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TOPIC PAPER

Holmium laser with MOSES technology (MoLEP) vs Thulium fiber laser enucleation of the prostate (ThuFLEP) in a real-world setting. Mid-term outcomes from a multicenter propensity score analysis

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Abstract

Purpose To compare Holmium laser with MOSES technology (MoLEP) and Thulium fiber laser enucleation of the prostate (ThuFLEP) in terms of surgical and functional outcomes.

Methods We performed a retrospective analysis of all patients who underwent either procedure in five centers (January 2020–January 2022). Exclusion criteria: previous urethral/prostatic surgery, radiotherapy, concomitant surgery. Propensity score matching (PSM) analysis was performed to adjust for the bias inherent to the different characteristics at baseline. Differences between procedures were estimated using Firth Penalized Likelihood regression for International prostate symptom score (IPSS), quality of life (QL), maximum flow rate (Qmax).

Results PSM retrieved 118 patients in each group. Baseline characteristics were similar except for PSA and number of men on indwelling catheter (higher in MoLEP group). Median surgical time was significantly longer in the MoLEP group despite the enucleation and morcellation times being similar. Median catheter dwelling time and postoperative length of stay were similar. Most of the early complications were Clavien ≤ 2 grade. There were only two Clavien grade 3 complications (one for each group), one grade 4 in MoLEP group. Rate and type of early and persistent incontinence (>3 months) were similar. At 12-month, proportion of patients reaching a decrease (Δ) of IPSS ≥ 18 from baseline was significantly larger in MoLEP group, with no significant difference in ΔQmax > 12 ml/sec and ΔQL $\geq$ -3.

Conclusion MoLEP and ThuFLEP were safe and efficacious procedures with similar short-term operative and functional outcomes. At 1-year, MoLEP patients had a sustained reduction of IPPS score.

Keywords Benign prostatic hyperplasia · Laser therapy · Endoscopic enucleation of the prostate · MoLEP · ThuFLEP

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Introduction

The definition of anatomical endoscopic enucleation of the prostate (EEP) was introduced by the European Association of Urology Guidelines in 2016 to group all surgical procedures irrespective of energy source [1]. From its inception in 1983 [2], transurethral EEP has evolved into a reproducible and anatomically defined surgery [3]. Holmium laser enucleation of the prostate (HoLEP) is now touted as a prostate-size independent surgical intervention of choice [4] and recommended as a first intervention by the European Association of Urology guidelines [5]. As new devices are introduced into urology practice, the quest for identifying the ideal laser or energy device for EEP remains still an enigma [6]. Recently, two high-power lasers have been introduced in clinical practice for EEP, namely HoLEP with MOSES Technology (MoLEP) [7] and Thulium fiber laser (TFL) enucleation of the prostate (ThuFLEP) [8]. There are single-center randomized controlled trials that have established the safety, efficacy, pros, and cons of using either of the energy sources with the conventional time-tested HoLEP [9, 10].

The present study aimed to assess complications, surgical and 1-year functional outcomes in a large multicenter real-life setting comparing MoLEP vis a vis ThuFLEP.

