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Research Article

High-power holmium laser versus thulium fiber laser for endoscopic enucleation of the prostate in patients with glands larger than 80 ml: Results from the Prostate Endoscopic EnucLeation study group

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ABSTRACT

Background: Endoscopic enucleation of the prostate (EEP) has gained acceptance as an equitable alternative to transurethral resection of the prostate for benign prostate hyperplasia (BPH). Our primary aim is to compare peri-operative outcomes of EEP using thulium fiber laser (TFL) against high-power holmium laser (HPHL) in hands of experienced surgeons for large prostates (≥80 ml in volume). Secondary outcomes were assess complications within 1 year of follow up.
Materials and Methods: We retrospectively reviewed patients with benign prostatic hyperplasia who underwent EEP with TFL or HPHL in 13 centers (January 2019-January 2023). Patients with prostate volume ≥80 ml were included, while those with concomitant prostate cancer, previous prostate/urethral surgery, and pelvic radiotherapy were excluded.
Results: Of 1,929 included patients, HPHL was utilized in 1,459 and TFL in 470. After propensity score matching (PSM) for baseline characteristics, 247 patients from each group were analyzed. Overall operative time (90 [70, 120] vs. 52.5 [39, 93] min, $P < 0.001$) and enucleation time (90 [70, 105] vs. 38 [25, 70] min, $P < 0.001$) were longer in the TFL group, with comparable morcellation time (13 [10, 19.5] vs. 13 [10, 16.5] min, $P = 0.914$). In terms of postoperative outcomes, there were no differences in 30-day complications such as acute urinary retention, urinary tract infection or sepsis. In the PSM cohort, univariable analyses showed that higher age, lower preoperative Qmax, higher preoperative PVRU, and

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longer operation time were associated with higher odds of postoperative incontinence, while 2-lobe enucleation had lower odds of incontinence compared to 3-lobe enucleation.

Conclusions: This real-world study reaffirms that HPHL and TFL in large prostates are equally efficacious in terms of 30-day complications. TFL with the en-bloc technique has a shorter operative time which significantly improves short- and medium-term functional outcomes.

1. Introduction

Since its introduction in 1983, endoscopic enucleation of the prostate (EEP) has gained acceptance as an equitable alternative to transurethral resection of the prostate for benign prostate hyperplasia (BPH), primarily due to the use of bipolar energy and lasers and the introduction of morcellators.[1] In large (>80 cc) and very large prostates (>100 cc), EEP and in particular holmium laser (HL) enucleation of the prostate,[2] has showed lower rates of postoperative catheterization and hospital stay, and complications with excellent functional outcomes as compared with open simple prostatectomy.[3–5]

With the recent introduction of the thulium fiber laser (TFL) for EEP which is gaining increasing popularity, a comparison to HPHL is sorely needed. Hence, we primarily aimed to compare perioperative outcomes of EEP between TFL and high-power holmium laser (HPHL) for large prostates (i.e., with a volume ≥80 ml), using data from experienced surgeons. Secondary outcomes were to assess complications within 1 year of follow up.

2. Methods

We performed a retrospective analysis of all BPH patients who underwent laser-guided EEP for BPH in 13 centers between January 2019 and January 2023. Inclusion criteria were prostate volume ≥80 ml, lower urinary tract symptoms not responding to or worsening despite medical therapy acute urinary retention, recurrent urinary tract infections or hematuria due to BPH, and bilateral hydronephrosis with renal impairment. Exclusion criteria were prostate cancer, previous prostate/urethral surgery, and pelvic radiotherapy. Concomitant bladder lithotripsy was permitted. Prostate cancer was ruled out before EEP in patients with elevated prostate-specific antigen (PSA) or when clinically suspected by performing a prostate biopsy. At baseline, the following data were gathered: age, American Society of Anesthesiologists (ASA) score, presence of a preoperative indwelling catheter, International Prostate Symptom Score (IPSS) with quality of life (QL) item, PSA, post-void residual urine (PVR), and maximum flow rate (Qmax) at uroflowmetry. 13 surgeons with previous experience of at least 200 laser EEP were involved in all procedures. Prostate volume was measured by ultrasonography or MRI-based imaging available to surgeon. Patients taking oral anticoagulants at baseline were switched to low-molecular weight heparin in preparation for surgery and resumed as per each center's discretion, while single antiplatelet agents were maintained. All patients received antibiotic prophylaxis following local protocols.

