

Evaluating Transperineal Laser Ablation as a Minimally Invasive Therapy for BPH: A Systematic Review and Meta-Analysis

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ABSTRACT

Benign prostatic hyperplasia (BPH) is a common illness in older men, marked by lower urinary tract symptoms (LUTS) that diminish quality of life. Although conventional therapies like medication and transurethral resection of the prostate (TURP) are effective, they frequently entail considerable adverse effects. Transperineal Laser Ablation (TPLA) has emerged as a viable minimally invasive surgical intervention that provides symptom alleviation with potentially reduced consequences. The objective of this study is to comprehensively assess the clinical effectiveness and safety of TPLA in the treatment of BPH through the analysis of aggregated data from previous cohort studies. A systematic review and meta-analysis were performed in accordance with PRISMA recommendations. A total of 449 people were enrolled across ten trials. The meta-analysis revealed a substantial enhancement in all evaluated outcomes following TPLA: a -58.435% decrease in IPSS (95% CI: -70.421 to -46.449), a -63.937% reduction in PVR (95% CI: -76.937 to -50.938), a +68.031% increase in Qmax (95% CI: 47.438 to 88.624), and a -27.927% decline in prostate volume (95% CI: -36.575 to -19.280). Significant heterogeneity ($I^2 > 90\%$) was observed across all outcomes. Discussion: The results indicate that TPLA markedly improves both subjective symptoms and objective urine function in individuals with BPH. TPLA is a promising, minimally invasive procedure for BPH, showing significant improvements in symptom severity and urine parameters. Although existing data endorse its effectiveness and safety, forthcoming randomized controlled studies are important to validate its long-term results and define its position in clinical practice.

KEYWORDS BPH, TPLA, Minimally invasive surgical therapy, LUTS, Meta-Analysis



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INTRODUCTION

About 70% of males over the age of 80 experience lower urinary tract symptoms (LUTS), making it a very common illness (Magnoni et al., 2017). Benign prostatic hyperplasia (BPH), in which the prostate's transition zone becomes overpopulated with epithelial and stromal cells, is the leading cause of lower urinary tract symptoms (LUTS) (Oelke et al., 2013; Parsons, 2010). Prostate hypertrophy, which obstructs urine outflow due to constriction of the prostatic tract of the urethra, is caused by cellular aging, hormonal changes, and hereditary predisposition (Sanda et al., 1994; Aaron et al., 2016). There are a number of variables that contribute to benign prostatic hyperplasia (BPH), but dihydrotestosterone (DHT) and estrogens are major ones. The effectiveness of 5 α -reductase inhibitors, the mainstays in the treatment of benign prostatic hyperplasia (BPH), further supports the significance of DHT-mediated signaling. New research suggests that hyperestrogenism and low testosterone levels may contribute to persistent prostate inflammation and benign prostatic hyperplasia (BPH) (Rastrelli et al., 2019; Xia et al., 2021).

Typical voiding symptoms of benign prostatic hyperplasia (BPH) include increased frequency of both daytime and nighttime urination (nocturia) and urine urgency (pollakiuria). Less common symptoms include a decrease in urine flow, discomfort in the urinary tract (stranguria), and the sensation that the bladder is not completely emptying (tenesmus) (Rees et al., 2014). International Prostate Symptom Score (IPSS) and quality of life (QoL) are two of the many questionnaires used to measure the intensity of these symptoms. LUTS have a negative impact on quality of life and significant financial consequences, according to many studies (Law et al., 2019; Wei et al., 2008; Schlattmann et al., 2022; Hollingsworth & Wilt, 2014).

When treating symptomatic BPH, a multimodal approach is frequently used. Alterations to one's way of life and pharmaceutical interventions, including phosphodiesterase-5 inhibitors, anticholinergics, beta-adrenergic agonists, alpha-adrenergic antagonists, and phytotherapeutics, constitute the conventional first-line therapy (Wilt & N'Dow, 2008). Surgical intervention may be necessary in certain instances or when pharmaceutical therapies no longer provide the desired results. The surgical treatment of LUTS can be either open prostatectomy (OP) or transurethral prostatic resection (TURP), with TURP being the more favored option (Walmsley & Kaplan, 2004).

