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The impact of minimally invasive surgical therapy for Benign prostatic hyperplasia on sexual function: a systematic review and meta-analysis

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INTRODUCTION: Benign prostatic hyperplasia (BPH) and associated lower urinary tract symptoms (LUTS) can significantly impair a man's quality of life. While traditional surgical treatments are effective, they often pose risks to sexual function, particularly in the form of ejaculatory and/or erectile dysfunction. Minimally invasive surgical treatments (MISTs) have emerged as alternative procedures that aim to alleviate LUTS while preserving sexual function.

OBJECTIVE: Investigate the impact of MISTs for BPH on sexual function including erectile and ejaculatory function.

METHODS: In May 2025, a systematic review and meta-analysis of sexual function outcomes in MISTs was performed using the Ovid, Embase, and Medline/PubMed databases. Articles were included if they were in English, assessed a MIST, and incorporated sexual function outcomes. Articles were excluded if they included pooled analyses, were abstracts without full text, and/or were ongoing incomplete clinical trials. We included studies on water vapor thermal therapy (Rezum), prostatic urethral lift (Urolift), prostatic artery embolization (PAE), temporary implantable nitinol device (iTIND), Optilume BPH catheter system, and transperineal laser ablation (TPLA). Outcomes included erectile function using International Index of Erectile Function (IIEF) scores and ejaculatory function using the Male Sexual Health Questionnaire (MSHQ).

RESULTS: The initial search yielded 2646 studies. After screening and full text review, 77 studies met inclusion criteria encompassing a total of 11,477 patients. Based on the pooled analyses, IIEF scores significantly improved after Rezum and Urolift. Urolift significantly improved MSHQ-function and bother scores, while Rezum only improved MSHQ-bother scores. PAE, iTind, Optilume, and TPLA did not significantly impact erectile or ejaculatory function.

CONCLUSIONS: MISTs are a promising option for management of BPH in patients interested in maintaining sexual function, preserving or even improving erectile and ejaculatory function.

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INTRODUCTION

Benign prostatic hyperplasia (BPH) is a histologic diagnosis referring to the proliferation of smooth muscle, epithelial, and connective tissue in the transition zone of the prostate [1]. BPH is a highly prevalent disease in aging men, and is often associated with bothersome lower urinary tract symptoms (LUTS) due to prostatic enlargement and obstruction. Treatment of LUTS may involve medications (i.e., alpha blockers and/or 5-alpha-reductase inhibitors) and/or surgery. Historically, transurethral resection of the prostate (TURP) has been considered the gold standard surgical treatment for BPH with LUTS. Additional surgical options have included simple prostatectomy, holmium laser enucleation of the prostate (HoLEP), and photoselective vaporization of the prostate (PVP). While these treatments have been shown to be efficacious in terms of urinary symptoms, they can cause sexual side effects including ejaculatory dysfunction (EjD) and potential

worsening of erectile dysfunction (ED) [2]. Unlike medication-related sexual side effects, those associated with BPH surgeries are often permanent. The 2023 American Urological Association (AUA) BPH guidelines therefore highlight the importance of counseling patients regarding potential sexual side effects preoperatively [3].

Several procedures defined as minimally invasive surgical treatments (MISTs) have emerged, aiming to achieve similar functional outcomes while preserving sexual function. MISTs include water vapor thermal therapy (wVTT, Rezum), prostatic urethral lift (PUL, Urolift), prostatic artery embolization (PAE), the Optilume BPH catheter system, the temporary implantable nitinol device (iTIND), and transperineal laser ablation (TPLA). Often performed in outpatient settings under local anesthesia, these procedures typically offer shorter recovery times and less post-operative bleeding than traditional BPH surgeries [4]. Concerns regarding erectile function and preservation of antegrade

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ejaculation also make MISTs an appealing option for many patients. The aim of this systematic review was to evaluate and compare sexual function outcomes among contemporary MISTs.

METHODS

Search strategy and study selection

In May 2025, a systematic electronic search of the published English literature was performed to identify relevant articles discussing sexual function related to MISTs in patients with BPH. MISTs were defined based on the prior literature as BPH treatments which incorporate the ability to be performed in the outpatient setting, lack the need for general anesthesia, have minimal bleeding risk, allow for early postoperative recovery of daily activities, and have reduced impact on urinary and sexual function [4]. Accordingly, MISTs that were included in our review were: Urolift, iTIND, Optilume BPH, Rezum, PAE, and TPLA. While aquablation therapy has been shown to have favorable sexual outcomes compared to traditional surgeries, it was not incorporated into our review as it did not meet the criteria above to be defined as a MIST, which is consistent with prior literature [4, 5]. A comprehensive search strategy was developed alongside a medical librarian (N.N.). Indexing terms and keywords with truncation were combined using Boolean operators. The following databases were searched from inception until May 19th, 2025: Medline (Ovid), Embase (Ovid), Scopus, and Cochrane Library. Search terms included: "BPH" AND "prostatic urethral lift" or "urolift" or "iTIND" or "temporary implantable nitinol device" or "optilume" or "drug coated balloon" or "rezum" or "water vapor" or "prostate artery embolization" or "MIST" or "TPLA" or "transperineal laser ablation" AND "sexual dysfunction" or "sex" or "erect" or "ejaculat" or "anejaculat" or "orgasm" or "anorgasm."

After removal of duplicates, search results were independently screened and the titles and abstracts were assessed by two authors (EC and BL) based on inclusion criteria. A third author (RB) resolved conflicts. Full text of all titles that met screening criteria by a majority vote were obtained. Full text was then reviewed. Studies were included if they assessed patients with BPH who underwent Urolift, Rezum, iTIND, TPLA, PAE, or Optilume treatment and evaluated sexual outcomes including erectile and/or ejaculatory function. Randomized controlled trials (RCTs), prospective, and retrospective cohort studies were included. Reference lists from included papers were checked for other relevant studies. Reviews, case reports, and abstracts without full text were excluded. The complete PRISMA flow chart is available in Fig. 1.

This systematic review adhered to PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines and utilized the PICO (Population, Intervention, Outcomes) criteria [6, 7]. Studies were included if they assessed men with BPH and LUTS (P) undergoing MIST (I) with or without comparison (C) evaluating the impact on erectile and/or ejaculatory function (O). This systematic review was registered with PROSPERO (CRD420251074473). Covidence systematic review software was used to manage, screen, deduplicate, and document this systematic review (Veritas Health Innovation, Melbourne, Australia).

Data extraction and analysis

For each of the included studies, the relevant data of interest was collected in a dedicated data extraction form, including: title, first author's name, publication year, number of patients, MIST(s) studied, sexual function outcome measures, and sexual function results. For erectile function, outcomes included various iterations of the International Index of Erectile Function (IIEF) including the IIEF-15, IIEF-5 (also known as the Sexual Health Inventory for men (SHIM)), and IIEF-Erectile Function (EF). For ejaculatory function, outcomes included rate of retrograde ejaculation (RE) and Male Sexual Health Questionnaire (MSHQ-EjD) function and bother scores.

Meta-analyses of the included studies were performed using Review Manager 5.4 (RevMan v.5.4; Cochrane Collaboration, Oxford, UK). The pooled analyses were conducted on studies including postoperative measurement of IIEF-EF, MSHQ-EjD, or RE rate at 12 months for each MIST. Results were reported as mean and standard deviation (SD) or the percentage of patients with a particular outcome. For continuous variables reported as the median (range), results were converted to mean \pm SD [8]. In order to pool the effects within the same MIST, the weighted mean difference (WMD) and 95% confidence intervals (CIs) were estimated and pooled for each surgical technique. Pooled mean differences were determined using a random-effects model. The results were displayed as forest plots showing mean effect sizes and I^2 was used to assess heterogeneity between studies. Statistical significance was set at $p = 0.05$. Data not suitable for meta-analysis were presented narratively.

Risk of bias

The risk of bias and quality of studies included in the meta-analyses were independently assessed using the standard Cochrane Collaboration risk-of-bias tools including the Risk of Bias in Non-Randomized Studies of Interventions (ROBINS-I) tool for comparative studies and the revised Cochrane risk-of-bias tool of randomized trials (ROB 2) for RCTs (Supplementary 1) [9, 10].

RESULTS

Literature search

Our initial electronic search yielded 2646 articles. After removal 1292 duplicates, 1354 studies remained. Title and abstract screening excluded 1187 articles not relevant to the query. This left 167 articles for full-text review, of which 90 articles were excluded. Ultimately, 77 articles, with a total of 11,477 patients, met the inclusion criteria and were included in the review as shown in the PRISMA diagram (Fig. 1).

Selected studies

A summary of the 77 selected studies including study characteristics and sexual function outcomes can be found in Table 1 [11–87]. Of the 77 studies selected, 27 (35.1%) evaluated Rezum, 3 (3.9%) evaluated iTIND, 22 (28.6%) evaluated PAE, 2 (2.6%) evaluated Optilume, 19 (24.7%) evaluated Urolift, and 9 (9.1%) evaluated TPLA. 17 (22.1%) studies were randomized controlled trials, while 34 (44.2%) were prospective non-randomized trials, and 24 (31.2%) were retrospective. 11 (14.3%) studies compared a MIST to a traditional BPH surgery and 3 (3.9%) compared two MISTs to each other.