Material and methods

We performed a retrospective analysis of all patients who underwent either MoLEP or ThuFLEP in 5 centers between January 2020 and January 2022. Inclusion criteria were lower urinary tract symptoms not responding to or worsening despite medical therapy, urinary retention, and absolute indication for surgery, namely recurrent urinary tract infection, and bilateral hydronephrosis with renal impairment or recurrent hematuria due to BPH. Patients with previous prostate/urethral surgery, prostate cancer, and pelvic radiotherapy were excluded. Patients who underwent concomitant lower urinary tract surgery were also excluded (i.e. internal urethrotomy, lithotripsy, or transurethral resection of bladder tumor). Prostate cancer was ruled out before enucleation with a prostate biopsy in case of suspicion. At baseline, the following data were gathered: age, comorbidity, presence of a preoperative indwelling catheter, International prostate symptom score (IPSS) with quality of life (QL) item, PSA, and maximum flow rate (Qmax) at uroflowmetry. IPSS, QL, and Qmax were assessed in outpatient clinics at 3 and 12 months after surgery. Early postoperative complications were considered up to 30 days after surgery and graded according to the modified Clavien-Dindo classification. Late complications within 1 year were also assessed. Nine surgeons with a previous experience in more than 200 transurethral prostate enucleations were involved in all procedures. ThuFLEP was performed in 4 centers, whilst 1 center performed both MOLEP and ThuFLEP. Oral anticoagulant agents were switched to low-weight molecular heparin in preparation for surgery and resumed as per each center's discretion. Antibiotic prophylaxis was administered to all patients according to local protocols. Prostate enucleation was performed using a 26 Ch 26-Ch (Karl Storz, Tuttlingen, Germany) resectoscope with a separate operative channel for the fiber. Enucleation was performed using either TFL (TFL U3, IRE-Polus, Russia or 60 W super pulse TFL IPG photonics, Oxford, MA) or 120 W Holmium:YAG laser with MOSES 1.0 technology (VersaPulse; Lumenis Ltd., Yokneam, Israel) using a 550-µm fiber in all cases. Morcellation was performed in all cases after enucleation using different morcellators as available. A 3-way 20 Ch or 22 Ch bladder catheter was placed at the end of the procedure with continuous irrigation and removed when urine cleared. Enucleation time was calculated from the start of enucleation to start of morcellation. Surgical time was considered from cystoscopy to catheter placement. Incontinence was defined as any urine leakage as reported by patients. Institutional board review approval was obtained by the leading center (AINU 11/2022) and the remaining centers had approvals from their Institutional board.

Statistical analysis

Continuous variables were assessed for their normal distribution with the Shapiro–Wilk test and are reported as median and interquartile range. Categorical variables are reported as absolute frequency and percentage. Comparison between groups was performed by the Mann–Whitney *U* test and Chi-square test. Outcome variables (i.e., IPSS, QL, and Qmax variation after 3 and 12 months) were dichotomized into under the median or above (or equal to) the median of the variable itself. To mitigate biases caused by potential non-convergence with a binary outcome, differences between ThuFLEP and MoLEP were estimated using Firth Penalized Likelihood regression for all the outcomes, adjusted for age, PV, baseline IPSS, baseline QL, baseline Qmax, and indwelling catheter. All analyses were repeated after propensity score matching (PSM) to adjust for the bias inherent to the different patient characteristics at baseline. The PSM was estimated by fitting a stepwise logistic regression model with intervention type as the dependent variable and age, prostate volume, IPSS, QL, and Qmax as covariates. The main outcomes were: IPSS, QL, and Qmax variation after 3 and 12 months. A two-tailed p value < 0.05 was

considered significant. Data were analyzed using STATA version 15.1 Statistical Software Package for Windows (StataCorp, College Station, TX).

Results

During the study period, 1898 patients met the inclusion criteria and were included in the analysis. Among them, 131 patients underwent MOLEP and 1767 ThuFLEP. Caseload for each center is presented in Supplementary Table 1. Table 1 shows patient baseline characteristics, intraoperative data, and postoperative outcomes before and after PSM. Patients in the MoLEP group were significantly older [69 (64–74) vs 67 (61–72) years, $p = 0.002$], had larger prostate volume [85 (60–105) vs 72 (60–90) ml, $p = 0.033$], higher PSA [5.5 (3.2–9.6) vs 4.3 (2.5–6.6) ng/ml, $p = 0.001$] and Qmax [9 (8–12.3) vs 8.5 (7–10.7) ml/s $p < 0.001$]. Patients with diabetes, cerebrovascular disease, and indwelling catheter were significantly more prevalent in the MoLEP group. PSM retrieved 118 patients in each group and baseline characteristics were similar in the two groups except for PSA and the number of men on indwelling catheters, which were still higher in the MoLEP group. After PSM, median surgical time was significantly longer in the MoLEP group [110 (90–147) vs 70 (50–90) min, $p < 0.001$] despite the enucleation and morcellation time being similar in both cohorts. There was a significant difference in the type of enucleation. The use of the 3-lobe technique was more prevalent in the MoLEP group (44.9% vs 4.2%) and the 2-lobe technique in the ThuFLEP group (77.1%). The early apical release technique was employed more frequently in the MoLEP group (50% vs 29.7%, $p = 0.01$). A significantly higher proportion of patients in the MoLEP group had surgery under antiplatelets/low-weight molecular heparin. Median catheter dwelling time and postoperative length of stay were similar between the two groups. Regarding early postoperative complications, most of the complications were Clavien ≤ 2 grade. There were only two Clavien grade 3 complications (one for each group) and one grade 4 in the MoLEP group. Diagnosis of incidental prostate cancer was similar between the two groups in the matched cohort (4.2% in MoLEP vs 2.5% in ThuFLEp, $p = 0.061$).