According to the major guidelines, modifying one's lifestyle should be the first line of defense against the pathology, followed by medication and, finally, surgery (Elshal et al., 2020). For prostates up to 80 cc in size, the European Association of Urologists (EAU) Guideline recommends Transurethral Resection of the Prostate (TURP) as the gold standard for surgical therapy. Patients with bigger prostates are best served by prostate enucleation (Elshal et al., 2020). Retrograde ejaculation, infection, hematuria, urethral strictures, and urine incontinence are among the non-negligible risks and adverse effects linked to these treatments (Behr et al., 2023; Pan et al., 2023; Yan et al., 2022; Cornu et al., 2015; Qian et al., 2017; Capogrosso et al., 2022).

A variety of MIST procedures have been developed for benign prostatic hyperplasia (BPH) in the past ten years. These include aquablation therapy, iTIND, Urolift, convective water vapor treatment (Rezum), and prostatic artery embolization (PAE). The preservation of sexual function and the ease to execute these procedures in an outpatient environment have made them a popular choice among males, even if they give worse clinical results compared to TURP and enucleation treatments. Although it has not yet been included in the European Association of Urology Guidelines, mounting data suggests that transperineal laser ablation (TPLA) of the prostate is a safe and effective procedure; hence, it is one of the most recent MIST. Patients and doctors alike have shown increasing interest in MISTs and uMISTs, or ultra-minimally invasive surgical procedures, in recent years (Nguyen et al., 2024; Checcucci et al., 2021). These methods seek to reduce the likelihood of adverse effects while simultaneously increasing the likelihood of successful treatment. Patients and healthcare systems may benefit from the novel minimally invasive surgical option of transperineal laser ablation (TPLA) for BPH (Sessa et al., 2023).

An important clinical demand for therapies that achieve a balance between effectiveness, safety, patient comfort, and maintenance of sexual and urinary function remains unfulfilled, despite the wide diversity of treatment options for benign prostatic hyperplasia (BPH). Although traditional surgical methods, like transurethral resection of the prostate

(TURP), can alleviate symptoms and improve urine flow, they come with serious risks, such as blood loss, incontinence, and extended hospital stays or catheterizations. The need for non-invasive methods of treating LUTS that are both long-lasting and safe is rising in tandem with the world's male population's average age. To meet this need, more recent minimally invasive surgical treatments (MISTs) have emerged, with the goals of symptom relief, a reduced risk of complications, and a shorter time to recovery.

An exciting new approach for minimally invasive prostate surgery (MIST) is transperineal laser ablation (TPLA), which uses imaging-guided laser energy delivery via the perineum to generate controlled coagulative necrosis of prostatic tissue. By avoiding urethral equipment, TPLA, in contrast to transurethral methods, preserves ejaculatory function and may lessen the likelihood of urethral damage. There is no universal agreement on its effectiveness or safety in comparison to conventional therapies, and the available information is scant and inconsistent due to its recent introduction. As a result, clinical decision-making and future research initiatives for BPH care might greatly benefit from a systematic review and meta-analysis that quantitatively evaluates all available evidence.

Given the emerging role of TPLA in contemporary BPH management and the need to synthesize the growing but heterogeneous body of evidence, this systematic review and meta-analysis was undertaken with several specific objectives. First, to comprehensively evaluate the clinical effectiveness of TPLA by quantifying changes in key urological parameters including IPSS, post-void residual volume, maximum urinary flow rate, and prostate volume following the procedure. Second, to assess the safety profile of TPLA by documenting reported complications and adverse events across included studies. Third, to determine the magnitude and consistency of treatment effects through pooled statistical analysis, thereby providing robust estimates of TPLA's therapeutic benefit. Fourth, to identify sources of heterogeneity in treatment outcomes and explore potential factors contributing to variability in results. Fifth, to compare the performance characteristics of TPLA with those of established treatment modalities based on available literature, contextualizing its role within the broader BPH treatment landscape.

The findings from this study are expected to provide substantial benefits to multiple stakeholder groups. For urologists and healthcare providers, this synthesis will offer evidence-based guidance on the appropriateness of TPLA for specific patient populations and clinical scenarios, facilitating informed treatment selection. For patients with BPH, the comprehensive assessment of both efficacy and safety outcomes will enable more informed shared decision-making regarding treatment options, particularly for those seeking minimally invasive alternatives with preservation of sexual function. For healthcare policymakers and administrators, the aggregated evidence may inform coverage decisions, resource allocation, and the incorporation of TPLA into clinical practice guidelines. For researchers, this systematic review will identify knowledge gaps and methodological limitations in the existing literature, highlighting priorities for future investigation including the need for randomized controlled trials with longer follow-up periods, standardized outcome measures, and comparative effectiveness studies. Finally, for medical device manufacturers and innovators, understanding the current evidence base for TPLA will guide continued refinement of laser technologies, imaging modalities, and procedural techniques to optimize patient outcomes. By synthesizing the available evidence on TPLA's effectiveness and safety, this meta-analysis contributes to the

ongoing evolution of BPH management toward less invasive, more patient-centered therapeutic approaches.

