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FUNCTIONAL UROLOGY

Erectile and ejaculatory outcomes after HoLEP: A longitudinal analysis during the learning curve

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Introduction Holmium laser enucleation of the prostate (HoLEP) is a well-established surgical technique for benign prostatic obstruction. Although functional outcomes have been widely reported, data on sexual function during the learning phase remain limited. The aim of this study was to describe longitudinal erectile and ejaculatory outcomes during the initial learning curve of HoLEP.

Material and methods The first 254 consecutive patients undergoing HoLEP by a single surgeon were prospectively collected and retrospectively analyzed. Erectile function was evaluated using the Sexual Health Inventory for Men (SHIM) preoperatively and at 1, 3, 6, and 12 months. Ejaculatory function was assessed at the same intervals. Descriptive and comparative statistics were used, and patients were stratified into case groups to explore surgical experience impact.

Results A total of 254 patients were included. Mean patient age was 70.1 ±7.7 years and mean prostate volume was 90.9 ±34.4 cc. Preoperative SHIM scores were available for 222 patients, with a median of 12.7 [5.0–20.0]. SHIM decreased at 1 month (9 [3–15]) and recovered at 3 (12 [5–20]) and 6 months (13 [6–22]). At 12 months, erectile function remained stable (12 [5–20]) with no clinically relevant deterioration. Anejaculation was observed in 93.2% at 1 month and persisted throughout follow-up (>94%), with no significant differences across case groups.

Conclusions In this real-world HoLEP series, erectile function was preserved at mid-term follow-up, with a high and persistent rate of anejaculation. Sexual outcomes did not appear influenced by surgical experience.

Key Words: enucleation ‹› HoLEP ‹› Holmium ‹› learning ‹› curve ‹› prospective ‹› erection ‹› ejaculation

INTRODUCTION

Over the last two decades, the surgical management of benign prostatic obstruction (BPO) has evolved substantially, driven by advances in surgical instrumentation that have enabled holmium laser enucleation of the prostate (HoLEP) to become progressively established as a reference surgical technique. Numerous studies have consistently demonstrated its favorable safety profile and excellent functional

outcomes when compared with transurethral resection of the prostate (TURP) and simple prostatectomy [1–7]. Despite these advantages, HoLEP is consistently associated with a high rate of postoperative ejaculatory dysfunction, which remains a relevant functional concern. In contrast, available evidence indicates that erectile function is generally preserved after HoLEP, with no clinically meaningful deterioration in scores derived from internationally validated erectile function questionnaires and no significant impact on overall sexual satisfaction. While sexual outcomes following HoLEP have been extensively reported in expert and high-volume centers, data specifically addressing the prevalence and evolution of ejaculatory and erectile function during the learning curve remain limited [8–13]. In particular, it is unclear whether ejaculatory outcomes during the initial learning curve differ from those reported after procedural proficiency has been achieved. Given the increasing relevance of sexual and ejaculatory function in treatment decision-making, a clearer understanding of ejaculatory outcomes during the learning curve of HoLEP is warranted. The aim of the present study was therefore to assess the longitudinal evolution of erectile and ejaculatory function and to determine whether these outcomes are influenced by the learning curve of HoLEP in a real-world clinical setting.

MATERIAL AND METHODS

Study design and setting

A single-surgeon observational study was conducted including the surgeon's first 254 consecutive HoLEP procedures, representing the learning curve period. All procedures were performed across two high-volume institutions following standardized surgical principles. Data were prospectively collected and retrospectively analyzed. Operative performance and perioperative outcomes were analyzed sequentially to assess evolution over time.

Patient population

Between December 2022 and December 2024, 254 consecutive patients underwent HoLEP and were included in the analysis. Baseline demographic and clinical variables were prospectively recorded, including abdominal ultrasound prostate volume (cc), International Prostate Symptom Score (IPSS), Sexual Health Inventory for Men (SHIM), peak urinary flow rate (Q_{max}), postvoid residual volume (PVR), prostate-specific antigen (PSA), and medical therapy for lower urinary tract symptoms (Table 1). No exclusion criteria were applied regarding age, prostate volume, or baseline sexual function.

