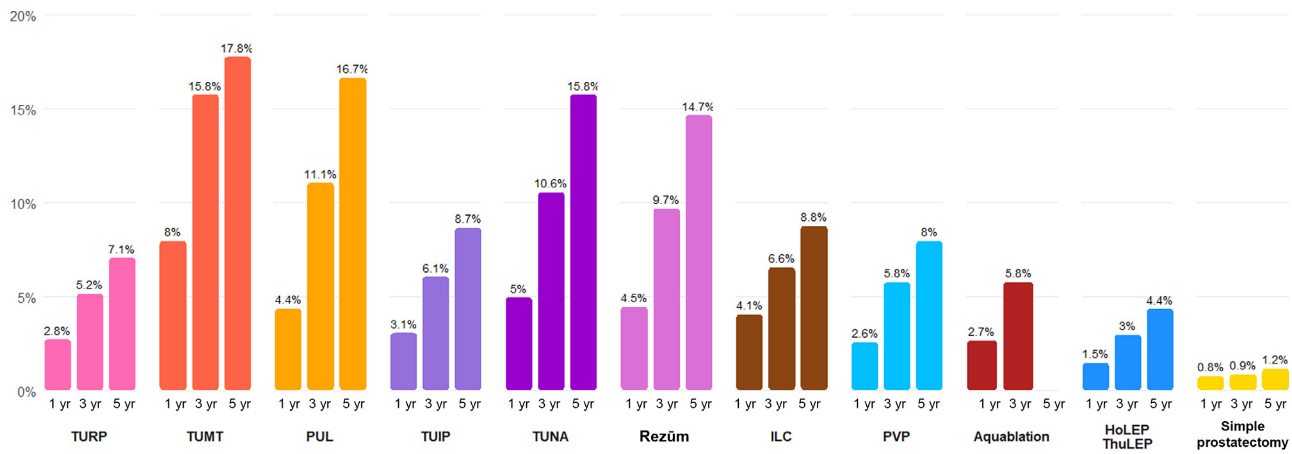

Fig. 4 – Cumulative 1-, 3-, and 5-yr retreatment rates for individual BPH procedures. BPH = benign prostatic hyperplasia; HoLEP = holmium laser enucleation of the prostate; ILC = intraprostatic laser coagulation; PUL = prostatic urethral lift; PVP = photoselective vapourisation of the prostate; Simple prostatectomy = open/laparoscopic/robot-assisted simple prostatectomy; Rezūm = water vapour therapy; ThuLEP = thulium laser enucleation of the prostate; TUIP = transurethral incision of the prostate; TUMT = transurethral microwave thermotherapy; TUNA = transurethral needle ablation; TURP = transurethral resection of the prostate.

significant. In contrast, HoLEP/ThuLEP (12%) and simple prostatectomy (6.5%) were associated with substantially lower reinitiation rates ($p < 0.001$).

3.5.3. Reinitiation rate of OAB medications

At 5 yr, the reinitiation rate of OAB medications following TURP was 23%. PVP (28%) and PUL (27%) showed significantly higher rates ($p < 0.001$). Rezūm, TUNA, TUIP, reTURP, and ILC ranged from 23% to 31%. Simple prostatectomy (9.4%) was associated with the lowest reinitiation rate ($p < 0.001$), whereas the reinitiation rate of HoLEP/ThuLEP (21%) did not differ significantly from that of TURP.

4. Discussion

To the best of our knowledge, this is the first study to evaluate surgical treatments, retreatment rates, and medication reinitiation after BPH surgery using Epic Cosmos. This analysis is particularly relevant as long-term surgical retreatment and medication restart rates serve as important indicators of treatment durability in a field where MISTs are gaining popularity.

Over the past decade, the gradual decline in TURP has been mirrored by a consistent growth in the adoption of HoLEP, ThuLEP, and Aquablation, while PVP has shown a notable decrease. Interestingly, although the popularity of MISTs peaked in 2021, a slight but consistent decline has been observed in recent years. Despite these trends, TURP remains the most performed procedure as of 2024, accounting for nearly half of all BPH interventions.

