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BENIGN PROSTATIC HYPERPLASIA (K MCVARY, SECTION EDITOR)

What Is New with Rezūm Water Vapor Thermal Therapy for LUTS/BPH?

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Abstract

Purpose of Review Rezum® is a novel convection-based thermal therapy for benign prostatic hyperplasia (BPH) induced lower urinary tract symptoms (LUTS). This review provides an overview of its safety, efficacy, cost, and potential role in the paradigm of BPH/LUTS therapies.

Recent Findings Data regarding Rezum® stems primarily from one large randomized controlled trial of 197 patients with 4 years of follow-up. The efficacy and safety of Rezum® is further supported by 4 additional studies including 1 prospective pilot study, 1 crossover study, and 2 retrospective studies. Durable improvements in IPSS (47–60%), QoL (38–52%), Qmax (45–72%), and PVR (11–38%) were seen without causing deterioration of sexual function.

Summary Rezum® offers a cost-effective and safe approach to treating BPH/LUTS and should be considered as a possible first-line therapy for patients with moderate to severe symptoms.

Keywords Rezum® · BPH · LUTS · MIST

Introduction

Benign prostatic hyperplasia (BPH) refers to the formation of discrete nodules composed of stromal and epithelial cells within the transition zone of the prostate. When these nodules become sufficiently large, they can cause a mechanical bladder outlet obstruction (BOO) leading to lower urinary tract symptoms (LUTS). It is estimated that LUTS secondary to BPH impacts nearly 15 million individuals in the USA, with nearly 80% of men over the age of 70 affected [1]. Thus, BPH/LUTS continues to remain a significant cost burden on our healthcare system.

Traditionally, medical management has dominated first-line treatment for BPH. Alpha adrenergic antagonists and 5-alpha reductase inhibitors have documented efficacy in treating the functional and obstructive components leading to LUTS [2]. However, medication compliance can be an issue, often secondary to cost (especially over an extended course), adverse effects, and failure to meet therapeutic expectations [3]. Thus, many seek out definitive surgical therapy. Transurethral resection of the prostate (TURP) has remained the gold standard for the surgical management of BPH. However, the invasive nature of the procedure often necessitates the use of general anesthesia and can cause complications such as bleeding requiring transfusion, urethral stricture, urinary incontinence, erectile dysfunction, and retrograde ejaculation leading to a poorer quality of life (QoL) [4].

Consequently, numerous minimally invasive surgical therapies (MISTs) have blossomed for the treatment of BPH/LUTS. These options are especially attractive because they generally have minimal anesthesia requirements and can be performed in an office-based setting. MISTs can be broadly divided into two categories based on their mechanism of action: mechanical expansion and thermal ablation. Prostatic urethral stents and prostatic urethral lift (UroLift®) are examples of MISTs that function by mechanical expansion, retracting tissue to expand the bladder outlet. MISTs that function via thermal ablation can be further subdivided into those that employ heat transfer via conduction, such as transurethral microwave therapy (TUMT) or transurethral needle ablation (TUNA), and those that utilize convective heat transfer, most notably Rezum®.

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With conduction-based therapies (TUNA and TUMT), higher energy requirements are needed to generate large temperature gradients for adequate tissue ablation, resulting in longer treatment times [5]. With Rezum®, a significant amount of stored thermal energy is released as water vapor condenses back to a liquid following tissue contact. This causes immediate cell membrane denaturation and eventual coagulative necrosis which can be later resorbed, as opposed to thermal fixation often caused by conduction-based therapies which leads to a foreign-body-like reaction [6•, 7]. Also, because convection is achieved by both the random diffusion of particles (Brownian motion) and the bulk flow of said particles (advection), heat transfer can be achieved with no significant temperature gradient [8]. In addition, the collagenous pseudocapsule of the adenoma serves as a natural barrier to the flow of the convective current, resulting in focused treatment on the obstructive nodules. Rezum® thus offers a novel approach in the paradigm of BPH/LUTS treatment.

