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ARTICLE

450-nm blue laser vaporization versus transurethral resection of the prostate for benign prostatic hyperplasia: a retrospective comparative study

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Background: *Transurethral resection of the prostate (TURP) remains the standard surgical treatment for benign prostatic hyperplasia (BPH), whereas laser-based procedures have increasingly been adopted as alternatives because of their potential advantages in hemostasis and postoperative recovery. This study compared coagulation depth, perioperative outcomes, postoperative complications, and short-term functional outcomes between 450-nm blue laser vaporization of the prostate (BVP) and TURP.*
Methods: *This retrospective single-center study included 260 patients with BPH who underwent either TURP ($n = 110$) or BVP ($n = 150$). Coagulation depth was compared between the two procedures using an ex vivo porcine kidney specimen experiment. Baseline characteristics, perioperative variables, intraoperative and postoperative complications, and postoperative functional outcomes at 1, 3, and 6 months were analyzed.*
Results: *BVP produced a significantly shallower coagulation depth than TURP. Baseline demographic and clinical characteristics were generally comparable between the two groups, although BMI and baseline QoL differed slightly. Compared with TURP, BVP was associated with a shorter operative time, earlier catheter removal, and a shorter hospital stay. Intraoperative complications were uncommon in both groups, and several postoperative complications were numerically less frequent in the BVP group. Both procedures resulted in substantial postoperative improvement in Q_{max}, PVR, IPSS, and QoL. In adjusted repeated-measures mixed-effects analyses, BVP showed greater improvement in Q_{max} and IPSS across follow-up and greater PVR reduction at 3 and 6 months, whereas QoL improved over time without a significant overall group effect.*
Conclusions: *Compared with TURP, 450-nm BVP was associated with a shallower coagulation depth, more favorable perioperative recovery, and comparable short-term functional outcomes in patients with BPH. These findings support BVP as a feasible and promising transurethral alternative for the surgical management of BPH. The reduced coagulation depth observed after BVP may also have implications for postoperative inflammatory recovery and warrants further investigation.*

Key Words: Benign prostatic hyperplasia, blue laser vaporization of the prostate, transurethral resection of the prostate, coagulation depth, perioperative outcomes, functional outcomes

Introduction

Benign prostatic hyperplasia (BPH) is one of the most common causes of lower urinary tract symptoms (LUTS) in older men. For patients who do not respond adequately to medical therapy, transurethral resection of the prostate (TURP) remains the standard

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surgical treatment for BPH. Despite technical advances, however, TURP is still associated with perioperative and postoperative complications, particularly bleeding and transurethral resection syndrome.[1] To reduce perioperative morbidity and shorten hospitalization, laser prostatectomy has been developed as an alternative to conventional TURP.[2,3] Currently available laser platforms for BPH surgery include green laser, holmium laser, thulium laser, and diode laser, and more recently, 450-nm blue laser systems have also been introduced into this field.[4,5]

Because of the optical characteristics of the 450-nm wavelength, particularly its strong absorption by hemoglobin, blue laser vaporization has emerged as a promising option for BPH surgery.[6,7] Preclinical studies have supported the technical feasibility of this platform and have provided preliminary evidence regarding postoperative wound healing, while early clinical studies have suggested favorable perioperative and functional outcomes.[8,9] However, as with other vaporization-based procedures, concern remains that thermal injury to the prostatic urethra and surgical cavity may prolong postoperative inflammation and contribute to related complications.[10,11] In addition, postoperative inflammatory manifestations after transurethral prostate surgery, such as pyuria and infection-related events, remain clinically relevant, whereas direct comparative evidence regarding the thermal effect and early postoperative recovery after 450-nm BVP is still limited.[12–15]

Therefore, we combined an *ex vivo* evaluation of coagulation depth using porcine kidney specimens with a retrospective clinical comparison of perioperative outcomes, postoperative complications, and short-term functional outcomes between BVP and TURP. By integrating the thermal-effect profile with clinical outcome data, this study may provide practical evidence for the clinical application of 450-nm BVP in the surgical management of BPH.

Methods

Study population

This retrospective single-center cohort study was approved by the Institutional Review Board of Qingjian County People's Hospital (Approval No.: 2023-IRB-01) and was conducted at Qingjian County People's Hospital (Shaanxi, China). We retrospectively reviewed the medical records of patients who underwent transurethral surgery for BPH between 1 October 2023, and 30 April 2025. Patients were eligible if they had lower urinary tract symptoms secondary to benign prostatic obstruction and underwent either BVP or TURP. Surgical indications were based on standard clinical criteria for BPH surgery, including refractory lower urinary tract symptoms, recurrent urinary retention, recurrent urinary tract infection, gross hematuria attributable to BPH, bladder stones, or renal insufficiency secondary to bladder outlet obstruction.

