Transurethral Thulium Laser Enucleation Versus Plasmakinetic Resection For Benign Prostatic Hyperplasia: A Retrospective Comparative Cohort Study

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Purpose: To compare the clinical efficacy of transurethral thulium laser enucleation of the prostate (ThuLEP) with that of transurethral plasmakinetic resection of the prostate (PKRP) for benign prostatic hyperplasia (BPH).

Materials and Methods: This retrospective study evaluated 182 patients with BPH who underwent surgery at the Affiliated Liyang People's Hospital of Kangda College of Nanjing Medical University from January 2023 to January 2025. Patients were divided by surgical procedure into the ThuLEP group (group A, n = 90) and the PKRP group (group B, n = 92). Baseline characteristics, perioperative indicators, postoperative follow-up parameters, and complication rates were compared.

Results: Baseline characteristics were comparable between the groups ($P > .05$). Compared with group B, group A had a significantly shorter operation time, catheterization duration, bladder irrigation time, and hospital stay; a greater resected tissue weight; and a smaller decrease in hemoglobin level ($P < .05$). In both groups, the International Prostate Symptom Score, quality of life score, maximum urinary flow rate, and postvoid residual urine volume improved significantly from baseline at 1, 3, and 6 months and 1 year ($P < .05$), with no significant intergroup differences at any time point ($P > .05$). Perioperative and long-term complication rates were similar between the groups ($P > .05$), and all complications were managed conservatively or with targeted interventions, including endoscopic treatment for urethral stricture and bladder neck contracture and counseling for retrograde ejaculation.

Conclusion: ThuLEP is safe and effective for BPH. Compared with PKRP, it is associated with a shorter operation time, a smaller decrease in hemoglobin level, greater resected tissue weight, and faster recovery, with comparable functional outcomes. ThuLEP represents a viable minimally invasive surgical option for BPH.

Keywords: prostatic hyperplasia; thulium; lasers; transurethral resection of prostate

INTRODUCTION

Benign prostatic hyperplasia (BPH) is a prevalent urological disorder that affects the health of aging men worldwide. In some countries, BPH is the primary urological health concern in this population.[1] As a progressive disease, BPH often leads to worsening lower urinary tract symptoms (LUTS). Consequently, most patients eventually require surgical intervention to relieve lower urinary tract obstruction, manage the associated complications, and improve their quality of life.[2] This growing demand for improved quality of life, together with continuous advances in medical devices and technologies, has driven the rapid development of minimally invasive treatments for BPH.[3,4]

Plasmakinetic resection of the prostate (PKRP) improves upon traditional surgical techniques by using a plasmakinetic resection loop rather than a conventional loop. It offers advantages such as a shorter operative time, minimal carbonization of the resection surface, and reduced damage to the surrounding tissues. The use of normal saline as the irrigation fluid reduces the incidence of transurethral resection syndrome (TURS), further enhancing the safety of the procedure.[5] Thulium laser enucleation of the prostate (ThuLEP) is a minimally invasive surgical procedure that uses the tissue-cutting and coagulation properties of thulium laser energy.[6] The thulium fiber laser used in this study has a wavelength of approximately 1940 nm, which is close to the peak absorption wavelength of water in human tissues. Because of the relatively shallow tissue penetration depth of the thulium laser (usually only 0.1 mm), precise tissue incision can be achieved during prostate surgery while thermal damage to adjacent tissues is minimized and unnecessary injury to deeper structures is avoided.[7] These properties play a crucial role in protecting the neurovascular structures surrounding the prostate; therefore, use of this laser can help reduce surgical risks and complications and achieve surgical precision, minimal invasiveness, and rapid recovery.[8] In recent years, the efficacy and safety of both ThuLEP and PKRP in clinical practice have attracted widespread attention.[9,10]

Nevertheless, these 2 surgical approaches differ in their technical characteristics and may have different perioperative profiles. ThuLEP enables anatomical enucleation of the hyperplastic adenoma along the surgical capsule, whereas PKRP removes prostatic tissue through sequential resection. Evidence from a randomized trial comparing plasmakinetic enucleation with PKRP showed that, in patients with prostate volumes greater

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Table 1. General characteristics of the patients in the 2 groups..

