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Feasibility, safety and efficacy of using low-power thulium: YAG laser enucleation of prostate compared to HoLEP in developing country

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Introduction We aimed to assess and compare the feasibility and perioperative outcomes using low-power thulium laser enucleation of the prostate (ThuLEP) compared to standard holmium laser enucleation of the prostate (HoLEP) in the management of BPO-related symptoms due to prostates volume exceeding 80 ml.

Material and methods One hundred and fifty patients with large prostates indicated for prostate enucleation were prospectively randomized into two groups: HoLEP group (74 patients), and the low-power ThuLEP group (76 patients). Preoperative assessment included digital rectal examination, serum prostate-specific antigen, transrectal ultrasonography, uroflowmetry, postvoid residual urine (PVR) measurement, and International Prostate Symptom Score (IPSS) and QoL scoring systems.

Results The mean age for the HoLEP group was 68 ±5.0 years and 69 ±4.8 years for the low-power ThuLEP group. The mean prostate volume was 87 ±11.5 cc for HoLEP and 90 ±12.0 cc for ThuLEP, with no statistically significant differences between both groups (p=0.1079). There was a statistically significant difference between both groups with regard the mean total operative time, which was 72 ±10.5 minutes for HoLEP and 92 ±11.5 minutes for ThuLEP, and the mean enucleation time, which was 50 ±8.5 minutes for HoLEP and 70 ±7.0 minutes for ThuLEP (p <0.001). No significant differences between the groups regarding catheterization time, hospital stay, or haemoglobin drop. Subjective and objective voiding parameters as IPSS and Qol scores, Q_{max}, and PVR improved significantly after treatment with both techniques with no statistically significant difference between both groups. The complication rate was low.

Conclusions Although HoLEP offers shorter operative time, low-power ThuLEP is a feasible choice for surgical management of benign prostatic obstruction as it offers similar clinical outcomes.

Key Words: low-power ThuLEP ‹› HoLEP ‹› BPH ‹› large prostates

INTRODUCTION

Benign prostatic obstruction (BPO) is a common ailment among elderly men that frequently requires surgical intervention to relieve symptoms [1]. Many laser systems, such as the holmium laser [2], thulium laser [3], green light laser [4], and diode laser [5] have been effectively introduced over the past few decades for the enucleation of the prostate.

Although transurethral techniques such as holmium laser enucleation of the prostate (HoLEP) have shown effectiveness [2, 6–8], managing large prostates more than 80 ml optimally may still present a clinical challenge because of the higher surgical complexity, possible complications and should be ought to be customized according to the surgeon's experience and the patient's comorbidities [9, 10]. The wavelength of the holmium laser is 2,140 nm,

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which is highly absorbed by water. It penetrates prostate tissue 0.4 mm deep and emits energy in short pulses [11, 12]. Prostatic tissue has a high-water content, which enhances thermal conductivity and makes tissue coagulable and ablative for the holmium laser [11]. This capability allows for precise incision, dissection, and enucleation of prostatic tissue, meanwhile the wavelength of the thulium laser is 2013 nm, and its depth of tissue penetration is 0.25 mm.

Thulium laser provides a continuous-wave pattern offering a shorter learning curve and good hemostatic effect in prostate enucleation [13]. In anatomical endoscopic enucleation of prostate (AEEP), thulium laser has demonstrated equivalent efficacy and safety to holmium laser [14]. For transurethral prostatectomy, thulium: YAG is a laser that has demonstrated safety and effectiveness across the therapeutic spectrum. Thus, of all the lasers taken into consideration in this discussion, it is the most suitable for endoscopic prostate surgery [15].

Low-power thulium laser enucleation of the prostate (ThuLEP) may be a feasible alternative that may provide advantages in tissue ablation and hemostasis [16, 17] especially in the absence of more advanced energy sources in developing countries. Nevertheless, there aren't many comparative studies that specifically evaluate its safety and efficacy in this patient population.

By comparing the results of low-power ThuLEP and HoLEP in patients with prostates exceeding 80 ml, we aim to provide evidence-based insights that help in providing more alternatives in managing BPO patients by analyzing operative and perioperative data, functional outcomes, and complications of both techniques.

The study's main goal was to determine whether endoscopic enucleation was feasible by comparing the enucleation time and total operative time using both techniques. The secondary outcomes were to detect hemoglobin drop, resected weight, catheter time, hospital stay, early or delayed complications and follow up functional outcomes at one, 3, 6, and 12 months.