Supplementary Table 2 lists the type and number of complications after PSM. Late complications within 1-year follow-up were noted in 8 patients, 5 bulbar urethral strictures, and one bladder neck sclerosis in the ThuFLEP group and one urethral stricture and bladder neck sclerosis in the MoLEP group. The rate and type of early (25.4% in MoLEP vs 17% in ThuFLEP, $p = 0.111$) and persistent incontinence (more than 3 months) was similar between the two groups (3.4% in MoLEP vs 2.5% in ThuFLEP). Overall, roughly two third of matched patients had a decrease (Δ) of IPSS ≥ 18 and of QL $\geq$ -3 at 3-month after surgery but the proportion of patients reaching those scores was significantly more prevalent in the MoLEP group (Table 2). Three months after surgery, almost half of the matched patients had an improvement of ≥ 12 ml/s of their Qmax with no difference between the groups. At 12-month, there was still a significantly larger proportion of matched patients in the MoLEP group who had ΔIPSS ≥ 18, with no significant difference in ΔQmax and ΔQL. Logistic regression analysis of matched populations shows a significant difference in favor of MoLEP in ΔIPSS at 3-month (OR 0.01 95% CI 0.00–0.04; Supplementary Table 3) and 12-month (OR 0.18 95% CI 0.06–0.57, Supplementary Table 4). At 12-month, there was a significant difference in favor of ThuFLEP in ΔQmax (OR 2.73 95% CI 1.17–6.39). Logistic regression analysis also highlighted that baseline IPSS, Qmax, and QL influenced their variation at 3 and 12-month (the higher baseline values, the lower their Δ) and baseline prostate volume influenced ΔIPSS at 12-month (OR 1.03 95% CI 1.00–1.05).

Discussion

Although the conceptualization of transurethral enucleation dates back to 1983 [2], EEP did not attract urologists until the introduction of the holmium laser and morcellator [3]. Since then, there has been a continuous increase in the popularity and adoption of EEP among urologists [11] due to the introduction of bipolar energy and new lasers [3] and its ability to achieve complete adenoma removal with significantly less morbidity as compared to traditional transurethral resection of the prostate and open prostatectomy [12].

In the present study, we assessed complications and early outcomes of EEP comparing MoLEP and ThuFLEP in a large, multicenter series of men with clinical BPH. We found that both procedures had a good safety profile with a low rate of minor and major complications and similar early functional outcomes.

The trifecta of any enucleation surgery for BPH is identifying the enucleation plane to ensure a complete anatomical dissection, ensuring hemostasis to prevent bleeding-related complications, and preventing urethral/prostatic injuries to allow for a seamless and early trial of void postoperatively [13].

In our study, median surgical time was significantly longer in the MoLEP group despite the enucleation and morcellation time and total energy delivered did not differ. This could perhaps be attributed to a few observations in our study such as the number of patients on antiplatelets who might have needed more time for immediate hemostasis. Because of its retrospective nature, it is difficult to comment on any extraneous factors such as instrument malfunction, intraoperative events, any concomitant

