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Initiating Holep for High-Volume Prostates: Impact on Learning Curve and Perioperative Outcomes

Yüksek Hacimli Prostatlar ile Holep Cerrahisine Başlama: Öğrenme Eğrisi ve Perioperatif Sonuçlar Üzerindeki Etkisi

Volkan Sabur[1], Abdullah Gölbaşı[2]

[1]Erciyes Hospital, Clinic of Urology, Kayseri, TÜRKİYE
[2]University of Health Sciences Medical Faculty of Kayseri, Kayseri City Hospital, Clinic of Urology, Kayseri, TÜRKİYE

Abstract

Background: This study aimed to comprehensively evaluate the learning curve, perioperative outcomes, and short-term functional results associated with initiating Holmium laser enucleation of the prostate (HoLEP) in patients with high-volume prostates in a real-world clinical setting.
Materials and Methods: In this retrospective study, 222 patients who underwent 3-lobe HoLEP technique between August 2023 and April 2025 were analyzed. Patients were chronologically divided into three equal groups to reflect surgical experience and enable balanced comparison across different phases of the learning curve. The groups were assessed according to perioperative outcomes, complications, and urinary incontinence at a 3-month follow-up. The cumulative sum (CUSUM) chart based on operative time, enucleation efficiency, and postoperative urinary incontinence was utilized to determine the learning curve.
Results: The mean prostate volume was highest in group 1 (96.82 ml vs. 83.13 ml and 71.41 ml, p=0.004). Enucleation (p=0.019) and morcellation efficiency (p=0.008) significantly improved across groups, while enucleation and morcellation times decreased (both p<0.001). At 3-month follow-up, group 3 demonstrated the lowest rate of incontinence (p=0.012). CUSUM analysis based on enucleation efficiency, operative time, and postoperative incontinence showed that Surgeon had passed the learning phase and was considered around 100 cases, corresponding to the transition phase of the learning curve.
Conclusions: Initiating HoLEP with large prostates may prolong the learning curve beyond commonly reported thresholds; however, increasing experience significantly improves efficiency and functional outcomes, confirming its safety and size-independent efficacy.
Keywords: Endoscopic Enucleation, HoLEP, Holmium Laser, Learning Curve, Prostate Hyperplasia

Öz

Amaç: Bu çalışma, gerçek yaşam klinik pratiğinde yüksek hacimli prostatlarda Holmium lazer prostat enükleasyonu (HoLEP) uygulamasına başlanmasının öğrenme eğrisi, perioperatif sonuçlar ve kısa dönem fonksiyonel sonuçlar üzerindeki etkilerini kapsamlı olarak değerlendirmeyi amaçladı.
Materyal ve metod: Bu retrospektif çalışmada, Ağustos 2023-Nisan 2025 tarihleri arasında 3 lob tekniği ile HoLEP uygulanan 222 hasta analiz edildi. Hastalar, cerrahi deneyimi yansıtmak ve öğrenme eğrisinin farklı fazları arasında dengeli karşılaştırma yapabilmek amacıyla kronolojik olarak üç eşit gruba ayrıldı. Gruplar; perioperatif sonuçlar, komplikasyonlar ve 3 aylık takipte üriner inkontinans açısından değerlendirildi. Öğrenme eğrisini belirlemek için operasyon süresi, enükleasyon etkinliği ve postoperatif inkontinansa dayalı kümülatif toplam (CUSUM) analizi kullanıldı.
Bulgular: Ortalama prostat hacmi en yüksek grup 1'de saptandı (96,82 ml'ye karşı 83,13 ml ve 71,41 ml, p=0,004). Enükleasyon (p=0,019) ve morcellasyon etkinliği (p=0,008) gruplar arasında anlamlı şekilde artarken, enükleasyon ve morcellasyon süreleri belirgin olarak azaldı (her ikisi için p<0,001). Üç aylık takipte en düşük inkontinans oranı grup 3'te gözlendi (p=0,012). Enükleasyon etkinliği, operasyon süresi ve postoperatif inkontinansa dayalı CUSUM analizi, cerrahın yaklaşık 100 vaka civarında öğrenme fazını tamamladığını ve öğrenme eğrisinin geçiş fazına ulaştığını gösterdi.
Sonuç: Yüksek hacimli prostatlarla HoLEP'e başlanması öğrenme eğrisini literatürde bildirilenin ötesinde uzatabilir; ancak artan deneyimle birlikte cerrahi etkinlik ve fonksiyonel sonuçlar belirgin şekilde iyileşmekte ve HoLEP'in güvenli, etkili ve prostat boyutundan bağımsız bir yöntem olduğu doğrulanmaktadır.
Anahtar Kelimeler: Endoskopik Enükleasyon, HoLEP, Holmiyum Lazer, Öğrenme Eğrisi, Prostat Hiperplazisi