MATERIAL AND METHODS

A total of 150 patients with a prostate volume of at least 80 ml, as determined by transrectal ultrasonography (TRUS), and voiding symptoms associated with BPO were included in the study. These patients had a maximum urinary flow rate (Q_{max}) ≤15 ml/s, International Prostate Symptom Score (IPSS) ≥8. The study period was between September 2022 through December 2024. Patients receiving anticoagulation or antiplatelet therapy, neurogenic bladder, and suspected prostate cancer or urethral strictures and patients with history of prior prostate surgery were excluded.

Sample size and randomization

The mean enucleation time for low power ThuLEP was used to determine the sample size based on previously published data [18] 80 ±12 minutes and for HoLEP [19] 69.5 ±27.9 minutes. Assuming a significance level of 0.05 and 80% power, the pooled standard deviation was calculated to be approximately 21.48 minutes. With an expected difference in means of 10.5 minutes, the required sample size was estimated to be 66 participants per group. For a 10% expected dropout rate, the sample size would increase to 74 participants per group.

The power and sample size programs in the MedCalc software were used for the calculations. The eligible patients were randomized by a medical statistician using sealed envelopes and block randomization. At the time of surgery, the patients were blind to the designated type of intervention.

Data collection

Digital rectal examination (DRE), prostate-specific antigen (PSA), prostate volume by TRUS and biopsy if needed in elevated PSA, uroflowmetry, postvoid residual urine (PVR), IPSS, and QoL scores were all part of the preoperative evaluation. Operative time, enucleation time, morcellation time, resected prostatic weight, blood loss (blood transfusion or pre- and post-operative hemoglobin), catheterization time, and hospital stay were all documented as intraoperative and immediate postoperative data. The IPSS, QoL scores, Q_{max}, and PVR were used to reevaluate each patient one, 3-, 6- and 12-months following surgery. Perioperative and postoperative complications were documented using the modified Clavien-Dindo method. Six months after surgery, PSA and TRUS measurements of the prostate volume were conducted and biopsy if needed. All original data presented in this study are available upon request.

Intervention

The holmium procedures were carried out using the high-power pulsed 140 W MultiPulse HoPLUS JENA SURGICAL laser unit with integrated morcellator, and with an energy setting of 100 W for cutting and 20W for coagulation, while the thulium: YAG laser unit (Revolix 150 W surgical laser,

Katlenburg, Germany) and a reusable 550-Micro-m laser fibre (RigiFibTM, Katlenburg, Germany) were used for the thulium procedures. The energy settings were set to 30 W for cutting and 25 W for coagulation utilising continuous wave mode. For enucleation, a 26 F continuous resectoscope (Karl Storz, Tuttlingen, Germany) and a 26 F continuous flow resectoscope with a modified inner sheath (Richard Wolf, Knittlingen, Germany) were used.

Two surgeons with over 250 HoLEP and 250 ThuLEP case experiences performed the procedures. Techniques for prostate enucleation with holmium: YAG; with thulium: YAG using the three-lobe or two-lobe technique according to prostate configuration, were comparable following the initial descriptions of HoLEP by Gilling [20] and ThuLEP by Herrmann [21].

Two incisions were made deep into the plane of the surgical capsule at the five and seven o'clock positions of the bladder neck, bringing them to the level proximal to the verumontanum. After the two ends of the incisions were united at the level of the verumontanum, the tissue was bluntly lifted with the resectoscope's beak along the surgical capsule towards the 6-o'clock direction of the bladder neck to begin enucleation of the median lobe. To open the plane for enucleation of the upper aspect of the lateral lobes, the resectoscope was set to the 12 o'clock position. The lateral plane was developed to the verumontanum at the apex of the lobes, and the enucleation process involved blunt raising towards the bladder neck. Throughout the entire procedures, physiological saline solution irrigation was used.

For tissue morcellation, a 26 Fr morcellation sheath is used along with a transurethral soft tissue morcellator (built-in for HoLEP cases). Morcellation for ThuLEP cases was accomplished by Storz morcellator (Karl Storz GmbH & Co., Tuttlingen, Germany). At the end of the procedure, all the patients received continuous bladder irrigation using a 3-way 22F silicone catheter until the next morning's urine colour was clear. All the patients received perioperative antibiotics according to preoperative urine culture and sensitivity. Indwelling catheters are removed the next day unless urine is not clear. All patients are discharged after being able to void properly and evaluated by PVR measurement.