Table 1 Patient's preoperative, intraoperative and postoperative characteristics

	Before propensity score matching				After propensity score matching			
	Overall ($n=1898$)	MoLEP ($n=131$)	ThuFLEP ($n=1767$)	p value	Overall ($n=236$)	MoLEP ($n=118$)	ThuFLEP ($n=118$)	p value
Preoperative characteristics								
Age, years	67 (61–72)	69 (64–74)	67 (61–72)	0.002	69.5 (63–74)	69 (64–73)	70 (63–75)	0.462
Prostate volume, ml	74 (60–92)	85 (60–105)	72 (60–90)	0.033	80 (60–100)	83 (58–100)	80 (70–100)	0.447
Baseline PSA, ng/ml	4.4 (2.6–6.8)	5.5 (3.2–9.6)	4.3 (2.5–6.6)	0.001	4.75 (2.6–8.06)	5.45 (3.2–9.58)	4.3 (2.38–6.89)	0.010
Baseline IPSS	23 (21–25)	23 (23–24)	23 (21–25)	0.021	23 (22–25)	23 (23–24)	23 (21–25)	0.087
Baseline QL	4 (4–5)	4 (4–5)	4 (3–5)	0.631	4 (4–5)	4 (4–5)	4 (4–5)	0.898
Baseline Qmax, ml/s	8.5 (7–10.9)	9 (8–12.3)	8.5 (7–10.7)	< 0.001	8.9 (7.7–11.8)	8.5 (7.7–11.4)	9.2 (7.7–12)	0.561
Diabetes	217 (11.4%)	22 (16.8%)	195 (11.0%)	0.046	38 (16.1%)	21 (17.8%)	17 (14.4%)	0.479
Hypertension	1086 (57.2%)	80 (61.1%)	1006 (56.9%)	0.633	138 (58.5%)	70 (59.3%)	68 (57.6%)	0.792
Cerebrovascular Disease	94 (5.0%)	15 (11.5%)	79 (4.5%)	< 0.001	19 (8.1%)	13 (11.0%)	6 (6.1%)	0.094
Indwelling catheter history	210 (11.1%)	58 (44.3%)	152 (8.6%)	< 0.001	65 (27.5%)	47 (39.8%)	18 (15.3%)	< 0.001
Intraoperative data								
Total energy delivered, KJ	70 (43–100)	1.5 (1.5–222)	70 (47–91)	0.138	82.8 (1.5–219)	85 (1.5–238.5)	78.1 (56.5–136.3)	0.420
Surgical time, min	68 (59–95)	114.8 (90–159.6)	65 (50–90)	< 0.001	90 (65–120)	110 (90–147)	70 (50–90)	< 0.001
Enucleation time, min	50 (40–80)	65 (45–84)	60 (40–80)	0.017	60 (45–81.1)	61.4 (45–81.5)	60 (50–75)	0.642
Morcellation time, min	25 (15–40)	33 (15–50)	20 (15–35)	0.009	26.4 (15–45.2)	30 (15–47.4)	25 (15–35)	0.507
Type of enucleation				< 0.001				< 0.001
3 lobes	132 (7.0%)	65 (49.6%)	67 (3.8%)		58 (24.6%)	53 (44.9%)	5 (4.2%)	
2 lobes	1388 (73.1%)	24 (18.3%)	1364 (77.2%)		115 (48.7%)	24 (20.3%)	91 (77.1%)	
En bloc	378 (19.9%)	42 (32.1%)	336 (19.0%)		63 (26.7%)	41 (34.8%)	22 (18.6%)	
Early apical release	530 (27.9%)	60 (45.8%)	470 (26.6%)	< 0.001	94 (39.8%)	59 (50.0%)	35 (29.7%)	0.001
Type of morcellator				< 0.001				< 0.001
Piranha	1829 (96.4%)	79 (60.3%)	1750 (99.0%)		181 (76.7%)	67 (56.8%)	114 (96.6%)	
Hawk	49 (2.6%)	41 (31.3%)	8 (0.5%)		42 (17.8%)	40 (33.9%)	2 (1.7%)	
Drillcut	20 (1.0%)	11 (8.4%)	9 (0.5%)		13 (5.5%)	11 (9.3%)	2 (1.7%)	
Anesthesia				< 0.001				< 0.001
General	132 (6.9%)	52 (39.7%)	80 (4.5%)		58 (24.6%)	51 (43.2%)	7 (5.9%)	
Spinal	1766 (93.1%)	79 (60.3%)	1687 (95.5%)		178 (75.4%)	67 (56.8%)	111 (94.1%)	
Type of anticoagulant				< 0.001				< 0.001
None	1639 (86.4%)	62 (47.3%)	1577 (89.3%)		166 (70.3%)	61 (51.7%)	105 (89.0%)	
ASA	16 (0.8%)	1 (0.8%)	15 (0.8%)		2 (0.8%)	1 (0.8%)	1 (0.8%)	
Clopidogrel	1 (0.1%)	1 (0.8%)	0 (0.0%)		1 (0.4%)	1 (0.8%)	0 (0.0%)	
Low weight molecular heparin	242 (12.7%)	67 (51.1%)	175 (9.9%)		67 (28.4%)	55 (46.6%)	12 (10.2%)	