At 5-yr follow-up, the retreatment rate following TURP was 7.1%, aligning with the 7% rate reported in a recent US claims-based analysis by Kaplan et al. [7] and 7.7% rate reported in a recent systematic review [8]. Our observed low retreatment rates for HoLEP/ThuLEP (4.4%) and simple prostatectomy (1.2%) are lower than prior reports of 5.7–8% [9,10] and align with recent findings [11–13]. Although 5-yr data for Aquablation are not yet available, the 3-yr retreatment rate of 5.8% appears higher than the previous report of 3% [8] but comparable with that of TURP, although not statistically significant. PVP showed a 5-yr retreatment rate of 8%, slightly lower than the 12% rate reported in a systematic review [11] and aligning with the 7% and 8.9% rates observed in other analyses [7,8]; yet, its retreatment rate remains higher than the rate seen with TURP. Notably, the 5-yr retreatment rate following PUL reached 16%, exceeding the 13.6% reported in prior studies [14], Rezūm retreatment rate was 14%, substantially higher than the 4.4% observed in a randomised multicentre trial [15].

As the reference standard, patients treated with TURP in our cohort demonstrated moderate long-term medication reliance. At 5 yr after TURP, 15% of patients resumed α-blockers, 17% resumed 5-ARIs, and 23% resumed OAB medications. These findings are higher than those reported by Kaplan et al. [16] in a US claims-based study, indicating that approximately 10% of patients resumed BPH medications within 5 yr, but in line with longer-term data from the study of Campbell et al. [17], who documented 10-yr reinitiation rates of 38% for α-blockers, 28% for 5-ARIs, and 20% for OAB medications. The need for OAB drugs in over one-fifth of patients treated previously with OAB medications confirms that relieving the obstruction does not universally resolve bladder dysfunction.

Patients undergoing HoLEP/ThuLEP exhibited lower long-term dependence on medications; at 5 yr 11% were back on α-blockers, 13% on 5-ARIs, and 22% on OAB drugs, the lowest reinitiation rates among all endoscopic procedures, as reported by previous studies [18,19]. Patients undergoing simple prostatectomy demonstrated the most favourable 5-y outcomes: 5.4% resumed α-blockers, 6.5% resumed 5-ARIs, and 9.4% resumed OAB drugs. These rates were substantially lower than those observed for any transurethral procedure.

At 5 yr, PVP was associated with the restart rates of 16% for α-blockers, 20% for 5-ARIs, and 28% for OAB medications, all higher than those observed following TURP, with a particularly significant difference in OAB therapy reinitiation (28% vs 23%). These findings partially align with the results of

Please cite this article as: F. Carletti, F. Tamborino, A. Turcan et al., Five-year Retreatment and Medication Restart Rates Following Benign Prostate Hyperplasia Treatments: A Nationwide Real-world Analysis Using Epic Cosmos, Eur Urol Focus (2026), https://doi.org/10.1016/j.euf.2026.01.003

Table 4 – Five-year reinitiation rates of medical therapy following surgical treatments for BPH