Laser choice and EEP technique were at the surgeon's discretion based on their experience and available resources. The HPHL arm comprised patients who underwent enucleation with any machine make that was HPHL >100 Watt, using HL enhanced with Moses technology, or virtual basket-HPHL depending on the machine available at the place of practice. TFL patients had enucleation using 60-Watt machines from IPG or Quanta.

Patients were assessed post-surgery according to the local standard of care. Follow-up time intervals were either 3, 6, 12, 24 months, or a combination of the above time points. 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 reported by patients. Data on preoperative characteristics and measurements were collected. The primary outcome was postoperative incontinence; the secondary outcomes were early complications (<30 days) and late complications (>30 days).

Institutional board review approval was obtained by the leading center (Asian Institute of Nephrology and Urology, AINU #11/2022), and the remaining centers had approvals from their Institutional boards. All patients were consented to collect their de-identified data.

2.1. Statistical analyses

All statistical analyses were performed using R Statistical language, version 4.3.0 (R Foundation for Statistical Computing, Vienna, Austria) with $P < 0.05$ indicating statistical significance. The Shapiro–Wilk test was used to assess for normality. Continuous variables were reported using medians and interquartile ranges (IQR), and categorical variables as absolute numbers and percentages. For this study, patient demographics, perioperative parameters, and outcomes were tabulated for each of the HPHL and TFL arms. Baseline characteristics, operative parameters, and postoperative outcomes were compared using the $\chi 2$ test or Fisher exact test for categorical parameters and the Mann–Whitney U test for continuous variables. For the outcome of postoperative incontinence, univariable analysis was performed to evaluate baseline and operative factors associated with this outcome. Relevant potentially prognostic variables in univariable analysis were entered into a multivariable generalized linear regression model to assess their significance as independent predictors. Predictors were described using odds ratios (OR), 95% confidence intervals (CI), and *P*-values.

For the outcomes of postoperative incontinence and 30-day complications, odds ratios for TFL versus HPHL were generated using four models. The first model adjusted for baseline characteristics and the second model adjusted for baseline and intraoperative characteristics. For the third and fourth models, propensity score matching (PSM) was performed for TFL versus HPHL with one-to-one nearest-neighbor matching by the baseline characteristics of age, prostate volume, preoperative IPSS, and preoperative Qmax. Caliper size for PSM was started at 0.2 and adjusted downwards in decrements of 0.01 until an absolute standardized mean difference (ASMD) threshold of <0.1 was reached, indicating favorable matching. All variables were described for the PSM cohort similar to the overall cohort. The third model utilized OR and 95% CI derived from the PSM cohort, while the fourth model utilized OR and 95% CI from multivariate analysis of the PSM cohort.

3. Results

1,929 patients were included in the analysis, of which 1,459 underwent EEP with HPHL and 470 underwent TFL (Table 1). Prior

Table 1
Baseline characteristics

	Unmatched cohort			PSM cohort		
	HL (N = 1,459)	TFL (N = 470)	ASMD	HL (N = 247)	TFL (N = 247)	ASMD
Age, median [IQR]	69 [64, 75]	68 [62, 74]	0.288	67 [62.5, 73]	68 [62, 73.5]	0.066
Prostate volume (ml), n (%)			0.482			0.061
80–100	388 (26.6)	64 (11.8)		19 (7.7)	23 (9.3)	
101–200	939 (64.4)	427 (78.6)		203 (82.2)	198 (80.2)	
>200	132 (9.0)	52 (9.6)		25 (10.1)	26 (10.5)	
Preoperative indwelling catheter, n (%)	296 (20.3)	65 (12.0)	0.318	23 (9.3)	27 (10.9)	0.054
Preoperative IPSS, median [IQR]	26 [22, 29]	23 [21, 24]	0.490	24 [22, 26]	23 [21, 26]	0.007
Preoperative QOL, median [IQR]	5.0 [5.0, 5.0]	4.0 [3.0, 5.0]	0.869	5.0 [4.0, 5.0]	4.0 [4.0, 5.0]	0.578
Preoperative Qmax, median [IQR]	8.0 [7.0, 10]	8.5 [7.0, 10.8]	0.124	9.0 [7.0, 11]	8.6 [7.1, 11]	0.074
Preoperative PVR, median [IQR]	69 [58, 80]	70 [55, 90]	0.151	69 [57, 90]	70 [60, 100]	0.205

