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Charles U. Nottingham

Tim Large

Deepak K. Agarwal

Marcelino E. Rivera

Amy E. Krambeck

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Transurethral and Lower Tract Procedures

Comparison of Newly Optimized Moses Technology *vs* Standard Holmium:YAG for Endoscopic Laser Enucleation of the Prostate

Charles U. Nottingham, MD [1], Tim Large, MD[2], Deepak K. Agarwal, MD[2], Marcelino E. Rivera, MD[2], and Amy E. Krambeck, MD[3]

Abstract

Introduction: The purpose of this study was to describe our initial experience of using a newly optimized Moses technology that is part of the second-generation Moses platform specifically designed for holmium laser enucleation of the prostate (M_2-HoLEP) and compare it with patients undergoing HoLEP using standard holmium:YAG technology (S-HoLEP).

Materials and Methods: We retrospectively collected data on patients who underwent M_2-HoLEP and compared it with the last 50 patients in whom we performed S-HoLEP. Specifically, we compared preoperative symptom scores for lower urinary tract symptoms (LUTS) and erectile dysfunction (ED), preoperative objective voiding metrics, as well as intraoperative characteristics, perioperative characteristics, postoperative complications, postoperative symptom scores for LUTS and ED, and postoperative objective voiding metrics. Additionally, we evaluated the ability for same-day discharge following surgery in the M_2-HoLEP group.

Results: We included 104 total patients for analysis. We compared the first 54 patients undergoing M_2-HoLEP with 50 patients undergoing S-HoLEP. Both groups had similar age, body mass index, use of anticoagulation medication, LUTS and ED scores, and objective voiding metrics. Operations performed with M_2-HoLEP had faster mean hemostasis time (8.7 *vs* 10.6 ± 6 minutes, $p = 0.03$) as well as hemostasis rate (0.13 *vs* 0.30 min/g, $p = 0.01$). Same-day discharge was achieved in 69.4% of patients in the M_2-HoLEP group. Postoperatively, both groups also had similar and low rates of urinary retention and complications. At follow-up, both groups had similar symptom scores for LUTS and ED, as well as similar objective voiding metrics.

Conclusions: The newly optimized Moses pulse modulation technology is safe and efficient for the treatment of benign prostate hyperplasia. Such technologic improvements in the laser have greatly enhanced the feasibility of same-day discharge of patients undergoing HoLEP.

Keywords: Moses, holmium laser enucleation of the prostate, laser, lower urinary tract symptoms, technology

[1]Division of Urology, Department of Surgery, Washington University in St. Louis School of Medicine, St. Louis, Missouri, USA.
[2]Department of Urology, Indiana University School of Medicine, Indianapolis, Indiana, USA.
[3]Department of Urology, Northwestern University School of Medicine, Chicago, Illinois, USA.

Introduction

Holmium laser enucleation of the prostate (HoLEP) using the standard holmium:YAG laser technology was initially described in 1998.[1] Since that time, endourologists have experimented with different holmium:YAG laser settings[2] and different energy sources for endoscopic enucleation of the prostate (EEP).[3] Although EEP is the key to robust and prolonged improvement in lower urinary tract symptoms from benign prostate hyperplasia (LUTS/BPH), the identification of an optimal energy source and technique is constantly being pursued. The ideal energy source would balance precise and efficient tissue incision with hemostasis of capsular vessels during and after tissue enucleation.

Despite the development or application of novel energy sources such as thulium:YAG, thulium fiber, diode lasers, and bipolar electrocautery, pulsed holmium:YAG laser technology continues to be a popular laser technology among enucleation surgeons. Until recently, there has been minimal advancements in holmium laser technology; however, in 2016, modulated pulsed holmium technology, developed to improve nephrolithotripsy,[4] was trialed for EEP. Moses by Lumenis is currently the most advanced form of modulated pulsed holmium laser technology and has been shown to improve enucleation and hemostasis times for HoLEP (M-HoLEP[5]). As part of the second-generation Moses platform, pulsed laser modulation optimized for HoLEP (M_2-HoLEP) was developed with the intent of stabilizing and reducing damage to the larger 550 µm, improving tissue enucleation and enhancing vessel hemostasis. We trialed this unique technology and compared the outcomes with a recent cohort of patients who underwent HoLEP using standard holmium:YAG technology. We therefore sought to compare the safety, feasibility, and efficacy of M_2-HoLEP *vs* standard HoLEP without pulse modulation.