Procedure Overview

The goal of the Rezum® system is to achieve focused ablation of prostatic adenomatous tissue without violation of the urethra and the prostate's natural zonal anatomy. The important components of the system are as follows: radiofrequency (RF) generator, single-use transurethral applicator with integrated 30° cystoscopic lens, polyether ether ketone (PEEK) 18-guage needle, and saline flush [6•, 9•]. The role of the RF generator is to vaporize the sterile water and control the amount of energy delivered to the target tissue. It was determined that 208 cal using 0.4 ml of vapor per injection is optimal for sufficient ablation. The transurethral applicator allows the surgeon to deploy the PEEK needle under direct visualization into the prostatic urethra. The PEEK needle contains 12 holes circumferentially spaced at 120° intervals to allow for adequate distribution of vapor throughout the adenoma. With the PEEK needle, water vapor is injected at a fixed depth of approximately 10 mm and is deployed over 9 s on average at a pressure just above that of the prostatic interstitium. The saline flush is employed for both visualization and cooling of the prostatic urethra between injections [9•].

Injections are deployed along the prostatic urethra distal to the bladder neck proximally and just proximal to the verumontanum distally. This is done so in intervals of approximately 0.5–1.0 cm in the caudal direction. Depending on the amount of adenomatous tissue, the length of the prostatic urethra, and the presence of a median lobe, the number of injections will vary. On average, 4.5–4.6 injections are utilized during each treatment, with the median lobe alone requiring approximately 1.3–1.6 injections [6•, 9•, 10]. This procedure is generally performed under oral sedation (~ 70%), with prostate blocks and intravenous conscious sedation utilized less frequently [10].

At 1-week post-procedure time, MRI data shows evidence of large ablative regions, visualized as gadolinium defects, within the transition zone of the prostate without penetration of the natural collagenous boundaries demarcating zonal anatomy. When multiple injections were utilized in sequence, a coalescence of these defects was seen. By 6 months, near complete resorption of the gadolinium defects was noted, with a consequent decrease in prostatic volume and transitional zone volume by 28.9% and 38.0% respectively [6•].

Not all patients are suitable for Rezum® therapy, however. Patients with the following features have been excluded from Rezum®'s only multicenter randomized controlled trial: PVR > 250 ml, PSA > 2.5 with free PSA < 20% (unless prostate cancer ruled out by biopsy), and recent UTI within 7 days or recurrent UTI over the past 6 months [10]. In addition, patients who have had prior surgery for BPH/LUTS were not candidates for Rezum® therapy. Of note, the presence of the median lobe is not an exclusion criterion for Rezum®, which contrasts with another increasingly popular MIST, UroLift® [11].

Efficacy

Durable outcomes for the Rezum® system have been generated most notably by a randomized controlled trial (RCT) with 4-year follow-up data. Outcomes from supportive studies are tabulated in Table 1.

Dixon et al. published the pilot study for Rezum®. In this prospective, nonrandomized trial, 65 patients were followed for 2 years and data was accrued at 1, 3, 6, 12, and 24 months. Inclusion criteria included patients aged 45 and older with prostates ranging from 20 to 120 cc, an IPSS ≥ 13, a Qmax ≤ 15 ml/s with voided volume ≥ 150 ml, and a PVR < 300 ml; patients with malignancy, active urinary infection, and prior surgery were excluded. Significant improvements in IPSS, QoL, and Qmax were noted by the first month, maximized at 3 months, and sustained at 24 months. At 24 months, the average change in IPSS and QoL were − 12.1 pts. (56%) and − 2.6 pts. (59%) respectively; Qmax improved by 3.7 ml/s (45%) [12].