Assessment of sexual outcomes

The most commonly utilized validated questionnaire for erectile function was the IIEF in its various forms (i.e., IIEF-5, IIEF-15, or IIEF-EF), reported in 68 (88.3%) studies. For ejaculatory dysfunction, 35 (45.5%) studies reported on rate of retrograde ejaculation and 33 (42.9%) studies utilized the MSHQ function and/or bother scores.

Outcomes by MIST

Rezum. Rezum therapy has been shown to preserve or improve erectile function across multiple studies [40, 41, 43, 66]. Babar 2023 reported no differences in erectile function outcomes based on the number of injections administered (1–4) [21]. Hawks Ladds 2024 found that patients with baseline ED demonstrated significant improvement in IIEF-EF scores at 48 months, despite no early differences compared with those without baseline dysfunction [46]. Long term data from McVary and colleagues confirmed preservation of sexual function up to five years post-procedure [59–61]. In contrast, McVary 2018 observed worsening erectile outcomes among patients managed with medical therapy, while those undergoing Rezum

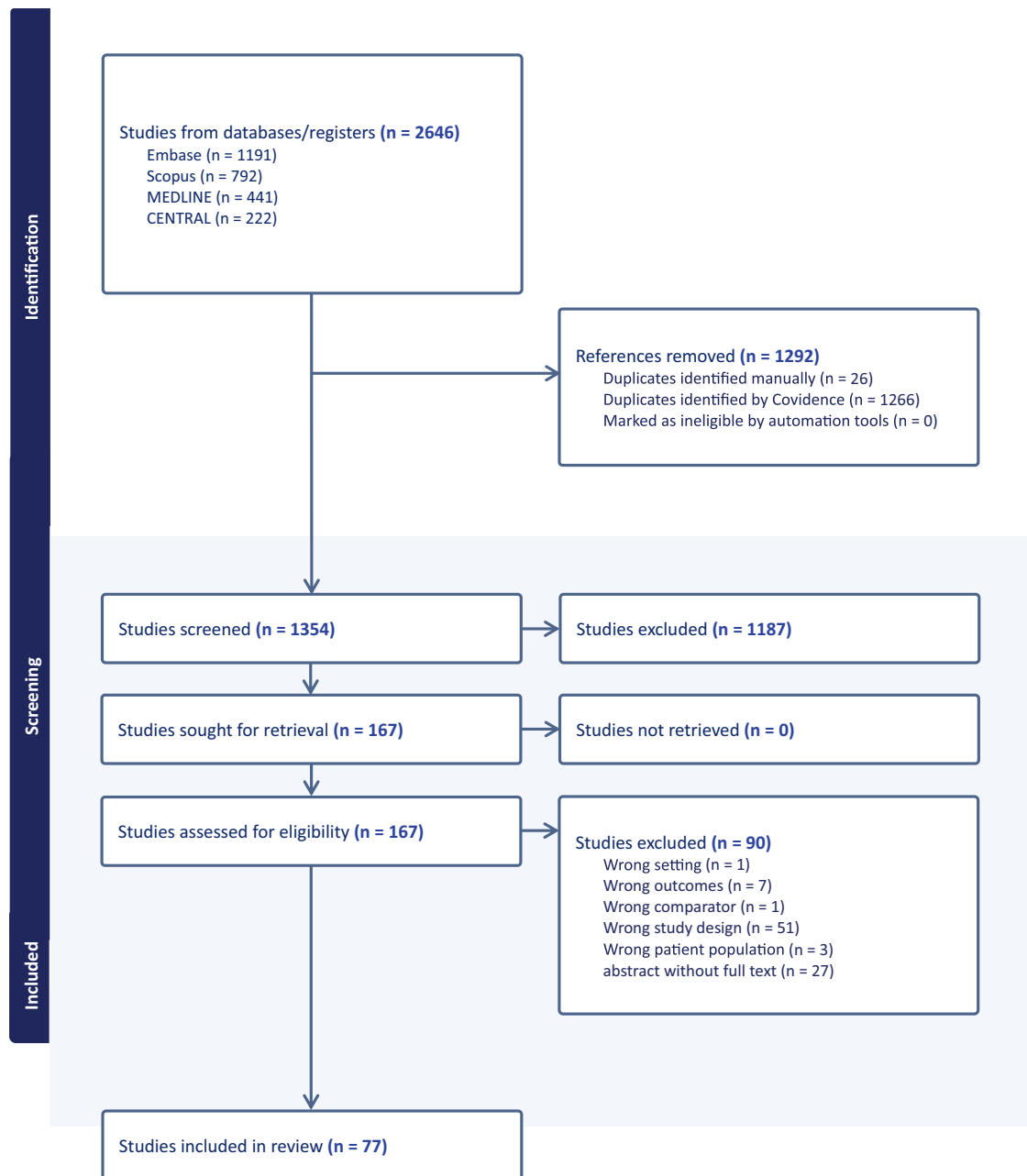


Fig. 1 PRISMA flow diagram for the systematic review. MIST therapies included Urolift, iTIND, Optilume BPH, Rezum, PAE, and TPLA. 1354 abstracts were screened leaving 167 full texts for review. 77 articles met inclusion criteria for the review.

maintained erectile and overall sexual function [62]. Similarly, Cindolo 2023 reported no significant differences in EF between patients who met versus did not meet 5-year RCT criteria (i.e., no history of urinary retention or previous prostate surgery, postvoid residual (PVR) < 250 mL, prostate volume > 30 mL and < 80 mL, no use of antiplatelet or anticoagulant medication, and few comorbidities) [32]. Alegorides 2020 and Dixon 2016 both noted stable EF with significant improvement in MSHQ bother scores at 1 and 2 years, respectively [14, 37]. Manfredi 2025 found comparable EF outcomes between Rezum and thulium laser enucleation of the prostate (ThuLEP) [57].

Ejaculatory function was also preserved or improved following Rezum in several studies. Campobasso 2023 and Minore 2025 reported increased rates of antegrade ejaculation post-treatment, likely related to medication discontinuation [27, 64]. McVary 2018 demonstrated maintenance of ejaculatory function

compared with deterioration in patients on medical therapy, while Cindolo 2023 observed no differences in ejaculatory outcomes between those who met the 5-year RCT criteria versus those who did not [32, 62]. In comparative analyses, Manfredi 2025 found Rezum significantly preserved ejaculation relative to THULEP, and Ozkaptan 2025 reported RE in over 94% of HoLEP patients versus 5% following Rezum [57, 67]. Additionally, Agüero 2025, Balsamo 2024 and Hawks Ladds 2024 found no significant differences in sexual outcomes between patients with large (> 80 g) and small (< 80 g) prostates [11, 23, 47].

Rezum IIEF pooled analysis: A meta-analysis was conducted on 14 studies [11, 14, 21–23, 27, 32, 37, 43, 46, 57, 64, 67, 76] ($n = 1505$ at baseline) to assess the change in IIEF scores following Rezum wVTT for BPH. The pooled estimate showed a statistically significant mean improvement in IIEF score of 1.26 (95% CI: -2.30

Table 1. Summary of included studies of MISTs and sexual function outcomes.