Surgical technique

All cases were performed using a 26-Ch Karl Storz continuous flow laser resectoscope and a laser fiber stabilizing bridge. Surgical techniques included 2-lobe (190 cases) (Figure 1), 3-lobe enucleation (30 cases) (Figure 2), or en-bloc (34 cases) (Figure 3), all with early apical release (EAR). The two-lobe technique represents our predominant approach and is therefore illustrated step-by-step. The three-lobe and en-bloc approaches are summarized schematically to highlight their conceptual differences. The choice of enucleation technique was based on prostate morphology, intraoperative conditions, and the surgeon's familiarity with each technique at the time of surgery. Enucleation was followed by intravesical morcellation. Technical details, operative times, enucleated tissue weight, and perioperative adverse events were recorded.

Table 1. *Baseline characteristics*

Baseline characteristics	n = 254
Age (years), mean ±SD	70.1 ±7.7
BMI, mean ±SD	27.4 ±3.9
Charlson Comorbidity Index (CCI), mean ±SD	3.5 ±2.0
Prostate volume (cc), mean ±SD	90.9 ±34.3
Urinary peak flow (UPF) (Q_{max}, ml/s), median [IQR]	8.9 [6.0–11.5]
Postvoid residual volume (PVR, ml), median [IQR]	0.0 [0.0;111.5]
Hemoglobin (g/dl), mean ± SD	14.9 ±1.5
PSA (ng/ml), mean ±SD	6.2 ±5.7
International Prostate Symptom Score (IPSS), median [IQR]	21.0 [16.0–26.0]
IPSS storage subscore, median [IQR]	9.1 [6.0–12.0]
IPSS voiding subscore, median [IQR]	10.7 [6.0–15.0]
IPSS Quality of Life (QoL) score, median [IQR]	5.0 [4.0–6.0]
Sexual Health Inventory for Men (SHIM), median [IQR]	12.7 [5.0–20.0]
Patients on antiplatelet therapy (%)	13.1%
Patients on anticoagulant therapy (%)	9.4%
Preoperative medical therapy for LUTS, n (%) *	
α-blocker	130 (54.6)
α-blocker + 5α-reductase inhibitor	70 (29.4)
α-blocker + antimuscarinic	17 (7.1)
α-blocker + β3-agonist	3 (1.3)

*Percentages are calculated among patients receiving medical therapy for LUTS
BMI – body mass index; IQR – Interquartile range; LUTS – lower urinary tract symptoms; PSA – prostate-specific antigen

Outcomes and sexual function assessment

Primary outcomes were longitudinal changes in SHIM scores and the prevalence of anejaculation over time, assessed solely as a binary self-reported outcome (yes/no). Partial ejaculation, reduced volume, or subjective bother were not captured. Secondary outcomes included descriptive perioperative and postoperative data. Erectile function was evaluated using the SHIM questionnaire, completed the day before surgery and at 1, 3, 6, and 12 months postoperatively. Higher SHIM scores indicate better