McVary et al. designed the only double-blind RCT for Rezum®. Four-year follow-up data has already been published and 5-year data will likely be published later this year. Inclusion criteria for this study were similar to those of the Dixon et al. pilot study, but had stricter requirements regarding prostate size (30–80 cc) and washout periods for medical therapy; exclusion criteria were also similar but the PVR cutoff was lowered to 250 ml [10]. Patients in this RCT were randomized to either Rezum® or a sham procedure involving insertion of a rigid cystoscope (19 to 21 Fr) with accompanying recreation of the sensations and sounds experienced during the actual procedure. One hundred ninety-seven patients were originally stratified by IPSS severity and randomized

Table 1 This table summarizes the results of all studies detailing the efficacy of Rezum®. Presented are changes in important quantitative and qualitative parameters from baseline to final follow-up visit. *IPSS* International Prostatic Symptom Score, *QoL* quality of life (an adjunct of IPSS), *IIEF-EF* International Index of Erectile Function, *Qmax* maximum urine flow rate, *PVR* post-void residual

Author	Type of study	Year	Number of participants	Follow-up period		IPSS	QoL	IIEF-EF	Qmax (ml/s)	PVR (ml)
Dixon et al. [9•]	Prospective pilot study	2015	65	24 months	Baseline	21.7 ± 5.3	4.4 ± 1.1	11.8 ± 12.4	8.2 ± 3.3	92.0 ± 79.1
					Final follow-up	9.6 ± 6.5	1.7 ± 1.4	15.5 ± 11.5	12.8 ± 6.3	63.1 ± 72.2
					Mean % change	55.7%	59%	30.5%	44.5%	19.8%
					Number of paired values	43	43	31	39	38
Darson et al. [17]	Retrospective study	2017	131	12 months	Baseline	19.4 ± 6.7	4.4 ± 1.3	n/a	8.5 ± 3.5	236.6 ± 341.3
					Final follow-up	10.1 ± 7.2	2.5 ± 1.4	n/a	10 ± 5	77.3 ± 122.1
					Mean % change	45.2%	37.8%	n/a	51.4%	34.9%
					Number of paired values	87	74	n/a	7	35
Mollengarden et al. [18]	Retrospective study	2018	129	90–180 days	Baseline	18.5 ± 7.6	n/a	n/a	10.8 ± 4.6	108 ± 129.1
					Final follow-up	6.9 ± 5.0	n/a	n/a	16.8 ± 6.9	73.1 ± 83.4
					Mean % change	60%	n/a	n/a	71.7%	32.3%
					Number of paired values	89	n/a	n/a	43	99
Roehrborn et al. [13]	Crossover study	2017	53	12 months	Baseline	19.4 ± 6.6	3.8 ± 1.3	22.8 ± 6.6	10.3 ± 3.8	101.0 ± 79.2
					Final follow-up	8.6 ± 6.6	1.7 ± 1.2	18.8 ± 10.0	16.2 ± 7.9	83.8 ± 80.5
					Mean % change	51%	52%	17%	68%	11%
					Number of paired values	45	45	26	45	44
McVary et al. [15••]	Randomized controlled trial	2019	197	48 months	Baseline	21.4 ± 4.4	4.3 ± 1.0	23.2 ± 7.0	9.5 ± 2.2	84.4 ± 55.3
					Final follow-up	11.4 ± 7.4	2.3 ± 1.5	20.8 ± 9.6	13.7 ± 5.7	75.2 ± 69.7
					Mean % change	46.7%	42.9%	7.6%	49.5%	38%
					Number of paired values	90	90	58	81	89

2:1, yielding 136 patients in the treatment group and 61 patients in the control group. At 3 months, significant improvements in IPSS (22 to 10.6), QoL (4.4 to 2.3), and Qmax (9.9 to 15.4 ml/s) were noted in the Rezum® group compared to sham. In fact, improvements in IPSS were most profound in individuals with severe baseline LUTS (IPSS 19 or greater). In addition, those treated with obstructive median lobes shared similar improvements in IPSS scoring to those without. At 3 months, patients in the control group were unblinded, and those who met the Qmax and IPSS inclusion criteria (53 of the 61 patients) underwent Rezum® therapy; significant improvements in IPSS (19.9 to 9.8), QoL (3.9 to 1.9), and Qmax (10.1 to 16.4) in this group replicated those of the original treatment cohort [13]. Improvements essentially were sustained at 4 years, suggesting durability of the treatment [14, 15••]. Retreatment rate was reported to be 4.4%, but failure to treat potentially obstructive median lobes earlier on in the trial likely inflated this value, which is probably closer to 2.2%. This compares favorably to the surgical retreatment rate and of other notable MISTs and TURP. In addition, the rate of pharmacotherapy initiation with alpha blockers, which is roughly 5.2% at 4 years for Rezum®, is also lower than that of other MISTs [15••].