Parameter	Group A (n = 90)	Group B (n = 92)	*P* value
Age, y, mean ± SD (range)	68.47 ± 7.20 (50-85)	69.14 ± 6.75 (54-81)	.515[a]
BMI, kg/m^2, mean ± SD (range)	24.82 ± 2.46 (19.4-30.4)	25.07 ± 2.28 (18.5-31.9)	.485[a]
Symptom duration, y, mean ± SD (range)	3.58 ± 1.61 (2-9)	4.07 ± 2.06 (1-9)	.077[a]
Hypertension, No. (%)	37 (41.1)	35 (38.0)	.672[b]
Diabetes mellitus, No. (%)	18 (20.0)	20 (21.7)	.773[b]
Coronary heart disease, No. (%)	12 (13.3)	11 (12.0)	.780[b]
Prostate volume, mL, mean ± SD (range)	58.57 ± 12.35 (28.6-87.3)	57.94 ± 11.79 (26.7-93.1)	.727[a]
History of urinary retention, No. (%)	21 (23.3)	24 (26.1)	.667[b]
PSA, ng/mL, mean ± SD (range)	4.25 ± 1.15 (1.8-7.0)	4.52 ± 1.35 (0.8-8.3)	.139[a]

Abbreviations: BMI, body mass index; PSA, prostate-specific antigen; SD, standard deviation.
[a]Independent-samples *t* test.
[b]$\chi 2$ test.

than 60 mL, enucleation was associated with a shorter operative time and less blood loss than resection, supporting the potential advantages of an enucleation-based approach for larger prostates.[11] However, ThuLEP is technically demanding and requires adequate training and surgical experience to achieve proficiency.[12]
We hypothesized that ThuLEP, by virtue of its precise enucleation technique and superior hemostasis, would offer perioperative advantages over PKRP while yielding comparable functional outcomes. This study was therefore designed to compare the perioperative parameters, functional outcomes, and complication rates of ThuLEP and PKRP in the treatment of BPH, providing evidence for clinical decision-making.

MATERIALS AND METHODS

Patient Selection

Between January 2023 and January 2025, a total of 241 patients underwent endoscopic surgery for BPH at our institution and were screened for eligibility. Of these, 59 were excluded for the following reasons: prior prostate or urethral surgery (n = 13), urethral stricture (n = 9), urinary calculi (n = 11), malignant tumors including prostate cancer (n = 16), neurogenic bladder (n = 3), severe vital organ dysfunction (n = 5), and incomplete clinical data or loss to follow-up (n = 2). The remaining 182 patients formed the final cohort: group A (ThuLEP, n = 90) and group B (PKRP, n = 92). The data cutoff date was January 31, 2026, by which time all included patients had completed the 1-year follow-up. Eligibility required complete follow-up at all scheduled time points; patients lost to follow-up were excluded at screening, and no imputation of missing data was required because all included patients had complete baseline and follow-up data. Follow-up completeness was 182/182 (100%) at 1, 3, and 6 months and at 1 year in both groups.
Both ThuLEP and PKRP were routinely offered at our institution, and the choice of procedure was determined through shared decision-making between the urologist and the patient after thorough counseling on the indications, expected benefits, potential risks, and recovery profile of each approach; no patient was excluded from either procedure on the basis of prostate volume or comorbidity. The inclusion criteria were as follows: (1) a definite diagnosis of BPH without prior surgical intervention; (2) definite surgical indications and tolerance of anesthesia and surgery; and (3) the availability of complete clinical and follow-up data. The exclusion criteria were as follows: (1) a history of prostate or urethral surgery, neurogenic bladder, urethral stricture, urinary calculi, or malignant tumors; (2) severe vital organ dysfunction; (3) hematological or autoimmune diseases; and (4) mental disorders or cognitive impairment. Prior medical therapy for BPH was not an exclusion criterion; however, the types of medications, treatment duration, and treatment response before surgery were not consistently or completely recorded and therefore were not included in the analysis.
This retrospective cohort study was conducted in accordance with the Declaration of Helsinki and was approved by the Ethics Committee of the Affiliated Liyang People's Hospital of Kangda College of Nanjing Medical University (approval number: 2025015). Written informed consent for participation in the study and the use of clinical data was obtained from all patients, as applicable under the approved protocol. All analyzed data were deidentified to protect patient confidentiality.