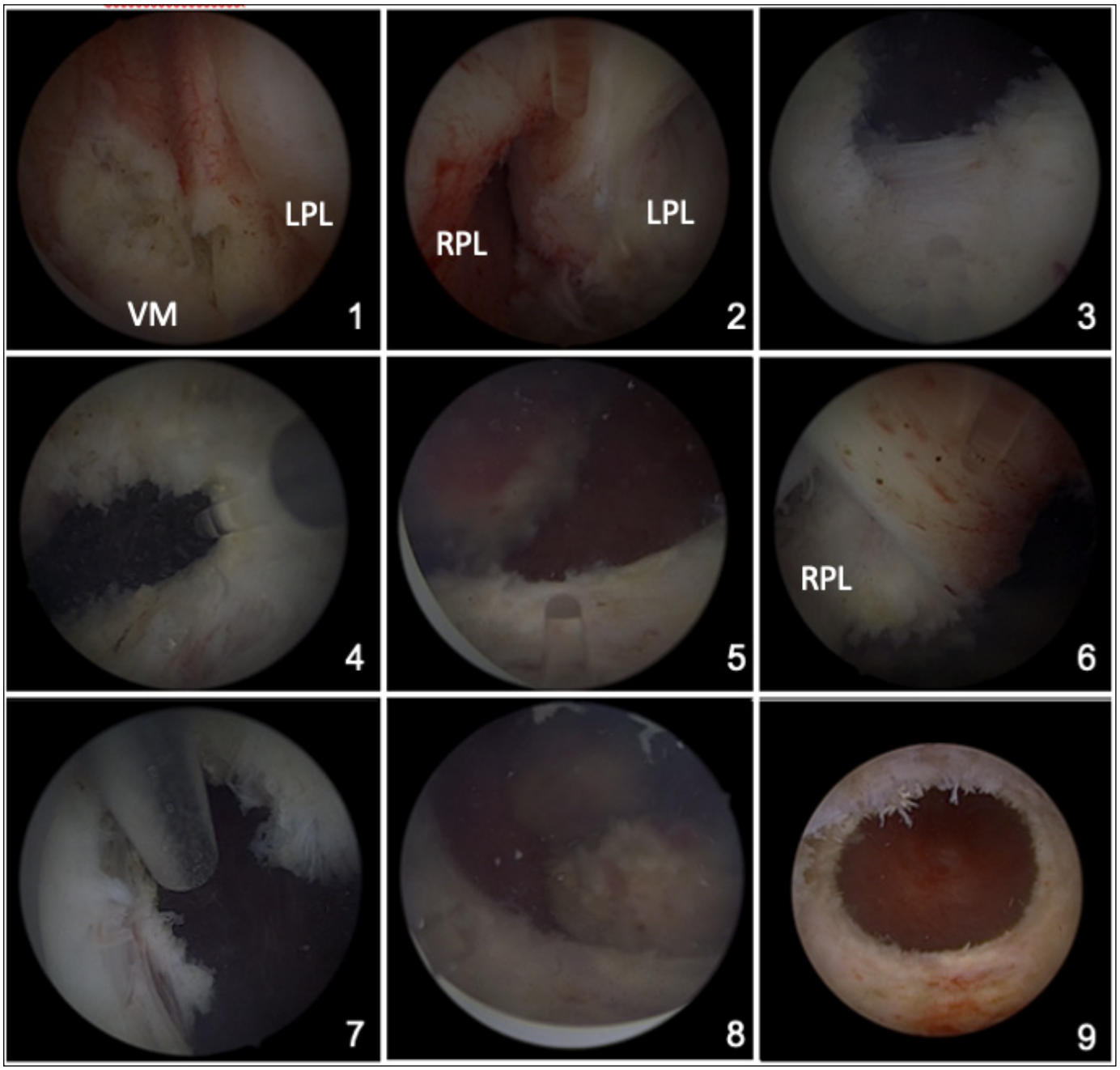

Figure 1. *2-lobe HoLEP technique.* **1.** *Horizontal incision anterior to the verumontanum.* **2.** *Apical dissection of the left prostatic lobe including sphincteric mucosa and anterior commissure.* **3.** *Division of the posterior commissure.* **4.** *Bladder neck dissection from the 6 o'clock to the 1 o'clock cystoscopic position.* **5.** *Release of the adenoma into the bladder.* **6.** *Apical dissection of the right prostatic lobe and sphincteric mucosa.* **7.** *Bladder neck dissection from the 6 o'clock to the 11 o'clock cystoscopic position.* **8.** *Complete release of both lobes into the bladder.* **9.** *Final enucleated fossa after hemostasis.*

LPL – left prostatic lobe; RPL – right prostatic lobe; VM – verumontanum

erectile function. Ejaculatory function was assessed by patient self-report at the same time points, and anejaculation was recorded as a dichotomous outcome.

Statistical analysis

Statistical analysis was performed using descriptive and comparative methods. Continuous variables were assessed for normality and are reported as mean ± standard deviation (SD) or median with interquartile range (IQR), as appropriate. Categorical variables are presented as absolute numbers and percentages. Changes in functional outcomes across follow-up time points were analyzed using appropriate non-parametric or parametric tests for repeated measurements, depending on data distribution, with a significance level set at $p < 0.05$.

Bioethical standards

The study was conducted in accordance with the Declaration of Helsinki. All patients provided informed consent for data collection and analysis for research purposes.