Data from the above double-blind RCT was utilized by Gupta et al. to compare the effectiveness of water vapor convective therapy to medical management with doxazosin and/or finasteride. The latter data was obtained from the MTOPS trial. Only subjects who fit the inclusion criteria of the Rezum® double-blind RCT were studied, which yielded 1140 (or 37.4%) patients from the original MTOPS cohort. Patients who had undergone Rezum® were noted to have similar IPSS improvements, improved Qmax, and lower clinical progression rates (IPSS increase of 4 or greater) than those being treated with combination medical management [16•].

Two retrospective studies were also published to demonstrate the efficacy of Rezum®. Given that these studies used less strict inclusion criteria, they may more accurately represent the effectiveness of convective thermal therapy on real-world clinical populations. Darson et al.'s study was a multicenter retrospective analysis of 131 patients who had a wide range of clinical presentations including prostate volumes ranging from 13 to 183 cc and those with previous surgical or MIST therapies (12%). IPSS (19.4 to 10.1), QoL (4.4 to 2.5), and PVR (236.6 to 77.3 ml) improvements were noted at 1 year, although follow-up was generally poor [17]. Mollengarden et al.'s study was a single surgeon retrospective analysis of 129 patients who underwent the Rezum® procedure. It included some patients from the Rezum® RCT (data from the same center), but notably studied many patients who did not undergo medical therapy washout. At 90–180 days, significant improvements in IPSS (18.5 to 6.9), Qmax (10.8 to 16.8 ml/s), and PVR (108 to 73.1 ml) were seen in this patient population; in addition, the prostate size was decreased by 17%, on average, when measured by transrectal ultrasound (TRUS) and compared to pre-operative imaging [18]. As was previously mentioned, MRI data suggests an even greater reduction in prostate volume (~ 29%) following Rezum® therapy. The reference of comparison in this study, however, was a 1-week post-operative MRI, and the degree of reduction at 6 months could have been amplified by a transient increase in size caused by post-operative edema at this 1-week timepoint [6•]. Regardless, both retrospective studies show that Rezum® has durable positive outcomes even in less strictly defined patient populations, suggesting efficacy in standard clinical practice.

Safety Profile

Overall, Rezum® appears to be a well-tolerated procedure with most complications being mild to moderate in nature and occurring within the first 30 days (Table 2).

In the pilot study, Dixon et al. reported adverse events (AEs) in 45 of the 65 patients (69%), although most of these AEs (75%) were Clavien-Dindo I–II complications (primarily LUTS) and self-resolved within 30 days. One patient had a Clavien-Dindo IIIb complication and presented with acute urinary retention 33 days post-operatively requiring a TURP [7]. In the RCT published by McVary et al. and Roehrborn et al., the following AEs were most common: dysuria (16.9%), hematuria (11.8%), frequency or urgency (5.9%), acute urinary retention (3.7%), and suspected UTI (3.7%). These AEs were all expected secondary to rigid cystoscopy and once again self-resolved within 30 days. Two patients in this study ($n = 197$) had more severe AEs with one patient having bladder neck contracture and bladder calculi noted at 6 months and the other developing urosepsis after a follow-up cystoscopy (unrelated to the original procedure) [10, 13, 14, 15••]. Darson et al. reported a higher rate of acute urinary retention than the Rezum® RCT at 10.7% (14 of 131 patients), although all cases resolved with short-term catheterization [16•]. Mollengarden et al. reported a UTI rate of 17.1% (22 of 129 patients), although this rate may be inflated because patients in this study were discharged with a catheter or a temporary prostatic stent (Spanner); thus, it is possible that LUTS post-operatively with bacteriuria from catheterization or stent placement could have mistakenly been categorized as a UTI (no febrile cases were noted). In addition, 4 patients in this study had Clavien-Dindo IIIb complications and were treated as follows: cystoscopic clot evacuation, balloon dilation of urethral stricture, resection of bladder neck contracture, and cystolithalopaxy [18].