First Author	Year	Procedure	Comparison	sample size	Follow up	study design	erectile function		ejaculatory function			Post-op % RE
							Pre-op IIEF (15*, 5#, EF) (Median (IQR) / Mean ± SD)	Post-op IIEF (15*, 5#, EF) (Median (IQR) / Mean ± SD)	Pre-op MSHQ-EjD (F, B) (Median (IQR) / Mean ± SD)	Post-op MSHQ-EjD (F, B) (Median (IQR) / Mean ± SD)	Post-op MSHQ-EjD (F, B) (Median (IQR) / Mean ± SD)	
Agüero [11]	2025	Rezüm	prostate size <80 g versus >80 g	131	12 months	Retrospective cohort	<80 g: 19 (18.5–23)# >80 g: 23 (18–24)# p = 0.51	<80 g: 22 (19–23)# >80 g: 22 (18–24)# p = 0.42	N/A	N/A	N/A	<80 g: 5% >80 g: 4% p = 0.1
Ahn [12]	2022	Urolift	healthy patients versus those with multiple comorbidities	66	24 months	Retrospective cohort	Healthy: 15.8 ± 6.6# High comorbidity: 9.4 ± 6.8# p = 0.001	Healthy: 16.2 ± 5.7# High comorbidity: 13 ± 5.2# p > 0.05	Healthy: 11.1 ± 3.8 (F), 1.6 ± 1.3 (B) High comorbidity: 9.8 ± 3.3 (F), 1.4 ± 0.9 (B) p > 0.05	Healthy: 10.9 ± 2.6 (F), 1.6 ± 1.3 (B) High comorbidity: 9.2 ± 3 (F), 1.4 ± 0.9 (B) p > 0.05	N/A	N/A
Aledesuru [13]	2022	Rezüm	N/A	52	12 months	Retrospective cohort	N/A	N/A	N/A	N/A	N/A	1.90%
Alegorides [14]	2020	Rezüm	N/A	65	12 months	Retrospective cohort	19.4 ± 5.5#	19.4 ± 5.6# p > 0.05	8.6 ± 4.9 (F), 2.0 ± 1.7 (B)	10 ± 3.5 (F), 0.9 ± 1.1 (B) F: p > 0.05 B: p = .008	N/A	10.80%
Alrawashdash [15]	2020	PAE	N/A	147	18 months	Prospective, non-randomized	21.3 ± 0.5#	23.46 ± 2.04# p < 0.001	N/A	N/A	N/A	11.50%
Al-Singary [16]	2022	Urolift	N/A	51	24 months	Retrospective cohort	N/A	N/A	N/A	N/A	N/A	0%
Amparore [17]	2021	tiTind	N/A	81	36 months	Prospective, non-randomized	N/A	N/A	N/A	N/A	N/A	4%
Anan [18]	2025	Urolift	N/A	160	3 months	Retrospective cohort	16.4 ± 4.5#	16.1 ± 5.0# p > 0.05	N/A	N/A	N/A	N/A
Annese [19]	2024	Urolift	N/A	20	12 months	Prospective, non-randomized	22 (20–25)#	23 (21–25)# p > 0.05	12 (11–13) (F)	12 (12–13) (F) p > 0.05	N/A	0%
Annese [20]	2021	Urolift	N/A	35	12 months	Retrospective cohort	20 (19.2–22.8) #	21 (21–24)# p > 0.05	11 (9.25–12) (F)	12 (10–13) (F)	N/A	0%
Babar [21]	2023	Rezüm	# injections (1, 2, 3 or 4)	179	12 months	Retrospective cohort	1 injection: 15.9 ± 8.3' 2 injections: 16.4 ± 8.5' 3 injections: 13.9 ± 8.2' 4 injections: 16.8 ± 9.1' 15.3 ± 0.7'	1 injection: 12.8 ± 10.4' 2 injections: 21.9 ± 12.2' 3 injections: (p < 0.05) 11.7 ± 7.6' 15.3 ± 0.7'	N/A	N/A	N/A	N/A
Baboudjian [22]	2021	Urolift	Rezüm	117	12 months	Retrospective cohort	Rezüm: 21 (19–23)# Urolift: 20 (16–22)#	Rezüm: 22 (20–23)# Urolift: 21 (20–23)# p > 0.05	Rezüm: 11 (8–13) (F) Urolift: 11 (9–13) (F)	Rezüm: 12 (10–14) (F) Urolift: 13 (11–14) (F) p > 0.05	N/A	Rezüm: 1.6% Urolift: 0%
Balsamo [23]	2024	Rezüm	prostate size <80 g versus >80 g	121	3 months	Prospective, non-randomized	<80 g: 15.56 ± 5.92# >80 g: 12.3 ± 7.42#	<80 g: 13.21 ± 2.8# >80 g: 20.24 ± 12.3#	N/A	N/A	N/A	<80 g: 1.4% >80 g: 5.8%

Table 1. continued

First Author	Year	Procedure	Comparison	sample size	Follow up	study design	erectile function		ejaculatory function			Post-op % RE
							Pre-op IIEF (15*, 5#, EF) / (Median (IQR) / Mean ± SD)	Post-op IIEF (15*, 5#, EF) / (Median (IQR) / Mean ± SD)	Pre-op MSHQ-EjD (F, B) / (Median (IQR) / Mean ± SD)	Post-op MSHQ-EjD (F, B) / (Median (IQR) / Mean ± SD)	Pre-op % RE	
Bertolo [24]	2022	PAE	N/A	52	14 months	Retrospective cohort	N/A	N/A	N/A	N/A	N/A	0%
Bertolo [25]	2023	TPLA	TURP	51	1 month	Randomized controlled trial	TPLA: 17 (15–21)# TURP: 20 (16–20.5)#	TPLA: 18 (14–23)# TURP: 19 (18–23)#	TPLA: 29 (25–30) (F) TURP: 20 (10–25) (F) <i>p</i> < 0.05	TPLA: 29 (25–30) (F) TURP: 20 (10–25) (F) <i>p</i> < 0.001	N/A	TPLA: 3.8% TURP: 72% <i>p</i> < 0.001
Bhatia [26]	2022	PAE	N/A	167	12 months	Retrospective cohort	17 (12–22)#	20 (16–24)# <i>p</i> > 0.05	N/A	N/A	N/A	N/A
Campobasso [27]	2023	Rezum	N/A	262	12 months	Retrospective cohort	17.4 ± 6.5#	17.2 ± 7.4 <i>p</i> > 0.05	N/A	N/A	43.50%	21.8% (<i>p</i> < 0.001)
Canat [28]	2023	TPLA	TURP	50	12 months	Randomized controlled trial	TPLA: 14.84 ± 3.93# TURP: 14.17 ± 4.09#	TPLA: 14.68 ± 3.92# TURP: 13.44 ± 4.53# <i>p</i> > 0.05	TPLA: 10.75 ± 2.42 (F); 2.92 ± 0.9 (B) TURP: 11.07 ± 1.87 (F); 3.33 ± 0.72 (B) <i>p</i> < 0.05	TPLA: 10.33 ± 2.31 (F); 2.83 ± 1.03 (B) TURP: 5.93 ± 4.01 (F); 1.8 ± 0.94 (B) <i>p</i> < 0.05	N/A	N/A
Cantwell [29]	2014	Urolift	sham control	53	3 months	Randomized controlled trial	16 ± 6.7#	16.3 ± 8.2# <i>p</i> > 0.05	8.9 ± 3.6 (F); 2.5 ± 1.7 (B)	9.9 ± 3.7 (F); 2.1 ± 1.6 (B)	N/A	N/A
Carnevale [30]	2016	PAE	TURP; original PAE	45	12 months	Randomized controlled trial	Perfected PAE: 17.3 ± 5.3# Original PAE: 14.3 ± 6.8# TURP: 12.5 ± 6.6#	Perfected PAE: 18.7 ± 3.2# Original PAE: 12.6 ± 7.7# TURP: 16.1 ± 5.7#	N/A	N/A	N/A	Perfected PAE: 6.7% reduced ejaculate volume Original PAE: 13.3% reduced ejaculate volume TURP: 100% RE
Chin [31]	2022	Rezum	Urolift	417	12 months	Retrospective cohort	Rezum: 15.6 ± 7.2# Urolift: 12.4 ± 8.3#	Rezum: 5.7 ± 5.7# Urolift: 13.3 ± 7.4#	N/A	N/A	N/A	Rezum: 1.6% Urolift: 0.9%
Cindolo [32]	2023	Rezum	Those who matched 5-year RCT criteria (A) vs. those who did not (B)	426	A: 17 months B: 15 months	Prospective, non-randomized	A: 20 (16–22)# B: 19 (15–22)#	A: 22 (20–23)# B: 22 (18–24)#	N/A	N/A	A: 65.5% B: 61.8%	A: 11.6% B: 14.4%
Copelan [33]	2025	Optilume	sham control	122	12 months	Randomized controlled trial	Optilume: 21.5 ± 9 Sham: 19 ± 7	Optilume: 23.1 ± 8.4 Sham: 26.6 ± 3.5' <i>p</i> > 0.05	Optilume: 9.1 ± 3.9 (F); 1.9 ± 1.6 (B) Sham: 9.3 ± 3.2 (F); 1.8 ± 1.7 (B) <i>p</i> > 0.05	Optilume: 10.1 ± 4.3 (F); 1.5 ± 1.4 (B) Sham: 11.1 ± 2.9 (F); 1.6 ± 1.8 (B) <i>p</i> > 0.05	N/A	N/A