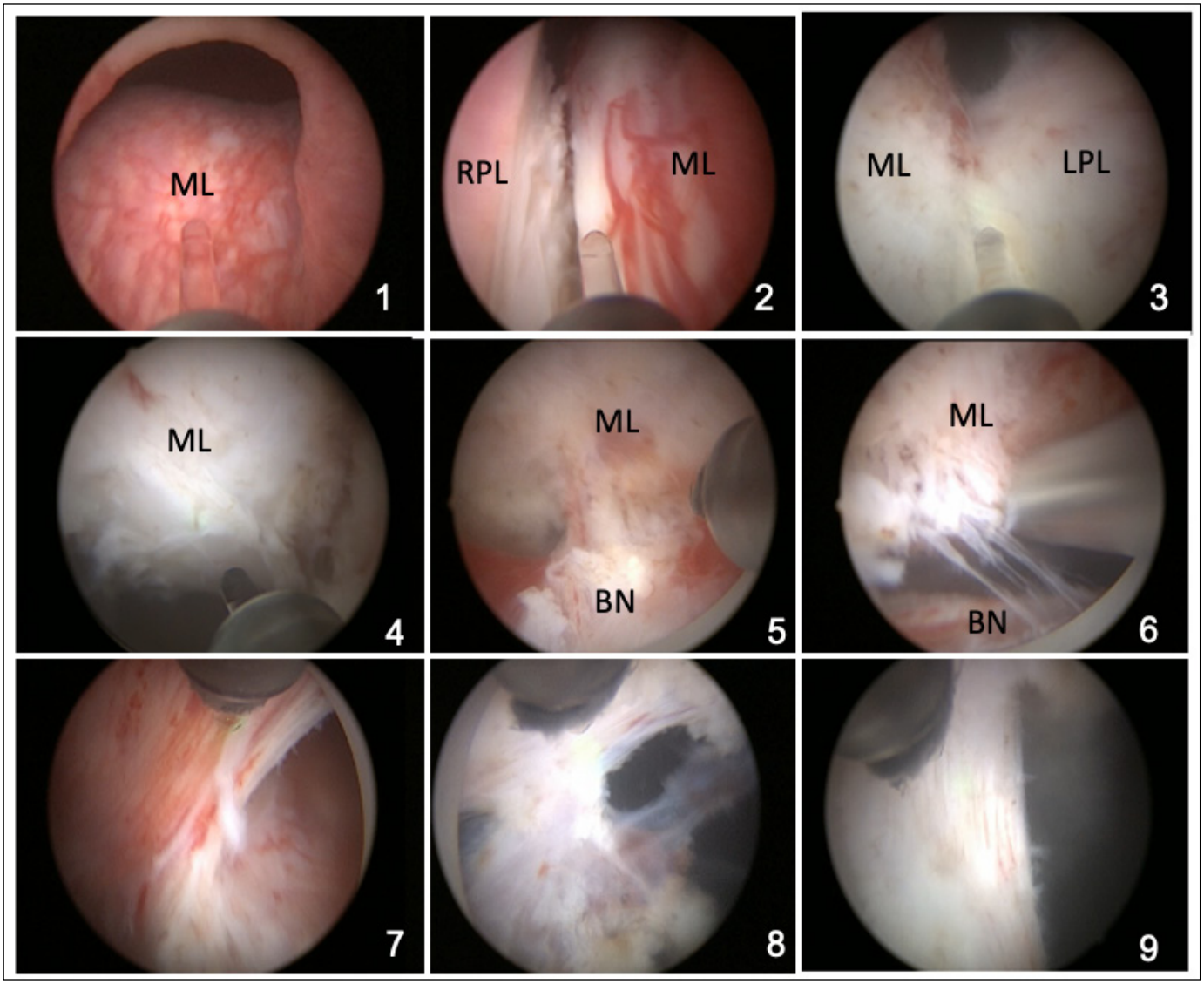

Figure 2. *3-lobe HoLEP technique.* **1.** *Endoscopic view of the prominent median lobe.* **2.** *Incision separating the right lateral lobe from the median lobe.* **3.** *Incision separating the left lateral lobe from the median lobe.* **4.** *Posterior plane development of the median lobe.* **5.** *Division of the posterior bladder neck mucosa.* **6.** *Release of the median lobe into the bladder.* **7.** *Apical dissection of the left lateral lobe.* **8.** *Bladder neck dissection.* **9.** *Release of the right lobe.*

BN – bladder neck; LPL – left prostatic lobe; ML – median lobe; RPL – right prostatic lobe

RESULTS

Urinary outcomes

Median follow-up was 6 months, with available data up to 12 months. Functional urinary outcomes improved markedly following surgery. Urinary peak flow increased significantly from baseline to all postoperative evaluations, with mean values exceeding 30 ml/s throughout follow-up ($p < 0.001$). PVR remained negligible at all time points. Median PSA levels decreased significantly after surgery and remained stable during follow-up ($p < 0.001$). Symptom burden showed substantial improvement, with median IPSS decreasing to 7 [3–12] at 1 month and further improving to 3 [1–5] at 12 months ($p < 0.001$). Both storage and voiding subscores demonstrated consistent improvement over time, accompanied by a parallel improvement in IPSS quality-of-life scores (all $p < 0.001$).