Corresponding Author: Volkan Sabur, Erciyes Hospital, Clinic of Urology, Kayseri, TÜRKİYE
E-mail: volkansabur@gmail.com / **ORCID ID:** 0000-0002-3166-9968
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Introduction

The incidence of benign prostatic hyperplasia (BPH) exhibits a positive correlation with advancing age, with prevalence increasing up to approximately 80% in males over the age of 80 years (1). Surgical intervention is typically considered in patients with lower urinary tract symptoms (LUTS) attributable to BPH who are refractory to pharmacological therapy. Holmium laser enucleation of the prostate (HoLEP) was first established approximately two decades ago as a surgical intervention for the alleviation of LUTS attributable to BPH (2). This method is notably size-independent, making it a robust and versatile alternative to other surgical techniques (3). HoLEP has emerged as the predominant surgical technique in contemporary urological practice. Several meta-analyses indicate that it entails longer operative durations; however, it is associated with shorter catheterization times, reduced hospital stay, decreased blood loss, and lower transfusion rates. Furthermore, it demonstrates comparable rates of urethral stricture (2.6% vs. 4.4%) and stress urinary incontinence (1.5% vs. 1.5%) compared to transurethral resection of the prostate (TURP) (4, 5).

HoLEP is feasible for patients on anticoagulant or antiplatelet therapy (6). Traditionally, two- and three-lobe techniques with late apical release were the standard approaches. Recently, en-bloc techniques have been increasingly adopted. The en-bloc early apical release technique has been associated with improved postoperative outcomes, particularly reduced stress urinary incontinence rates (7-9). Although HoLEP is an effective surgical method for BPH, it requires specialized equipment and is characterized by a steep and relatively prolonged learning curve. The length of the learning curve has been estimated as 40 to 50 cases (10, 11).

The aim of this study was to evaluate the learning curve, perioperative outcomes, and short-term functional results of initiating HoLEP in patients with high-volume prostates in a real-world clinical setting.

Materials and Methods

Patients

Following approval from the Kayseri City Hospital Non-Interventional Clinical Research Ethics Committee (approval no. 2026/778, date: February 3, 2026), we retrospectively reviewed the data of patients who underwent HoLEP in the Department of Urology at Kayseri City Hospital between July 2023 and April 2025.

A total of 222 patients met the inclusion criteria and were enrolled in the analysis. Patients with urethral stricture, bladder neck stenosis, large bladder diverticula, or neurogenic bladder were excluded. Patients were divided chronologically into three equal groups to reflect the progression of surgical experience over time. Equal group sizes were selected to ensure balanced statistical comparisons and to facilitate evaluation of changes in surgical performance across different phases of the learning curve (group 1: patients 0-74; group 2: patients 75-148; group 3: patients 149-222).

Parameters

Demographic and clinical information was collected for the study cohort and included age, anticoagulation therapy, American Society of Anesthesiology (ASA) score, urine retention, preoperative prostate volume, preoperative incontinence, total prostate-specific antigen (PSA) levels, maximum urinary flow rate (Q_{max}), PVR, TURP and prostate biopsy history, presence of bladder stones, and use of alpha-adrenergic antagonists and dutasteride.