Materials and Methods

Data collection

This study was approved by the institutional review board at Indiana University (No. 1909168105). Clinical data on patients at our institution undergoing HoLEP are prospectively collected in a REDCap database.[6] As part of our preoperative clinical visit, we perform a detailed history and physical examination. In addition, patients complete a packet of validated symptom assessment tools regarding their voiding and sexual function. Specifically, we include the International Prostate Symptom Score (IPSS) including the IPSS quality of life (IPSS QoL),[7] Michigan Incontinence Symptom Index (MISI) bother score,[8] Sexual Health Inventory for Men (SHIM),[9] and the Male Sexual Health Questionnaire for Ejaculatory Dysfunction (MSHQ-EjD).[10] Cumulatively, we refer to these symptom assessment tools as the symptom scores for LUTS and erectile dysfunction (ED). We also measure a postvoid residual (PVR) bladder volume by ultrasound for all patients and urine flow metrics for those who are able to void in office. Postoperatively, patients return to the office 3 months from the date of surgery. At this time, we obtain symptom scores for LUTS and ED, as well as a PVR and urine flow metrics.

All operations were performed by two endourologists who were fellowship-trained in HoLEP (A.E.K. and T.L.). One surgeon has performed more than 2000 HoLEP procedures at the time of this study and the other ~200 procedures. For this study, we first included a cohort of 50 patients whose standard HoLEP was performed using a 550 µm diameter holmium:YAG laser fiber without pulse modulation. These patients will be referred to as the S-HoLEP group, and this cohort was previously described in a study comparing S-HoLEP with commercially available Moses pulse modulation technology. In brief, these were the first 50 patients (chronologically) who underwent S-HoLEP between August 2018 through January 2019 at our institution.[5] The novel element for the current study is inclusion of our initial group of patients who underwent HoLEP with a newly optimized pulse modulation technology designed specifically for interaction with BPH tissue (referred to as M_2-HoLEP) beginning in June 2019. M_2-HoLEP is performed

using a 550 μm diameter Moses laser fiber. Unlike the first-generation Moses technology, M_2-HoLEP does not have a contact or distance mode routinely used for laser lithotripsy to treat urinary tract stones. Contact and distance mode refer to differences within the pulse modulation used for lithotripsy of stones different distances from the tip of the laser.[11] Instead, this second generation of Moses technology has a single mode of pulse modulation. Patients would have been excluded if their operation was not entirely completed with either S-HoLEP or M_2-HoLEP technology for each respective group.

Operative and postoperative details

A complete description of the HoLEP procedure at our institution has been previously described.[5,12] Briefly, we use a dual pedal Pulse™ 120 hours watt holmium:YAG laser platform (Lumenis, Yokneam, Israel). We typically begin by making incisions at the 5 and 7 o'clock positions to enucleate the median lobe first. If no median lobe is present, we make a single incision at 6 o'clock. We then perform a bottom-up enucleation starting at the apex. The left pedal is used for tissue enucleation with specific settings of 2 joules (J) and 40 Hertz (Hz) with Moses for BPH enabled in the M_2-HoLEP cohort. The right pedal is assigned hemostasis settings of 1 J and 20 Hz with a long pulse width for S-HoLEP and Moses enabled for M_2-HoLEPs. All Pulse 120 hours laser units store pedal application times along with the unique fiber identifier, which were incorporated into our RedCap database as enucleation and hemostasis times (minutes). At the conclusion of all cases, an 18F or 22F three-way urethral catheter is placed and continuous bladder irrigation (CBI) is initiated through the immediate postoperative period.

During the time period when the S-HoLEP group had their operations (July 2018 through March 2019), patients were routinely kept in the hospital overnight for CBI and the catheter was removed on postoperative day 1. However, after transitioning to M-HoLEP and continuing with M_2-HoLEP, we instituted a practice change in which patients were discharged home the day of the surgery from the post-anesthesia care unit with an anticipated void trial (VT) as an outpatient on the day of surgery or on post-HoLEP day 1. We will refer to this as same-day discharge (SDD).

As mentioned above, patients do not return for follow-up until 3 months after surgery unless complications arise in the meantime. Typically, patients do not return after this single follow-up unless there is an ongoing issue such as incontinence or complications. Our practice mostly consists of referrals from other urologists, so patients will resume care for additional urologic issues unrelated to BPH with the referring urologist once treatment and postoperative care are complete.