Surgical Methods

All patients underwent a comprehensive preoperative evaluation. Blood pressure, blood glucose levels, lipid profiles, and circulatory and respiratory functions were optimized to meet the requirements for perioperative tolerance. After completion of standard preoperative preparation, patients underwent ThuLEP or PKRP. All

Table 2. Comparison of perioperative indicators between the 2 groups.

Indicator	Group A (n = 90)	Group B (n = 92)	Mean difference (95% CI)	*P* value
Operation time, min, mean ± SD (range)	50.23 ± 10.45 (28-79)	85.71 ± 15.25 (57-141)	−35.47 (−39.29 to −31.65)	< .001[a]
Catheterization duration, d, mean ± SD (range)	2.11 ± 0.77 (1-4)	4.25 ± 1.15 (1-8)	−2.14 (−2.43 to −1.85)	< .001[a]
Bladder irrigation time, d, mean ± SD (range)	1.21 ± 0.53 (0-3)	2.75 ± 0.90 (1-5)	−1.54 (−1.75 to −1.32)	< .001[a]
Hospital stay, d, mean ± SD (range)	3.54 ± 1.07 (2-6)	5.83 ± 1.46 (3-9)	−2.29 (−2.66 to −1.91)	< .001[a]
Resected tissue weight, g, mean ± SD (range)	42.33 ± 8.58 (18.8-64.5)	31.51 ± 7.23 (14.1-52.3)	10.82 (8.49 to 13.14)	< .001[a]
Hemoglobin decrease, g/L, median (IQR)	1.22 (0.4-1.8)	3.19 (2.4-3.8)	NA	< .001[b]

Abbreviations: CI, confidence interval; IQR, interquartile range; NA, not applicable; SD, standard deviation.
[a]Independent-samples *t* test.
[b]Mann-Whitney *U* test.

Table 3. Comparison of postoperative follow-up parameters between the 2 groups.

Parameter	Group A (n = 90)	Group B (n = 92)	*P* value[a]
IPSS, score, mean ± SD (range)			
Preoperative	21.52 ± 4.21 (12-31)	22.02 ± 4.56 (13-30)	.444
1 mo	8.52 ± 2.25 (3-16)	8.33 ± 2.47 (4-14)	.577
3 mo	6.24 ± 1.75 (2-10)	6.12 ± 2.06 (1-11)	.660
6 mo	4.07 ± 1.16 (2-7)	3.87 ± 1.42 (0-7)	.306
1 y	3.16 ± 0.94 (1-5)	3.00 ± 1.17 (0-6)	.323
Group effect	F = 0.043, *P* = .835		
Time effect	F = 1684.411, *P* < .001		
Interaction effect	F = 0.656, *P* = .519		
Qmax, mL/s, mean ± SD (range)			
Preoperative	8.21 ± 2.05 (3.6-14.8)	8.45 ± 2.33 (2.2-16.0)	.470
1 mo	18.53 ± 3.23 (12.0-26.4)	18.45 ± 3.62 (9.8-26.0)	.866
3 mo	21.25 ± 3.84 (12.3-29.1)	20.86 ± 4.02 (11.4-28.0)	.506
6 mo	23.45 ± 4.17 (14.0-33.2)	23.12 ± 4.25 (13.2-35.8)	.598
1 y	24.17 ± 4.53 (10.0-37.2)	23.96 ± 4.69 (12.0-36.4)	.762
Group effect	F = 0.334, P = .564		
Time effect	F = 539.978, *P* < .001		
Interaction effect	F = 0.204, *P* = .922		
QOL, score, mean ± SD (range)			
Preoperative	4.44 ± 0.78 (3-6)	4.45 ± 0.89 (2-7)	.992
1 mo	1.99 ± 0.66 (1-4)	2.07 ± 0.71 (1-4)	.454
3 mo	1.51 ± 0.53 (0-2)	1.49 ± 0.64 (0-3)	.800
6 mo	1.10 ± 0.34 (0-2)	1.03 ± 0.48 (0-2)	.275
1 y	0.84 ± 0.36 (0-1)	0.85 ± 0.36 (0-1)	.950
Group effect	F = 0.001, *P* = .970		
Time effect	F = 1139.059, *P* < .001		
Interaction effect	F = 0.367, *P* = .774		
PVR, mL, mean ± SD (range)			
Preoperative	85.59 ± 25.34 (21-144)	88.08 ± 27.07 (27-161)	.523
1 mo	25.25 ± 8.12 (5-48)	26.13 ± 8.53 (4-48)	.479
3 mo	18.24 ± 6.47 (5-36)	18.76 ± 6.75 (5-36)	.600
6 mo	12.06 ± 4.31 (3-21)	12.49 ± 4.47 (3-25)	.510
1 y	8.51 ± 3.17 (1-19)	8.84 ± 3.26 (3-16)	.480
Group effect	F = 1.200, *P* = .275		
Time effect	F = 1132.037, *P* < .001		
Interaction effect	F = 0.219, *P* = .721		