The primary outcome was to assess enucleation feasibility comparing the mean enucleation time and total operative time for both techniques. Secondary Outcomes include hemoglobin drop, resected weight, catheter time, hospital stay, and complications detected. Also, to record the functional outcomes as IPSS and QoL scores, Q_{max} and PVR recorded at one, 3, 6 and 12 months postoperatively

Statistical analysis

MedCalc ver. 20 was used for data entry, processing, and statistical analysis (MedCalc, Ostend, Belgium). The following tests of significance were applied: factorial ANOVA, ROC Curve analysis, Friedman, Mann-Whitney, Wilcoxon, and Chi square testing. Data was shown, and appropriate analysis was carried out based on the type of data (parametric and non-parametric) that were collected for every variable. P-values were regarded as statistically significant if they were less than 0.05 (5%) or 5.

Bioethical standards

All patients provided their informed consent, and the study was approved by Cairo University Hospitals' institutional board review ethical committee under IRB number MD-381.

RESULTS

Out of two hundred and five patients assessed for eligibility, only 150 patients were finally randomized in the study and allocated to HoLEP group including 74 patients and low-power ThuLEP group including 76 patients (Figure 1).

Baseline characteristics and preoperative data between the 2 groups revealed non-significant differ-

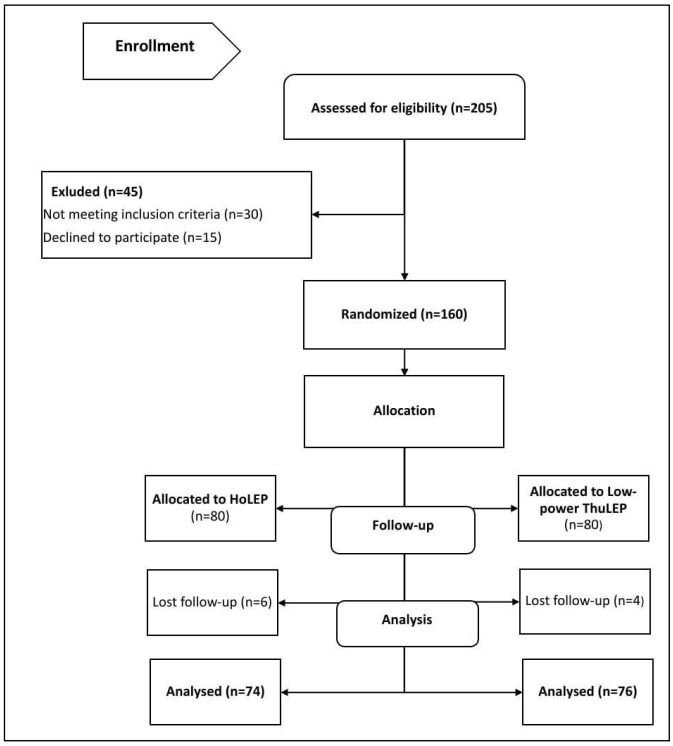

Figure 1. *Consort diagram.*

ences as regards age and indications of operation, Q_{max}, IPSS score, QoL score, PVR, prostate volume, PSA and hemoglobin level (p >0.05; Table 1).

As regards perioperative data, there was a statistically significant difference for operative time in HoLEP group compared to low-power ThuLEP (72 ±10.5 vs 92 ±11.5 respectively) and for enucleation time (50 ±8.5 vs 70 ±7.0 respectively). No statistically significant difference between both groups as regard morcellation time, enucleation weight, hemoglobin drop (0.85 ±0.5 for HoLEP group vs 0.8±0.2 for low-power ThuLEP group), catheter duration or hospital stay (Table 2).

There was no significant difference between the two groups with regard immediate postoperative complications as mild hematuria and transient urinary incontinence (urgency or stress) within the first month (four patients in HoLEP group and three in low-power ThuLEP group). These issues were managed with antimuscarinics and pelvic floor muscle training.

Only two patients in the HoLEP group, and one in the low-power ThuLEP group required re-catheterization for immediate postoperative urine retention. Urinary tract infection in 3 patients in HoLEP group vs 4 patients in low-power ThuLEP group, both managed antibiotics. No need for blood transfusion in both groups (Table 3).

No patients in both groups had UUI or SUI at 3, 6 or 12 months postoperatively. Furthermore, there was no statistically significant difference between both groups as regard delayed complications as urethral strictures and bladder neck contracture (Table 3).