Data analysis

Patients were placed into either M_2-HoLEP or S-HoLEP groups based on which laser technology was used. We compared preoperative patient characteristics of age, body mass index (BMI), therapeutic anticoagulation medication usage, LUTS scores, ED scores, urine flow metrics scores, and PVR values between the two groups. Therapeutic anticoagulation included 325 mg daily dosage of aspirin, whereas 81 mg daily aspirin dosage was not considered therapeutic anticoagulation. Intraoperative characteristics of total energy, enucleated prostate weight, total procedure time, total time spent on enucleation, time spent depressing only the pedal on enucleation settings during enucleation, time spent depressing the laser pedal for hemostasis, total enucleation pedal time (addition of enucleation only pedal time and hemostasis pedal time), and time for morcellation were compared between the groups.

Additionally, we calculated the enucleation, hemostasis, and morcellation time per gram (g) of prostate tissue for each patient, and median values were compared between the groups. These are referred to as the rates in that they are calculated as the time in minutes spent for these respective portions of the operation divided by the gram weight of enucleated prostate tissue. These were completed for all the aforementioned components: total time spent on enucleation, time spent depressing only the pedal on enucleation settings during enucleation, time spent depressing the laser pedal for hemostasis, total enucleation pedal time

(addition of enucleation only pedal time and hemostasis pedal time), and time for morcellation were compared between the groups.

Postoperatively, we compared day of discharge, patients who failed their first VT, visits to the emergency department, and complications by the Clavien–Dindo[13] grade between the groups. At the 3-month postoperative visit, we compared LUTS scores, ED scores, urine flow metrics, and PVR.

All statistical analyses were performed using IBM SPSS software, version 25 (Armonk, NY). Means were compared with Student's *t*-test, and medians were with a Median test. Categorical variables were compared with Pearson's chi-squared and Fisher's exact tests. Significance was determined with a *p*-value <0.05.

Results

All results are included in Table 1. We included 104 total patients, with 54 (51.9%) undergoing M_2-HoLEP. There was no difference in mean age or BMI between the M_2-HoLEP and S-HoLEP groups (Table 1). Both cohorts had ~20% of patients on an anticoagulant or antiplatelet agent. Preoperative LUTS, ED symptom scores, uroflow, and PVR were all statistically similar between M_2-HoLEP and S-HoLEP groups (all $p > 0.05$).

Table 1. Patient Demographics, Subjective Symptom Scores, and Objective Characteristics Before Holmium Laser Enucleation of the Prostate (Table view)

	M_2-HoLEP (n = 54)	*S-HoLEP (n = 50)*	*p*
Age in years, mean (SD)	72 (8)	71 (9)	0.736
BMI, mean (SD)	28.2 (5.1)	27.7 (5.4)	0.669
On therapeutic anticoagulation, *n* (%)			
Aspirin 325 mg	3 (5.6)	0	0.091
Clopidogrel	2 (3.7)	4 (8.0)	0.348
Warfarin	2 (3.7)	2 (4.0)	0.937
Direct oral anticoagulant	4 (7.4)	5 (10.0)	0.638
Preop GAD-7, mean (SD)	5 (6)	4 (5)	0.592
Preop IPSS, mean (SD)	22 (8)	20 (8)	0.154
Preop IPSS QoL, mean (SD)	5 (1)	5 (1)	0.797
Preop MISI bother, median (IQR)	2 (2)	2 (2)	0.833
Preop SHIM, mean (SD)	9 (8)	9 (8)	0.769
Preop MSHQ-EjD, mean (SD)	9 (6)	8 (6)	0.616
Preop urinary retention (indwelling or intermittent catheterization), *n* (%)	17 (31.5)	22 (44.0)	0.187
Preop postvoid residual in mL, mean (SD)	140 (111)	96 (111)	0.254
Preop peak urine flow rate in mL/s, mean (SD)	6.7 (4.7)	5.8 (4.6)	0.665
Preop average urine flow rate in mL/s, mean (SD)	2.5 (1.3)	2.9 (2.2)	0.529

BMI = body mass index; GAD-7 = generalized anxiety disorder 7-item score; HoLEP = holmium laser enucleation of the prostate; IPSS = International Prostate Symptom Score; IQR = interquartile range; M_2-HoLEP = optimized Moses technology for HoLEP; MSHQ-EjD = Male Sexual Health Questionnaire for Ejaculatory Dysfunction; MISI = Michigan Incontinence Symptom Index; Preop = preoperative; SHIM = Sexual Health Inventory for Men; SD = standard deviation; QoL = quality of life.