Abbreviations: ANOVA, analysis of variance; IPSS, International Prostate Symptom Score; PVR, postvoid residual urine volume; Qmax, maximum urinary flow rate; QOL, quality of life; SD, standard deviation.
aIndependent-samples *t* test (between-group comparison at each time point); repeated-measures ANOVA was used to evaluate the group effect, time effect, and group × time interaction.

procedures were performed by the same senior urologist, who had completed a dedicated standardized fellowship in endoscopic enucleation; a single surgical team assisted throughout, ensuring consistent perioperative management. Both techniques were performed concurrently throughout the same study period. Anesthesia (general or neuraxial) was administered on the basis of each patient's condition. Patients were placed in the lithotomy position, followed by routine disinfection and draping.

ThuLEP: A 26F endoscope was inserted under direct vision and connected to a 1940-nm thulium fiber laser system (Youlu, Raykeen Corporation, Shanghai, China) with a 365-μm side-firing laser fiber; the laser was set at 50 W for enucleation and 20 W for coagulation, with normal saline irrigation. Using the verumontanum as a landmark, the urethral mucosa was incised 5 mm anterior to the verumontanum, and laser vaporization was performed layer by layer to reach the prostatic surgical capsule. The middle lobe was enucleated toward the bladder neck through incisions at the 5 and 7 o'clock positions, and the bilateral lateral lobes were then enucleated along the surgical capsule until they reached the 12 o'clock incision. The completely enucleated tissue was pushed into the bladder, and bleeding points were meticulously coagulated. The enucleated tissue was morcellated and aspirated using a tissue morcellator (Fengyun, Raykeen Corporation, Shanghai, China); no morcellation-related bladder injury occurred. A 22F 3-way catheter was inserted, and its balloon was inflated with 50 mL for hemostasis, followed by continuous bladder irrigation.

PKRP: A plasmakinetic resectoscope system (UES-40, Olympus Corporation, Tokyo, Japan) was used with generator settings of 280 W for resection and 160 W for coagulation. The middle lobe was resected layer by layer from the 5 to 7 o'clock positions of the bladder neck toward the verumontanum, followed by sequential resection of the lateral lobes with concurrent electrocoagulation. Residual apical tissue was trimmed to ensure a smooth prostatic urethra. Prostatic chips were aspirated with an Ellik evacuator, and hemostasis was confirmed. A 22F 3-way catheter was inserted, and its balloon was inflated with 50 mL for hemostasis, followed by continuous bladder irrigation. No intraoperative conversion between the 2 techniques was required in any patient.

Data Collection

The following parameters were systematically collected and statistically analyzed in the present study:

(1) Baseline characteristics included age, body mass index (BMI), symptom duration, hypertension, diabetes mellitus, coronary heart disease, prostate volume, history of urinary retention, serum prostate-specific antigen (PSA) level, International Prostate Symptom Score (IPSS), maximum urinary flow rate (Qmax), quality of life (QOL) score, and postvoid residual urine volume (PVR). Prostate volume was measured by transabdominal ultrasonography and calculated using the prolate

Table 4. Comparison of complications between the 2 groups.