Procedure	*N*	Alpha-blockers				5-Alpha reductase inhibitors				Overactive bladder medications			
		Therapy at surgery (%)	Therapy restart 5 yr after surgery (%)	OR (95% CI)	*p* value	Therapy at surgery (%)	Therapy restart 5 yr after surgery (%)	OR (95% CI)	*p* value	Therapy at surgery (%)	Therapy restart 5 yr after surgery (%)	OR (95% CI)	*p* value
TURP	67 065	52 038 (77)	7913 (15)	1 (reference)	–	27 638 (41)	4848 (17)	1 (reference)	–	8426 (12)	1947 (23)	1 (reference)	–
PUL	10 796	8904 (82)	1903 (21)	1.52 (1.43–1.6)	**<0.001**	3789 (35)	961 (25)	1.6 (1.48–1.73)	**<0.001**	1928 (17)	534 (27)	1.28 (1.14–1.43)	**<0.001**
Rezūm	1472	1232 (83)	212 (17)	1.16 (1–1.35)	**0.001**	623 (42)	141 (22)	1.38 (1.14–1.67)	0.054	216 (14)	50 (23)	1.01 (0.73–1.39)	>0.9
TUIP	1572	1101 (70)	181 (16)	1.1 (0.94–1.29)	**0.02**	373 (23)	83 (22)	1.35 (1.06–1.73)	0.2	285 (18)	69 (24)	1.07 (0.81–1.41)	0.6
TUMT	300	258 (86)	42 (16)	1.09 (0.79–1.52)	0.18	168 (56)	36 (21)	1.29 (0.9–1.87)	0.6	77 (25)	13 (16)	0.7 (0.39–1.25)	0.2
reTURP	7259	4939 (68)	934 (18)	1.3 (1.21–1.4)	**<0.001**	2971 (40)	632 (21)	1.27 (1.16–1.39)	**<0.001**	1033 (14)	265 (25)	1.15 (0.99–1.33)	**0.073**
PVP	32 738	24 270 (74)	4229 (17)	1.18 (1.13–1.23)	**<0.001**	12 642 (38)	2575 (20)	1.2 (1.14–1.27)	**<0.001**	3950 (12)	1105 (28)	1.29 (1.19–1.41)	**<0.001**
ILC	497	354 (71)	63 (17)	1.21 (0.92–1.6)	0.3	186 (37)	37 (19)	1.18 (0.82–1.69)	0.18	64 (12)	20 (31)	1.53 (0.91–2.59)	0.13
TUNA	1509	1251 (82)	193 (15)	1.02 (0.87–1.19)	0.5	594 (39)	110 (18)	1.07 (0.87–1.32)	0.8	267 (17)	62 (23)	1.01 (0.76–1.35)	0.9
HoLEP/ThuLEP	8759	6366 (72)	705 (11)	0.69 (0.64–0.75)	**<0.001**	3230 (36)	409 (12)	0.68 (0.61–0.76)	**<0.001**	948 (10)	207 (21)	0.93 (0.79–1.09)	0.3
Simple prostatectomy	1009	765 (75)	41 (5.4)	0.32 (0.23–0.44)	**<0.001**	465 (46)	30 (6.5)	0.33 (0.23–0.48)	**<0.001**	170 (16)	16 (9.4)	0.36 (0.21–0.59)	**<0.001**
Aquablation	56	36 (63)	–	–	–	17 (30)	–	–	–	0	–	–	–

BPH = benign prostatic hyperplasia; CI = confidence interval; HoLEP = holmium laser enucleation of the prostate; ILC = intraprostatic laser coagulation; OR = odds ratio; PUL = prostatic urethral lift; PVP = photoselective vapourisation of the prostate; Rezūm = water vapour therapy; reTURP = repeated transurethral resection of the prostate; simple prostatectomy = open/laparoscopic/robot-assisted simple prostatectomy; ThuLEP = thulium laser enucleation of the prostate; TUIP = transurethral incision of the prostate; TUMT = transurethral microwave thermotherapy; TUNA = transurethral needle ablation; TURP = transurethral resection of the prostate.

Kaplan et al. [16], who reported comparable 5-yr medication rates between TURP and PVP. However, our data suggest that patients treated with PVP may be more likely to experience persistent or recurrent storage symptoms than those undergoing TURP.

Among MISTs, both PUL and Rezūm were associated with high rates of postoperative medication reinitiation. At 5 yr, α-blockers were resumed in 21% of PUL patients, 5-ARIs in 25%, and OAB medications in 27%, higher than those reported previously [16]. Rezūm showed comparable reinitiation rates: α-blockers in 18%, 5-ARIs in 18%, and OAB medications in 14%. All α-blocker and 5-ARI restart rates were significantly higher than that following TURP, and the elevated OAB medication rate among PUL patients underscores persistent storage symptoms despite intervention. Despite a decade of innovation in surgical management, TURP remains the most performed intervention in the USA and continues to serve as the benchmark for evaluating procedural outcomes. However, our analysis shows that anatomical approaches, such as HoLEP/ThuLEP and simple prostatectomy, are associated with superior procedural durability, as evidenced by the lowest retreatment and medication reinitiation rates.

In contrast, while MISTs, such as PUL and Rezūm, offer advantages in terms of reduced perioperative morbidity and faster recovery, these may fail to address the underlying anatomical obstruction adequately, predisposing to recurrence or incomplete symptom relief. Although the initial enthusiasm surrounding MISTs contributed to a rapid uptake in clinical practice, more recent utilisation trends reveal an unexpected decline. This reversal may likely reflect a growing recognition among clinicians of their limited long-term durability compared with enucleative or resective techniques.