METHOD

The procedures and documentation of this meta-analysis followed the guidelines set out by PRISMA, the Preferred Reporting Items for Systematic Reviews and Meta-Analyses. By utilizing ScienceDirect, the Cochrane Library, and PubMed up until June 1st, 2025, a thorough literature evaluation was carried out. The search terms utilized in the literature review were "(transperineal laser ablation OR TPLA) AND (Benign Prostate Hyperplasia OR BPH)". Articles with appropriate titles and abstracts will be a part of this process to help with a comprehensive review and subsequent quantitative and qualitative analysis.

Inclusion criteria for the studies were as follows: (1) studies had to include BPH patients; (2) studies had to disclose the results of TPLA surgery as a single arm trial. As a result, we settled on these exclusion criteria: First, papers with full texts that cannot be accessed; second, research that are not acceptable because of their methodology, intervention, or results. Figure 1 shows the study's search approach in detail.

Subsequently, we extracted data from our selected articles. Articles were also assessed in terms of quality by using ROBINS-I Tool provided by cochrane. Quality assessment was done collaboratively by all reviewers until consensus were reached.

A meta-analysis was conducted using Review Manager version 5.4 (Copenhagen: The Nordic Cochrane Centre, The Cochrane Collaboration). The Mean and its 95% confidence interval (CI) were recognized as prevalent metrics. To account for clinical variability, random-effects models were used to consolidate effect estimates. The investigation of heterogeneity was performed using the Higgins I-squared (I^2) statistical model. The findings of the heterogeneity test were categorized as minimal (0-25%), low (25%-50%), moderate (50-75%), or high (>75%).

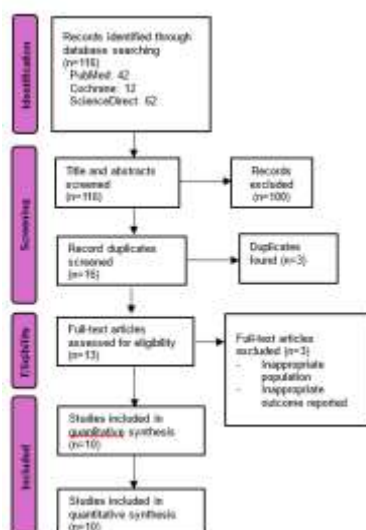


Figure 1. Diagram flow of literature search strategy for this meta-analysis

Table 1. Characteristics and results of the included studies

Author, year	Study design	Interventi on	Samp le size	IPSS % Change		PVR % Change		Qmax % Change		Volume % Change	
				Intervent ion	SD	Intervent ion	SD	Intervent ion	SD	Intervent ion	SD
Pacella, 2019	Retrospect ive cohort	Transperi neal Percutane ous Laser Ablation (TPLA)	160	-68	12. 9	-88.2	22. 9	88.8	72. 6	-33	19. 4
Frego, 2021	Prospectiv e cohort	Ultrasoun d-guided Transperi neal Percutane ous Laser Ablation (TPLA)	22	-75.5	31. 9	-50.76	22. 9	115.8	72. 6	-41	19. 4
Manenti, 2021	Prospectiv e cohort	Ultrasoun d-guided Transperi neal Percutane ous Laser Ablation (TPLA)	44	-71.2	31. 9	-86.4	22. 9	113.2	72. 6	-53	19. 4
de Rienzo, 2019	Prospectiv e cohort	Transperi neal Percutane ous Laser Ablation (TPLA)	21	-66.67	31. 9	-82.8	30. 5	51.1	72. 6		
Cai, 2021	Retrospect ive cohort	Ultrasoun d-guided Transperi neal Percutane ous Laser Ablation (TPLA)	20	-59.9	16. 3	-61.5	30. 5	44.7	46. 5	-22.7	15. 6
Sessa, 2022	Prospectiv e cohort	Transperi neal Percutane ous Laser Ablation (TPLA)	39	-35	16. 5	-55	29. 5	32	26		
van Kollenbu rg, 2023	Prospectiv e cohort	Transperi neal Percutane ous Laser Ablation (TPLA)	20	-45.5	31. 9	-17.5	30. 5	53.6	76. 2	-7.1	25. 9
Lagana, 2023	Prospectiv e cohort	Ultrasoun d-guided Transperi neal Percutane ous Laser Ablation (TPLA)	63	-59.6	31. 9	-67.5	30. 5	88.4	76. 2	-32.7	25. 9
Minafra, 2023	Prospectiv e cohort	Transperi neal Percutane ous Laser	20	-37.2	4.4	-85.7	15. 2	45.8	39. 5	-20.4	4.6 5