Table 1. continued

First Author	Year	Procedure	Comparison	sample size	Follow up	study design	erectile function		ejaculatory function		Post-op % RE	Post-op % RE
							Pre-op IIEF (15#, 5#, EF) (Median (IQR) / Mean \pm SD)	Post-op IIEF (15#, 5#, EF) (Median (IQR) / Mean \pm SD)	Pre-op MSHQ-EJ-D (F, B) (Median (IQR) / Mean \pm SD)	Post-op MSHQ-EJ-D (F, B) (Median (IQR) / Mean \pm SD)		
Delazar [34]	2025	PAE	N/A	46	12 months	Prospective, non-randomized	17 \pm 2.2#	19 \pm 0.9#	N/A	N/A	N/A	N/A
DeNunzio [35]	2021	tTind	N/A	70	6 months	Prospective, non-randomized	16.1 \pm 7.7#	18.2 \pm 8.2# <i>p</i> < 0.05	9.2 \pm 4.9 (F)	11.2 \pm 4.8 (F) <i>p</i> < 0.01	N/A	N/A
DeRienzo [36]	2021	TPLA	N/A	21	6 months	Prospective, non-randomized	17.8 \pm 6.6#	18.3 \pm 5.7#	5.7 \pm 4.5 (F); 1.2 \pm 0.5 (B)	8.6 \pm 3.1 (F); 1.4 \pm 0.8 (B)	N/A	N/A
Dixon [37]	2016	Rezum	N/A	65	24 months	Prospective, non-randomized	13.3 \pm 12*	15.5 \pm 11.5* <i>p</i> < 0.05	5.9 \pm 4.8 (F); 2.3 \pm 2.3 (B)	7 \pm 4.8 (F); 0.8 \pm 0.5 (B) <i>p</i> < 0.05	N/A	N/A
Dogan [38]	2022	PAE	N/A	30	12 months	Prospective, non-randomized	8.25 \pm 0.67#	8.45 \pm 0.7#	N/A	N/A	N/A	N/A
Elterman [39]	2023	tTind	sham control	185	12 months	Randomized controlled trial	iTind: 13.2 \pm 7.3# Sham: 14.2 \pm 6.6#	iTind: 13.13 \pm 7.88 Sham: 13 \pm 7.72 <i>p</i> > 0.05	N/A	N/A	N/A	0%
Elterman [40]	2022	Rezum	N/A	83	12 months	Prospective, non-randomized	40.7 \pm 21*	57.1 \pm 17.6* <i>p</i> > 0.05	8.5 \pm 3.5 (F); 1.8 \pm 1.5 (B)	10.1 \pm 4 (F); 1.3 \pm 1.3 (B) <i>p</i> > 0.05	N/A	N/A
Elterman [41]	2022	Rezum	N/A	229	12 months	Prospective, non-randomized	45.3 \pm 19.3*	52.9 \pm 19* <i>p</i> > 0.05	9.8 \pm 4.4 (F); 1.8 \pm 1.5 (B)	9.4 \pm 4 (F); 1.6 \pm 1.4 (B) <i>p</i> > 0.05	N/A	N/A
Frego [42]	2021	TPLA	N/A	22	12 months	Prospective, non-randomized	22 (16.5–24)#	21.5 (17.25–23.75)# <i>p</i> < 0.05	N/A	N/A	N/A	4.50%
Ghahhari [43]	2022	Rezum	N/A	84	18 months	Retrospective cohort	17.6 \pm 7.1#	22 \pm 3.5# <i>p</i> < 0.05	N/A	N/A	N/A	4.70%
Gonzalez [44]	2025	Urolift	Continued medical therapy	136	6 months	Prospective, non-randomized	Urolift: 14.5 \pm 0.8# Control: 15.8 \pm 1.11#	Urolift: 13.78 \pm 0.84# Control: 15.41 \pm 1.16#	Urolift: 6.85 \pm 0.51 (F); 2.04 \pm 0.17 (B) Control: 8.7 \pm 0.69 (F); 1.36 \pm 0.23 (B)	Urolift: 9.1 \pm 0.53 (F); 1.81 \pm 0.17 (B) Control: 7.98 \pm 0.73 (F); 1.45 \pm 0.24 (B)	N/A	N/A
Gratzke [45]	2017	Urolift	TURP	80	24 months	Randomized controlled trial	Urolift: 20.3 \pm 4.3# TURP: 17.6 \pm 6.2#	Urolift: 20.3 \pm 5.6# TURP: 16.7 \pm 7.3#	Urolift: 10.6 \pm 2.6 (F); 1.8 \pm 1.8 (B) TURP: 8.6 \pm 2.5 (F); 1.9 \pm 1.7 (B)	Urolift: 10.9 \pm 3.3 (F); 1.3 \pm 1.4 (B) TURP: 4.9 \pm 4.6 (F); 1.7 \pm 1.4 (B)	N/A	Urolift: 0% TURP: 34%
Hawks-Ladds [46]	2024	Rezum	Patients with versus without baseline ED	91	48 months	Retrospective cohort	No ED: 19 (13–20) ED: 13 (8.3–17)	No ED: 29 (24–30) ED: 24 (15–30)	N/A	N/A	N/A	N/A

Table 1. continued

First Author	Year	Procedure	Comparison	sample size	Follow up	study design	erectile function		ejaculatory function			Pre-op % RE	Post-op % RE
							Pre-op IIEF (15*, 5#, EF) / (Median (IQR) / Mean \pm SD)	Post-op IIEF (15*, 5#, EF) / (Median (IQR) / Mean \pm SD)	Pre-op MSHQ-EJD (F, B) (Median (IQR) / Mean \pm SD)	Post-op MSHQ-EJD (F, B) (Median (IQR) / Mean \pm SD)	Post-op IIEF (15*, 5#, EF) / (Median (IQR) / Mean \pm SD)		
Hawks-Ladds [47]	2024	Rezum	Patients with prostate volume <30 g, 30–80 g, >80 g	252	12 months	Retrospective cohort	<30 g: 16.5 (9.5–23.5) 30–80 g: 16 (11–21) >80 g: 17 (9.5–26)	<30 g: 14.5 (6.8–23) 30–80 g: 12 (3.8–24) >80 g: 17.5 (10–25)	N/A	N/A	N/A	N/A	N/A
Jankauskas [48]	2023	PAE	N/A	70	6 months	Prospective, non-randomized	1.79 \pm 4.49#	2.14 \pm 4.57# p > 0.05	N/A	N/A	N/A	N/A	N/A
Kaplan [49]	2024	Optilume	sham control	148	24 months	Randomized controlled trial	15.6 \pm 10.3#	20.4 \pm 10.2#	7.5 \pm 3.9 (F); 2.5 \pm 1.7 (B)	8.6 \pm 4.6 (F); 1.8 \pm 1.6 (B)	N/A	N/A	N/A
Kato [50]	2024	Urolift	N/A	120	1.5 months	Prospective, non-randomized	4 (2–7)#	N/A	N/A	N/A	N/A	N/A	0%
Kim [51]	2020	Urolift	N/A	32	12 months	Retrospective cohort	18.8 \pm 4.7#	17.9 \pm 4.5# p > 0.05	N/A	N/A	N/A	N/A	0%
Lim [52]	2025	PAE	HoLEP	108	3 months	Prospective, non-randomized	PAE: 9.8 \pm 3.8# HoLEP: 8.8 \pm 4.5#	PAE: 14.8 \pm 3# (p < 0.05) HoLEP: 7.7 \pm 3.3# (p < 0.05)	PAE: 10.1 \pm 1.7 (F) (p < 0.05) HoLEP: 6.4 \pm 2.7 (F) (p > 0.05)	N/A	N/A	N/A	N/A
Lin [53]	2016	PAE	N/A	18	3 months	Prospective, non-randomized	49.9 \pm 22.5*	50.1 \pm 24.4* p > 0.05	N/A	N/A	N/A	N/A	0%
Loffroy [54]	2024	PAE	N/A	103	6 months	Prospective, non-randomized	15.8 \pm 6.8#	15.3 \pm 6.8# >0.05	N/A	N/A	N/A	N/A	N/A
Lombardo [55]	2024	Urolift	N/A	20	6 months	Prospective, non-randomized	23 (21–25)#	22 (21–25)# p > 0.05	10 (3–13) (F)	12.5 (6–14) (F) p < 0.05	N/A	N/A	N/A
LongDepaquit [56]	2025	Rezum	Urolift	60	3 months	Retrospective cohort	Rezum: 22 (21–23)# Urolift: 24 (23–24)#	Rezum: 22 (21–23)# Urolift: 24 (23–24)#	N/A	N/A	N/A	N/A	Rezum: 12% Urolift: 8%
Manfredi [57]	2025	Rezum	ThuLEP	246	12 months	Prospective, non-randomized	Rezum: 20.3 \pm 3.7# ThuLEP: 19.6 \pm 3.9#	Rezum: 24.1 \pm 2.8# ThuLEP: 23.8 \pm 3.3#	Rezum: 6.5 \pm 3.1 (F); 1.5 \pm 1 (B) ThuLEP: 6 \pm 2.4 (F); 3 \pm 1 (B)	Rezum: 11.2 \pm 3 (F); 1.5 \pm 1 (B) ThuLEP: 5.4 \pm 2.3 (F); 3 \pm 1 (B)	N/A	N/A	Rezum: 4.2% ThuLEP: 88.9%
Marzano [58]	2020	PAE	N/A	50	6 months	Retrospective cohort	56.1 \pm 13.5*	58 \pm 13.8* p > 0.05	N/A	N/A	N/A	N/A	N/A
McVary [59]	2021	Rezum	sham control	125	60 months	Randomized controlled trial	22.6 \pm 7.4'	21 \pm 10.2' p < 0.05	9.4 \pm 3.3 (F); 2.1 \pm 1.7 (B)	8.4 \pm 4.5 (F); 1.6 \pm 1.7 (B)	N/A	N/A	N/A
McVary [60]	2016	Rezum	sham control	197	12 months	Randomized controlled trial	Rezum: 22.6 \pm 7.4' Control: 21.2 8.3'	Rezum: 22.7 \pm 8.4' Control: 21 \pm 9.1'	Rezum: 9.3 \pm 3.1 (F); 2.2 \pm 1.7 (B) Control: 9.8 \pm 3.6 (F); 2 \pm 1.7 (B)	Rezum: 9.7 \pm 4.5 (F); 1.8 \pm 1.7 (B) Control: 9.6 \pm 4.3 (F); 1.8 \pm 1.8 (B)	N/A	N/A	Rezum: 2.9% Control: 0%