We also collected data on perioperative parameters, enucleation weight, enucleation time, enucleation efficiency (enucleation weight/enucleation time; g/min), morcellation time, and morcellation efficiency (morcellation weight / morcellation time; g/min). We evaluated the catheter removal time, need for blood transfusion, and complications according to the Clavien-Dindo classification within the first 30 days postoperatively. Qmax, PVR, and incontinence were documented at the third month following the surgical procedure. Postoperative incontinence was evaluated in all patients, regardless of preoperative continence status, reflecting real-world clinical practice.

Technique and laser settings

One surgeon without prior experience in endoscopic prostate enucleation surgery initiated and performed all HoLEP procedures. The surgeries involved the early apical release 3-lobe enucleation method. The HoLEP technique was performed with the previously described “omega sign” method based on the 3-lobe technique (8).

The laser settings were 80 W (2 J and 40 Hz) for enucleation and 24 W (0.6 J and 40 Hz) for coagulation. The HoLEP equipment included a high-power 150-W Ho:YAG laser (Quanta), a 550-µm fiber, a modified 26-Fr Storz continuous-flow resectoscope with a working element for stabilizing the laser fiber, an extra-long Storz rigid nephroscope, and a tissue morcellator (Hawk). The position of the morcellator was above the trigone and away from the bladder mucosa. We used the two 3-L flexible bags of

0.9% NaCl during enucleation and four bags during morcellation. The flexible bags were strategically situated at a height of 1.6 m above the patient. Bipolar coagulation was used in only a few cases post-enucleation to achieve optimal hemostasis.

Statistical Analysis

Demographic, preoperative, and postoperative follow-up data were compared among the groups, and statistical analysis was performed with the software IBM SPSS (version 30, Armonk, New York, NY, USA). A significance threshold of $p<0.05$ was used. The Kolmogorov-Smirnov test was used to assess the normality of continuous data. Continuous variables were expressed as the mean (standard deviation), while categorical variables were presented as absolute frequencies. The Kruskal-Wallis and analysis of variance (ANOVA) were used for analysis of continuous variables. The chi-squared test was employed for categorical data.

To minimize potential confounding due to baseline differences, a multivariable linear regression analysis was performed. Enucleation efficiency and morcellation efficiency were included as dependent variables. Independent variables included group (chronological order), prostate volume, preoperative PSA, preoperative incontinence, and age.

The cumulative summation (CUSUM) examination was utilized to ascertain the learning trajectory in this investigation. The CUSUM produces a diagram by the cumulative summation (running total) of the disparity between each value and the average of all values in a collection of values. It identifies minor deviations from the average value in a procedure. Consequently, it is employed in learning curve analysis. To better reflect the multidimensional nature of the learning curve, additional CUSUM analyses were performed using operative time and postoperative incontinence, in addition to enucleation efficiency. The identification of the CUSUM breakpoint based on the first peak followed by a sustained downward trend is consistent with previously published surgical learning curve studies and reflects the transition from the learning phase to procedural proficiency (12).

Results

A cohort of 222 consecutive patients who underwent HoLEP performed by one surgeon between July 2023 and April 2025 was analyzed. The baseline characteristics of the patient cohort are detailed in Table 1. There was no statistically significant difference between groups 1, 2, and 3 in terms of age and preoperative use of anticoagulants, alpha blockers, and dutasteride. A total of 81 patients received a urethral catheter for bladder distention prior to surgery. There were 19 patients who presented with bladder calculi. Concurrent cystolitholapaxy was performed, and the duration of this procedure was excluded from the total time of the HoLEP.