It is important to interpret these findings in the context of observational research. The associations observed here do not imply causality. Specifically, the favourable outcomes associated with HoLEP/ThuLEP and simple prostatectomy may be influenced by patient selection; these procedures are often reserved for larger prostates or performed by high-volume specialists, factors that are associated with better outcomes. Conversely, MISTs are often offered to patients seeking to preserve sexual function or those unfit for more invasive surgery, potentially biasing the results against these therapies. These factors could not be measured or adjusted for in this study and may meaningfully influence the observed associations.

Certain limitations merit consideration. This is a retrospective study based on aggregated, deidentified electronic health records, which may be susceptible to misclassification or incomplete capture of the key clinical variables, such as geographic variations in practice patterns, insurance-driven selection bias, surgeon experience, baseline symptom severity, patient-reported outcome measures, prostate volume, institution characteristics, or urodynamic findings. The aggregated nature of the data restricted access to row-level patient timestamps, preventing the calculation of person-time or the use of time-to-event analyses such as Kaplan-Meier curves or Cox proportional hazard models. To mitigate the bias from varying follow-up durations, we employed a fixed-cohort design, restricting analyses to patients with sufficient follow-up opportunity; however, these rates represent a cumulative incidence in a closed population rather than actuarial survival probabilities. Consequently, our statistical comparisons are unadjusted and could not control for the influence of these potential confounders. Data regarding reasons for retreatment and specific indications for medication reinitiation were not available, nor were data on patient adherence or over-the-counter medication use, which may have led to over- or underestimation of rates. Our reliance on CPT codes introduced further limitations: early Rezūm procedures were not included due to CPT code unavailability, and we could not distinguish Greenlight laser enucleation of the prostate from standard PVP, as both procedures share the same code, which may act as a confounder for that group's outcomes. Techniques not coded reliably in the dataset, such as PAE and iTIND, were excluded. Additionally, limited longitudinal data precluded 5-yr retreatment analyses for Aquablation. While a 10-yr follow-up would offer deeper insights, we selected the 5-yr endpoint to ensure an adequately powered cohort, as extending the follow-up further would have limited the available patient numbers severely. Lastly, our "index procedure" may not represent the patient's first-ever BPH surgery, as procedures performed at nonparticipating institutions or before the study's start date would not be captured. This could lead to misclassification of a retreatment as an index procedure. Despite the large cohort size, residual confounding due to unmeasured variables cannot be ruled out. Future studies should focus on the long-term durability of MISTs.

5. Conclusions

In the evolving landscape of surgical management of BPH, our large-scale, real-world analysis provides critical comparative data on the long-term outcomes of traditional procedures and MISTs. While TURP remains the most performed procedure, patients undergoing anatomical approaches such as HoLEP, ThuLEP, and simple prostatectomy experienced the lowest retreatment rates and medication restart rates. In contrast, higher observed rates of retreatment and medication reinitiation were noted with MISTs, specifically PUL and Rezūm, raising concerns regarding their long-term durability.

As the use of MISTs declines following its initial widespread adoption, future research should clarify which clinical characteristics, prostate profiles, and treatment-selection pathways contribute to these observed differences.

Author contributions: Filippo Carletti had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Study concept and design: Carletti, Crivellaro.
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Analysis and interpretation of data: Carletti, Valenzi.
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Critical revision of the manuscript for important intellectual content: Carletti, Tamborino, Turcan, Santarelli, Valenzi, Morgantini, Haberal.
Statistical analysis: Carletti, Valenzi.
Obtaining funding: None.
Administrative, technical, or material support: None.
Supervision: Crivellaro, Dal Moro.
Other: None.

Financial disclosures: Filippo Carletti certifies that all conflicts of interest, including specific financial interests and relationships and affiliations relevant to the subject matter or materials discussed in the manuscript (eg, employment/affiliation, grants or funding, consultancies, honoraria, stock ownership or options, expert testimony, royalties, or patents filed, received, or pending), are the following: Simone Crivellaro is a consultant for Intuitive Surgical, Inc. All other authors have nothing to disclose.

***Funding/Support and role of the sponsor*:** None.

***Ethics statement*:** This study utilised deidentified patient data extracted from the Epic Cosmos platform and did not require institutional review board approval.

Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.euf.2026.01.003.

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Please cite this article as: F. Carletti, F. Tamborino, A. Turcan et al., Five-year Retreatment and Medication Restart Rates Following Benign Prostate Hyperplasia Treatments: A Nationwide Real-world Analysis Using Epic Cosmos, Eur Urol Focus (2026), https://doi.org/10.1016/j.euf.2026.01.003