Table 1. continued

First Author	Year	Procedure	Comparison	sample size	Follow up	study design	erectile function		ejaculatory function		Post-op % RE	
							Pre-op IIEF (15%, 5#, EF) (Median (IQR) / Mean ± SD)	Post-op IIEF (15%, 5#, EF) (Median (IQR) / Mean ± SD)	Pre-op MSHQ-EjD (F, B) (Median (IQR) / Mean ± SD)	Post-op MSHQ-EjD (F, B) (Median (IQR) / Mean ± SD)		
McVary [61]	2021	Rezum	sham control	135	60 months	Randomized controlled trial	22.7 ± 7.4'	21.1 ± 10.2'	9.3 ± 3.1 (F); 2.2 ± 1.7 (B)	8 ± 4.4 (F); 1.7 ± 1.7 (B)	N/A	N/A
McVary [62]	2018	Rezum	medical therapy	1563	36 months	indirect comparison using two cohorts from randomized trials	17.2 ± 10.2'	p > 0.05	7.7 ± 4.1 (F); 2.6 ± 1.7 (B)	p > 0.05	N/A	N/A
Minafra [63]	2023	TPLA	N/A	20	36 months	Prospective, non-randomized	17 (15–21)#	17 (15–20)# p > 0.05	4 (3–8) (F)	11 (7–12) (F) p < 0.05	N/A	N/A
Minore [64]	2025	Rezum	N/A	10	12 months	Prospective, non-randomized	21 (17–23)#	22 (20–24)# p > 0.05	N/A	N/A	40%	0%
Mullhaupt [65]	2024	PAE	TURP	103	60 months	Randomized controlled trial	PAE: 15.2# TURP: 13.1#	PAE: 18.8# TURP: 12.6 p > 0.05	N/A	N/A	N/A	N/A
Nguyen [66]	2024	Rezum	N/A	20	6 months	Prospective, non-randomized	46 ± 7.4*	48 ± 10.3* p > 0.05	11 ± 0.8 (F)	11 ± 1.1 (F) p > 0.05	N/A	N/A
Ozkaptan [67]	2025	Rezum	HoLEP	338	12 months	Retrospective cohort	Rezum: 14.7 ± 3.6# HoLEP: 12.1 ± 5.6#	Rezum: 14.9 ± 4.6# HoLEP: 14.2 ± 2.2#	N/A	N/A	N/A	Rezum: 5.34% HoLEP: 94.6%
Patel [68]	2021	PAE	N/A	80	12 months	Retrospective cohort	14.3 ± 6.5#	15.5 ± 7.7# p > 0.05	N/A	N/A	N/A	N/A
Pisco [71]	2013	PAE	N/A	255	30 months	Prospective, non-randomized	18.9 ± 8.73#	20.1#	N/A	N/A	N/A	0%
Pisco [70]	2016	PAE	N/A	630	72 months	Retrospective cohort	18.5 ± 8.08#	19.77 ± 5.86# p > 0.05	N/A	N/A	N/A	N/A
Pisco [69]	2013	PAE	N/A	89	24 months	Prospective, non-randomized	18.3 ± 8.73#	21.57#	N/A	N/A	N/A	N/A
Richardson [72]	2025	PAE	traditional versus coil embolization	878	24 months	Retrospective cohort	Traditional: 17 (10–21)# Coil: 13 (8–20)#	Traditional: 18 (15–22)# Coil: 18 (15–18)#	N/A	N/A	N/A	N/A
Roehrborn [73]	2017	Urolift	sham control	206	12 months	Randomized controlled trial	16.28 ± 7.12#	16.69 ± 7.76# p > 0.05	8.92 ± 3.08 (F); 2.15 ± 1.65 (B)	10.25 ± 3.16 (F); 1.43 ± 1.37 (B) p < 0.05	N/A	N/A
Roehrborn [74]	2022	Urolift	medical therapy	188	24 months	indirect comparison using two cohorts from randomized trials	16.1 ± 7.4#	p < 0.05	8.9 ± 3.1 (F)	p < 0.05	N/A	N/A
Salem [75]	2018	PAE	N/A	45	12 months	Prospective, non-randomized	N/A	N/A	9.7 ± 3.1 (F)	9.9 ± 2.8 (F) p > 0.05	N/A	N/A

Table 1. continued

First Author	Year	Procedure	Comparison	sample size	Follow up	study design	erectile function		ejaculatory function		Pre-op % RE	Post-op % RE
							Pre-op IIEF (15*, 5#, EF) / (Median (IQR) / Mean ± SD)	Post-op IIEF (15*, 5#, EF) / (Median (IQR) / Mean ± SD)	Pre-op MSHQ-EjD (F, B) (Median (IQR) / Mean ± SD)	Post-op MSHQ-EjD (F, B) (Median (IQR) / Mean ± SD)		
Samir [76]	2024	Rezum	TURP	100	24 months	Randomized controlled trial	Rezum: 12.6 ± 5.3# TURP: 13 ± 6#	Rezum: 13.6 ± 4.6# TURP: 11.5 ± 5.1#	N/A	N/A	N/A	Rezum: 2% TURP: 80%
Sapoval [77]	2023	PAE	medical therapy	90	9 months	Randomized controlled trial	PAE: 39.1 ± 21.9* Medical therapy: 44.9 ± 22.3*	PAE: 48.6 ± 21* Medical therapy: 41 ± 22*	N/A	N/A	N/A	N/A
Sessa [78]	2022	TPLA	N/A	38	12 months	Prospective, non-randomized	15 (7-24)#	18 (9-22)#	6 (2-10) (F); 3 (2-4) (B)	8 (7-11) (F); 2 (2-3) (B)	N/A	N/A
Sheba [79]	2025	Urolift	TURP	200	12 months	Randomized controlled trial	N/A	N/A	N/A	N/A	N/A	Urolift: 0% TURP: 90%
Siena [80]	2021	Rezum	N/A	135	6 months	Prospective, non-randomized	20 (16-22)#	23.5 (21-25.5) # <i>p</i> < 0.05	N/A	N/A	N/A	N/A
Sonksen [81]	2015	Urolift	TURP	79	12 months	Randomized controlled trial	Urolift: 20 ± 4.9# TURP: 18 5.5#	Urolift: 20.7 ± 5.2# TURP: 17.7 6.3#	Urolift: 11 ± 2.7 (F); 1.7 ± 1.8 (B) TURP: 9 ± 2.3 (F); 2 ± 1.5 (B)	Urolift: 11.9 ± 3 (F); 1.2 ± 1.1 (B) TURP: 5.6 ± 4 (F); 2 ± 1.3 (B)	N/A	N/A
Theurich [82]	2022	PAE	N/A	351	24 months	Prospective, non-randomized	N/A	<i>p</i> > 0.05	N/A	N/A	N/A	N/A
Thulasidasan [83]	2019	PAE	N/A	156	12 months	Prospective, non-randomized	14.8 ± 7.4#	16.3 ± 6.9# <i>p</i> > 0.05	N/A	N/A	N/A	N/A
Totaro [84]	2025	Rezum	N/A	84	24 months	Prospective, non-randomized	N/A	<i>p</i> > 0.05	N/A	N/A	N/A	2%
vankollenburg [85]	2024	TPLA	N/A	20	12 months	Prospective, non-randomized	35.4 ± 23.6*	31.1 ± 24.4* <i>p</i> > 0.05	N/A	N/A	N/A	15%
Woo [86]	2012	Urolift	N/A	64	12 months	Prospective, non-randomized	18.2 ± 4.9#	19.4 ± 5.3# <i>p</i> > 0.05	10.6 ± 2.1 (F); 1.5 ± 1.4 (B)	11.1 ± 2.9 (F) (<i>p</i> > 0.05); 0.8 ± 0.9 (B) (<i>p</i> < 0.05)	N/A	N/A
Young [87]	2022	PAE	N/A	39	12 months	Retrospective cohort	N/A	N/A	11.4 ± 5.3 (F); 0.82 ± 1.1 (B)	11.4 ± 5.3 (F); 0.82 ± 1.1 (B)	N/A	10.30%

HoLEP holmium laser enucleation of the prostate, IIEF international index of erectile function, MSHQ-EjD male sexual health questionnaire- ejaculatory dysfunction (F= function score, B= bother score), PAE prostate artery embolization, RE retrograde ejaculation, SD standard deviation, ThuLEP thulium laser enucleation of the prostate, TPLA transperineal laser ablation, TURP transurethral resection of the prostate.