Table 1. Preoperative demographic and clinical characteristics of patients

	All patients	**Group 1**	**Group 2**	**Group 3**	**P value**
Age (years)	68.2 (8.76)	69.4 (9.28)	**67.6 (7.97)**	**67.4 (8.96)**	**0.302°**
ASA score					
1	102	30	34	38	
2	61	25	23	13	
3	55	19	16	20	
4	4	0	1	3	
Anticoagulation (n)	69	22	24	23	0.939^
Preoperative urinary catheter (n)	81	34	23	24	0.269^
Alpha-blocer (n)	193	67	61	65	0.329^
Dutasterid (n)	68	29	20	19	0.145^
Preoperative incontinans (n)	72	33	20	19	0.023^
Bladder stone (n)	19	8	4	7	0.473^
Prostat biopsy (n)	18	4	6	8	0.484^
TUR-P surgery (n)	32	10	9	13	0.622^

Table 1. Continued

Prostat volume (ml)	83.46 (40.15)	96.82 (48.03)	83.18 (35.41)	71.41 (31.76)	0.004◆
Preoperative Q_{max} (ml/s)	5.89 (5.27)	5.89 (6.3)	6.37 (4.79)	5.41 (4.59)	0.317◆
PVR (ml)	117.01 (130.33)	100.3 (112.01)	117.92 (140.39)	132.79 (136.38)	0.321◆
Preoperative PSA (ng/ml)	5.27 (6.16)	5.97 (7.17)	6.13 (7.01)	3.75 (3.45)	0.047◆

All values represent the mean ± SD and frequency (n).
ASA: American society of Anesthesiology Score, TUR-P: Trans-urethral resection of prostate
Qmax: Maximal flow rate, PVR: Post-voiding residual urine
PSA: Prostate specific antigen
°: Anova test, ^: chi-square test, ◆: Kruskal-Wallis test

A cumulative total of 18 patients had previously undergone prostate biopsy, while 32 patients had undergone TURP. No statistically significant difference was observed between the groups in this regard. Preoperative prostate volume was measured by abdomen ultrasonography for all patients, and the mean volume was highest in group 1 (group 1: 96.82 ml; group 2: 83.13 ml; group 3: 71.41 ml; p=0.004). The preoperative PSA value exhibited a marginally notable distinction between groups (p=0.047). The measurements of preoperative Qmax and PVR did not exhibit statistically significant differences (p=0.317, p=0.321, respectively).

The perioperative and postoperative parameters are presented in Table 2. The mean enucleation weight was higher in group 1 than other groups (55.61 g, 49.15 g, and 40.03 g in groups 1-3, respectively; p<0.001). The mean enucleation and morcellation times were lower in group 3 (p<0.001, p<0.001, respectively) (Figure 1). The mean enucleation and morcellation efficiencies were also higher in group 3 (p=0.019, p=0.008, respectively) (Figure 2). A total of 14 patients underwent blood transfusions in the early postoperative period. Of these patients, 8 were in group 1, while groups 2 and 3 each had 3 patients, with no significant differences among the groups (p=0.149). The mean catheter removal time was 38.84 hours in group 3 and lower than in other groups (p=0.021).

Table 2. Peroperative and postoperative measures

	All patients	**Group 1**	**Group 2**	**Group 3**	**P value**
Enucleation time (min)	62.34 (28.83)	77.1 (30.41)	60.63 (25.12)	48.21 (18.64)	<0.001^
Morcellation time (min)	16.23 (9.44)	19.63 (9.89)	16.19 (9.6)	12.79 (6.55)	<0.001^
Enucleation efficiency (gr/min)	0.76 (0.7)	0.69 (0.19)	0.79 (0.28)	0.81 (0.26)	0.019^
Morcellation efficiency (gr/min)	1.92 (0.7)	1.72 (0.49)	1.91 (0.59)	2.03 (0.76)	0.008^
Enucleation weight (gr)	47.87 (28.2)	55.61 (30.43)	49.15 (27.3)	40.03 (22.42)	<0.001^
Blood transfusion (n)	14	8	3	3	0.149°
Catheter removal time (hr)	41.69 (10.59)	43.88 (9.99)	42 (11.99)	38.84 (9.24)	0.021^
Clavien 0	159	45	58	56	
1	33	18	7	8	
2	13	7	3	3	
3a	4	1	2	1	
3b	2	1	0	1	