To reduce potential bias related to surgical technique and perioperative management, all procedures were performed by the same experienced urologist during the study period. Baseline demographic and clinical characteristics were extracted from the electronic medical records, including age, body mass index, prostate volume, postvoid residual urine volume (PVR), maximum urinary flow rate (Q_{max}), International Prostate Symptom Score (IPSS), quality-of-life (QoL) score, total prostate-specific antigen (PSA), bacteriuria, preoperative antibiotic use, indwelling catheterization, operative time, catheter removal time, and length of hospital stay. Because some patients had preoperative urinary retention or indwelling catheterization, baseline uroflowmetry and PVR data were not available for all cases.

Surgical technique

All patients were placed in the lithotomy position and were operated on using a low-pressure continuous irrigation system.

TURP group: Transurethral bipolar plasmakinetic resection of the prostate was performed using a bipolar resectoscope. After insertion of the resectoscope through the urethra, the verumontanum, bladder neck, and bilateral ureteral orifices were identified. The resection sequence began with the median lobe (if present), making an incision along the 6 o'clock position from the bladder neck toward the verumontanum and removing tissue layer by layer until reaching the surgical capsule. The lateral lobes were then resected, typically starting from the 12 o'clock position and cutting toward both sides, or making layer-by-layer cuts from one lobe (e.g., from the 7 o'clock to 5 o'clock direction), with each pass removing small pieces of tissue until the surgical capsule (visible circular fibers) was reached. The 12 o'clock area was trimmed when significant hyperplasia was present. Hemostasis was achieved by electrocoagulation of all arterial bleeding points. Finally, the residual glandular tissue was repaired to create a smooth, funnel-shaped transition from the urethra to the bladder neck. A 22-Fr three-way Foley catheter with a 30–50 mL balloon was inserted at the end of the procedure.

BVP group: BVP was performed using a 450-nm blue laser platform in continuous-wave mode with an end-firing fiber. After thorough lubrication, the laser scope sheath was inserted through the urethra under direct vision, passing through the membranous urethra into the posterior urethra. The verumontanum was identified as the distal safety boundary to avoid damaging the external sphincter, and the bilateral ureteral orifices were checked to prevent accidental injury. After filling the bladder, laser activation began at the 5 to 7 o'clock positions on the bladder neck. Continuous vaporization from left to right was used to vaporize and cut the hyperplastic tissue, creating a 360° incision of the bladder outlet while protecting the bladder mucosa and internal sphincter. The endoscope sheath was then advanced approximately 1 cm distally, and a retrograde technique was used to remove glandular tissue, rapidly establishing a voiding channel from the bladder neck to the prostate. This technique was repeated, swinging the fiber left and right along the surgical capsule layer, to maximize vaporization of the remaining hyperplastic glands. Hemostasis was achieved by laser coagulation of any visible active bleeding points. At the end of the procedure, a 20-Fr three-way Foley catheter with a 30 mL balloon was inserted, and continuous bladder irrigation was applied as needed.

For both procedures, all patients received prophylactic intravenous antibiotics approximately 1 h before surgery according to institutional routine. Catheter removal was routinely attempted on postoperative day 2, provided that hematuria had improved and voiding conditions were acceptable.

Assessment of coagulation depth

To compare the thermal effect of the two procedures, an *ex vivo* experiment was conducted using porcine kidney specimens. The kidney specimens were obtained from a local commercial slaughterhouse (Qingjian County, Shaanxi, China); therefore, no animals were specifically euthanized for this study, and formal animal ethics approval was not required. The specimens were prepared under comparable conditions to minimize differences in tissue size and thickness.

A total of 24 specimens were included, with 12 assigned to the TURP group and 12 to the BVP group. For each treatment, the following parameters were applied: TURP group: resection was performed using a standard monopolar resectoscope with cutting power set to 120 W and coagulation power set to 80 W. The resectoscope loop was moved across the tissue surface at a speed of approximately 1 cm/s, and each pass covered a length of about 2 cm with a contact time of approximately 2 s per pass. BVP group: the 450-nm blue laser platform was used in continuous-wave mode with an end-firing fiber. The laser power was set to 150 W. The fiber was swept across the tissue surface at a speed of approximately 0.5 cm/s, with a contact time of approximately 1 s per treated area. After treatment, each specimen was sectioned through the center of the treatment area, and representative cross-sectional gross images were obtained. Coagulation depth was defined as the vertical distance from the treated tissue surface to the deepest visible coagulation boundary. Measurements were performed on the cut surface, and the mean coagulation depth was compared between the two groups using Student's *t*-test.