Table 1 (continued)

	Before propensity score matching				After propensity score matching			
	Overall ($n=1898$)	MoLEP ($n=131$)	ThuFLEP ($n=1767$)	p value	Overall ($n=236$)	MoLEP ($n=118$)	ThuFLEP ($n=118$)	p value
Postoperative outcomes								
Length of stay (day)	2 (1–3)	2 (1–2)	2 (1–3)	0.587	2 (1–3)	2 (1–2)	2 (1–3)	0.148
Catheter dwelling time (days)	2 (1–3)	2 (1–2)	2 (1–3)	0.813	2 (1–2)	2 (1–2)	2 (1–3)	0.255
Clavien grade				< 0.001				< 0.001
No complication	1611 (84.9%)	92 (70.2%)	1519 (86.0%)		191 (80.9%)	87 (73.7%)	107 (88.1%)	
1	192 (10.1%)	9 (6.9%)	183 (10.4%)		18 (7.6%)	7 (5.9%)	11 (9.3%)	
2	66 (3.5%)	28 (21.4%)	38 (2.1%)		24 (10.2%)	22 (18.6%)	2 (1.7%)	
3a	24 (1.3%)	1 (0.8%)	23 (1.3%)		2 (0.8%)	1 (0.8%)	1 (0.8%)	
3b	2 (0.1%)	0 (0.0%)	2 (0.1%)		0 (0.0%)	0 (0.0%)	0 (0.0%)	
4	3 (0.2%)	1 (0.8%)	2 (0.1%)		1 (0.4%)	1 (0.8%)	0 (0.0%)	
Immediate postoperative incontinence	328 (17.3%)	31 (23.7%)	297 (16.8%)	0.045	50 (21.2%)	30 (25.4%)	20 (17.0%)	0.111
Type of incontinence				0.190				0.270
No incontinence	1570 (82.7%)	100 (76.3%)	1470 (83.2%)		186 (78.8%)	88 (74.6%)	98 (83.1%)	
Urge	40 (2.1%)	3 (2.3%)	37 (2.1%)		6 (2.5%)	3 (2.5%)	3 (2.5%)	
Stress	118 (6.2%)	12 (9.2%)	106 (6.0%)		18 (7.6%)	12 (10.2%)	6 (5.1%)	
Mixed	28 (1.5%)	1 (0.8%)	27 (1.5%)		4 (1.7%)	1 (0.8%)	3 (2.5%)	
Not specified	142 (7.5%)	15 (11.4%)	127 (7.2%)		22 (9.3%)	14 (11.9%)	8 (6.8%)	
Duration of incontinence				0.037				0.178
No incontinence	1570 (82.7%)	100 (76.3%)	1470 (83.2%)		186 (78.8%)	88 (74.6%)	98 (83.1%)	
Up to 1 month	241 (12.7%)	22 (16.8%)	219 (12.4%)		31 (13.1%)	21 (17.8%)	10 (8.5%)	
Between 1 and 3 months	68 (3.6%)	5 (3.8%)	63 (3.6%)		12 (5.1%)	5 (4.2%)	7 (5.9%)	
More than 3 months	19 (1.0%)	4 (3.1%)	15 (0.8%)		7 (3.0%)	4 (3.4%)	3 (2.5%)	
Delayed complications (> 30 days after surgery)				0.896				0.381
None	1843 (97.1%)	129 (98.5%)	1714 (97.0%)		228 (96.6%)	116 (98.3%)	112 (94.9%)	
Urethral stricture requiring dilatation	29 (1.5%)	1 (0.8%)	28 (1.6%)		4 (1.7%)	1 (0.8%)	3 (2.5%)	
Urethral stricture requiring urethrotomy	4 (0.2%)	0 (0.0%)	4 (0.2%)		2 (0.8%)	0 (0.0%)	2 (1.7%)	
Bladder neck sclerosis requiring transurethral incision	21 (1.1%)	1 (0.8%)	20 (1.1%)		2 (0.8%)	1 (0.8%)	1 (0.8%)	

Table 1 (continued)