Table 2. Continued

Post 3rd mo Qmax (ml/s)	21.53 (8.37)	22.87 (8.47)	22.56 (9)	19.04 (7)	0.019^
Post 3rd mo PVR (ml)	31.33 (40.19)	42.7 (53.16)	29.27 (30.52)	25.68 (34.7)	0.118^
Post 3rd mo inkontinans (n)	52	24	19	9	0.012°
Post 3rd mo urethral stricture (n)	11	2	4	5	0.564°

All values represent the mean ± SD and frequency (n).
Q_{max}: Maximal flow rate, PVR: Post-voiding residual urine
°: Chi-square test. ^:Kruskal-Wallis test

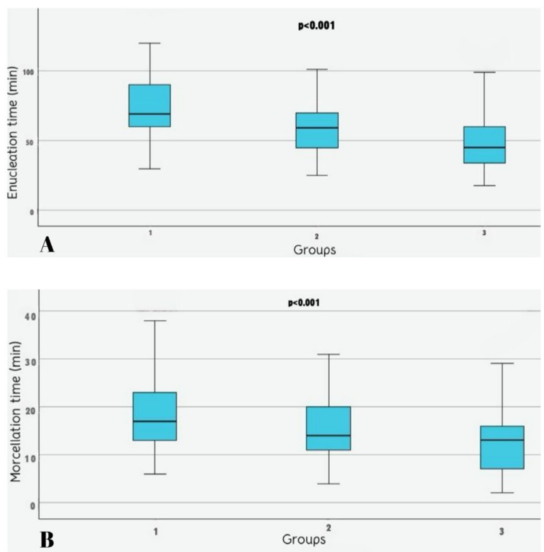

Figure 1. Comparison of enucleation and morcellation times between groups. Data are presented as median and interquartile range. Kruskal-Wallis test was used.
A: Enucleation time in groups, B: Morcellation time in groups

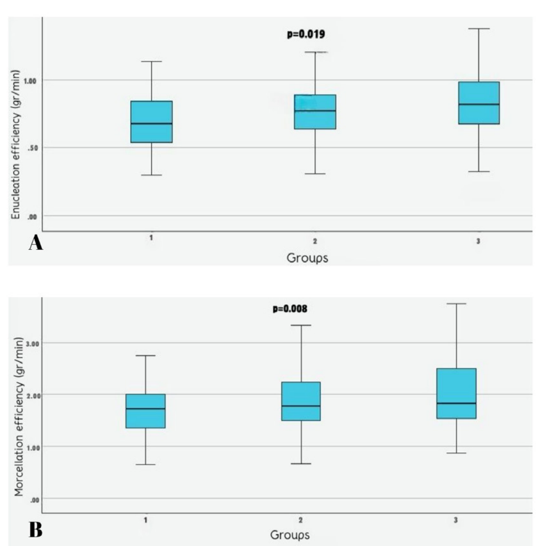

Figure 2. Comparison of enucleation and morcellation efficiency between groups. Data are presented as median and interquartile range. Kruskal-Wallis test was used.
A: Enucleation efficiency in groups**,** B: Morcellation efficiency in groups

A total of 52 complications were documented. Most complications were minor (Clavien-Dindo grade I and II) and no severe complications (Clavien-Dindo grade IV and V) were observed. Complications with grade 1 primarily involved significant catheter-associated discomfort and urinary retention, which was noted in 18 patients in group 3. The grade 2 complications were urinary tract infection and bleeding requiring transfusion, which occurred in 13 patients, including 7 patients in group 1 and 3 patients in each of the other two groups. Endoscopic evacuation for clot retention was performed for four patients (grade 3a complication). Only two patients required anesthesia for coagulation due to significant hemorrhage (grade 3b complication).