Perioperative, postoperative, and follow-up outcomes

Perioperative outcomes included operative time, lasing time, catheter removal time, length of hospital stay, and fiber usage. Postoperative complications were categorized as intraoperative complications, early postoperative complications (≤30 days), and medium-term complications (≤6 months). Intraoperative complications included TUR syndrome, capsular perforation, bleeding, fiber defect, conversion to TURP, and ureteral orifice injury. Early postoperative complications included blood transfusion, hematuria, urosepsis, failure of the initial voiding trial, failure of the second voiding trial, stress incontinence, urge incontinence, dysuria, and reintervention. Medium-term complications included urethral stricture, bladder neck stricture, reintervention, and persistent dysuria.

Functional outcomes were evaluated at 1, 3, and 6 months after surgery. The assessed variables included Q_{max}, PVR, IPSS, and QoL score. Follow-up data available at each time point were collected from outpatient records. These follow-up indicators were selected to reflect both objective improvement in voiding function and subjective changes in symptom burden and quality of life after surgery. Together, they provided a structured assessment of the short-term therapeutic effect of the two procedures.

Statistical analysis

Continuous variables were tested for normality using the Shapiro–Wilk test. Normally distributed variables were expressed as mean ± standard deviation (SD) and compared using Student's *t*-test; non-normally distributed variables were expressed as median (interquartile range) and compared using the Mann–Whitney U test. Categorical variables were summarized as frequencies and percentages and compared using the chi-square test or Fisher's exact test, as appropriate.

Postoperative functional outcomes measured repeatedly at 1, 3, and 6 months were analyzed using linear mixed-effects models. For Q_{max}, PVR, IPSS, and QoL, change from baseline was used as the dependent variable. Surgical group, follow-up month, and the group-by-follow-up-month interaction were included as fixed effects. The models were adjusted for the baseline value of the corresponding outcome, age, body mass index, prostate volume, diabetes mellitus, and hypertension. Follow-up month was modeled as a repeated factor within patient to account for within-patient correlation. Least-squares mean changes and 95% confidence intervals were estimated for each group at each follow-up time point. Adjusted between-group differences were calculated as BVP minus. Overall tests for surgical group, follow-up month, and the group-by-follow-up-month interaction were used to assess between-group differences, temporal change, and whether the postoperative change trajectory differed between groups. Because individual postoperative complication events were sparse, complication outcomes were compared descriptively using unadjusted tests, and fully adjusted multivariable models were not fitted for these binary outcomes.

Coagulation depth was compared between the two groups using Student's *t*-test. A two-sided p value < 0.05 was considered statistically significant. Statistical analyses were performed using SPSS version 25.0 and SAS version 9.4.

3 Results

Coagulation depth comparison

Representative gross findings and quantitative analysis showed that BVP produced a shallower coagulation zone than TURP. As shown in Figure 1, the coagulation depth in the BVP group was significantly lower than that in the TURP group ($p < 0.001$).

Baseline characteristics and perioperative outcomes

A total of 260 patients were included, comprising 110 patients in the TURP group and 150 patients in the BVP group. Age, prostate volume, diabetes mellitus, hypertension, PVR, Q_{max}, IPSS, total PSA, bacteriuria, preoperative antibiotic use, and indwelling catheterization were generally comparable between groups. BMI was lower in the BVP group than in the TURP group (22.4 ± 3.3 vs. 23.2 ± 2.5 kg/m², $p = 0.032$), and baseline QoL score was slightly higher in the BVP group (5.7 ± 0.5 vs. 5.6 ± 0.3, $p = 0.046$). Diabetes mellitus was present in 22 patients (20.0%) in the TURP group and 40 patients (26.7%) in the BVP group, and hypertension was present in 28 patients (25.5%) and 44 patients (29.3%), respectively.

In terms of perioperative outcomes, the mean operative time was shorter in the BVP group than in the TURP group (26.6 ± 11.7 vs. 46.6 ± 22.3 min). Catheter removal was achieved earlier in the BVP group (2.7 ± 1.4 vs. 4.7 ± 2.3 days), and the length of hospital stay was also shorter after BVP (5.6 ± 2.2 vs. 7.6 ± 3.1 days). The mean lasing time in the BVP group was 20.1 ± 15.5 min, and only one fiber was required per procedure (Table 1).