Complication	Group A (n = 90)	Group B (n = 92)	*P* value
Perioperative complications			
Capsular perforation, No. (%)	1 (1.1)	1 (1.1)	>.99[b]
Urinary tract infection, No. (%)	5 (5.6)	7 (7.6)	.577[a]
Bladder spasm, No. (%)	7 (7.8)	8 (8.7)	.822[a]
Blood transfusion, No. (%)	0 (0.0)	1 (1.1)	>.99[b]
Reoperation for bleeding, No. (%)	0 (0.0)	1 (1.1)	>.99[b]
Deep vein thrombosis, No. (%)	1 (1.1)	3 (3.3)	.621[b]
Recatheterization, No. (%)	0 (0.0)	3 (3.3)	.246[b]
Temporary urinary incontinence, No. (%)	1 (1.1)	1 (1.1)	>.99[b]
Total, No. (%)	15 (16.7)	25 (27.2)	.125[a]
Long-term complications			
Urethral stricture, No. (%)	1 (1.1)	2 (2.2)	>.99[b]
Retrograde ejaculation, No. (%)	0 (0.0)	1 (1.1)	>.99[b]
Bladder neck contracture, No. (%)	2 (2.2)	2 (2.2)	>.99[b]
Total, No. (%)	3 (3.3)	5 (5.4)	.721[b]

[a]$\chi 2$ test.
[b]Fisher exact test.

ellipsoid formula (volume = 0.52 × transverse × anteroposterior × longitudinal diameter). Serum PSA was measured preoperatively, before any urethral catheterization, to avoid elevation induced by catheter manipulation. History of urinary retention was defined as a history of acute urinary retention requiring urethral catheterization before surgery and was recorded as a binary variable (yes/no); its severity and duration were not systematically documented. Prior medical therapy for BPH (including α-blockers and 5α-reductase inhibitors) was noted when present but was not consistently or completely recorded; therefore, medication type, treatment duration, and response were not included in the analysis. At each follow-up visit, IPSS and QOL were obtained by structured questionnaire, Qmax by uroflowmetry, and PVR by transabdominal ultrasonography.

(2) Perioperative indicators included operation time, catheterization duration, bladder irrigation time, hospital stay, resected tissue weight, and decrease in hemoglobin level. Operation time was defined as the interval from insertion of the endoscope/resectoscope to its removal at the end of the procedure; in the ThuLEP group, morcellation time was included in this interval. Continuous bladder irrigation was discontinued when the effluent became clear or pale pink without gross hematuria or clots. The 3-way urethral catheter was removed when the urine remained clear after bladder irrigation was discontinued and no active bleeding or clots were observed. Spontaneous voiding and PVR were assessed after catheter removal. Patients were considered ready for hospital discharge when vital signs were stable, the patient was afebrile, oral intake was tolerated, no acute complication required intervention, and the patient could void spontaneously with an acceptable PVR without a catheter. Venous hemoglobin was measured on the day of surgery and at 1 hour postoperatively; the hemoglobin decrease was calculated as the preoperative value minus the 1-hour postoperative value and is reported in g/L.