No notable difference in mean PVR was observed within 3 months postoperatively, but the mean Qmax value was significantly elevated in group 3 (p=0.118, p=0.019, respectively). Urinary incontinence persisted in 52 patients at the 3-month postoperative assessment, including 24 patients in group 1, 19 patients in group 2, and 9 patients in group 3 (p=0.012). Furthermore, 11 patients exhibited severely obstructive voiding at 3 months postoperatively and were diagnosed with urethral stricture. Internal urethrotomy was performed in these cases (2, 4, and 5 patients in groups 1-3, respectively).

In multivariable analysis, group progression remained an independent predictor of increased enucleation efficiency (p<0.001) and morcellation efficiency (p<0.001).

Prostate volume was an independent predictor of morcellation efficiency (p<0.001), but was not an independent predictor of enucleation efficiency (p=0.164) (Table 3) .

CUSUM analyses based on enucleation efficiency, operative time, and postoperative incontinence showed that the surgeon surpassed the initial learning phase at approximately 100 cases, revealing distinct patterns of improvement. (Figure 3). Operative time demonstrated an earlier inflection point, whereas enucleation efficiency improved more gradually over time. Postoperative incontinence showed delayed improvement, indicating that functional outcomes were optimized at later stages of the learning process.

Table 3: Multivariable regression analysis for predictors of enucleation efficiency

Predictor	B	Std. Error	Standardized Beta β	t	P value	95% CI Lower	95% CI Upper
Group	0.263	0.467	0.308	3.391	0.001	0.664	2.507
Age	-0.005	0.005	-0.059	-0.874	0.383	-0.015	0.006
Prostat volume	0.002	0.001	0.104	1.397	0.164	-0.001	0.004
Pre-op PSA	0.012	0.008	0.108	1.510	0.133	-0.004	0.028
Pre-op incontinance	-0.053	0.103	-0.035	-0.511	0.610	-0.255	0.150

B (Unstandardized Coefficient): Effect size of the predictor, Std. Error: Standard error of B, Standardized Beta (β): Allows comparison of predictors with different units, t and p: Significance of each predictor, 95% CI: Confidence interval for the coefficient, PSA: Prostate specific antigene

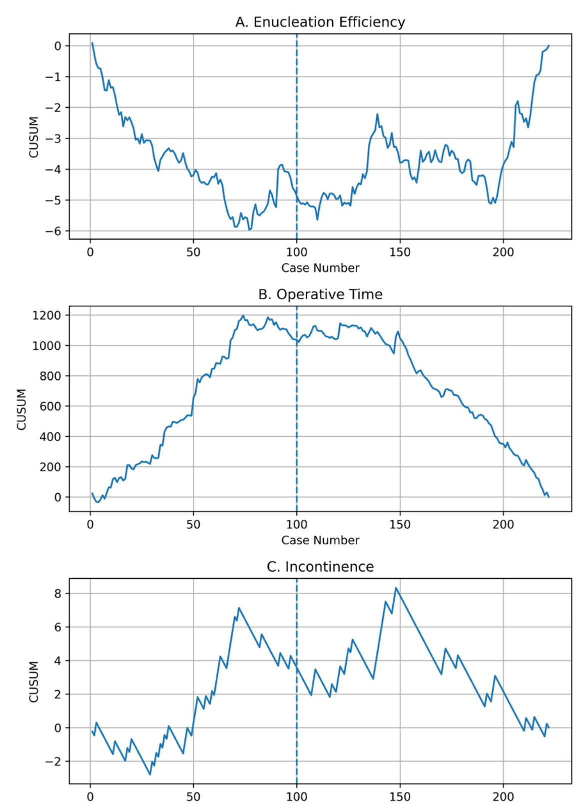

Figure 3. CUSUM chart based on enucleation efficiency, operative time, and postoperative incontinence. The dashed line represents the mean value

Discussion

HoLEP has ascended to prominence as the gold standard surgical intervention for BPH and has largely replaced conventional techniques in many centers. Gilling et al were the first to describe the HoLEP technique for BPH (13), and various HoLEP techniques have been described over the years, such as three-lobe, two-lobe, and en-bloc techniques. We initiated the HoLEP procedure using the "omega sign technique," which is a modified three-lobe early apical release technique described by Tunc et al (8).