Sexual outcomes

Sexual function outcomes are summarized in Table 2 and Figures 4 and 5. Erectile function showed

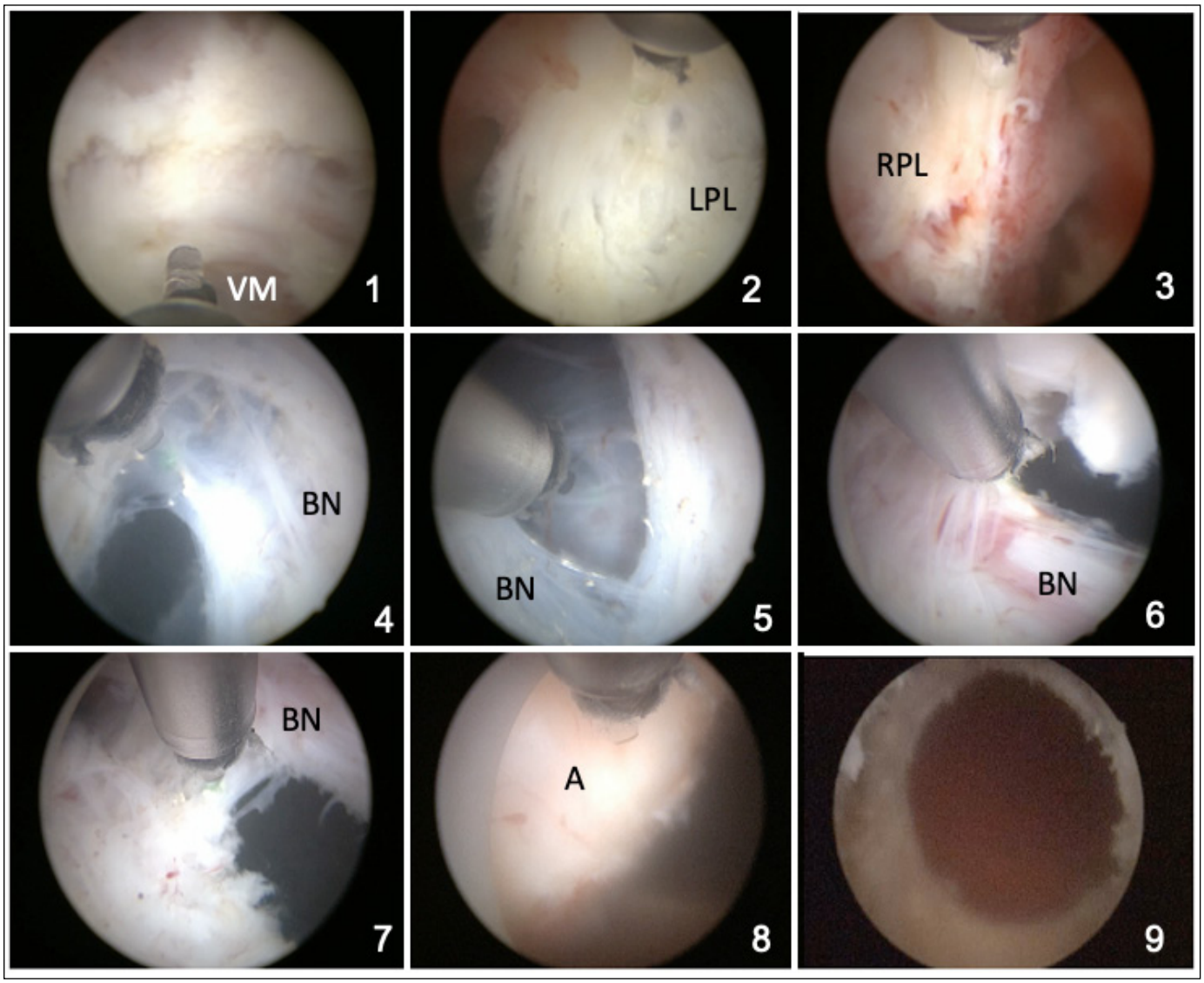

Figure 3. *En-bloc HoLEP technique.* **1.** *Horizontal incision anterior to the verumontanum.* **2.** *Apical dissection of the left prostatic lobe and sphincteric mucosa.* **3.** *Apical dissection of the right prostatic lobe and sphincteric mucosa.* **4.** *Bladder entry at the 3 o'clock cystoscopic position.* **5.** *Bladder entry at the 9 o'clock cystoscopic position.* **6.** *Bladder entry at the 6 o'clock cystoscopic position.* **7.** *Bladder entry at the 12 o'clock cystoscopic position with complete adenoma enucleation.* **8.** *Adenoma freely floating within the bladder.* **9.** *Final enucleated fossa after hemostasis.*

A – adenoma; BN – bladder neck; LPL – left prostatic lobe; RPL – right prostatic lobe; VM – verumontanum

a transient postoperative decline at 1 month (median 9 [3–15]), followed by progressive recovery and stabilization during follow-up, with median scores at 12 months comparable to baseline values ($p = 0.78$).

Ejaculatory function was markedly affected after surgery. The rate of anejaculation was 93.2% at 1 month, increasing to 96.0% at 3 months, 96.5% at 6 months, and 94.9% at 12 months, with no statistically significant differences across follow-up time points ($p = 0.56$).