		Ablation (TPLA)									
		Transperi neal									
Destefani s, 2023	Prospectiv e cohort	Percutane ous Laser Ablation (TPLA)	40	-68	31. 9	-40	30. 5	50	76. 2	-10.5	25. 9

RESULTS AND DISCUSSION

Results

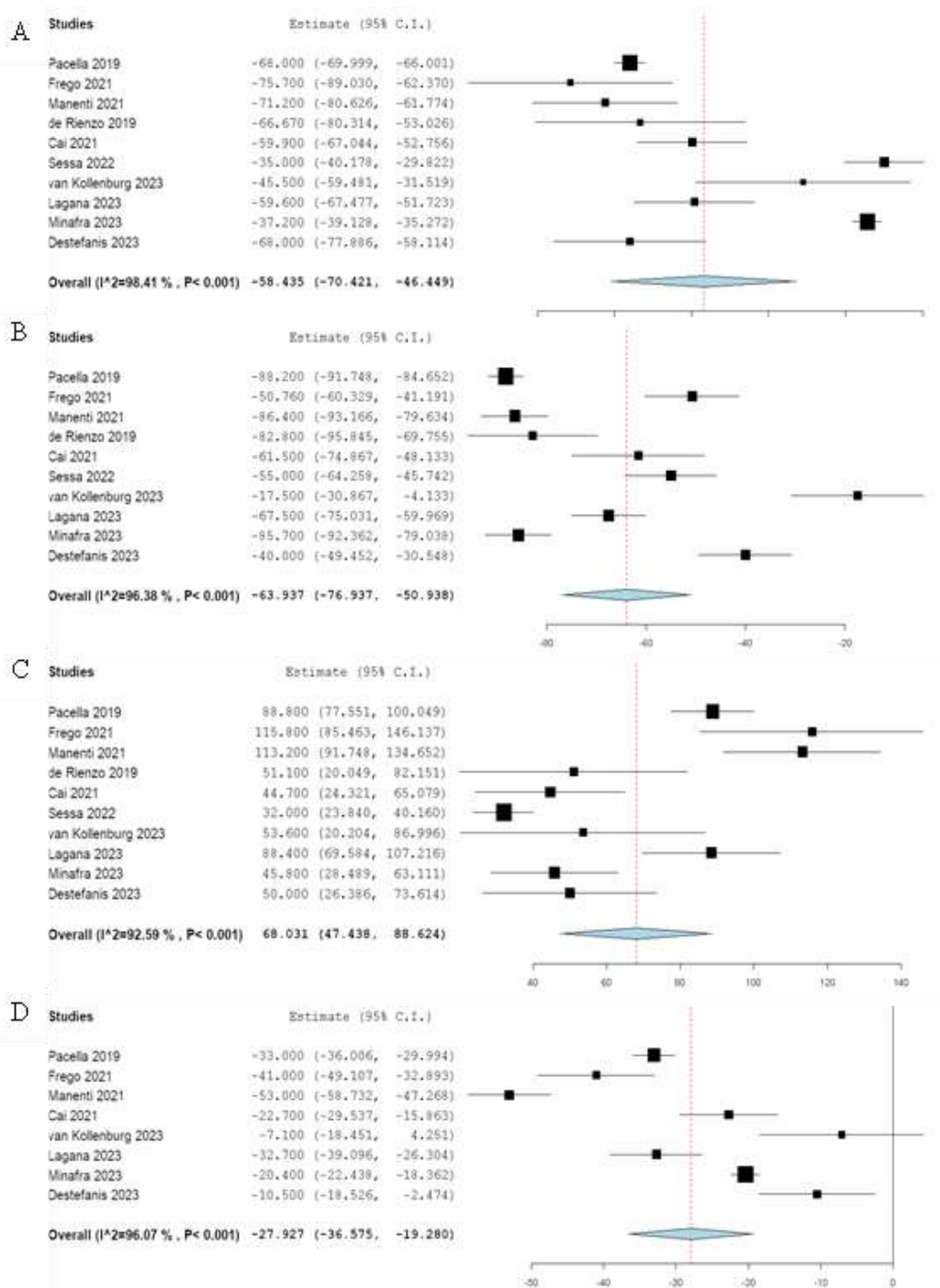


Figure 2. Pooled results for (A) %Change in IPSS Score, (B) %Change in PVR, (C) %Change in Qmax, and (D) %Change in prostate volume.