Intraoperative and postoperative complications

Intraoperative complications were uncommon in both groups. In the TURP group, one patient developed TUR syndrome, two experienced capsular perforation, and one had intraoperative bleeding. No such events were observed in the BVP group. No ureteral orifice injury occurred in either group, and there were no cases of fiber defect or conversion to TURP in the BVP group.

Early postoperative complications were generally less frequent in the BVP group. Hematuria occurred in three patients after TURP and in one patient after BVP. Urosepsis was observed in two patients in the

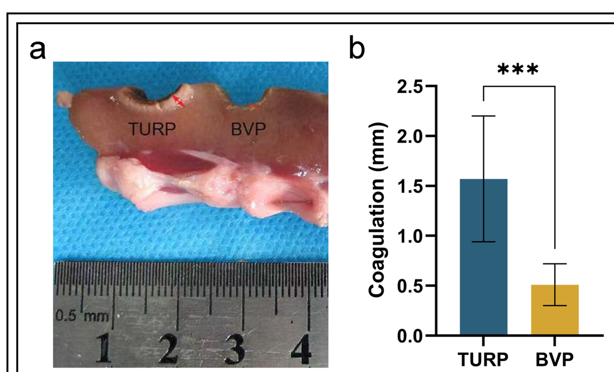

FIGURE 1. Comparison of coagulation depth between transurethral resection of the prostate (TURP) and blue laser vaporization of the prostate (BVP) in porcine kidney specimens. (a) Representative gross appearance of the coagulation zone after TURP and BVP. (b) Quantitative analysis of coagulation depth in the two groups (n = 12 per group). ***$p < 0.001$

TABLE 1. **Baseline characteristics and perioperative outcomes of patients undergoing TURP or BVP**

Variable	Surgical type		
	TURP (N = 110)	**BVP (N = 150)**	***p* value**
Mean age (year)	71.6 ± 3.1	72.1 ± 11.2	$p = 0.576$
BMI (kg/m^2)	23.2 ± 2.5	22.4 ± 3.3	$p = 0.032$
Diabetes mellitus	22 (20.00%)	40 (26.67%)	$p = 0.213$
Hypertension	28 (25.45%)	44 (29.33%)	$p = 0.490$
Prostate volume (mL)	59.1 ± 23.3	60.5 ± 32.7	$p = 0.704$
PVR (mL)	156.3 ± 20.8 (n = 45)	160.1 ± 21.7 (n = 60)	$p = 0.391$
Q_{max} (mL/s)	5.9 ± 3.3 (n = 65)	6.1 ± 1.1 (n = 90)	$p = 0.569$
IPSS	23.5 ± 3.4	24.3 ± 4.7	$p = 0.125$
QoL	5.6 ± 0.3	5.7 ± 0.5	$p = 0.046$
Total PSA (ng/mL)	6.6 ± 3.2	7.6 ± 5.7	$p = 0.092$
Bacteriuria	6 (5.5%)	9 (6.1%)	$p = 0.84$
Antibiotic	24 (21.8%)	23 (15.3%)	$p = 0.17$
Indwelling catheter	36 (32.8%)	55 (36.4%)	$p = 0.56$
Total operative time (min)	46.6 ± 22.3	26.6 ± 11.7*	$p < 0.001$
Lasing time (min)	/	20.1 ± 15.5	/
Catheter removal (d)	4.7 ± 2.3	2.7 ± 1.4*	$p < 0.001$
Hospital stay (d)	7.6 ± 3.1	5.6 ± 2.2*	$p < 0.001$
Fiber usage (n)	/	1	/

Note. *Indicates a statistically significant difference ($p < 0.05$).

TURP group but in none of the BVP patients. Failure of the initial voiding trial occurred in 10 TURP patients and 5 BVP patients, while failure of the second voiding trial occurred in 3 TURP patients and in no BVP patient. Urge incontinence, dysuria, and reintervention were also numerically lower after BVP.

At medium-term follow-up, urethral stricture was observed in 5 patients in the TURP group and 2 in the BVP group. Bladder neck stricture occurred in 7 TURP patients but was not observed in the BVP group. Reintervention and persistent dysuria were also more common after TURP than after BVP (Table 2).

Functional outcomes during follow-up

Postoperative functional outcomes were analyzed using linear mixed-effects models adjusted for the baseline value of the corresponding outcome, age, BMI, prostate volume, diabetes mellitus, and hypertension. Follow-up month was modeled as a repeated factor within patient.