ASMD, absolute standardized mean difference; HL, holmium laser; IPSS, International Prostate Symptom Score; IQR, interquartile range; PSM; propensity score matched; PSM, propensity score matched; PVR, post-void residual urine volume; Qmax, peak flow rate; QoL, quality of life score; TFL, thulium fiber laser.

to matched analysis, median age higher in the HPHL group (ASMD = 0.288), with prostate volume >100 cc in 73.4% of the HPHL group and 88.2% of the TFL group. Table 2 shows the intra-operative characteristics of the cohort. In terms of peri-operative outcomes (Table 3), the TFL had a higher rate of 30-day complications at 14.9% compared to the HPHL group at 10.6% ($P = 0.013$) in the unmatched cohort. Clavien–Dindo (CD) grade 3 and above complications comprised 55.6% of all complications in the TFL group and 26.4% of all complications in the HL group.

After PSM, 247 patients from each group were included in the analysis with ASMD <0.1 in all matched characteristics (Table 1). In the TFL group, all cases were performed using a scope size of 26Fr, whereas in the HPHL group 19% utilized 24Fr with 8.5% using a 27Fr scope (Table 2). Overall operative time (90 [70, 120] vs. 52.5 [39, 93] min, $P < 0.001$) and enucleation time (90 [70, 105] vs. 38 [25, 70] min, $P < 0.001$) were longer in the TFL group, with comparable morcellation time (13 [10, 19.5] vs. 13 [10, 16.5] min, $P = 0.914$) (Table 2). In terms of postoperative outcomes, there was a significant difference in need for prolonged irrigation for hematuria, defined as between 12 to 48 hours, in the TFL group compared to the HPHL group (4.9% vs. 2.4%, $P = 0.015$), and no differences in other 30-day complications such as acute urinary retention, urinary tract infection or sepsis (Table 3). Overall, type and duration of postoperative incontinence was not significantly different between the two groups.

In the PSM cohort, univariable analyses showed that higher age, lower preoperative Qmax, higher preoperative PVRU, and longer operation time were associated with higher odds of postoperative incontinence, while 2-lobe enucleation had lower odds of incontinence compared to 3-lobe enucleation (Table 4).

Results of the four models adjusted for baseline characteristics and/or propensity score matching are shown in Table 5. TFL was associated with lower odds of postoperative incontinence compared to HPHL in three of four models, with only the PSM model showing no significant difference. For 30-day complications, three of four models showed no significant difference, with only the second model (adjusting for baseline and operative characteristics in the unmatched cohort) showing higher rates of complications in the TFL arm.

For follow-up measurements within 1 year of surgery, similar IPSS was observed in both HL and TFL arms (Table 6). In the PSM cohort, significantly higher QoL was seen in the HL arm, but this was mainly on comparing average scores rather than median scores, which were 1 in both arms. Higher Qmax was also observed in the HL arm but this was unlikely to be clinically significant (mean, 22.5 vs. 20.4 ml/s, $P = 0.009$). Significantly higher PVR was