To explore the relationship between surgical experience and functional outcomes, patients were stratified into consecutive case groups (1–50, 51–100, 101–150, 151–200, and 201–254). No statistically significant differences were observed in SHIM scores or anejaculation rates across these groups at any postoperative time point (all $p > 0.05$). These findings suggest that neither erectile nor ejaculatory outcomes were significantly influenced by increasing surgical experience during the learning phase.

DISCUSSION

The present study provides a longitudinal assessment of sexual function outcomes during the learning curve of HoLEP. Erectile function, as assessed by SHIM, remained stable over time, with only a transient early postoperative decline followed

Table 2. *Functional outcomes*

Functional outcomes	1 month postop	3 months postop	6 months postop	12 months postop	p-value
UPF (Q_{max}) (ml/s), mean ±SD	30.9 ±9.0	28.9 ±10.7	30.9 ±10.7	32.2 ±10.1	<0.001
PVR (ml), median [IQR]	0 [0–0]	0 [0–0]	0 [0–0]	0 [0–0]	0.43
PSA (ng/ml), median [IQR]	0.49 [0.30–0.88]	0.41 [0.20–0.85]	0.49 [0.30–0.88]	0.62 [0.36–0.93]	<0.001
IPSS, median [IQR]	7 [3–12]	4 [2–8]	3 [2–6]	3 [1–5]	<0.001
IPSS storage subscore, median [IQR]	4 [3–7]	3 [2–5]	2 [1–3.5]	2 [1–3]	<0.001
IPSS voiding subscore, median [IQR]	2 [0–5]	1 [0–2]	0 [0–1.5]	0 [0–1]	<0.001
IPSS Quality of Life (QoL) median [IQR]	2 [1–3]	1 [0–2]	1 [0–2]	0 [0–1]	<0.001
SHIM score, median [IQR]	9 [3–15]	12 [5–20]	13 [6–22]	12 [5–20]	0.78
Anejaculation rate, %	93.2	96.0	96.5	94.9	0.56

IPSS – International Prostate Symptom Score; IQR – Interquartile range; PSA – prostate-specific antigen; PVR – postvoid residual volume; SHIM – Sexual Health Inventory for Men; UPF – urinary peak flow