(3) Postoperative follow-up and complications: All patients were followed up at 1, 3, and 6 months and 1 year postoperatively. Postoperative complications were identified through review of medical records and structured follow-up assessments. Perioperative complications were defined as events occurring during surgery or within the index hospitalization, with the following operational definitions: capsular perforation was defined as visible violation of the surgical capsule observed endoscopically during enucleation or resection; urinary tract infection was defined as symptomatic dysuria or frequency accompanied by a positive urine culture ($\geq 10^3$ colony-forming units [CFU]/mL) or fever ≥38.5 °C with pyuria; bladder spasm was defined as suprapubic pain with pericatheter leakage requiring antispasmodic medication; blood transfusion was defined as any allogeneic red blood cell transfusion given for a postoperative hemoglobin decline; reoperation for bleeding was defined as a return to the operating room for surgical hemostasis; deep vein thrombosis was defined as a thrombus confirmed by lower-extremity Doppler ultrasonography; recatheterization was defined as reinsertion of a urethral catheter for urinary retention after initial catheter removal; and temporary urinary incontinence was defined as stress or urge incontinence documented during the inpatient recovery period that resolved before discharge or the 1-month follow-up visit. Longer-term complications were assessed at the 1-, 3-, and 6-month and 1-year follow-up visits and included urethral stricture (obstructive voiding symptoms confirmed by cystoscopy or by uroflowmetry with elevated PVR), bladder neck contracture (bladder neck narrowing confirmed cystoscopically), retrograde ejaculation (patient-reported absence of antegrade ejaculate during orgasm), and persistent urinary incontinence (any stress or urge incontinence still present at the 1-year follow-up). Sexual function and ejaculation-related outcomes were assessed by patient self-report during follow-up interviews; validated sexual function questionnaires were not used. Patients who were not sexually active or who declined to discuss these outcomes were considered nonevaluable for the corresponding outcome. Of the 182 patients, 86 (42 in group A and 44 in group B) were sexually active before surgery and were thus eligible for sexual function assessment; 81 (40 in group A and 41 in group B) completed the 1-year interview, and the remaining 5 (2 in group A and 3 in group B) were either no longer sexually active or declined to discuss these outcomes and were considered nonevaluable.

(4) Postoperative efficacy outcomes: Postoperative efficacy was assessed using IPSS, QOL, Qmax, and PVR at each follow-up time point.

Statistical Analysis

Statistical analyses were performed using SPSS software (version 21.0; IBM Corp, Armonk, NY, USA). The Shapiro-Wilk test was used to evaluate the normality of continuous variables. Continuous variables are expressed as mean ± standard deviation (SD) or median (interquartile range [IQR]), depending on the distribution, and were compared using the independent-samples t test or the Mann-Whitney U test. Categorical variables are presented as numbers and percentages. The χ^2 test was used when all expected cell frequencies were ≥5; when any expected cell count was <5, the Fisher exact test was applied instead. For repeated measurements (IPSS, Qmax, QOL, and PVR) obtained at multiple postoperative time points (1, 3, and 6 months and 1 year), repeated-measures analysis of variance (ANOVA) was conducted to evaluate the group effect, time effect, and group × time interaction. The Mauchly test of sphericity was applied, and the Greenhouse-Geisser correction was used when the sphericity assumption was violated. All P values were 2-tailed, and $P < .05$ was considered to indicate statistical significance. The sample size was determined by the number of eligible patients available during the study period. Because this was a retrospective study using an existing cohort, no a priori sample size or power calculation was performed. No single primary outcome or time point was prespecified in this retrospective exploratory study. Individual time-point comparisons were considered exploratory, and no formal adjustment for multiplicity across multiple outcomes and time points was applied.

RESULTS

Comparison of General Characteristics

Of the 241 patients screened, 182 met the inclusion criteria and were retrospectively evaluated (90 in group A and 92 in group B); 59 were excluded according to the prespecified inclusion and exclusion criteria. All 182 patients completed follow-up at 1, 3, and 6 months and 1 year postoperatively. Comparative analysis of baseline characteristics, including age, BMI, symptom duration, hypertension, diabetes mellitus, coronary heart disease, prostate volume, history of urinary retention, and PSA level, revealed no significant differences between the 2 groups ($P > .05$), indicating that the 2 cohorts were well balanced with respect to the measured baseline characteristics (**Table 1**).

Comparison of Perioperative Indicators

Compared with group B, group A had a shorter operation time (mean difference, −35.47 min; 95% confidence interval [CI], −39.29 to −31.65), shorter catheterization duration (−2.14 days; 95% CI, −2.43 to −1.85), shorter bladder irrigation time (−1.54 days; 95% CI, −1.75 to −1.32), shorter hospital stay (−2.29 days; 95% CI, −2.66 to −1.91), greater resected tissue weight (10.82 g; 95% CI, 8.49 to 13.14), and a smaller decrease in hemoglobin level (median, 1.22 vs 3.19 g/L). All between-group differences were statistically significant ($P < .001$) (**Table 2**).