This systematic review and meta-analysis include 10 trials including 449 participants with clinically confirmed benign prostatic hyperplasia (BPH). The studies conducted between 2019 and 2023 utilized prospective or retrospective cohort designs, indicating the recent introduction of Transperineal Laser Ablation (TPLA) as a treatment option. The investigations were conducted in several clinical environments and utilized different imaging-guided laser ablation methods, mostly under ultrasound guidance, to provide minimally invasive therapy for prostatic hyperplasia. Sample sizes ranged from a minimum of 20 individuals in studies by Cai (2021) and Minafra (2023) to a maximum of 160 in the seminal research by Pacella (2019), thereby offering a comprehensive representation of TPLA's therapeutic use across both pilot and more established study groups. Table 1 delineates the fundamental attributes of each trial, including sample size, intervention type, and percentage alterations in key outcomes such as IPSS, PVR, Qmax, and prostate volume. These diverse sample designs illustrate the actual heterogeneity in patient characteristics and procedure applications, highlighting the significance of pooled analysis in deriving relevant clinical conclusions.

The meta-analysis demonstrated a combined percentage change in the International Prostate Symptom Score (IPSS) of -58.435% (95% CI: -70.421 to -46.449), signifying a statistically and clinically significant decrease in the intensity of lower urinary tract symptoms (LUTS) post-TPLA. This result, serving as the most immediate measure of symptom alleviation, corresponds with the findings of Pacella (2019), Frego (2021), and Manenti (2021), all of whom documented decreases in symptom scores above 65–75%. The enhancements were both statistically significant and clinically relevant, as a decrease in IPSS by over 3–5 points is often deemed beneficial for patient care. The significant heterogeneity reported ($I^2 = 98.41\%$) is anticipated, considering the variations in patient selection, follow-up periods, and baseline symptoms among the studies. Despite the observed variation, the uniformly negative effect across all investigations enhances the believability of TPLA in alleviating symptom load, indicating that TPLA provides significant symptomatic relief regardless of specific therapeutic situations.

A significant outcome evaluated was the post-void residual volume (PVR), which acts as a physiological indicator of bladder emptying efficacy and exhibits a high correlation with the severity of blockage. The aggregated percentage decrease in PVR after TPLA was -63.937% (95% CI: -76.937 to -50.938), indicating a significant enhancement in voiding function. Elevated PVR is linked to a heightened risk of urinary tract infections, detrusor overactivity, and chronic renal impairment; hence, its mitigation is a crucial treatment objective. Research by de Rienzo (2019) and Pacella (2019) indicated significant improvements in PVR, reaching as high as 85%, in alignment with the aggregated estimate. The substantial heterogeneity ($I^2 = 96.38\%$) signifies considerable variance in effect sizes, possibly attributable to inconsistencies in pre-treatment PVR levels, changes in laser parameters, and disparities in the duration between intervention and post-procedure assessment. Notwithstanding this, the consistently substantial and advantageous reductions across all investigations confirm that TPLA successfully mitigates mechanical outflow blockage.

The maximum urine flow rate (Qmax), an objective measure of urethral patency and bladder contractility, exhibited a substantial and positive alteration after to TPLA. The

aggregated estimate indicated a +68.031% enhancement (95% CI: 47.438 to 88.624), underscoring a significant functional advancement. This impact was particularly evident in experiments by Frego (2021) and Manenti (2021), when Qmax increased by more than 110%, signifying a substantial decrease in urethral resistance and a restoration of dynamic flow. The enhancements in Qmax are significantly associated with reductions in IPSS and PVR, indicating that alleviation of symptoms and urodynamic enhancement are interconnected after TPLA. Significant heterogeneity ($I^2 = 92.59\%$) was seen, which is explicable due to Qmax's sensitivity to patient hydration state, measurement methodology, and baseline bladder function. Nonetheless, the extent and uniformity of the enhancement across investigations highlight the therapeutic efficacy of TPLA in restoring natural urine dynamics.