In terms of functional outcomes, there was no statistically significant difference between the two groups regarding subjective voiding parameters (IPSS score and QoL scores) and objective voiding parameters (Q_{max} and PVR) at one month, three months, 6 months, and twelve months of follow-up. There were no statistically significant differences between both groups for postoperative PSA drop

Table 1. *Baseline characteristics for both groups*

Variable	HoLEP group (n = 74)	Lo-ThuLEP group (n = 76)	p-value
Age (years)	68 ±5.0	69 ±4.8	0.9234
Indication of intervention Failed medical treatment Hematuria Refractory retention Hematuria and refractory retention	 56 (75.7%) 4 (5.4%) 13 (17.6%) 1 (1.4%)	 53 (69.7%) 6 (7.89%) 17 (22.3%) 0 (0%)	 0.5385
IPSS	26 ±2.5	26 ±2.8	0.2945
PVR (ml)	118 ±30	128 ±35	0.655
Q_{max} (ml/s)	7.2 ±1.5	6.4 ±1.7	0.1228
Prostate volume (ml)	97 ±11.5	100 ±12.0	0.1079
PSA (ng/dl)	4.1 ±0.5	4.5 ±0.6	0.1112
Hemoglobin (g/dl)	12.9 ±0.4	13 ±0.3	0.7409
Qol score	4 ±1.0	4 ±1.1	0.6789

IPSS – International Prostate Symptom Score; PSA – prostate-specific antigen; PVR – postvoid residual urine; Q_{max} – maximum urinary flow rate

Table 2. *Perioperative data for both groups*

Variable	HoLEP group Mean (SD)	Lo-ThuLEP group Mean (SD)	p-value
Enucleation time (min)	50.0 ±8.5	70.0 ±7.0	<0.001
Morcellation time (min)	22.0 ±3.5	23.0 ±4.0	0.9646
Total operative time (min)	72 ±10.5	92.0 ±11.5	**<0.001**
Resected prostate weight (g)	61.0 ±10.5	63.0 ±8.5	0.0732
Catheter duration (h)	15.0 ±2.5	16.0 ±2.8	0.8564
Hospital stay (h)	24.0 ±4.5	24.0 ±4.8	0.9241
Hemoglobin drop (gm/dl)	0.85 ±0.5	0.8 ±0.2	0.0857

Table 3. *Early and delayed complications*

Complications	Clavien-Dindo grade	Treatment	HoLEP n (%)	Lo-ThuLEP n (%)	p-value
Early postoperative complications (1st 3 months)					
Postoperative hematuria	Grade I	Continuous bladder irrigation	3 (4.1)	3 (3.95)	0.7275
Transient incontinence	Grade I	Pelvic floor training	4 (5.4)	3 (3.95)	0.712
Retention	Grade IIIa	Recatheterization	2 (2.7)	1 (1.3)	0.561
Bladder mucosal injury	Grade I	No treatment	2 (2.7)	2 (2.63)	0.978
Urinary tract infection	Grade II	Antibiotics	3 (4.1)	4 (5.2)	0.697
Total			14 (18.9)	13 (17.1)	0.210
6-months follow up complications					
Urethral stricture	Grade IIIb	Internal urethrotomy	2 (2.7)	1 (1.3)	0.561
Total			2 (2.7)	1 (1.3)	0.561
12-months follow up complications					
Urethral stricture	Grade IIIb	Internal urethrotomy	1 (1.4)	1 (1.3)	0.986
Bladder neck contracture	Grade IIIb	Bladder neck incision	2 (2.7)	2 (2.63)	0.978
Total			3 (4.1)	3 (3.95)	0.7275