Table 2
Intraoperative characteristics

	Unmatched cohort			PSM cohort		
	HL (N = 1,459)	TFL (N = 470)	*P*	HL (N = 247)	TFL (N = 247)	*P*
Scope size (Fr), n (%)			<0.001			<0.001
22	53 (3.6)	0		0	0	
24	99 (6.8)	1 (0.2)		47 (19.0)	0	
26	1,262 (86.5)	469 (99.8)		179 (72.5)	247 (100.0)	
27	45 (3.1)	0		21 (8.5)	0	
Enucleation type, n (%)			<0.001			<0.001
3-lobe	156 (10.7)	35 (7.4)		48 (19.4)	29 (11.7)	
2-lobe	182 (12.5)	389 (82.8)		68 (27.5)	188 (76.1)	
En-bloc	1,121 (76.8)	46 (9.8)		131 (53.0)	30 (12.1)	
Early apical release, n (%)	156 (10.7)	35 (7.4)	<0.001	220 (89.1)	56 (22.7)	<0.001
Total operation time, median [IQR]	70 [48, 100]	86 [66, 120]	<0.001	52.5 [39, 93]	90 [70, 120]	<0.001
Enucleation time, median [IQR]	40 [28, 60]	90 [70, 104]	<0.001	38 [25, 70]	90 [70, 105]	<0.001
Morcellation time, median [IQR]	15 [10, 19]	15 [10, 20]	0.743	13 [10, 16.5]	13 [10, 19.5]	0.914
Morcellator, n (%)			<0.001			<0.001
Cyberblade	50 (3.4)	1 (0.2)		26 (10.5)	1 (0.4)	
Hawk	0	1 (0.2)		0	0	
Jena	423 (29.0)	0		130 (52.6)	0	
Lumenis	43 (2.9)	0		12 (4.9)	0	
Piranha	812 (55.7)	465 (98.9)		57 (23.1)	246 (99.6)	
Storz	131 (9.0)	3 (0.6)		22 (8.9)	0	
Spinal anesthesia, n (%)	601 (41.2)	79 (16.8)	<0.001	121 (49.0)	61 (24.7)	<0.001

Table 3
Outcomes

	Unmatched cohort			PSM cohort		
	HL (N = 1,459)	TFL (N = 470)	p	HL (N = 247)	TFL (N = 247)	*P*
Postoperative IDC duration (days), median [IQR]	2.0 [1.0, 2.0]	2.0 [1.0, 2.0]	0.001	2.0 [2.0, 2.0]	2.0 [1.0, 3.0]	0.172
30-day complications, n (%)	154 (10.6)	70 (14.9)	0.013	34 (13.8)	46 (18.6)	0.179
Post op ARU needing re-catheterization CD 1	43 (2.9)	20 (4.3)	0.216	6 (2.4)	12 (4.9)	0.230
Prolonged irrigation for hematuria CD2	15 (1.0)	15 (3.2)	0.002	2 (0.8)	12 (4.9)	0.015
Blood transfusion CD3	7 (0.5)	0	0.288	3 (1.2)	0 (0.0)	0.247
Intra op bleeding requiring surgical control with roller ball CD2	14 (1.0)	1 (0.2)	0.193	2 (0.8)	1 (0.4)	>0.99
UTI needing antibiotics CD 2	39 (2.7)	19 (4.0)	0.175	14 (5.7)	14 (5.7)	>0.99
Sepsis needing ICU CD 4	3 (0.2)	3 (0.6)	0.323	0 (0.0)	1 (0.4)	>0.99
Delayed/secondary morcellation CD2	9 (0.6)	9 (1.9)	0.023	1 (0.4)	4 (1.6)	0.369
Ureteric orifice injury needing stenting CD 3	2 (0.1)	2 (0.4)	0.540	0 (0.0)	1 (0.4)	>0.99
Cardiovascular complications CD 4	8 (0.5)	0	0.232	0	0	–
Prolonged bleeding despite conservative measures with need for additional hemostasis CD3	7 (0.5)	0	0.288	3 (1.2)	0 (0.0)	0.247
Energy device/morcellator malfunction	4 (0.3)	0	0.58	0	0	-
Minor bladder injury from morcellation CD2	5 (0.3)	1 (0.2)	>0.99	4 (1.6)	1 (0.4)	0.369
Redo surgery	1 (0.1)	0	>0.99	1 (0.4)	0 (0.0)	>0.99
Postoperative incontinence, n (%)	151 (10.3)	67 (14.3)	0.025	51 (20.6)	41 (16.6)	0.298
Type of incontinence, n (%)			0.341			0.362
Urge	29 (20.4)	8 (12.1)		12 (23.5)	5 (12.5)	
Stress	87 (61.3)	44 (66.7)		27 (52.9)	26 (65.0)	
Mixed	26 (18.3)	14 (21.2)		12 (23.5)	9 (22.5)	
Duration of incontinence for those affected, n (%)			0.955			0.883
<1 month	67 (48.2)	33 (50.0)		28 (54.9)	21 (51.2)	
1–3 months	45 (32.4)	20 (30.3)		15 (29.4)	12 (29.3)	
>3 months	27 (19.4)	13 (19.7)		8 (15.7)	8 (19.5)	
Kegel exercise needed, n (%)	118 (80.3)	66 (97.1)	0.002	43 (84.3)	40 (95.2)	0.175
Any cause 30-day readmission, n (%)						
Delayed complications, n (%) 6 months to 1 year	26 (2.6)	4 (0.9)	0.044	8 (3.2)	0 (0.0)	0.013
Delayed complications, n (%)	20 (2.0)	10 (2.1)	>0.99	9 (3.6)	3 (1.2)	0.144
Urethral stricture requiring dilation only	11 (1.1)	2 (0.4)	0.324	4 (1.6)	0 (0.0)	0.132
Urethral stricture requiring urethrotomy	5 (0.5)	6 (1.3)	0.197	2 (0.8)	3 (1.2)	>0.99
Bladder neck stenosis requiring TURBNI	2 (0.2)	2 (0.4)	0.811	2 (0.8)	0 (0.0)	0.479
Stress incontinence requiring sling	2 (0.2)	0	0.833	1 (0.4)	0 (0.0)	>0.99