Importantly, Rezum® has been shown to preserve sexual function, with de novo erectile dysfunction and anejaculation being very rare AEs. The Rezum® RCT reported anejaculation in 4 patients (2.9%) within the first 3 months

Table 2 This table summarizes the recorded adverse events (AEs) delineated by each Rezum® study. Each AE is categorized by its Clavien-Dindo classification; the most common complications under each category are listed

Author	Year	Number of participants	Number of participants with AEs	Clavien-Dindo I–II complications	Clavien-Dindo III–IV complications
Dixon et al. [9•]	2015	65	45	Urinary retention ($N = 22$)	Persistent LUTS requiring TURP ($N = 1$)
				Dysuria ($N = 14$)	
				Urinary urgency ($N = 13$)	
Darson et al. [17]	2017	131	19	Urinary retention ($N = 14$)	N/A
				Frequency, urgency, hematuria, and nocturia ($N = 5$)	
Mollengarden et al. [18]	2018	129	61	Urinary tract infection ($N = 22$)	Persistent LUTS requiring BPH surgery ($N = 3$)
				Urinary retention ($N = 18$)	Urinary retention requiring clot evacuation ($N = 1$)
				Post-void dribbling and urinary incontinence ($N = 6$)	Urethral stricture requiring balloon dilation ($N = 1$)
					Bladder neck contracture requiring resection ($N = 1$)
					Bladder stones requiring cystolithalopaxy ($N = 1$)
Roehrborn et al. [13]	2017	53	19	Dysuria ($N = 10$)	Bladder neck contracture and bladder stones ($N = 1$)
				Gross hematuria ($N = 6$)	Sepsis ($N = 1$)
				Urinary retention ($N = 3$)	
McVary et al. [15••]	2019	197	52	Dysuria ($N = 23$)	Persistent LUTS requiring BPH surgery ($N = 6$)
				Hematuria ($N = 6$)	Bladder neck contracture and bladder stones ($N = 1$)
				Frequency and urgency ($N = 8$)	Nausea/vomiting requiring hospitalization ($N = 1$)

of therapy; erectile function was universally maintained, however, with IIEF-EF scores improving from baseline at 4-year follow-up (23.2 to 20.8) [9•, 14]. Mollengarden et al. was the only study to report de novo erectile dysfunction with 4 patients affected (3.1%); this study also reported a similar anejaculation rate as the Rezum® RCT at 3.1%. In addition, medical therapy, which generally is the first line of therapy in the armamentarium for BPH/LUTS, has been shown to cause significant sexual dysfunction when compared to Rezum®. After 3 years of use, doxazosin was associated with worsened sexual desire and erectile function while finasteride and combination medical therapy caused a significant decrease in sexual desire, erectile function, and ejaculatory function. This was not seen with Rezum® therapy [19].

Future Role of Rezum

Rezum® appears to be a safe, efficacious, and cost-effective treatment for BPH/LUTS. The procedure itself is quick in nature with most treatments ranging between 2 and 4 min of actual procedure time [18]. It can generally be performed with oral sedation in an outpatient setting, eliminating the morbidity and cost associated with general anesthesia. In addition, post-operative catheterization time in the Rezum® RCT was 3.4 ± 3.2 days, with most individuals able to resume their normal activities at a median of 4 days, coinciding with catheter removal [10].

Rezum® results in both qualitative and quantitative improvements in BPH induced LUTS, resulting in a 46.7%, 42.9%, and 49.5% sustained improvement in IPSS, QoL, and Qmax at 4-year follow-up in the Rezum® RCT [15••]. In addition, although inclusion criteria were strict in the aforementioned RCT, durable results were noted in retrospective studies which included cohorts with a wider range of preoperative characteristics, suggesting that Rezum® is effective in the standard clinical environment [17, 18]. In addition, as opposed to other MISTs such as UroLift®, Rezum® can also effectively treat obstructive median lobes [11]. Overall, rates of retreatment are lower than that of TURP and MISTs and the rate of BPH progression after treatment is lower than that of sustained medical therapy [15••, 16].