Table 4. *Functional outcomes for both groups at 1, 3, 6, and 12 months*

Variable	HoLEP	Low power ThuLEP	p-value
	Mean ±SD (n = 74)	Mean ±SD (n = 76)	
Q_{max} (pre)(ml/s)	7.2 ±1.5	6.4 ±1.7	0.1228
Q_{max} (post 1 month)	26.0 ±2.0	25.5 ±3.0	0.5900
Q_{max} (post 3 months)	33.0 ±1.0	33.0 ±2.0	0.5835
Q_{max} (post 6 months)	35.0 ±1.0	35.5 ±2.0	0.9752
Q_{max} (post 12 months)	37.5 ±2.0	37.0 ±2.0	0.7736
p-value (pre vs post 12 months)	**<0.004**	**<0.002**	
PVR (pre) (ml)	118 ±30	128 ±35	0.655
PVR (post 1 month)	35.0 ±5.0	36.0 ±6.0	0.2163
PVR (post 3 months)	22.0 ±3.0	22.0 ±4.0	0.2819
PVR (post 6 months)	20 ±2.0	19 ±2.0	0.5413
PVR (post 12 months)	15.0± 3.0	14.5 ±2.5	0.4679
p-value (pre vs post 12 months)	**<0.0021**	**<0.002**	
IPSS (pre)	26 ±2.5	26 ±2.8	0.2945
IPSS (post 1 month)	8 ±0.8	8.5 ±1.0	0.6944
IPSS (post 3 months)	7.0 ±1.0	7.0 ±1.0	0.2148
IPSS (post 6 months)	5.0 ±1.0	5.0 ±1.0	0.9747
IPSS (post 12 months)	4.0 ±0.5	4.0 ±0.5	0.6828
p-value (pre vs post 12 months)	**<0.004**	**<0.0034**	
Prostate size (pre)	87.0 ±11.5	90.0 ±12.0	0.1079
Prostate size (post)	22.2 ±1.76	22.0 ±1.60	0.2022
PSA (pre)	4.1 ±0.5	4.5 ±0.6	0.1112
PSA (post)	1.0 ±0.5	1.05 ±0.3	0.1869
QoL (pre)	4.0 ±1.0	4.0 ±1.1	0.6789
QoL (post)	1.0 ±0.5	1.05 ±0.3	0.1869
p-value	**<0.0023**	**<0.003**	

IPSS – International Prostate Symptom Score; PSA – prostate-specific antigen; PVR – postvoid residual urine; Q_{max} – maximum urinary flow rate

in 6 months (Table 4). Postoperative pathology revealed BPH in all cases.

DISCUSSION

The effects of holmium laser enucleation of the prostate (HoLEP) and thulium laser enucleation of the prostate (ThuLEP) in the treatment of benign prostatic obstruction have been thoroughly compared in earlier research [14, 22–24]. According to these studies, both laser treatments produce comparable results in terms of safety and efficacy. A meta-analysis of randomized controlled trials and cohort studies found that ThuLEP and HoLEP significantly improved voiding parameters and relieved lower urinary tract symptoms. Furthermore, both therapies have been associated with similar hospital stays, catheterization times, and operation times.

Previous research has shown that low-power HoLEP is not inferior in terms of perioperative metrics or functional outcomes and that low-power HoLEP may be an effective and reliable option [25–27].

In our earlier research on low power ThuLEP, we were able to attain functional and urinary outcomes that were on par with high power ThuLEP. This comparison showed that low power ThuLEP has acceptable perioperative outcomes and functional outcomes. Reducing the initial cost of the laser procedure especially in developing countries was another important benefit of using low-power equipment. The low power ThuLEP offers a more affordable and convenient alternative for many healthcare facilities by doing away with the need for high-current sockets, which are not usually installed in operating rooms. Low-power ThuLEP offers a valuable alternative in the surgical management of benign prostatic hyperplasia due to its cost-effectiveness and demonstrated efficacy in absence of more advanced energy sources [16, 17].

In this study, no statistically significant difference between HoLEP and low-power ThuLEP groups as regard hemoglobin decrease (which is better clinically in ThuLEP group compared to HoLEP group, 0.80 ±0.2 vs 0.85 ±0.5 respectively) or blood transfusion rates. Advantages of hemostasis and less blood loss using different types of lasers were contradictory in literature as some studies showed that hemoglobin drop was less with ThuLEP [14, 23] or more with ThuLEP group [28], while others noticed no difference [24, 29]. We can explain the less hemoglobin drop on the lower power ThuLEP group due to proper ablative and hemostatic effect of thulium laser in addition, to our insistence to use mechanical dissection to be more strict to the proper plane between the prostate adenoma and the capsule which can be easily identified using the low power energy with minimal tissue carbonization "black escharing" avoiding leaving residual tissues that may causes continuous bleeding. Consequently, there is no statistically significant difference between both groups as regards the catheter time removal and hospital stay, early or delayed complications.