Alongside enhancements in symptoms and flow, TPLA also produced a quantifiable structural alteration, evidenced by a pooled prostate volume reduction of -27.927% (95% CI: -36.575 to -19.280). This discovery corroborates the concept that TPLA induces its effects by specific coagulative necrosis, resulting in tissue contraction and urethral lumen decompression. Decreases in prostate volume, albeit less pronounced than alterations in IPSS or PVR, remain clinically significant, particularly for individuals with higher initial prostate dimensions. Research such as Lagana (2023) and Cai (2021) indicated volume decreases beyond 30%, although studies like van Kollenburg (2023) shown more moderate reductions, maybe attributable to shorter follow-up periods or discrepancies in imaging techniques. Significant heterogeneity ($I^2 = 96.07\%$) indicates inter-study variability; nonetheless, the trend of volume decrease remains consistent and comforting. Anatomical changes frequently occur after symptom recovery; hence, extended follow-up periods may result in more significant volume decline.

Despite the absence of statistical subgroup analysis by intervention type (ultrasound-guided vs. non-guided TPLA) due to limited sample sizes and inadequate stratified data, a descriptive review of the studies indicates that ultrasound guidance may provide increased precision and potentially improved outcomes. Frego (2021), Manenti (2021), and Cai (2021)—all utilizing ultrasound guidance—documented substantial decreases in both IPSS and PVR, while preserving good safety profiles. This indicates that imaging may improve the precision and consistency of laser treatment, reducing problems and optimizing ablation effectiveness. Furthermore, the consistent application of a transperineal approach in all investigations facilitates the isolation of the intervention's impact and suggests that this strategy is a feasible alternative to transurethral techniques without sacrificing efficacy.

The findings of this meta-analysis endorse the clinical efficacy of TPLA as a less invasive alternative to more invasive surgical procedures such as TURP or open prostatectomy. The noted enhancements in symptom ratings, voiding efficiency, urine flow, and gland size significantly indicate that TPLA can fulfill therapeutic objectives while circumventing the complications often linked to traditional methods. Significantly, these outcomes arise despite substantial variation, underscoring the idea that the advantages of TPLA are resilient across diverse clinical environments and patient demographics. These results correspond effectively with the overarching objective of contemporary BPH management: to maximize treatment efficacy while ensuring patient safety, comfort, and quality of life. Although more randomized studies are necessary to determine long-term durability and comparative efficacy, the existing data suggests that TPLA is a potential alternative in the advancing field of BPH treatment.

Discussion

Benign prostatic hyperplasia (BPH) is a common urological condition marked by the nonmalignant expansion of prostatic epithelial and stromal tissues, especially in the prostate's transition zone. The subsequent growth of the gland compresses the prostatic urethra, resulting in urine flow blockage and a range of lower urinary tract symptoms (LUTS). The symptoms encompass frequency, urgency, nocturia, diminished urine stream, and a feeling of incomplete bladder evacuation. The illness disproportionately impacts older guys, with a frequency surpassing 70% in individuals aged over 80. Although several pharmacologic and surgical interventions exist, many therapies have disadvantages like inadequate symptom alleviation, negative sexual side effects, and postoperative complications. The pursuit of safer, similarly efficacious, and function-preserving alternatives has resulted in the emergence of minimally invasive surgical treatments (MISTs), notably the newly introduced transperineal laser ablation (TPLA), which is the central subject of this systematic review and meta-analysis.

This study carefully analyzed 10 clinical trials involving 449 individuals to objectively evaluate the therapeutic efficacy of TPLA in treating symptomatic BPH. The variation in research design (from retrospective cohorts to prospective trials), differences in sample size, and diversity in procedural approaches illustrate the progressive clinical integration of TPLA. Notwithstanding this variability, a uniform trend of symptomatic and functional improvement was noted across almost all investigations, validating the potential of TPLA to serve as a feasible alternative to traditional surgical methods. Ultrasound-guided, image-targeted transmission of laser light via the perineum allows doctors to precisely ablate prostatic tissue while preserving neighboring structures essential for urine and sexual function—an benefit that distinguishes TPLA from transurethral methods.