Intraoperative variables are presented in Table 2. Overall, procedure times and total energy utilized were similar between the M_2-HoLEP and S-HoLEP groups. Patients from both groups also had a statistically similar amount of prostate tissue enucleated (77 g *vs* 73 g, respectively). The amount of time spent depressing the laser pedal for enucleation was similar for both groups; however, when we adjusted for total resected weight and surgeon, we identified that the junior surgeon improved their resection speed by 44% from 0.65 ± 0.84 to 0.45 ± 0.62 min/g. The senior surgeon's average resection speed was more than 0.31

min/g at baseline, making further time improvements challenging. The time spent depressing the pedal for hemostasis was also significantly shorter for the M_2-HoLEP group (8.1 ± 5.9 minutes *vs* 10.6 ± 6.0 minutes; $p = 0.033$). Furthermore, time to achieve hemostasis indexed against gland size was significantly less for M_2-HoLEP compared with S-HoLEP (0.13 ± 0.08 min/g *vs* 0.30 ± 0.43 min/g, $p = 0.006$, respectively). For reference, enucleation of 100 g of adenoma would on average take 13 minutes to achieve hemostasis using M_2-HoLEP *vs* 30 minutes to achieve hemostasis using S-HoLEP. Additionally, the surgeons subjectively appreciated enhanced fiber stability and minimal fiber degradation, or burnback, in the M_2-HoLEP group, as demonstrated in the Supplementary Video S1.

Table 2. Intraoperative Comparison Between M_2-HoLEP and S-HoLEP (Table view)

	M_2-HoLEP (n = 54)	*S-HoLEP (n = 50)*	*p*
Total procedure time in minutes, mean (SD)	81 (32)	91 (33)	0.123
Total energy in kJ, mean (SD)	110.4 (47.7)	95.9 (39.7)	0.089
Total enucleation time in minutes, mean (SD)	45.9 (18.8)	47.1 (18.0)	0.730
Total enucleation pedal time in minutes, mean (SD)	32.1 (13.9)	33.1 (11.5)	0.659
Enucleation only pedal time in minutes, mean (SD)	23.9 (9.8)	22.5 (7.2)	0.413
Hemostasis pedal time in minutes, mean (SD)	**8.1 (5.9)**	**10.6 (6.0)**	**0.033**
Morcellation time in minutes, mean (SD)	10.4 (9.8)	11.6 (11.0)	0.556
Enucleated prostate weight in grams, mean (SD)	77 (61)	73 (50)	0.647
Enucleation only rate in min/g, mean (SD)	0.57 (0.62)	0.73 (1.02)	0.128
Hemostasis rate in min/g, mean (SD)	**0.13 (0.08)**	**0.30 (0.43)**	**0.006**

Bold values indicate $p < 0.05$.

It should be noted that we instituted a practice change ~3 months after transitioning to M-HoLEP. We established a pathway for SDD, which when applied to the M_2-HoLEP cohort was achieved in 69.4% of cases (Table 3). There were no SDD cases in the S-HoLEP cohort, as the typical postoperative protocol was for overnight admission to the hospital at the time when this cohort's data were collected, and two patients (8.0%) required an additional day of CBI because of persistent hematuria. The one patient in the M_2-HoLEP group that failed their initial VT was severely deconditioned but did void on postoperative day 2. Among the patients in the S-HoLEP group who failed their VT, three patients were in urinary retention preoperatively (one was not), and all were able to void by postoperative day 10. Within the entire series, there were only three (2.8%) patients (two M_2-HoLEP and one S-HoLEP) who required delayed urinary catheter replacement several days after a VT. One patient had a deconditioned bladder, and the other two cases involved restarting anticoagulation therapy with clot retention occurring 3 days after VT. For all three patients, the catheters were permanently removed within 4 days of placement.

Table 3. Postoperative Complications, Subjective Symptom Scores, and Objective Characteristics After Holmium Laser Enucleation of the Prostate (Table view)

	M_2-HoLEP (n = 54)	*S-HoLEP (n = 50)*	*p*
Postop day of discharge, *n* (%)			
0 (SDD)	**37 (68.5)**	**0**	**<0.001**
1	**17 (31.5)**	**46 (92.0)**	
2	**0**	**4 (8.0)**	
Failed POD1 voiding trial, *n* (%)	1 (1.9)	4 (8.0)	0.143
Delayed urinary retention following POD1 voiding trial, *n* (%)	2 (4.2)	1 (2.0)	0.610
Complications by the Clavien–Dindo grade, *n* (%)			0.718
I	8 (14.8)	9 (18.0)	
II	0	0	
IIIa	0	1 (2.0)	
IIIb	2 (3.7)	2 (4.0)	
IV	0	0	