seen in the HL arm although unlikely to be clinically significant and well within normal limits (mean, 30.5 vs. 15.3 ml, $P < 0.001$).

4. Discussion

EAU, NICE, and AUA guidelines currently endorse laser-based EEP for prostates larger than 80 ml as a reference standard being currently held for large prostates.[6] Although minimally invasive approaches such as laparoscopic or robotic simple prostatectomy has been advocated for prostates >80 ml,[7,8] recent evidence has demonstrated that EEP with HL is as safe and equally effective with shorter hospitalizations, lower transfusion rates, shorter catheterization time, lower costs, and even feasible for same-day discharge.[9] However, most of the published studies include single-center series with the majority of the large prostate volumes ranging between 80–100 ml with even fewer studies report outcomes for prostate volumes of more than 150–200 ml.[5,10,11]

In brief, rigorous analysis of postoperative outcomes found significantly lower odds of postoperative incontinence but no difference in postoperative complications for TFL versus HPHL, with three of four adjusted models in agreement for each outcome. In the existing literature, Hartung et al compared HL and TFL in a

Table 4
Univariate analysis of incontinence

	Unmatched cohort			PSM cohort		
	OR	95% CI	*P*	OR	95% CI	*P*
TFL (vs. HL)	1.44	1.052–1.953	0.021	0.765	0.483–1.204	0.249
Age	1.013	0.995–1.031	0.169	1.031	1–1.063	0.049
Prostate volume (vs. 80–100 ml)						
101–200 ml	1.221	0.86–1.769	0.277	1.702	0.705–5.076	0.281
>200 ml	1.251	0.713–2.143	0.422	2.277	0.764–7.733	0.156
Preoperative indwelling catheter	1.949	1.402–2.681	<0.001	1.437	0.692–2.798	0.305
Preoperative IPSS	0.97	0.94–1.001	0.057	0.984	0.91–1.061	0.671
Preoperative Qmax	0.871	0.815–0.929	<0.001	0.846	0.774–0.92	<0.001
Preoperative PVR	1.005	1.003–1.006	<0.001	1.005	1.003–1.008	<0.001
Enucleation type (vs. 3-lobe)						
2-lobe	0.518	0.337–0.805	0.003	0.466	0.253–0.877	0.016
En-bloc	0.414	0.279–0.624	<0.001	0.821	0.44–1.56	0.539
Early apical release	0.882	0.65–1.21	0.429	1.711	1.072–2.778	0.026
Total operation time	1.01	1.006–1.013	<0.001	1.012	1.007–1.018	<0.001