Both groups showed significant improvement in Q_{max}, PVR, IPSS, and QoL over time. For Q_{max} and IPSS, the adjusted improvement was greater in the BVP group than in the TURP group at all follow-up time points, with significant overall group, time, and group-by-time effects. For PVR, the between-group difference was not significant at 1 month but favored BVP at 3 and 6 months; the overall group, time, and group-by-time effects were significant. For QoL, the overall time effect and group-by-time interaction were significant, whereas the overall group effect was not. Detailed estimates are shown in Table 3.

Discussion

In the present study, BVP demonstrated several perioperative and short-term postoperative advantages over TURP. Compared with TURP, BVP was associated with a shorter operative time, earlier catheter removal, and a shorter hospital stay. In addition, several intraoperative and postoperative complications were numerically less frequent in the BVP group. At follow-up, both procedures achieved substantial improvement in urinary function and symptom scores. The adjusted repeated-measures analysis showed greater improvement in Q_{max} and IPSS after BVP, with later differences in PVR favoring BVP, whereas QoL improved over time in both groups without a significant overall group effect.

TABLE 2. **Intraoperative and postoperative complications in the TURP or BVP groups**

Variable	Surgical type		
	TURP (N = 110)	**BVP (N = 150)**	***p* value**
Intraoperative			
TUR syndrome	1 (0.9%)	0	$p = 1.000$
Capsule perforation	2 (1.8%)	0	$p = 0.544$
Bleeding	1 (0.9%)	0	$p = 1.000$
Fiber defect	/	0	/
Conversion to TURP	/	0	/
Ureteral orifice injury	0	0	/
Early postoperative (≤30 days)			
Blood transfusion	0	0	/
Hematuria	3 (2.7%)	1 (0.9%)	$p = 0.615$
Urosepsis	2 (1.8%)	0	$p = 0.541$
Failure of the initial voiding trial	10 (9.1%)	5 (4.5%)	$p = 0.236$
Failure of the second voiding trial	3 (2.7%)	0	$p = 0.247$
Stress incontinence	0	0	/
Urge incontinence	7 (6.4%)	3 (2.7%)	$p = 0.315$
Dysuria	5 (4.5%)	3 (2.7%)	$p = 0.721$
Reintervention	2 (1.8%)	0	$p = 0.541$
Medium term (≤6 months)			
Urethral stricture	5 (4.5%)	2 (1.8%)	$p = 0.431$
Bladder neck stricture	7 (6.4%)	0	$p = 0.011$
Reintervention	12 (10.9%)	2 (1.8%)	$p = 0.003$
Dysuria	11 (10%)	5 (4.5%)	$p = 0.160$

One of the most noteworthy findings of this study was the significantly shallower coagulation depth observed with BVP than with TURP in the *ex vivo* porcine kidney model. This finding is clinically relevant because excessive coagulation may contribute to deeper thermal injury, delayed wound healing, and subsequent irritative or obstructive complications. Previous preclinical studies have shown that the 450-nm wavelength combines effective tissue vaporization with strong hemoglobin absorption and a relatively limited coagulation zone, while experimental studies have also suggested a favorable wound-healing profile after blue laser vaporization.[4–6,16,17] Therefore, the shallower coagulation depth observed in our study may partly explain the numerically lower rates of hematuria, urosepsis, dysuria, urethral stricture, bladder neck stricture, and reintervention after BVP.

From a broader clinical perspective, the reduced coagulation depth and faster postoperative recovery observed after BVP may also have implications for postoperative inflammatory recovery. From a practical clinical perspective, these findings may be particularly relevant in patients in whom rapid recovery and reduced perioperative burden are important considerations. Earlier catheter removal and shorter hospitalization may not only improve patient comfort, but may also facilitate postoperative mobilization and reduce the overall burden of inpatient care.[18,19] While these benefits should be interpreted cautiously in the absence of long-term data, they nonetheless support the potential value of BVP as a less invasive transurethral alternative for selected patients with BPH. Although pyuria and postoperative urinary tract infectious sequelae were not directly evaluated as primary endpoints in the present study, these postoperative phenomena are clinically relevant after transurethral prostate surgery and may be influenced by the extent of tissue injury and wound healing.[12,13] In this context, the more limited thermal effect of BVP may suggest a more favorable postoperative inflammatory course, which could be relevant to the interpretation of postoperative pyuria and infection-related events.