Rezum® appears to be safe with most AEs being classified as Clavien-Dindo I–II and resolving within 30 days. In addition, Rezum® preserves sexual function, with de novo erectile and ejaculatory dysfunction being rare, as opposed to the traditional armamentarium, such as medical therapy and TURP, which yields noticeably higher rates of clinical deterioration [19, 20].

Finally, Rezum® appears to be one of the more cost-effective treatment options available for BPH/LUTS. In an economic analysis conducted by Ulchaker et al., Rezum® outperformed other BPH management options, including combination medical therapy, TURP, Greenlight photovaporization (PVP), UroLift®, and Prostiva®, due to a combination of low index price, fewer AE-related costs, and lower retreatment rates. According to this model, TURP, which provides, on average,

4 more points of IPSS relief than Rezum®, does so at a cost of approximately $250 an IPSS point over a 2-year stretch and at a baseline cost twice that of Rezum® ($5181 vs. $2582). In addition, while combination medical therapy is cheaper at 2 years, their cost surpasses Rezum® in as little as 4 years primarily due to their lack of efficacy. Rezum® also outperforms Urolift® in a cost analysis as it has both a lower retreatment rate (4.4% vs 7.5%) and a lower index cost ($2582 vs $6386) [21•]. Thus, given the combination of cost, efficacy, and safety, Rezum® should be considered a first-line treatment option for patients with moderate to severe LUTS, even in those patients with a prominent median lobe.

Conclusion

Rezum® is a minimally invasive convection-based thermal therapy that allows for the focused treatment of BPH nodules within the transition zone of the prostate. It can be done so in the outpatient setting, with minimal sedation, and in a cost-effective manner. Both quantitative and qualitative improvements have been durable in patients with varied prostate characteristics. The procedure is safe, preserves sexual function, and boasts a low retreatment rate.

Compliance with Ethical Standards

Conflict of Interest The authors declare nothing to disclose.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

References

Papers of particular interest, published recently, have been highlighted as:
- • Of importance
- •• Of major importance