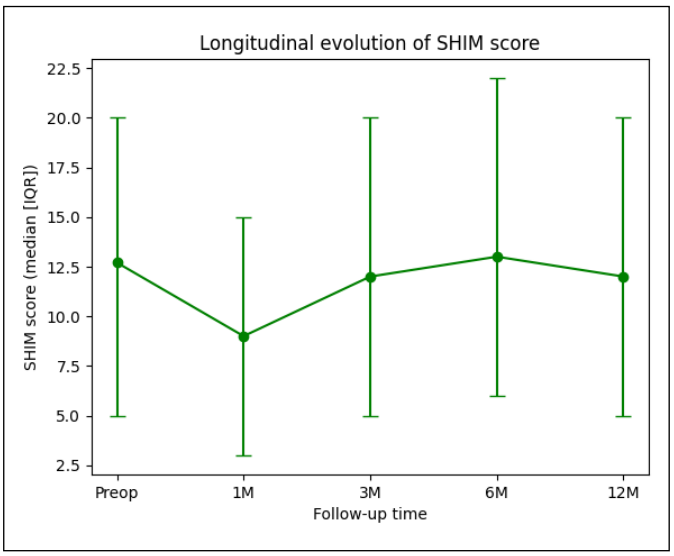

Figure 4. *Longitudinal evolution of Sexual Health Inventory for Men (SHIM) scores before surgery and during postoperative follow-up. Data are presented as median with interquartile range (IQR).*

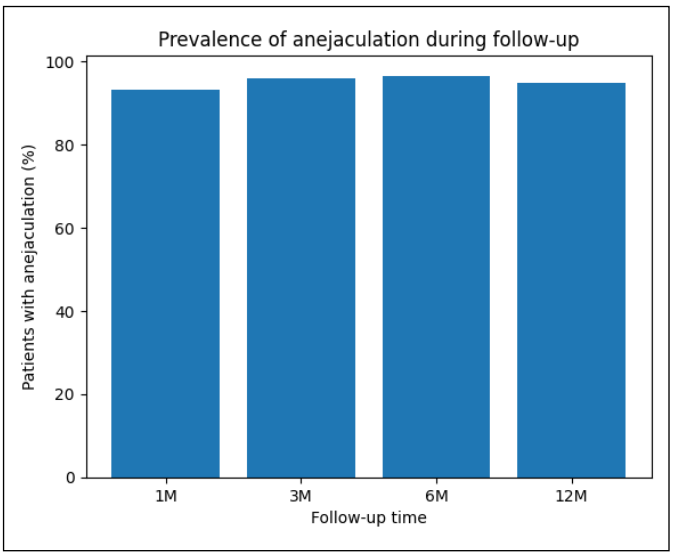

Figure 5. *Postoperative rates of anejaculation at 1, 3, 6, and 12 months following holmium laser enucleation of the prostate (HoLEP). Percentages are calculated among patients evaluated at each follow-up visit.*

by recovery to baseline values. In contrast, ejaculatory dysfunction was highly prevalent, with anejaculation rates exceeding 90% at all postoperative time points. These findings suggest that sexual function results remain largely stable throughout the learning curve and are not significantly modified by increasing procedural experience.

Several studies from expert and high-volume centers have specifically evaluated ejaculatory outcomes following HoLEP, reporting high rates of postoperative ejaculatory dysfunction, while a proportion of patients retain some degree of ejaculatory function. In the study by Elshal et al. [9], ejaculatory function was assessed using the Male Sexual Health Questionnaire–Ejaculatory Dysfunction (MSHQ-EjD) questionnaire, demonstrating a significant increase in ejaculatory dysfunction at 12 months after HoLEP compared with baseline and control groups. In this series, reduced ejaculatory volume was the most common abnormality, affecting more than 80% of patients, while complete anejaculation was less frequently reported. Overall, ejaculatory dysfunction rates following HoLEP in this and similar expert series have typically ranged around 70–80%. Comparable findings were reported by Briganti et al. [13] and Wilson et al. [14], who observed retrograde ejaculation rates of 78.3% and approximately 75%, respectively, following HoLEP, with preserved erectile function in most patients. Taken together, these data suggest that although ejaculatory dysfunction is a well-recognized consequence of HoLEP, a proportion of patients retain some degree of ejaculatory function in expert settings. In contrast to our initial hypothesis does not appear to be directly attributable to the surgeon's learning curve. Temporal analysis across consecutive case groups failed to demonstrate any significant variation in ejaculatory outcomes with increasing surgical experience. This suggests that the high rate of anejaculation may largely reflect an inherent consequence of the technique itself rather than a function of surgical proficiency. Notably, recent reports on ejaculation-preserving anatomical enucleation strategies have demonstrated maintenance of antegrade ejaculation in a substantial proportion of patients without compromising functional outcomes [11], suggesting that technical refinements aimed at preserving ejaculatory pathways may represent a promising direction for future evolution of enucleation surgery.