HL, holmium laser; IPSS, International Prostate Symptom Score; PSM; propensity score matched; PVR, post-void residual urine volume; Qmax, peak flow rate; QoL, quality of life score; SD, standard deviation; TFL, thulium fiber laser.

Table 5
Adjusted odds ratios for TFL versus HL, selected outcomes

	OR	95% CI	P
Incontinence (all types and duration)			
Model 1	0.655	0.446–0.958	0.030
Model 2	0.427	0.251–0.719	0.002
Model 3 (PSM)	0.765	0.483–1.204	0.249
Model 4 (PSM, additional adjustment)	0.520	0.292–0.918	0.025
30-day complications			
Model 1	1.231	0.826–1.842	0.308
Model 2	2.216	1.243–4.043	0.008
Model 3 (PSM)	1.430	0.887–2.340	0.144
Model 4 (PSM, additional adjustment)	1.413	0.756–2.708	0.286

Model 1: adjusted for age, prostate volume, preoperative indwelling catheter, preoperative IPSS, preoperative Qmax, preoperative PVRU.
Model 2: adjusted for covariates in model 1 plus enucleation type, early apical release, and total operation time.
Model 3: propensity score-matched model.
Model 4: propensity score-matched model with correction for significant covariates.
HL, holmium laser; OR, odds ratio; PSM; propensity score matched; TFL, thulium fiber laser.

systemic review and meta-analysis of EEP and demonstrated that there were no observed significant differences in operating time, enucleation weight, catheterization time, or hospital stay; Albeit taking into account a lower certainty of evidence, TFL showed minor advantages for blood loss and the incidence of transient incontinence.[12] There was also no significant differences for other complications or functional measure and symptom scores. However, these studies only had prostate volumes <100 ml. Gauhar et al also reported in a recent analysis of 4,512 patients from REAP registry comparing HPHL with TFL for median prostate volume of 80 ml, shows that early and delayed outcomes of enucleation were comparable between both groups, with similar improvements in micturition parameters and IPSS.[13]

TFL has been demonstrated to have a sort of “eschar-like” effect on the surface of the incised tissue owing to its physical characteristics, which contrasts with the “scar-free” quality of with HL; This potentially can account for the longer operative time in TFL due to poorer visualization of the capsule.[14] It is well known that when approaching >100 cc prostates, surgery is time consuming and laborious, and time-consuming, extraction can be associated with marked hemorrhage often needing electrocautery, and often significant intravesical protrusion can lead to accidental ureteric orifice injury and sometimes prostates larger than 200 ml needed adenoma extraction by cystotomy.[13]

In our study, longer operative time was found to increase the odds of postoperative incontinence. It has been proposed that a longer operation time implies a longer time during which the scope is moving in the urethra; thus, the sphincter is exposed for a longer period to a force that may cause damage, leading to an increased chance of sphincter damage. In addition, sphincteric dysfunction does not account completely for incontinence; There are other contributory reasons such as a symptomatic urge caused by healing of the fossa or secondary detrusor instability caused by benign prostate hyperplasia or possible thermal damage of the prostatic capsule by laser exposure.[15,16] Moreover, after radical removal of an adenoma, the large prostatic fossa can lead to transient urine trapping and leakage with stress maneuvers.[17] Our study also demonstrates that even as the prostate size increases up to 200 ml, there is no difference in type nor duration of incontinence. Similar results are reported by recent systemic reviews and meta-analyses.[18–20]