TABLE 3. **Adjusted changes from baseline in postoperative functional outcomes at 1, 3, and 6 months after TURP or BVP**

Change from baseline	TURP group	BVP group	Difference BVP minus TURP (95% CI)[b]	p value	Overall test[c]		
	Mean change (95% CI)[a]	Mean change (95% CI)			Group	Time	Group-by-time interaction
Q_{max} (mL/s)					<0.001	<0.001	<0.001
1st month	9.09 (8.86, 9.31)	11.65 (11.48, 11.82)	2.56 (2.19, 2.94)	<0.001			
3rd month	12.91 (12.70, 13.13)	14.47 (14.31, 14.63)	1.55 (1.19, 1.92)	<0.001			
6th month	13.35 (13.14, 13.57)	15.27 (15.11, 15.43)	1.91 (1.55, 2.28)	<0.001			
PVR (mL)					<0.001	<0.001	<0.001
1st month	−152.63 (−152.91, −152.35)	−152.50 (−152.66, −152.33)	0.13 (−0.29, 0.55)	0.54			
3rd month	−153.45 (−153.73, −153.17)	−154.37 (−154.53, −154.20)	−0.92 (−1.33, −0.50)	<0.001			
6th month	−153.27 (−153.54, −153.00)	−154.64 (−154.79, −154.48)	−1.37 (−1.78, −0.96)	<0.001			
IPSS					<0.001	<0.001	<0.001
1st month	−12.55 (−12.72, −12.38)	−14.02 (−14.14, −13.89)	−1.46 (−1.75, −1.18)	<0.001			
3rd month	−17.24 (−17.41, −17.08)	−18.64 (−18.76, −18.52)	−1.40 (−1.67, −1.12)	<0.001			
6th month	−17.69 (−17.86, −17.53)	−19.05 (−19.17, −18.93)	−1.35 (−1.63, −1.08)	<0.001			
QoL					0.52	<0.001	<0.001
1st month	−3.49 (−3.57, −3.42)	−3.23 (−3.29, −3.18)	0.26 (0.15, 0.38)	<0.001			
3rd month	−4.16 (−4.22, −4.09)	−4.22 (−4.26, −4.17)	−0.06 (−0.17, 0.05)	0.30			
6th month	−4.46 (−4.52, −4.39)	−4.57 (−4.61, −4.52)	−0.11 (−0.22, 0.00)	0.053			

Note. Q_{max}, maximum urinary flow rate; PVR, postvoid residual urine volume; IPSS, International Prostate Symptom Score; QoL, quality of life; CI, confidence interval. [a]Adjusted mean changes were estimated using a linear mixed-effects model with surgical group, follow-up month, and the group-by-follow-up-month interaction as fixed effects. The model was adjusted for the baseline value of the corresponding outcome, age, body mass index, prostate volume, diabetes mellitus, and hypertension. Follow-up month was modeled as a repeated factor within patient to account for within-patient correlation. [b]The difference was calculated as BVP minus TURP. The time-specific p value corresponds to the adjusted between-group comparison at each follow-up month. [c]The overall group, time, and group-by-time p values were obtained from the Type III fixed-effect tests of the mixed-effects model.

This potential relationship warrants further investigation in future studies specifically designed to assess these outcomes.

The perioperative advantages of BVP observed in the present cohort are also consistent with the growing clinical literature on 450-nm blue laser surgery. Recent studies have reported that blue laser surgery can be performed safely and effectively in patients with BPH, including elderly, high-risk, and urinary retention populations, with favorable perioperative and functional outcomes.[6,7] In our study, BVP required less operative time than TURP and was associated with earlier catheter removal and shorter hospitalization. These findings support the practical value of BVP as a transurethral surgical option, particularly in patients in whom rapid postoperative recovery and effective hemostasis are desirable.[20]

The repeated-measures mixed-effects analysis further supported the short-term functional effectiveness of both procedures. After adjustment for baseline outcome value, age, BMI, prostate volume, diabetes mellitus, and hypertension, both TURP and BVP were associated with marked postoperative improvement in Q_{max}, PVR, IPSS, and QoL. Compared with TURP, BVP showed greater adjusted improvement in Q_{max} and greater adjusted reductions in IPSS at all follow-up time points. PVR reductions were also greater in the BVP group at 3 and 6 months. For QoL, the overall time effect and group-by-time interaction were significant, although the overall group effect was not. These findings suggest that BVP provides at least comparable short-term functional recovery and may offer modest advantages in selected postoperative functional outcomes. This interpretation is supported by recent clinical studies reporting satisfactory symptom relief and functional outcomes after blue laser surgery.[8,9] Moreover, a recent comparative study suggested that blue laser vaporization may offer faster recovery and better functional preservation than other transurethral laser approaches in selected patients,[18] further supporting the clinical potential of this technology.