From a methodological perspective, the present study addresses an important gap in the literature by specifically evaluating the temporal relationship between surgical experience and functional outcomes. While previous studies have primarily reported overall rates of sexual dysfunction, few have explored whether these outcomes evolve during the learning phase. Our findings suggest that, within the limits of this cohort, sexual outcomes remain consistent over time, reinforcing the concept that postoperative ejaculatory dysfunction following HoLEP is largely technique-dependent.

A substantial proportion of patients in the present cohort were receiving medical therapy for lower urinary tract symptoms prior to surgery, including alpha-blockers alone or in combination with 5α-reductase inhibitors, antimuscarinics, or β3-agonists. It is well established that these pharmacological treatments, particularly alpha-blockers and combination therapies, may impair ejaculatory function, resulting in reduced ejaculate volume or anejaculation even before surgical intervention [15, 16]. Consequently, a relevant subset of patients undergoing HoLEP may already present with baseline ejaculatory dysfunction related to medical therapy. In this context, the high postoperative rate of anejaculation observed in our study should be interpreted with caution, as the additional impact of surgery on ejaculatory function may be perceived differently in patients who have already experienced treatment-related ejaculatory changes. This consideration may partially explain the limited clinical relevance of postoperative anejaculation in daily practice for a proportion of patients, despite its high reported prevalence.

From a clinical perspective, these findings have relevant implications for preoperative counseling. While patients can be reassured regarding the preservation of erectile function, they should be adequately informed about the high likelihood of postoperative anejaculation, which appears to be consistently observed regardless of surgical experience. This aspect is especially important in shared decision-making, as patient expectations regarding sexual outcomes increasingly influence treatment selection. Awareness of these functional outcomes may help surgeons provide more balanced information and tailor counseling according to patient priorities, particularly in individuals for whom preservation of ejaculatory function is a major concern.

In recent years, increasing attention has been directed toward the preservation of ejaculatory function in the surgical management of benign prostatic obstruction. Minimally invasive techniques such as Aquablation and Rezūm have been specifically developed with the aim of minimizing sexual side effects. Both Aquablation and Rezūm rely on water-based technologies, using either a high-velocity waterjet or water vapor to achieve focal prostatic tissue abla-

tion. In the randomized WATER trial, Aquablation was associated with a markedly lower rate of postoperative anejaculation compared with transurethral resection of the prostate, with reported rates of approximately 10% at follow-up [17]. Similarly, data from the first French Aquablation clinical registry showed de novo ejaculatory dysfunction in 26.7% of patients at 12 months, assessed using validated questionnaires including the MSHQ, suggesting a more favorable ejaculatory profile compared with conventional surgical techniques [18]. Regarding Rezūm therapy, both randomized and comparative studies have consistently demonstrated minimal impact on sexual function. Long-term results from a randomized controlled trial showed no clinically significant deterioration in sexual function up to 4 years following Rezūm treatment [19], while a recent matched-pair analysis comparing HoLEP and Rezūm reported a postoperative anejaculation rate of only 5.8% in the Rezūm group [20]. Although HoLEP remains a highly effective and durable treatment, particularly for larger prostates, these data highlight the growing importance of individualized treatment selection. In this context, the high and persistent rate of anejaculation observed during the learning phase of HoLEP in the present study further emphasizes the need for thorough preoperative counseling, balancing functional efficacy with patient preferences regarding sexual outcomes.

This study has some limitations that should be acknowledged. Its observational design limits the ability to establish causal relationships between surgical experience and sexual function outcomes. In addition, the lack of systematic recording of phosphodiesterase type 5 inhibitor use represents a limitation, as changes in medical treatment during follow-up may have influenced postoperative erectile function. Finally, baseline ejaculatory function was not systematically assessed, and a proportion of patients were receiving medical therapy known to impair ejaculation prior to surgery, which may have affected postoperative ejaculatory outcomes.

CONCLUSIONS

In this series of patients undergoing HoLEP during the surgeon's learning phase, erectile function was preserved over follow-up, with only a transient early decline and subsequent recovery. Ejaculatory dysfunction was highly prevalent, with anejaculation rates exceeding 90% at all time points. Importantly, no significant association was observed between surgical experience and sexual outcomes, suggesting that these results are not substantially influenced by the learning curve. These findings provide clinically relevant information for patient counseling and contribute to a more accurate understanding of sexual function outcomes during the initial learning phase of HoLEP.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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ETHICS APPROVAL STATEMENT

The ethical approval was not required.

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