	Before propensity score matching				After propensity score matching			
	Overall ($n=1898$)	MoLEP ($n=131$)	ThuFLEP ($n=1767$)	p value	Overall ($n=236$)	MoLEP ($n=118$)	ThuFLEP ($n=118$)	p value
Redo surgery for BPH	1 (0.1%)	0 (0.0%)	1 (0.1%)		0 (0.0%)	0 (0.0%)	0 (0.0%)	
Pathology				0.009				0.061
BPH	1866 (98.3%)	126 (96.2%)	1740 (98.5%)		228 (96.6%)	113 (95.8%)	115 (97.5%)	
Incidental prostate cancer	22 (1.2%)	5 (3.8%)	17 (1.0%)		8 (3.4%)	5 (4.2%)	3 (2.5%)	
Not available	10 (0.5%)	0 (0.0%)	10 (0.5%)		–	–	–	

Data are presented as *n* (%) or median (IQR)

Qmax maximum flow rate, *QL* quality of life, *IPSS* International Prostate Symptoms Score, *MoLEP* Holmium laser enucleation of the prostate with MOSES technology, *ThuFLEP* Thulium fiber laser enucleation of the prostate, *KJ* kilo joule, *BPH* benign prostatic hyperplasia

Table 2 Lower urinary tract symptoms, quality of life and micturition parameter 3 and 12 months after surgery

	Before propensity score matching				After propensity score matching			
	3 months follow-up							
	Overall ($n=1898$)	MoLEP ($n=131$)	ThuFLEP ($n=1767$)	p value	Overall ($n=236$)	MoLEP ($n=118$)	ThuFLEP ($n=118$)	p value
Δ IPSS (3 month) ≥ −18	1128 (59.4%)	126 (96.2%)	1002 (56.7%)	< 0.001	177 (75.0%)	113 (95.8%)	64 (54.2%)	< 0.001
ΔQL (3 month) ≥ −3	1385 (73.0%)	112 (85.5%)	1273 (72.0%)	0.001	185 (78.4%)	99 (83.9%)	86 (72.9%)	0.040
ΔQmax (3 month) ≥ 12	1001 (52.7%)	57 (43.5%)	944 (53.4%)	0.028	109 (46.2%)	56 (47.5%)	53 (44.9%)	0.695
	Before propensity score matching				After propensity score matching			
	12 months follow-up							
	Overall ($n=1495$)	MoLEP ($n=79$)	ThuFLEP ($n=1416$)	p value	Overall ($n=126$)	MoLEP ($n=63$)	ThuFLEP ($n=63$)	p value
ΔIPSS (12 month) ≥ −18	870 (58.2%)	61 (77.2%)	809 (571%)	< 0.001	73 (57.9%)	46 (73.0%)	27 (42.9%)	0.001
ΔQL (12 month) ≥ −3	946 (63.3%)	49 (62.0%)	897 (63.4%)	0.812	77 (61.1%)	36 (57.1%)	41 (65.1%)	0.361
ΔQmax (12 month) ≥ 15	753 (50.4%)	16 (20.3%)	737 (52.1%)	< 0.001	45 (35.7%)	16 (25.4%)	29 (46.0%)	0.695

Data are presented as *n* (%)

Qmax maximum flow rate, *QL* quality of life, *IPSS* International Prostate Symptoms Score, *MoLEP* Holmium laser enucleation of the prostate with MOSES technology, *ThuFLEP* Thulium fiber laser enucleation of the prostate

pre-enucleation urethral dilatation, and difficulty of immediate catheter insertion needing instrumentation as probable causes that could prolong surgery. Importantly, postoperative catheter indwelling time and hospital time were similar in the match-paired analysis reiterating that laser source, technique, and surgical duration are not the key influences on surgical outcomes unless the procedure is planned for day surgery or early trial of the catheter. We were unable to ascertain this in our study limited by its multicenter retrospective nature where other demographic

factors would have influenced the decision on the catheter removal and the need for retaining patients in the hospital.