Previous studies have reported a relatively shorter learning curve for HoLEP, typically ranging between 40 and 50 cases (11). However, these studies often involved structured mentoring, smaller prostate volumes, or stepwise case selection. In contrast, our cohort included a substantial proportion of large prostates from the early phase, without strict case selection. This difference in case complexity likely contributed to the prolonged learning curve observed in our study. Therefore, our findings may better reflect real-world conditions in centers initiating HoLEP without gradual case selection.

The present study demonstrates that the learning curve of HoLEP is not defined by a single inflection point but rather comprises multiple distinct phases. While operative time improved early in the learning process, reflecting rapid gains in procedural familiarity, enucleation efficiency demonstrated a more gradual improvement, indicating progressive technical refinement. In contrast, functional outcomes such as postoperative incontinence improved at later stages, suggesting that mastery of delicate anatomical dissection and sphincter preservation requires more extensive experience.

These findings highlight the importance of a multidimensional assessment of surgical learning curves. Relying on a single parameter may oversimplify the complexity of skill acquisition. Instead, a phase-based interpretation provides a more accurate representation of surgical proficiency development. The definition of the breakpoint in CUSUM analysis may involve some degree of subjectivity; however, the approach used in this study is consistent with previously published learning curve analyses (12).

In investigations concerning the learning curve of HoLEP procedures, enhancements have been documented across varying patient populations. Wenk et al used the en-bloc enucleation methodology, and Enikeev et al. employed the two-lobe enucleation approach and achieved analogous outcomes that support the findings of our research (14, 15). In these investigations, there was no significant difference between the groups in terms of prostate dimensions.

In the present study, prostate volume was identified as a significant independent predictor of enucleation efficiency in multivariable analysis. This finding is expected, as larger prostates are known to influence operative performance and technical complexity. However, importantly, surgical experience (group progression) remained an independent determinant of enucleation efficiency after adjustment for prostate volume and other baseline variables.

This suggests that although case complexity plays a substantial role, the progressive improvement observed in our cohort cannot be explained solely attributed to prostate size and strongly reflects cumulative surgical experience.

In a retrospective investigation involving 903 HoLEP patients, a comparison was conducted regarding the outcomes of individuals with and without urinary retention prior to HoLEP. The cohort exhibiting urinary retention presented with a larger prostate and more pronounced bladder outlet obstruction (BOO) than those devoid of urinary retention, which may have contributed to extended operative and morcellation durations in patients experiencing urinary retention. Nevertheless, findings indicated no statistically significant disparities in postoperative micturition symptoms or complications between the non-urinary retention and urinary retention cohorts. Furthermore, no significant variation was detected in the prevalence of intraoperative complications (16).

In the present investigation, the average prostate dimensions and enucleation weight were markedly greater in the initial patients in comparison to subsequent patients. To initiate HoLEP, we opted for arbitrary prostate dimensions rather than exclusively selecting small and moderate size prostates. Being adequately equipped for prostates of any size at the beginning of the educational process seems to be beneficial for progression. A small prostate poses numerous challenges but also presents benefits for educational purposes.

In the majority of small prostates, enucleation from the capsule is unfeasible due to factors such as fibrosis, but in most instances, a large prostate can be enucleated with significantly greater ease. Conversely, a large prostate is associated with hazards such as erroneous surgical margins and capsule perforation. In extensive prostate surgical intervention, increased excision of tissue and extended operative duration were expected issues. We did not encounter any literature on the learning curve in HoLEP surgery in which the initial group consisted of larger prostates.