Several limitations of this study should be acknowledged. First, this was a retrospective single-center study, and selection bias could not be completely avoided. Second, the follow-up period was limited to 6 months, and therefore, the long-term durability of BVP could not be assessed. Third, although the repeated functional outcomes were reanalyzed using mixed-effects models adjusted for clinically relevant baseline covariates, including diabetes mellitus and hypertension, residual confounding remains possible because of the retrospective observational design. In addition, several postoperative complications were rare, which limited the feasibility and stability of fully adjusted multivariable analyses for individual complication outcomes. Fourth, the comparison of coagulation depth was based on *ex vivo* porcine kidney specimens rather than human prostatic tissue, and therefore, the thermal-effect findings should be interpreted with appropriate caution when extrapolated to clinical settings. Finally, postoperative pyuria and infection-related sequelae were not directly analyzed in this study, and any discussion of their relationship to reduced coagulation depth and improved recovery should therefore be considered hypothesis-generating rather than confirmatory. Future studies with larger multicenter cohorts and longer follow-up are warranted to further validate the durability, safety, and clinical applicability of BVP.

Despite these limitations, the present study provides clinically meaningful comparative evidence on BVP and TURP. In the *ex vivo* porcine kidney model, BVP was associated with a shallower coagulation depth than TURP. In the clinical cohort, BVP was associated with shorter operative time, earlier catheter removal, shorter hospitalization, and numerically lower complication rates, while maintaining favorable short-term functional outcomes. These findings support the feasibility and potential clinical advantages of BVP as an alternative transurethral treatment for BPH. In addition, the more limited thermal effect observed with BVP may provide a rationale for future studies investigating postoperative inflammatory recovery after blue laser surgery.

Conclusions

Compared with TURP, 450-nm BVP was associated with shallower coagulation depth, faster perioperative recovery, and favorable short-term functional improvement after adjustment for clinically relevant baseline covariates. BVP showed greater adjusted improvements in several postoperative functional outcomes, although the retrospective design and sparse complication events require cautious interpretation. These findings support BVP as a feasible and promising transurethral alternative for the surgical management of BPH and warrant confirmation in larger prospective studies with longer follow-up.

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Author Contributions

The authors confirm contribution to the paper as follows: Conceptualization, Baoli Li and Xiangbo Chen; methodology, Nana Liu and Xiangbo Chen; validation, Nana Liu, Jinjin Zhang and Wanli Liu; formal analysis, Nana Liu; investigation, Nana Liu, Jinjin Zhang and Wanli Liu; data curation, Nana Liu and Jinjin Zhang; writing—original draft preparation, Nana Liu; writing—review and editing, Baoli Li and Xiangbo Chen; supervision, Baoli Li and Xiangbo Chen; project administration, Xiangbo Chen. All authors reviewed and approved the final version of the manuscript.

Availability of Data and Materials

The data that support the findings of this study are available from the Corresponding Authors, Baoli Li and Xiangbo Chen, upon reasonable request.

Ethics Approval

This retrospective study was approved by the Institutional Review Board of Qingjian County People's Hospital (Approval No.: 2023-IRB-01). The requirement for informed consent was waived due to the retrospective nature of the study and the use of anonymized data. All procedures were conducted in accordance with the 1964 Helsinki Declaration and its later amendments.

Conflicts of Interest

The authors declare no conflicts of interest.

Abbreviations

The following abbreviations are used in this manuscript:

BPH Benign prostatic hyperplasia
BMI Body mass index
BVP Blue laser vaporization of the prostate
IPSS International Prostate Symptom Score
LUTS Lower urinary tract symptoms
PSA Prostate-specific antigen
PVR Postvoid residual urine volume
Q_{max} Maximum urinary flow rate
QoL Quality of life
TURP Transurethral resection of the prostate