The only notable variation in our study was noted in the total operative time and the enucleation time favoring the HoLEP approach. The answer that makes sense could be the variation in the energy setting. An energy setting of 100 W was used for cutting and 20 W for coagulation during the HoLEP procedure. For the ThuLEP procedure, the energy settings were 25 W for coagulation and 30 W for cutting.

Higher energy settings could lead to shorter operation times and faster enucleation rates. Also, the cavitation effect of the holmium laser enhances tissue dissection and ablation, facilitating quicker enucleation of prostatic adenoma.

Both HoLEP and low power ThuLEP have scarless features with easier identification of correct surgical planes between the prostate adenoma and capsule which is an important technical advantage compared to previous studies utilizing high power ThuLEP.

In his 18-month follow-up prospective randomised study, Zang et al. [14] compared the clinical outcomes of ThuLEP (70 W) and HoLEP (90 W). They discovered that both are equally safe and efficient, and that ThuLEP outperformed HoLEP in terms of operation time and blood loss. Apart from using (70 W) instead of our low power settings, these findings are consistent with our results.

In 2018, Becker et al. [22] demonstrated that thulium vapoenucleation using 70 W and HoLEP are safe and efficient methods for treating large volume benign prostatic hyperplasia, with little morbidity and satisfactory results.

Bozzini et al. [23] showed that both ThuLEP and HoLEP both have comparable efficacy and safety. There were no discernible differences between the perioperative and postoperative parameters. The energy settings were 35 W for coagulation and 120 W for cutting, compared to our low power settings with the same efficacy and safety.

However, in our study, total operative and enucleation time was statistically better in HoLEP compared to ThuLEP, which may be explained by our low power settings in the thulium arm. In contrast, Zhang et al. [24] demonstrated that both techniques are comparable, but ThuLEP (120 W) was statistically better than HoLEP in both enucleation

and operation times, while the differences were essentially insignificant.

Herrmann et al. [15] in their critical analysis to thulium: YAG laser use, they stated that, Although the optimum energy source for EEP depends on individual preference, thulium: YAG provides the greatest option for the entire spectrum of surgical techniques for transurethral prostatectomy for BPO, including vaporization, resection, enucleation, and vapoenucleation.

Also, there is no statistically significant difference between both groups as regard functional outcomes as IPSS and QoL scores, Q_{max} and PVR aligning with existing literature. This supports the thesis that functional outcomes after AEEP are mainly related to surgical technique used and the accumulated experience rather than the type of energy source used.

Aybal et al. [28] compared HoLEP, ThuLEP, and ThuFLEP using propensity score matching. They found all methods to be safe, effective, and comparable in improving functional parameters.

Hartungy et al. [30] found that Both ThuLEP and HoLEP improve postoperative voiding parameters and alleviate urinary symptoms. Both treatments are relatively safe, with few major effects. ThuLEP showed slight benefits in terms of blood loss and temporary urine incontinence.

Meng et al. [31] carried out a meta-analysis and systematic review comparing HoLEP and ThuLEP, finding no significant difference in functional parameters at 6 and 12 months postoperatively.

We assume that the use of mechanical dissection with low-power thulium: YAG during prostate enucleation might lower the possibility of thermal damage to nearby tissues and might achieve a comparable result to standard HoLEP in developing countries with lack of resources. To our knowledge, this is the first prospective study that directly compares low-power ThuLEP (30 W) to HoLEP to assess its feasibility and safety.

Due to the study's small sample size and single-center approach, More comparative multi-center studies are required to demonstrate the safety of low-power ThuLEP. Additionally, a longer follow-up period is required to thoroughly evaluate the long-term durability of the functional outcomes. Moreover, the study did not assess the erectile function, sexual function, or irritable symptoms between the two techniques. Only two surgeons carried out all the procedures, which may introduce selection and performance bias. Rather, this study might promote the use of low-power ThuLEP, especially for surgeons who have access to low-power equipment. This is relevant for surgeons who do not have holmium laser machines.

CONCLUSIONS

Low-power ThuLEP using the thulium:YAG laser is a safe and effective alternative to HoLEP, particularly for larger prostate volumes, despite the longer operative time. Both procedures demonstrate similar safety profiles and efficacy in terms of reducing prostate size, improving urinary symptoms with minimal complications.

CONFLICT OF INTERESTS

The authors declare no conflict of interest.

FUNDING

This research received no external funding.

ETHICS APPROVAL STATEMENT

The study was approbated by Cairo University Hospitals' institutional board review ethical committee with IRB number MD-381 and a written consent was obtained from all participants.

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