1. Egan KB. The epidemiology of benign prostatic hyperplasia associated with lower urinary tract symptoms: prevalence and incident rates. Urol Clin North Am. 2016;43(3):289–97.
2. Verhamme KM, Dieleman JP, Bleumink GS, et al. Treatment strategies, patterns of drug use and treatment discontinuation in men with LUTS suggestive of benign prostatic hyperplasia: the Triumph project. Eur Urol. 2003;44:539–45.
3. Cindolo L, Pirozzi L, Fanizza C, et al. Drug adherence and clinical outcomes for patients under pharmacological therapy for lower urinary tract symptoms related to benign prostatic hyperplasia: population-based cohort study. EurUrol. 2015;68:418.
4. Parsons JK, Mcvary KT. Re: Surgical management of lower urinary tract symptoms attributed to benign prostatic hyperplasia: AUA guideline amendment 2019. J Urol. 2020. https://doi.org/10.1097/JU.0000000000000802.
5. Bhowmick P, Coad JE, Bhowmick S, Pryor JL, Larson T, de la Rosette J, et al. In vitro assessment of the efficacy of thermal therapy in human benign prostatic hyperplasia. Int J Hyperth. 2004;20:421–39.
6. • Mynderse LA, Hanson D, Robb RA, et al. Rezum system water vapor treatment for lower urinary tract symptoms/benign prostatic hyperplasia: validation of convective thermal energy transfer and characterization with magnetic resonance imaging and 3-dimensional renderings. Urology. 2015;86:122 **This paper shows objective MRI data regarding prostatic size reduction at various time points following Rezum® therapy.**
7. Coad JE. Thermal fixation: a central outcome of hyperthermic therapies (Invited Paper). Proc. SPIE 5698, Thermal Treatment of Tissue: Energy Delivery and Assessment III. 2005.
8. Incropera FP, DeWitt DP. Fundamentals of heat and mass transfer. 3rd ed. Wiley; 1990. p. 28. See Table 1.5.
9. • Dixon C, Cedano ER, Pacik D, et al. Efficacy and safety of Rezūm system water vapor treatment for lower urinary tract symptoms secondary to benign prostatic hyperplasia. Urology. 2015;86(5):1042–7 **Pilot study delineating the efficacy of Rezum®.**
10. Mcvary KT, Gange SN, Gittelman MC, et al. Minimally invasive prostate convective water vapor energy ablation: a multicenter, randomized, controlled study for the treatment of lower urinary tract symptoms secondary to benign prostatic hyperplasia. J Urol. 2016;195(5):1529–38.
11. Sievert KD, Schonthaler M, Berges R, Toomey P, Drager D, Herlemann A, et al. Minimally invasive prostatic urethral lift (PUL) efficacious in TURP candidates: a multicenter German evaluation after 2 years. World J Urol. 2019;37(7):1353–60.
12. Dixon CM, Cedano ER, Pacik D, Vit V, Varga G, Wagrell L, et al. Two-year results after convective radiofrequency water vapor thermal therapy of symptomatic benign prostatic hyperplasia. Res Rep Urol. 2016;8:207–16.
13. Roehrborn CG, Gange SN, Gittelman MC, Goldberg KA, Patel K, Shore ND, et al. Convective thermal therapy: durable 2-year results of randomized controlled and prospective crossover studies for treatment of lower urinary tract symptoms due to benign prostatic hyperplasia. J Urol. 2017;197(6):1507–16.
14. Mcvary KT, Roehrborn CG. Three-year outcomes of the prospective, randomized controlled Rezūm system study: convective radiofrequency thermal therapy for treatment of lower urinary tract symptoms due to benign prostatic hyperplasia. Urology. 2018;111:1–9.
15. •• Mcvary KT, Rogers T, Roehrborn CG. Rezūm water vapor thermal therapy for lower urinary tract symptoms associated with benign prostatic hyperplasia: 4-year results from randomized controlled study. Urology. 2019;126:171–9 **Four-year follow-up results for the seminal study and only randomized-controlled trial regarding Rezum®.**
16. • Gupta N, Rogers T, Holland B, Helo S, Dynda D, Mcvary KT. Three-year treatment outcomes of water vapor thermal therapy compared to doxazosin, finasteride and combination drug therapy in men with benign prostatic hyperplasia: cohort data from the MTOPS trial. J Urol. 2018;200(2):405–13 **This paper compares the efficacy of Rezum to combination medical management.**
17. Darson MF, Alexander EE, Schiffman ZJ, Lewitton M, Light RA, Sutton MA, et al. Procedural techniques and multicenter postmarket experience using minimally invasive convective radiofrequency thermal therapy with Rezūm system for treatment of lower urinary tract symptoms due to benign prostatic hyperplasia. Res Rep Urol. 2017;9:159–68.
18. Mollengarden D, Goldberg K, Wong D, Roehrborn C. Convective radiofrequency water vapor thermal therapy for benign prostatic hyperplasia: a single office experience. Prostate Cancer Prostatic Dis Springer US. 2018;21:379–85.

19. Mcvary KT, Rogers T, Mahon J, Gupta NK. Is sexual function better preserved after water vapor thermal therapy or medical therapy for lower urinary tract symptoms due to benign prostatic hyperplasia? J Sex Med. 2018;15(12):1728–38.
20. El-assmy A, Elshal AM, Mekkawy R, El-kappany H, Ibrahiem EHI. Erectile and ejaculatory functions changes following bipolar versus monopolar transurethral resection of the prostate: a prospective randomized study. Int Urol Nephrol. 2018;50(9):1569–76.
21.• Ulchaker J, Martinson M. Analyzing the cost-effectiveness of six therapies for treating lower urinary tract symptoms due to benign prostatic hyperplasia. J Urol. 2018;199:29–43 **This study divulges detailed cost-analyses of various BPH treatment strategies, including medical therapy, surgical therapy, and MISTs.**