References

1. Baboudjian M, Creta M, Pyrgidis N et al. Summary paper on the 2026 European association of urology guidelines on the management of non-neurogenic male lower urinary tract symptoms. *Eur Urol* 2026;90(1):44–59. doi:10.1016/j.eururo.2026.03.020.
2. Silvinato A, Floriano I, Bernardo WM. Photoselective vaporization with green laser versus monopolar transurethral resection for benign prostatic hyperplasia. *Rev Assoc Med Bras* 2024;70(8):e2024D708. doi:10.1590/1806-9282.2024d708.
3. Deng Z, Sun M, Zhu Y et al. Thulium laser VapoResection of the prostate versus traditional transurethral resection of the prostate or transurethral plasmakinetic resection of prostate for benign prostatic obstruction: a systematic review and meta-analysis. *World J Urol* 2018;36(9):1355–1364.
4. Xu X, Jiang D, Liu G et al. *In vitro* evaluation of the safety and efficacy of a high-power 450-nm semiconductor blue laser in the treatment of benign prostate hyperplasia. *Lasers Med Sci* 2022;37(1):555–561. doi:10.1007/s10103-021-03297-y.
5. Mu L, Zhu X, Yang B et al. Development of a high-power blue diode laser for precision vaporization of prostate tissue for the surgical management of benign prostatic hyperplasia. *UroPrecision* 2023;1(3):105–115. doi:10.1002/uro2.30.
6. Li S, Fu C, Liu X, Hou J. Comparative efficacy of 450 nm blue-laser vaporization versus transurethral plasma kinetic enucleation of the prostate (TUPKEP) for benign prostatic hyperplasia in high-risk elderly patients: a focus on safety, efficacy, and sexual function preservation. *Lasers Med Sci* 2025;40(1):294. doi:10.1007/s10103-025-04547-z.
7. Wang C, Fu X, Ji Y et al. Application of transurethral blue laser vaporization of the prostate in patients aged 80 and above: a single-center clinical analysis of 157 cases. *Lasers Med Sci* 2025;40(1):532. doi:10.21203/rs.3.rs-7533815/v1.
8. Hu Z-J, Liu F, Li B-H et al. Preservation of sexual function with blue laser vaporization in the treatment of benign prostatic hyperplasia: a prospective study. *Aging Male* 2025;28(1): 2473609. doi:10.1080/13685538.2025.2473609.
9. Gu H, Gao K, Wu B, Ni J, Wang B, Wu G. Clinical efficacy and safety of transurethral prostate blue laser vaporization versus green laser vaporization in the treatment of benign prostatic hyperplasia with different prostate volumes: a retrospective comparative study. *Medicine* 2025;104(28):e43304. doi:10.1097/md.0000000000043304.
10. Yang MH, Huang YH, Hsieh TY et al. Pyuria and post-operation urinary tract infection after diode laser vaporesection of the prostate. *Surg Infect* 2020;21(3):255–261. doi:10.1089/sur.2019.117.
11. Zhao R, Wang X, Jiang C et al. Finasteride accelerates prostate wound healing after thulium laser resection through DHT and AR signalling. *Cell Prolif* 2018;51(3):e12415. doi:10.1111/cpr.12415.
12. Kim M-K, Kim KH. Postoperative microscopic pyuria and role of damage-associated molecular pattern: a literature review. *Urogenit Tract Infect* 2024;19(3):73–79.
13. Elshal AM, Allam KA, Abolazm AE, Nabeeh A, Osman Y. The headache of post-transurethral prostate surgery pyuria: pursuit for evidence. *J Endourol* 2024;38(6):629–636. doi:10.1089/end.2023.0667.
14. Elsaqa M, Dowd K, El Mekresh A, Doersch KM, El Tayeb MM. Predictors of postoperative urinary tract infection following holmium laser enucleation of the prostate. *Can Urol Assoc J* 2023;17(11):E364–E368. doi:10.5489/cuaj.8269.
15. Kim JK, Bae J, Lee HW, Lee KS, Cho MC. Does postoperative leukocyturia influence treatment outcomes after photoselective vaporization of the prostate (PVP)? A prospective short-term serial follow-up study. *Urology* 2015;86(3):581–586. doi:10.1016/j.urology.2015.06.024.
16. Yi X, Zhu G, Zhu B et al. Three surgical techniques using different energy sources for anatomical endoscopic enucleation of the prostate. *Front Surg* 2025;12:1668140. doi:10.3389/fsurg.2025.1668140.
17. Shah H, Arbelaez M, Shah K et al. Histopathological assessment of depth of coagulation necrosis with Holmium, Moses, and Thulium fiber lasers in human prostate tissue. *World J Urol* 2023;41(11):3059–3063. doi:10.1007/s00345-023-04617-3.
18. Lu X, Tang K, Li X, Li B, Ji J. Transurethral blue laser vaporization offers faster recovery and superior sexual function preservation in benign prostatic hyperplasia compared to hemi-holmium laser enucleation of the prostate: early results of a prospective randomized trial. *J Sex Med* 2026;23(1):qdaf337. doi:10.1093/jsxmed/qdaf337.
19. Zhang SY, Hu H, Zhang XP et al. Efficacy and safety of bipolar plasma vaporization of the prostate with "button-type" electrode compared with transurethral resection of prostate for benign prostatic hyperplasia. *Chin Med J* 2012;125(21):3811–3814. doi:10.1038/srep39583.
20. Cao Q, Shao N, Cui X, Kang J. Clinical experience and the learning curve of the treatment of benign prostatic hyperplasia with blue laser vaporization. *J Clin Urol* 2025;40(3): 280–283.