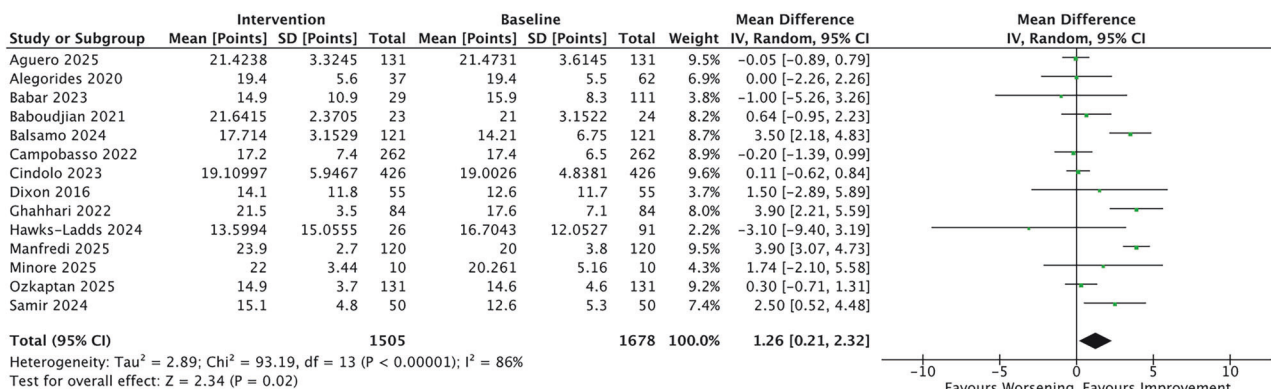


Fig. 2 IIEF 12 months after Rezum for BPH. BPH Benign prostatic hyperplasia, CI confidence interval, df degree of freedom, IIEF international index of erectile function, IV inverse variance.

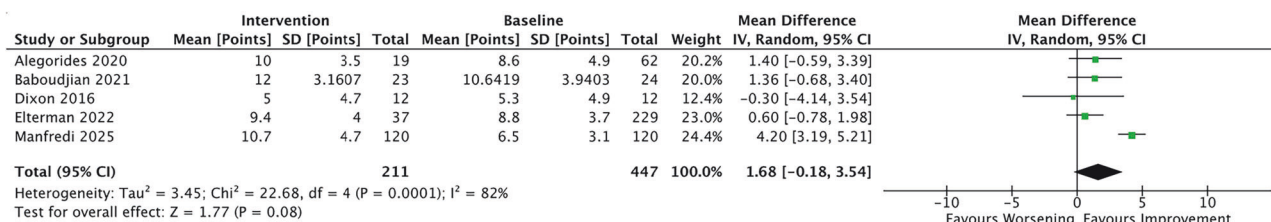


Fig. 3 MSHQ-EjD 12 months after Rezum for BPH. BPH Benign prostatic hyperplasia, CI confidence interval, df degree of freedom, IV inverse variance, MSHQ-EjD male sexual health questionnaire—ejaculatory dysfunction.

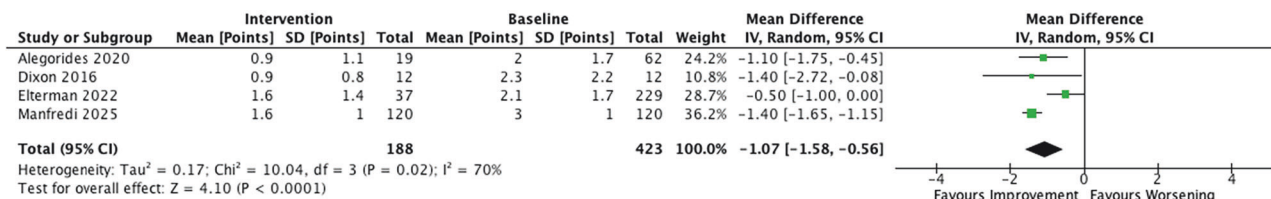


Fig. 4 MSHQ—Bother 12 months after Rezum for BPH. BPH Benign prostatic hyperplasia, CI confidence interval, df degree of freedom, IV inverse variance, MSHQ-Bother male sexual health questionnaire—bother score.

to -0.18 ; $p = 0.02$) at 12 months. The total change is displayed in the forest plot (Fig. 2). Significant statistical heterogeneity was observed across the included studies, with an I^2 value of 86% and a Chi [2] value of 93.19 (df = 13, $p < 0.00001$). The substantial heterogeneity suggests that the true effect size varies significantly among the studies, likely due to differences in patient characteristics, follow-up duration, or measurement protocols. The Tau [2] was 2.89, which is also indicative of high true variance between studies. While the overall pooled effect showed a small increase, the effect sizes varied substantially among individual studies, ranging from a mean difference of 3.90 (Manfredi 2025) [57] to -3.10 (Hawks-Ladds 2024) [46]. Four studies (Manfredi 2025 [57], Ghahhari 2022 [43], Balsamo 2024 [23], and Samir 2024 [76]) reported a statistically significant improvement. The remaining studies reported changes that were not statistically significant [11, 14, 21, 22, 27, 32, 37, 46, 64].

Rezum MSHQ-EjD pooled analysis: For MSHQ—EjD scores, a meta-analysis of five studies [14, 22, 37, 41, 57], encompassing 211 patients in the intervention arm, was conducted to assess the change in MSHQ-EjD function score at 12 months after the procedure. The pooled mean difference was calculated at 1.68 points (95% CI: -0.18 to 3.54), which did not achieve statistical significance ($Z = 1.77$, $p = 0.08$), suggesting no robust evidence for a definitive overall change in this outcome following the Rezum procedure. (Fig. 3) Significant statistical heterogeneity was

observed across the included studies ($I^2 = 82\%$, $Chi^2 = 22.68$, $p = 0.0001$, indicating substantial variability in effect size among the trials. While one study (Manfredi 2025 [57]) reported a large, statistically significant improvement (4.20 points, 95% CI: 3.19–5.21), the non-significant pooled result highlights that this positive effect was not consistently demonstrated across the meta-analysis.

Rezum MSHQ-bother pooled analysis: For MSHQ –bother sub-score, a meta-analysis was conducted on four studies [14, 37, 41, 57] ($n = 188$ patients) to assess the change in MSHQ-EjD Bother. The pooled mean difference of -1.07 points (95% CI: -1.58 to -0.56) indicates a statistically significant overall improvement in this specific sub-score following the Rezum procedure ($Z = 4.10$, $p < 0.0001$) (Fig. 4). Moderate statistical heterogeneity was observed ($I^2 = 70\%$, $p = 0.02$). Furthermore, all four individual studies reported a decrease in score, and three of the four (Alegorides 2020 [14], Dixon 2016 [37], and Manfredi 2025 [57]) reported a statistically significant improvement, supporting the conclusion of a significant aggregate improvement in this sexual function outcome.

Urolift. Several studies showed no difference in erectile or ejaculatory function post-urolift [16, 19, 20, 29, 51, 55]. Ahn 2022 found that Urolift did not impact erectile or ejaculatory function in patients who were healthy or in those with high comorbidities

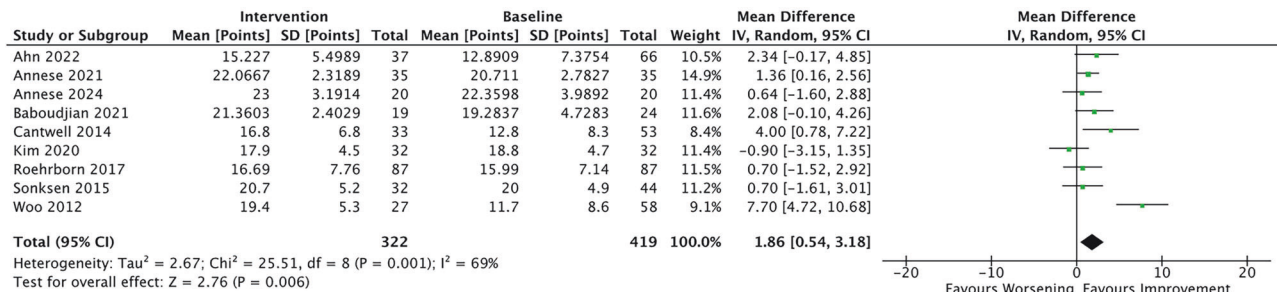


Fig. 5 IIEF 12 months after Urolift for BPH. BPH Benign prostatic hyperplasia, CI confidence interval, df degree of freedom, IIEF international index of erectile function, IV inverse variance.