A key observation in our study is the incidence of complications in the immediate and 1-year follow-up when performed in the "everyday practice" where strict inclusion and exclusion criteria are not applied. In our analysis, the low rate of immediate and short-term complications and incontinence were similar in both cohorts and this shows that both lasers offered good surgical outcomes in experienced hands irrespective of enucleation technique. The rate of bleeding complications was low in both groups with only one patient in each group requiring a blood transfusion and only one patient in the ThuFLEP group demanding postoperative surgical hemostasis after PSM. These excellent results can be explained by surgeon experience but are also related to the physical propriety of both lasers. MOSES technology delivers the laser pulse in two peaks. The first peak splits water and produces a bubble, whilst the second one delivers laser energy to the target [14], ensuring an amplified energy transport to the target without higher tissue damage in comparison with a standard holmium laser [15]. The better energy delivery from the MOSES technology translates into a more effective tissue ablation and separation, allowing for improved hemostasis [7]. TFL radiation at 1.940 nm wavelength is near to the absorption peak of water and has an optical penetration depth of 0.077 mm [16]. After traveling the distance of its optical penetration depth, the TFL energy pulse reduces to 1.7% only, and this in conjunction with its high water absorption ensures a high energy delivery to the prostatic tissue with a thin layer of carbonization followed by larger layers of cellular vacuolization and thermal-coagulation zone, providing adequate hemostasis in highly vascular tissue [17].

Surgical interventions for benign prostatic hyperplasia (BPH) should also offer improvement in lower urinary tract symptoms and micturition parameters and herein we found that even though the number of patients achieving a $\Delta Qmax \geq 12$ ml was the same in both groups, MoLEP achieved a $\Delta IPSS \geq 18$ in a significantly higher proportion of men at 12-month follow-up. This reflects that the improvement in symptom scores in patients offered by MoLEP is more sustainable at 1-year. The degree of lower urinary tract symptoms improvement after BPH surgery depends on the individual case and the extent of the bladder outlet obstruction. Similarly, the degree of flow improvement depends on bladder contractility. This is one of the reasons that might have influenced our results and partially explains the difference in improvement in IPSS and Qmax between the two groups. Unfortunately, flow/pressure studies were not performed in most cases in our cohort. BPH patients choosing treatments favor no side effects, and rapid symptom and QL improvement [18]. In our study, the number of men reaching $\Delta QL \geq -3$ was similar between the two groups at 12 months, confirming that both procedures were equally effective.

A well-established side effect of EEP is the occurrence of transient and persistent incontinence. At 6-month follow-up, the rates of stress and urge urinary incontinence after EEP was reported to be 6.0% and 7.3%, respectively [19] but no difference in the rate of both types of incontinence was found among various energy sources in EEP [20]. In our study, the incidence of early and persistent urge and stress incontinence was in line with the literature [8, 21] with no significant difference in the rate of the type of incontinence between the two groups. Studies on early apical release and en-bloc have shown a significantly lower incidence of transient stress incontinence [22, 23]. Despite this technique being used in a larger proportion of men having MoLEP, this was not observed between the two cohorts in our study as also found in a recent study by Press et al. who showed no difference in postoperative continence rate at 3, 6, and 12 months between standard HoLEP and en-bloc enucleation with early apical release [24].

Our study has some limitations starting from its retrospective nature. PSM analysis permitted us to adjust selection bias related to the different patient characteristics at baseline and to demonstrate that both procedures were equally safe in terms of bleeding and high-grade complications in daily practice and had satisfactory early functional outcomes. However, some bias may remain due to sample reduction and omission of variables [25] but we followed the recommendation regarding the application of propensity score methods in urology to allow scientific reproducibility and obtain valid measures [26]. Secondly, even though different experiences in EEP and multiple operators cannot be controlled in the analytic phase, all involved surgeons were experienced in EEP. Yet, we also acknowledge that postoperative patients' management was not standardized and we might have missed some minor complications given the retrospective nature of our study. Finally, the present study results represent high-volume centers, and this could limit the generalization of our findings in centers with a lower experience.

Conclusions

This is the first large-volume real-world study reporting outcomes on patients followed up to 1 year comparing MoLEP vs ThuFLEP. MoLEP and ThuFLEP were both safe and efficacious enucleation procedures with similar short-term operative and functional outcomes. At 1-year, MoLEP patients had a sustained reduction of their IPPS score compared to those who had ThuFLEP despite the improvement of QL

from baseline being similar. Surgeons may want to consider this when counseling their patients.

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Data availability Data is available on request from the authors.

Declarations

Conflict of interest Fernando Gomez-Sancha is a consultant for Quanta system and Lumenis. Thomas R.W. Herrmann is a consultant for, has received honoraria from, and is involved in research collaboration with Karl Storz.

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