Comparison of Postoperative Follow-up Parameters

All patients completed the follow-up protocol. In repeated-measures ANOVA, a significant time effect was noted for all 4 parameters (IPSS, Qmax, QOL, and PVR) in both groups ($P < .001$), indicating significant improvements in all parameters from the preoperative baseline to all postoperative time points. However, neither the group effect nor the group × time interaction was statistically significant for any parameter ($P > .05$). Specifically, compared with the preoperative baseline values, the postoperative IPSS, QOL, Qmax, and PVR improved significantly at 1, 3, and 6 months and 1 year in both groups ($P < .05$). No significant intergroup differences were observed at any individual time point ($P > .05$) (**Table 3**).

Comparison of Complications

No statistically significant differences were observed in the incidence of perioperative or long-term complications between the 2 groups ($P > .05$) (**Table 4**). All perioperative complications resolved with conservative or targeted management: urinary tract infections resolved after a 7-day course of culture-directed antibiotics; bladder spasms resolved after oral antispasmodic medication; the 4 cases of deep vein thrombosis (1 in group A and 3 in group B) were treated with a 3-month course of anticoagulation, with no sequelae; the single blood transfusion and the single reoperation for bleeding in group B resulted in no long-term consequences; and all 3 recatheterizations in group B were successful on the second attempt, with no persistent retention. The 2 cases of temporary urinary incontinence (1 in each group) resolved spontaneously within 1 month. No patient had persistent urinary incontinence at the 1-year follow-up. Among long-term complications, urethral stricture (1 in group A and 2 in group B) was successfully treated with direct-vision internal urethrotomy or visual dilation, with no recurrence at the 1-year visit; bladder neck contracture (2 in each group) was treated with transurethral bladder neck incision and resolved without reoperation; and the single case of retrograde ejaculation in group B was managed with counseling.

DISCUSSION

BPH typically presents with varying degrees of LUTS, including urinary frequency, urgency, and incomplete voiding, and it is strongly associated with complications such as urinary tract infections, acute urinary retention, urolithiasis, and acute renal failure.[13] Since the 1970s, traditional transurethral resection of the prostate (TURP) has been the gold standard for the surgical management of BPH.[14] However, its limitations include significant perioperative bleeding, prolonged operative time in patients with large prostates, and the risk of TURS, which may seriously threaten patient safety; thus, in recent years, the status of TURP as the definitive gold standard has been increasingly debated.[15]

PKRP, an improved variant of TURP, uses normal saline as the irrigation medium and employs plasma energy for adenoma resection. This approach not only fundamentally eliminates the risk of TURS but also significantly reduces the risk of intraoperative bleeding, enhances surgical safety, alleviates postoperative discomfort, and decreases complication rates; its clinical value is also well established.[16] Despite these advantages, PKRP has limitations, including a fragmented resection pattern, loss of plasma energy, and operational limitations with an elevated risk of capsular injury; these factors often result in incomplete removal of the hyperplastic tissue. Currently, most investigators agree that laser surgery has superior clinical advantages over plasma-based procedures for the treatment of BPH.[17] Compared with holmium, green-light, and diode lasers,

thulium lasers offer distinct benefits, including rapid and precise tissue cutting, shallow penetration depth, and excellent hemostatic properties.[18] The ThuLEP approach effectively leverages these favorable properties: the laser energy is absorbed by water in biological tissues and produces diverse thermal effects, enabling precise tissue vaporization, incision, and hemostasis through coagulation. Thus, the approach facilitates complete anatomical enucleation of the hyperplastic glandular tissue, leading to optimal therapeutic outcomes.[19]