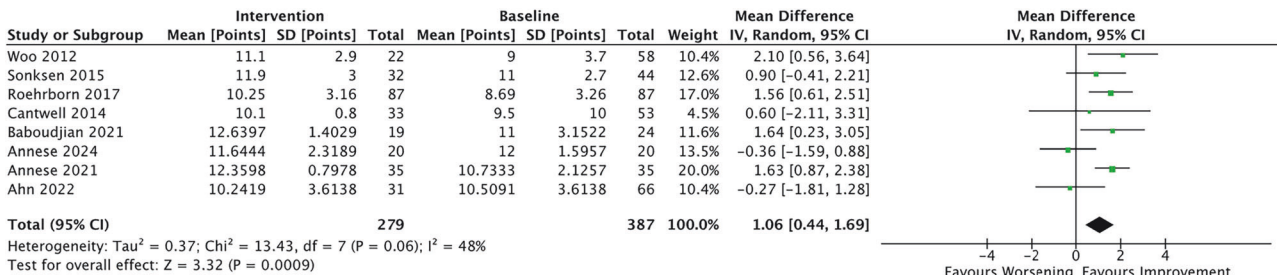


Fig. 6 MSHQ- EjD 12 months after Urolift for BPH. BPH Benign prostatic hyperplasia, CI confidence interval, df degree of freedom, MSHQ-EjD male sexual health questionnaire-ejaculatory dysfunction.

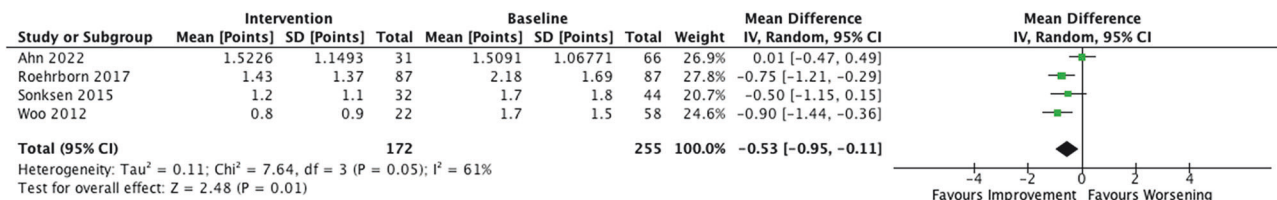


Fig. 7 MSHQ- Bother 12 months after Urolift for BPH. BPH Benign prostatic hyperplasia, CI confidence interval, df degree of freedom, MSHQ-bother male sexual health questionnaire-bother score.

[12]. Annese 2024 also found no difference in semen parameters including volume, sperm counts, and motility post-Urolift in young men [19]. When comparing patients who opted for Urolift versus continued medical management, Gonzalez Enguita 2025 found that those undergoing Urolift were more often able to preserve ejaculation [44]. Roehrborn 2022 found improvements in ejaculatory function scores at 12 months post-Urolift compared to sham control [73]. In a RCT compared to TURP, patients undergoing Urolift were more likely to preserve ejaculation [45].

Urolift IIEF pooled analysis: A meta-analysis of nine studies [12, 19, 20, 22, 29, 51, 73, 81, 86] encompassing 322 patients in the intervention arm, was conducted to assess the change in IIEF score at 12 months (Fig. 5). The pooled estimate demonstrated a statistically significant overall improvement in this score, with a mean increase of 1.86 points (95% CI: 0.54–3.18, Z = 2.76, $p = 0.006$). Moderate statistical heterogeneity was observed ($I^2 = 69$, $p = 0.001$), indicating some variability in the effect size among the studies. Notably, eight of the nine studies reported a mean improvement (positive mean difference), with the largest effect reported by Woo 2012 [86] (4.70 points, 95% CI: 4.72–10.68). Only one study (Kim 2020 [51]) reported a negative mean difference (worsening), which was not statistically significant.

Urolift MSHQ-EjD pooled analysis: For MSHQ-EjD, a meta-analysis of eight studies [12, 19, 20, 22, 29, 73, 81, 86] including 279 patients who underwent the Urolift procedure, was conducted to assess the change in this sexual function score. The pooled mean

difference demonstrated a statistically significant overall improvement of 1.06 points (95% CI: 0.44 to 1.69, Z = 3.32, $p = 0.0009$) (Fig. 6). Moderate statistical heterogeneity was observed across the studies ($I^2 = 48\%$, $p = 0.06$ for Chi [2]), indicating that the magnitude of the effect was somewhat varied but not highly inconsistent. The majority of studies showed a mean improvement, with four studies reporting statistically significant improvements [20, 22, 73, 86]. Only two studies (Annese 2024 [19] and Ahn 2022 [12]) reported a non-significant decline in MSHQ-EjD.

Urolift MSHQ-Bother pooled analysis: A meta-analysis of four studies [12, 73, 81, 86], including 172 patients, was conducted to assess the change in MSHQ Bother scores following the Urolift procedure (Fig. 7). The mean difference was calculated as Post-Intervention Score minus Baseline Score, where a negative value (lower score) indicates improvement (less bother). The pooled mean difference demonstrated a statistically significant overall reduction in ejaculatory bother of -0.53 points (95% CI: -0.95 to -0.11, $p = 0.01$). Moderate statistical heterogeneity was observed across the studies ($I^2 = 61\%$, $p = 0.05$). Two of the four individual studies reported a statistically significant improvement (Roehrborn 2017 [73] and Woo 2012 [86]), supporting the overall conclusion of a net decrease in ejaculatory bother.

PAE. Studies have shown overall preservation of erectile function post PAE, with improved ejaculatory function compared to traditional BPH surgery [26, 34, 38, 54, 70]. Alrawashdash 2020 found improvements in IIEF-5 at 18 months, with 88.5% of

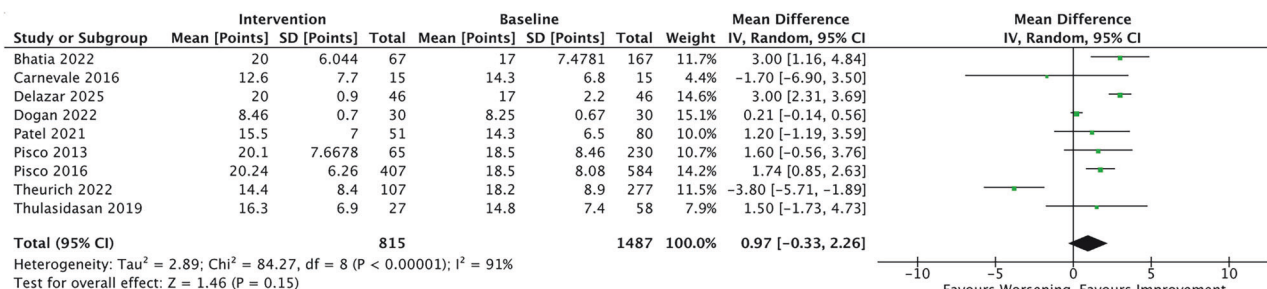


Fig. 8 IIEF 12 months after PAE for BPH. BPH Benign prostatic hyperplasia, CI confidence interval, df degree of freedom, IV inverse variance, IIEF international index of erectile function, IV inverse variance, PAE prostatic artery embolization.

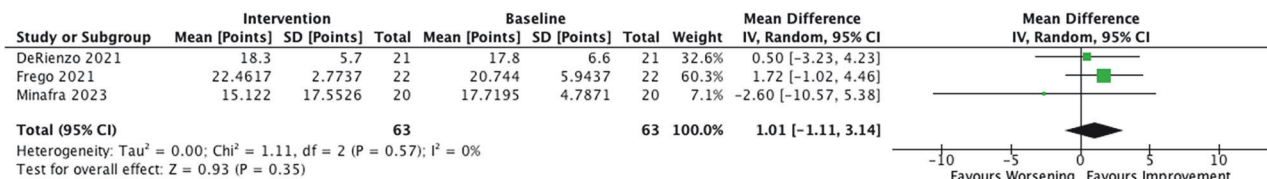


Fig. 9 IIEF 6 months after TPLA for BPH. BPH Benign prostatic hyperplasia, CI confidence interval, df degree of freedom, IIEF international index of erectile function, IV inverse variance, TPLA transperineal laser ablation.

patients preserving antegrade ejaculation [15]. Compared to TURP, Carnevale 2016 showed lower rates of ejaculatory dysfunction following PAE [30]. In a comparison with HoLEP, PAE was found to better preserve both ejaculatory and erectile function [52]. Richardson 2025 found no difference in erectile or ejaculatory function when comparing traditional versus coil embolization [72].

PAE IIEF pooled analysis: A meta-analysis of nine studies [26, 30, 34, 38, 68, 70, 71, 82, 83], encompassing 815 patients in the intervention arm, was conducted to assess the change in IIEF scores following PAE (Mean Difference = Post-Intervention Score minus Baseline Score, where a positive value indicates improvement). The pooled mean difference suggested an overall mean increase of 0.97 points (95% CI: -0.33 to 2.26). However, this overall effect did not reach statistical significance ($Z = 1.46$, $p = 0.15$), suggesting no definitive overall change in IIEF score following PAE (Fig. 8). Extremely high statistical heterogeneity was observed ($I^2 = 91\%$, $\text{Chi}^2 = 84.27$, $p < 0.00001$), indicating substantial variability in the reported effects across the trials. While three studies (Bhatia 2022 [26], Delazar 2025 [34] and Pisco 2016 [70]) reported statistically significant improvements, another study (Theurich 2022 [82]) reported a statistically significant worsening, further emphasizing the lack of a robust, consistent overall effect.