The catheter removal time was found to be longer in group 1 and paralleled the prostate size. Our findings are consistent with those of Krambeck et al, who investigated the outcomes of HoLEP in cases with prostates exceeding 175 g (17). The need for postoperative transfusion was highest in group 1 and exceeded previously reported rates (15, 17, 18). Grade 1 and 2 complications (Clavien-Dindo classification) were more prevalent in group 1, as anticipated. These complications primarily included catheter discomfort, bleeding necessitating transfusion, and urinary infections, and the prolonged surgical duration was hypothesized to be the cause. Conversely, the incidence of grade 3a and 3b complications was comparable across the groups. There were no cases of bladder perforation.

At the 3-month assessment, group 1 exhibited a markedly higher incontinence rate than the other groups. Although rates in groups 2 and 3 were lower, they remained elevated compared with prior reports. Cho et al. (19) noted that most post-HoLEP stress incontinence improves within the first month, with a 3-month incidence of 4.7% in a cohort with a mean prostate volume of 55 ml. In contrast, the mean prostate volume in our study was 83 ml, which likely contributed to the higher incontinence rates observed. Known predictors of post-HoLEP incontinence-such as larger prostate size, prolonged operative time, surgeon experience, diabetes mellitus, and increased blood loss-may also have influenced outcomes (20). It should be noted that longer follow-up durations may lead to improved continence outcomes. Several studies have reported a significant reduction in urinary incontinence rates and an improvement in symptom scores within 6 months after HoLEP, suggesting that early postoperative results may underestimate long-term functional recovery (21).

Urethral stricture remains a key complication of endoscopic procedures. Yalcin et al. (18) reported 14 strictures in a large HoLEP cohort. In our series, 11 strictures were identified at the 3-month follow-up-an incidence higher than typically reported-and most occurred during the plateau phase of the learning curve. All were successfully managed with internal urethrotomy without recurrence.

Study Limitations

Several limitations of this study should be acknowledged. First, the analysis was retrospective, which inherently carries risks of selection bias and limits causal interpretation. Moreover, quality-of-life measures and prostate symptom scores were not consistently available due to the retrospective design of the study, preventing any assessment of functional or symptomatic impact. The postoperative follow-up was restricted to 3 months; longer follow-up periods would likely provide a more robust understanding of clinical outcomes and potential late complications. Additionally, although multivariable analysis was performed, residual confounding related to differences in prostate volume and case complexity between groups cannot be entirely excluded. The evaluation of postoperative incontinence should be interpreted in light of preoperative continence status, as patients with baseline incontinence were included in the analysis. This may have influenced the observed rates and represents a limitation of the study. Despite its limitations, this study provides a realistic representation of the HoLEP learning process in a high-volume prostate setting. The combination of advanced statistical analysis and comprehensive outcome assessment strengthens the validity of our findings and contributes meaningful data to the existing literature.

Conclusion

Analysis of the 222 procedures in this study demonstrated a clear improvement in surgical performance with increasing HoLEP case volume. Although many reports describe an average learning curve of approximately 50 cases, our findings indicate that initiating HoLEP with large prostates may significantly prolong this process. Despite this, progressive experience leads to substantial improvements in efficiency and functional outcomes, ultimately establishing HoLEP as a safe, effective, and size-independent technique.

Ethical Approval: *Ethical approval was obtained from the Kayseri City Hospital Non-Interventional Clinical Research Ethics Committee (approval no: 2026/778, date: February 03, 2026).*
Author Contributions:
Concept: V.S., A.G.
Literature Review: V.S., A.G.
Design: V.S., A.G.
Data acquisition: V.S., A.G.
Analysis and interpretation: V.S., A.G.
Writing manuscript: V.S., A.G.
Critical revision of manuscript: V.S., A.G.
Conflict of Interest: *The authors have no conflicts of interest to declare.*
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