The present study yielded the following findings. First, ThuLEP was associated with a shorter operative time than PKRP. On the one hand, this benefit can be attributed to the thulium laser wavelength of approximately 1940 nm, which matches the peak water absorption, with an absorption coefficient of up to 120 cm^{-1}.[20] This close match can result in higher cutting and vaporization efficiency and significantly improved surgical efficiency. Moreover, the shallow tissue penetration depth of the thulium laser, typically only 0.1 mm, enables precise intraoperative control of the treatment range, facilitating smooth surgical progression. On the other hand, even at low power, the thulium laser can achieve rapid hemostasis, ensuring a clearer surgical field throughout the procedure and easier identification of anatomical structures; these factors result in a shorter operation time. These findings differ from those of previous related studies.[21,22] This discrepancy may be explained by the fact that, although ThuLEP is technically demanding and generally associated with a steep learning curve,(12) the surgeon in this study had undergone systematic standardized fellowship training at professional institutions and had completed the required number of cases before the study period, which likely facilitated early achievement of surgical proficiency.[23] Second, ThuLEP was associated with a smaller postoperative decrease in hemoglobin level, as well as shorter bladder irrigation and catheterization durations; these benefits are attributable to the efficient coagulation capability of the thulium laser. Unlike the broad electrocoagulation hemostasis achieved with the plasmakinetic resection loop, the thulium laser achieves precise hemostasis via circular radial irradiation combining spot and surface effects; thus, extensive thermal injury to the surrounding tissues is substantially mitigated. The reduced damage to adjacent tissues results not only in a low risk of secondary hemorrhage caused by postoperative sloughing of necrotic tissue but also in a marked shortening of the bladder irrigation duration, which in turn reduces the length of hospital stay. These results are consistent with those of a prospective randomized controlled study by Yang et al., which also reported favorable perioperative outcomes with ThuLEP compared with PKRP.[24] Furthermore, a larger volume of prostate tissue was resected in the ThuLEP group than in the PKRP group. This is attributable to the anatomical enucleation technique combined with the low-penetration, low-damage energy characteristics of the thulium laser, which facilitate enucleation along the surgical capsule. Currently, both the American Urological Association (AUA) and the European Association of Urology (EAU) guidelines recognize endoscopic enucleation techniques, including ThuLEP, as effective surgical options for BPH, with particular advantages in larger prostates.[25,26] Through effective enucleation of hyperplastic prostate tissue and complete relief of urethral obstruction, ThuLEP yields a substantial improvement in Qmax, enables more complete bladder emptying, reduces PVR, and decreases the risk of urinary tract infection. In addition, ThuLEP involves a shorter duration of traction on the urethral sphincter when the 12 o'clock position of the prostatic apex is treated, preserves adequate urethral mucosal tissue, and further reduces the incidence of complications such as postoperative urinary incontinence.[6] In a different clinical population, the GRAND study compared perioperative outcomes after holmium laser enucleation of the prostate (HoLEP), ThuLEP, and TURP in patients with prostate cancer; these findings provide complementary, indirect evidence on perioperative outcomes across endoscopic techniques.[27]

This study has several limitations. It is a single-center retrospective study with a relatively small sample size and a short follow-up period, which may affect the generalizability and reliability of the results. No formal sample size calculation was performed before the study; although the primary perioperative outcomes demonstrated clear between-group differences, the low event rate of complications may limit the ability to detect rare adverse events. Moreover, because the procedure was assigned through shared decision-making rather than randomization, residual selection bias cannot be excluded despite the comparable baseline characteristics; operator-dependent factors, although minimized by having a single experienced surgeon perform both techniques, may still have influenced the observed outcomes. Furthermore, sexual function and ejaculation outcomes were not evaluated with validated questionnaires, which may have led to underrecording of these complications. Finally, the comparative nature of this study limits its novelty, and no multivariable adjustment was performed to account for potential confounders. Larger multicenter prospective studies with longer follow-up are warranted to validate these findings.

CONCLUSIONS

Both ThuLEP and PKRP provide significant improvements in postoperative functional outcomes in patients with BPH, with no significant between-group differences, and they have similar complication rates. Compared with PKRP, ThuLEP offers advantages, including a shorter operation time, a smaller decrease in hemoglobin level, greater resected tissue weight, and faster postoperative recovery. Given its safety and effectiveness, ThuLEP is a reliable minimally invasive surgical option for BPH.

SUMMARY

Laser surgery (ThuLEP) and plasma resection (PKRP) for an enlarged prostate improved urinary symptoms equally well. The laser operation was quicker, caused less blood loss, removed more tissue, and allowed earlier catheter removal and discharge.

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CONFLICT OF INTEREST

The authors report no conflicts of interest.

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