Due to a general paucity of studies utilizing MSHQ-EjD or the MSHQ Bother score following PAE, a formal quantitative synthesis (meta-analysis) of these ejaculatory outcomes could not be performed. While some studies have reported on these measures, their inclusion criteria, follow-up times, and reporting formats were too heterogeneous or sparse to allow for pooled data analysis.

iTind. Three studies evaluated sexual outcomes after iTind. When compared to a sham control, Elterman 2023 found no differences in IIEF-5 3 months after iTind [39]. DeNunzio 2021 found significant improvements in both IIEF-5 and MSHQ-EjD 6 months after iTind [35]. Amparore 2021 reported a 4% RE rate post-iTind [17].

A formal quantitative synthesis (meta-analysis) of erectile and ejaculatory outcomes using the IIEF, MSHQ-EjD function or bother scores following the iTind procedure could not be performed due to a limited number of published studies that report these outcomes with extractable mean and standard deviation data. While individual trials and reviews consistently suggest that iTind

preserves or has a negligible effect on ejaculatory function, the current evidence base lacks the necessary homogeneity and volume to calculate a statistically robust, aggregate pooled effect size for MSHQ-EjD scores. This necessitates reliance on single-study data for drawing conclusions on ejaculatory bother and function preservation.

TPLA. Overall, studies have shown preservation of erectile and ejaculatory function post-TPLA [36, 42, 85]. Minafra 2023 found TPLA to improve ejaculatory function and preserve erectile function at three-years post-procedure [63]. TPLA was shown to preserve ejaculatory function significantly more often compared to TURP across two studies [25, 28].

TPLA IIEF pooled analysis: In the case of TPLA there was only data available suitable for a meta-analysis for a follow-up time of 6 months in 3 studies [36, 42, 63]. The pooled mean difference in IIEF scores suggested an overall mean increase of 1.01 points (95% CI: -1.11 to 3.14) (Fig. 9). However, this overall effect did not achieve statistical significance ($Z = 0.93$, $p = 0.35$), showing no definitive overall change in this outcome following the intervention. Notably, no heterogeneity was detected across the studies ($I^2 = 0\%$, $p = 0.57$). While two studies (DeRienzo 2021 [36] and Frego 2021 [42]) reported non-significant improvements, one study (Minafra 2023 [63]) reported a non-significant worsening, ultimately contributing to the inconclusive pooled result.

In the case of MSHQ-EjD and MSHQ bother scores, a formal meta-analysis could not be done due to the limited number of available studies. The two studies that report MSHQ-EjD data, (de Rienzo 2021 [36] and Minafra 2023 [63]), both report a discreet improvement after 6 months, with no available follow up data at 12 months.

Optilume BPH. Only two studies were identified for Optilume BPH. Both Copelan 2025 and Kaplan 2024 found preservation of erectile and ejaculatory function 12-24 months post-Optilume BPH compared to a sham control [33, 49].

Risk of publication bias

There was no clear publication bias evidenced in the funnel plots of the respective meta-analyses (Supplementary 2). Funnel plots did not show a clear asymmetry in any comparisons.

However, these results must be judged with caution because only one of the eight comparison groups exceed the recommended ten-record threshold to adequately assess the presence of a publication bias.

DISCUSSION

Since their introduction, MISTs have become increasingly utilized for patients with BPH seeking definitive treatment [88]. While enucleation techniques may offer superior durability for LUTS, the benefits of MISTs include same-day discharge, minimal anesthesia, and preservation of sexual function [4, 45]. In this systematic review and meta-analysis, we found that both erectile and ejaculatory function were either preserved or improved across multiple MISTs. Specifically, patients who underwent Urolift and Rezum had significant improvements in erectile and ejaculatory function, while those undergoing TPLA, iTind, PAE, and Optilume preserved sexual function as compared to traditional BPH surgery.

When counseling patients interested in surgical management for BPH, it is critical to assess their priorities for sexual function [89]. A survey of 300 BPH patients found that over 90% considered erectile and ejaculatory function to be important considerations when considering treatment [90]. While men aged 50–59 were most concerned with permanent impacts on sexual function, over 60% of men over age 70 indicated that maintaining erectile and ejaculatory function was important to them. Therefore, it is essential to engage in shared decision-making with patient across all ages. While validated questionnaires such as the IIEF and MSHQ should certainly be utilized, clinicians must recognize their limitations. As noted in a recent review of ejaculatory dysfunction after various BPH treatments, the current questionnaires lack specific questions regarding the force, consistency, sensation, volume, and pain associated with ejaculation [91]. Additionally, clinicians must recognize that small changes in these questionnaires may not be clinically meaningful. A study by Rosen et al., for example, found that the minimal clinically important difference in IIEF scores was a change in four points or more [92]. Therefore, in addition to validated questionnaires, clinicians should seek to gain a detailed understanding of patient symptoms and bother in order to best address sexual health.

MISTs offer superior outcomes to medical therapy for both urinary and sexual function. Prior research has shown MISTs offer an average IPSS reduction of 50% and a Qmax improvement of 40–90%, while pharmacological combination therapy yields an IPSS reduction of 20% and Qmax improvement of 10% [93–95]. Furthermore, both alpha-blockers and 5-alpha-reductase inhibitors are associated with sexual side effects including retrograde ejaculation, decreased libido, and erectile dysfunction. Thus, minimally invasive treatments should be considered in patients dissatisfied with the sexual side effects of medical therapy. Across several studies comparing MISTs to medical therapy, we found improved sexual function outcomes with MISTs [44, 62, 74, 77]. It is important to note that the included studies in the present systematic review inconsistently reported pre- and post-operative data for whether patients were on alpha-blockers, 5-alpha-reductase inhibitors, and/or phosphodiesterase-type 5 inhibitors such as daily tadalafil for urinary symptoms. The use of and potential discontinuation of these medications post-operatively has the ability to impact the results of each study and our pooled outcomes on sexual function, especially for retrospective studies.

While MISTs may offer superior outcomes for erectile and ejaculatory function compared to traditional surgeries, head to head comparisons have shown that they may not be as efficacious in terms of reducing urinary symptoms [45]. Studies have shown there may be a higher need for surgical re-treatment and/or need for medical therapies for BPH after undergoing treatment with a MIST [96]. One study found that 31% of patients who underwent Rezum resumed medical treatment for BPH with alpha-blockers,

daily tadalafil, and/or 5-alpha-reductase inhibitors at a mean of 9 months post-procedure [97]. It is therefore important for clinicians to understand a patient's priorities and counsel patients effectively regarding potential symptomatic improvement and side effects relative to other BPH treatment options.

Our findings show overall favorable outcomes for erectile and ejaculatory function after MISTs. This is similar to a recent pooled analysis, which showed ejaculatory dysfunction rates of 5% for TPLA, 3% for Rezum, 1% for iTIND, and 0% for Urolift, respectively [95]. Manfredi et al. (2022) compared sexual function outcomes across traditional surgeries to MIST, finding a statistically significantly higher rate of retrograde ejaculation after TURP (RR 13.31, 95% CI 8.37, 21.17), enucleation (RR 34.77, 95% CI 10.58, 127.82), and laser surgery (RR 17.37, 95% CI 5.93, 50.81) compared to the MISTs [98]. Data comparing MISTs to each other is currently limited. In three studies comparing Rezum and Urolift, there were no differences in erectile or ejaculatory outcomes [22, 31, 56]. Accordingly, patient characteristics, surgeon expertise, and institutional resources will likely continue to drive MIST selection in real-world settings until further comparative research is done.

Our study is not without limitations. Notably, the included studies were heterogeneous in terms of baseline erectile/ejaculatory function, sexual function questionnaires utilized (e.g. IIEF-5 vs. IIEF-EF vs. IIEF-15), and follow up duration. Additionally, many of the included studies were retrospective in nature. Differing numbers of patients in the included studies were on medical therapy for BPH and/or ED pre-operatively, and it is unclear how many of these patients discontinued therapy post-operatively, which may confound sexual function outcomes. This heterogeneity limits our ability to compare outcomes across MISTs. Despite these limitations, to the best of our knowledge this is the most up-to-date and comprehensive analysis of sexual function after MISTs. Future directions include long term follow up of both sexual function and urinary symptoms after MISTs, comparison of sexual outcomes amongst different MISTs, and evaluation of MISTs in patients with baseline erectile/ejaculatory dysfunction. Additionally, consideration should be given to the creation of more comprehensive questionnaires for ejaculatory function after various BPH treatments.

CONCLUSION

MISTs represent a promising option for patients with LUTS secondary to BPH who wish to preserve sexual function. This systematic review and meta-analysis demonstrated overall preservation or improvement in erectile and ejaculatory outcomes across MISTs compared with traditional BPH surgery. For patients considering surgical management for BPH, urologists must assess sexual function priorities and incorporate discussion of minimally invasive approaches as part of shared decision-making.

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COMPETING INTERESTS

The authors declare no competing interests.

ADDITIONAL INFORMATION

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