In our study, 4.9% in the TFL group required prolonged irrigation for hematuria with a higher rate of incontinence after adjusting for co-founders. This can multifactorial attributed to shape and anatomical factors influencing dissection of the prostate, the efficacy of the laser energy devices used, technique, surgeon skill and patient factors.[5,10,11] It has also been demonstrated by Gauhar et al that Moses enhanced HL has superior hemostasis.[21] Bozzini et al[22] also reported HL EEP with “Virtual Basket™” technology achieving comparable hemostasis to conventional HL. Our findings may differ from other studies perhaps because this multicentre database is reflective of the surgeon's experience leading to a better understanding of technique and a careful pre and intraoperative approach in large and very large prostate. Also contributory is the availability of better surgical equipment as we can see many different energy sources, resectoscope sizes, and morcellators used in our study.

You et al[23] compared type of enucleation techniques in a meta-analysis and systemic review, showing that although En-bloc and two-lobe laser-based enucleation techniques are feasible and safe alternative to three-lobe technique with comparable surgical outcomes and similar functional outcomes; A superior enucleation efficiency was associated with En-bloc and the two-lobe techniques compared to the three-lobe technique. Tamalunas et al[24] also reported that the Enbloc approach with HL EEP, in comparison to 3-lobe enucleation, not only has comparable functional and hemostatic outcomes but more efficient surgical performance with shorter operative time.

This study was not without its limitations. As a retrospective nonrandomized cohort, a degree of selection bias is inevitable. In PSM studies, there is the possibility of misrepresentation of the respective cohort characteristics at baseline. Additionally, there is a reduced sample size for analysis after the score-matching algorithm, which may cause type 2 errors.[25] Lastly, we were unable to perform cost-comparison analyses or analyze the impact on sexual function between the two lasers.

Table 6
Follow-up measurements within 1 year

	Unmatched cohort			PSM cohort		
	HL (N = 1,459)	TFL (N = 470)	P	HL (N = 247)	TFL (N = 247)	P
IPSS, mean (SD)	5.53 (2.74)	5.33 (3.13)	0.252	6.06 (2.90)	5.79 (3.38)	0.346
IPSS, median [IQR]	5.00 [0, 21.0]	5.00 [0, 24.0]		6.00 [0, 21.0]	6.00 [0, 24.0]	
QoL, mean (SD)	1.36 (0.879)	1.15 (0.849)	<0.001	1.38 (0.859)	1.07 (0.806)	<0.001
QoL, median [IQR]	1.00 [0, 6.00]	1.00 [0, 4.00]		1.00 [0, 5.00]	1.00 [0, 4.00]	
Qmax, mean (SD)	20.6 (11.4)	21.1 (9.63)	0.378	22.5 (8.06)	20.4 (9.51)	0.009
Qmax, median [IQR]	21.0 [0, 64.0]	23.5 [1.00, 35.0]		22.0 [0, 56.0]	21.6 [1.00, 35.0]	
PVR, mean (SD)	31.3 (32.6)	15.2 (26.5)	<0.001	30.5 (28.4)	15.3 (32.1)	<0.001
PVR, median [IQR]	26.0 [0, 444]	0 [0, 434]		26.0 [0, 180]	0 [0, 434]	

Data are derived from follow-up visits within 1 year of surgery, i.e., at follow-up times of 1, 3, 6, or 12 months depending on institutional protocol.
HL, holmium laser; IPSS, International Prostate Symptom Score; PSM; propensity score matched; PVR, post-void residual urine volume; Qmax, peak flow rate; QoL, Quality of Life score; SD, standard deviation; TFL, thulium fiber laser.

5. Conclusions

This real-world study reaffirms that HPHL and TFL in large prostates are equally efficacious in terms of 30-day complications. In our experience TFL with the enbloc technique has a shorter operative time which significantly and positively influences short- and medium-term functional outcomes. We do caution that attention to hemostasis in EEP of large prostates with any laser is quintessential to minimize morcellation related as well as post-operative morbidity. Our study successfully shows how EEP is confidently being adopted with different lasers by different techniques even in large prostates.

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Authors contribution statement

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Conflicts of interest

None.

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