The main symptomatic outcome evaluated in this meta-analysis was the percentage change in the International Prostate Symptom Score (IPSS), a validated instrument that measures the intensity of lower urinary tract symptoms (LUTS) in patients with benign prostatic hyperplasia (BPH). The aggregated outcome demonstrated a significant 58.4% decrease in IPSS after TPLA, with a 95% confidence range ranging from -70.421 to -46.449. This data is clinically relevant, as a decrease of 3 to 5 points in IPSS is typically considered the lowest threshold for substantial symptomatic improvement. Research conducted by Pacella et al. (2019), Frego et al. (2021), and Manenti et al. (2021) shown that symptom score reductions varied from 66% to over 75%, highlighting the efficacy of TPLA in diverse clinical settings. Despite the observed significant heterogeneity ($I^2 = 98.41\%$), it likely indicates variations in baseline symptom intensity, follow-up lengths, and uniformity of techniques rather than discrepancies in treatment efficacy. The effect's directionality consistently remained advantageous.

In addition to symptom perception, TPLA significantly affected objective urodynamic metrics, particularly post-void residual volume (PVR). The aggregated percentage decrease in PVR was 63.9% (95% CI: -76.937 to -50.938), indicating significant improvement in bladder evacuation. Increased PVR indicates detrusor underactivity and obstructive voiding, both linked to long-term problems such as urinary tract infections, stone formation, and upper tract degeneration. The significant decreases in PVR seen in the research conducted by de Rienzo (2019), Pacella (2019), and Cai (2021) validate the efficacy of TPLA in tackling the anatomical

and functional underlying reasons of blockage. Despite the substantial heterogeneity ($I^2 = 96.38\%$), this may be understood as variability in baseline bladder function and the time of post-procedure PVR evaluation. Nevertheless, the uniformity in result enhancement across all investigations indicates that TPLA consistently facilitates more thorough bladder evacuation.

The examination of maximal urine flow rate (Q_{max}) further corroborates the efficacy of TPLA. The meta-analytical pooled estimate revealed a 68% increase in Q_{max} (95% CI: 47.438 to 88.624), indicating a significant enhancement in urethral patency and voiding efficiency. Q_{max} is a critical objective metric, frequently associated with patient satisfaction and therapeutic efficacy. Enhancements in Q_{max} were particularly significant in investigations utilizing ultrasound guiding, notably those conducted by Manenti (2021) and Frego (2021), where average gains exceeded 100%. This underscores the significance of procedural precision and real-time imaging in enhancing therapy outcomes. Despite strong variability ($I^2 = 92.59\%$), the overall trend demonstrated a significant and continuous improvement in urine flow dynamics, suggesting that TPLA provides both subjective alleviation and quantifiable restoration of voiding function.

The pooled analysis indicated that prostate volume decreased by an average of 27.9% after TPLA (95% CI: -36.575 to -19.280). While less significant than the volume reductions achieved through more invasive techniques like HoLEP or open prostatectomy, this level of decrease remains therapeutically pertinent, especially when considered alongside symptomatic and functional improvements. Modest decreases in periurethral volume may provide substantial relief from both dynamic and static blockage. The action mechanism is predominantly coagulative necrosis, triggered by localized laser energy, succeeded by progressive resorption of necrotic tissue and fibrotic rebuilding. Research conducted by Lagana (2023) and Cai (2021) indicated reductions ranging from 22% to 41%, implying variability contingent upon initial prostate size, laser specifications, and follow-up length.

The physiological basis for TPLA's efficacy is its capacity to specifically cause necrosis in hyperplastic prostate tissue while preserving essential anatomical components. The transperineal technique completely bypasses the urethra, hence reducing stress to the mucosa and external sphincter while safeguarding antegrade ejaculation. This is especially significant for younger individuals or those for whom sexual function is paramount. Unlike transurethral resection, which poses a considerable risk of retrograde ejaculation and urethral strictures, TPLA enables precise tissue reduction while preserving the integrity of the ejaculatory ducts and urethral sphincter. Moreover, by utilizing imaging guidance, practitioners may guarantee precise positioning of the laser fibers and sustain uniform energy delivery, hence enhancing safety and efficacy.

A comparative examination with different MISTs demonstrates various benefits that are unique to TPLA. Although methods like Urolift and Rezum are less invasive and have reduced procedure durations, they frequently produce only small improvements in symptoms. For instance, Urolift has shown decreases in IPSS of just 30–35% in the majority of studies, with restricted durability exceeding two years. Rezum, although linked to superior results compared to Urolift, yet necessitates temporary catheterization and urethral instrumentation. TPLA, conversely, attains symptom reductions over 50% without urethral access and seems to provide a more sustained volumetric response. Its effectiveness in enhancing Q_{max} and PVR surpasses

that of prostatic artery embolization (PAE), another non-resective minimally invasive surgical technique (MIST).

In comparison to the conventional gold standard TURP, TPLA has similar efficacy in alleviating LUTS and enhancing flow metrics, however with less anatomical debulking. TURP results in volume reductions of 35–50%, frequently associated with increased intraoperative bleeding, the necessity for irrigation, and catheter retention. The less invasive characteristics of TPLA lead to expedited recovery, reduced anesthetic needs, and a diminished occurrence of sexual adverse effects. Nonetheless, longitudinal data remain essential to validate the sustainability of TPLA's advantages compared to TURP, especially in prostates larger than 80 cc, where TURP or enucleation are generally favored.

Notwithstanding these encouraging results, this meta-analysis possesses several limitations. The primary issue is the prevalence of non-randomized cohort studies, many of which lacked control groups, blinding, or long-term follow-up. The lack of direct comparisons with other interventions constrains the robustness of comparative conclusions. Moreover, outcome measurement lacked standardization between trials; for instance, the time of post-treatment assessments differed, potentially influencing consistency. The significant variation shown across all outcome categories highlights these methodological discrepancies and emphasizes the necessity for procedure standardization in forthcoming research.

A significant restriction is the underreporting of adverse events and patient-reported outcomes, including quality of life, sexual function, and satisfaction. Given that TPLA is presented as a function-preserving option, it is essential to evaluate not just symptom alleviation but also the wider aspects of patient well-being. Only a limited number of research incorporated data on ejaculatory function or continence outcomes, and an even smaller fraction utilized validated tools to measure these parameters. Subsequent research should rectify this deficiency to provide a comprehensive evaluation of TPLA's benefit-risk profile.

The studies analyzed exhibited variability in laser energy settings, fiber quantity, and treatment time, potentially affecting the extent of tissue ablation attained. These technical discrepancies highlight the necessity for defined procedural protocols and training to guarantee uniform clinical results. The economic implications of TPLA have not been comprehensively examined. Although the technique may decrease hospitalizations and problems, the expenses associated with equipment and imaging might be considerable. Formal cost-effectiveness analyses are crucial for guiding reimbursement and policy determinations.

Considering these constraints, further investigations should emphasize meticulously constructed, multicenter randomized controlled trials that directly compare TPLA with TURP, HoLEP, Rezum, and other minimally invasive surgical techniques (MISTs). These studies must encompass long-term follow-up of a minimum of 2–5 years, consistent criteria for success and failure, and thorough documentation of adverse events. The use of patient-reported outcome measures, including the IIEF (International Index of Erectile Function), MSHQ-EjD (Male Sexual Health Questionnaire), and quality of life scores, would yield significant insights into the comprehensive effects of the operation.

This meta-analysis indicates that TPLA is most appropriate for patients with moderate-to-severe LUTS who are either unfit for TURP or prefer to evade its sexual adverse effects. This surgery may be optimal for people with small to medium-sized prostates who favor an outpatient treatment with quick recovery. Shared decision-making, informed by specific

patient values and anatomical factors, will be essential for identifying suitable candidates for TPLA. As usage increases, the learning curve and procedural consistency are anticipated to improve, hence benefiting results.

This comprehensive review and meta-analysis demonstrate that TPLA is a successful and less invasive therapy for BPH. It provides substantial improvements in LUTS, flow dynamics, and prostate dimensions with a reduced risk profile compared to several conventional surgical procedures. Although the present findings are promising, they should be analyzed considering methodological heterogeneity and restricted long-term follow-up. As the evidence base expands, TPLA may play a pivotal role in the care protocol for BPH, providing patients with a function-preserving, outpatient option to more invasive interventions.

CONCLUSION

Transperineal Laser Ablation (TPLA) shows promise as a minimally invasive option for benign prostatic hyperplasia (BPH), with ten studies reporting significant improvements in symptom severity, urinary flow, bladder emptying, and reduced prostate volume, alongside favorable safety profiles that position TPLA as a potential alternative to TURP, especially for patients who value preservation of sexual function and quicker recovery. However, limitations from study design variability and short follow-up temper the strength of the conclusions. Future research should prioritize high-quality randomized controlled trials with longer follow-up to firmly establish long-term efficacy, safety, and direct comparative effectiveness versus standard surgical approaches.

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