	M_2-HoLEP (n = 54)	S-HoLEP (n = 50)	p
V	0	0	
Postop IPSS, mean (SD)	10 (8)	8 (8)	0.527
Postop IPSS QoL, mean (SD)	2 (2)	2 (2)	0.200
Postop MISI bother, mean (SD)	2 (2)	1 (2)	0.106
Postop SHIM, mean (SD)	7 (7)	8 (8)	0.366
Postop MSHQ-EjD, mean (SD)	6 (4)	7 (5)	0.152
Postop postvoid residual in mL, mean (SD)	62 (62)	51 (73)	0.492
Postop peak urine flow rate in mL/s, mean (SD)	18.0 (11.7)	16.2 (9.9)	0.584
Postop average urine flow rate in mL/s, mean (SD)	8.7 (5.9)	13.7 (26.2)	0.379

Bold values indicate $p < 0.05$.
Postop = postoperative; POD = postoperative day.

We noted no difference in complications by the Clavien–Dindo grade between procedure groups ($p = 0.667$) over a median follow-up of 3 months. Of the M_2-HoLEP group patients who had a grade I complication, eight patients had a urinary tract infection and one required a delayed catheter replaced for transient clot retention. There were three M_2-HoLEP patients who required return to the operating room: one for a urethral stricture dilation at 3 months postoperatively, and the other two for a laser incision of a bladder neck contracture at 4 months postoperatively. Similarly, eight patients in the S-HoLEP group had a urinary tract infection and one had to have a catheter replaced for delayed transient clot retention. One S-HoLEP patient had urethral strictures able to be dilated in the office (IIIa) at 3 months postoperatively, one patient had to have an operating room clot evacuation (IIIb) 1 week postoperatively, and another patient had a recurrent urethral stricture requiring dilation in the operating room 5 months postoperatively (IIIb). There were no grade II, IV, or V complications.

Postoperative IPSS, IPSS QoL, MISI bother, SHIM, and MSHQ-EjD symptom scores did not differ between groups (all $p > 0.05$). Objectively, urine flow metrics and PVR values were all statistically similar between patients (all $p > 0.05$)

Discussion

We performed a retrospective comparison of our initial experience with M_2-HoLEP and compared it with recent but prior cohort of patients who underwent S-HoLEP at our institution. We observed faster rates of hemostasis overall and indexed against enucleated prostate weight. Additionally, we demonstrated feasibility of SDD in most patients using M_2-HoLEP. This comfortably allowed for a practice shift to make SDD the routine pathway for most of our patients.

While urologists have used several different energy sources for EEP, the single best modality has yet to be determined.[3,14,15] Holmium:YAG technology for prostate enucleation has been highly studied with multiple publications dedicated to the procedure,[14,15] but until recently, most publications were on technique variances[15,16] and long-term outcomes.[17] The first publications using modulated pulsed laser technology showed improvements in operator speed[5] and improved success with same-day discharge after HoLEP.[16–18] This is the first article demonstrating the benefits of pulsed laser modulation designed specific for BPH surgery by comparing S-HoLEP performed with standard holmium:YAG technology with M_2-HoLEP.

Our study demonstrated Moses optimized for BPH expedited hemostasis compared with standard holmium:YAG. The improved speed of hemostasis with M_2-HoLEP should be recognized as truly significant. During this time period, we transitioned to outpatient, SDD HoLEP. To achieve SDD HoLEP, we required a much greater degree of hemostasis,[16–18] with minimal to no appreciable hematuria at the end of the case, which is far different from what we tolerated during the S-HoLEP time period where overnight CBI was the norm. There are multiple publications[16–21] showing that SDD after HoLEP ranges from 88% to

94% and that hematuria-related complications are the greatest obstacle to complete adoption. Despite requiring more extensive hemostasis for SDD, which only occurred in the M_2-HoLEP cohort, M_2-HoLEP was still significantly faster than S-HOLEP when hemostasis time was indexed against gland size. These findings are consistent with prior publications using the first-generation Moses technology, where hemostasis was 40% faster compared with S-HoLEP.[5]

Enucleation efficiency is paramount to outpatient HoLEP. In fact, we recently started performing the VT immediately after HoLEP (same day as surgery) and we have identified, in addition to significant hematuria, that prolonged enucleation, morcellation, and intraoperative narcotics as risk factors for immediate VT failure. Our experience with M_2-HoLEP showed average enucleation efficiency of 3.23 g/min for the senior surgeon, which is a marked improvement compared with prior publications on mean (range) transurethral resection of the prostate (TURP) and S-HoLEP enucleation efficiency of 0.56 (0.15–1.56) and 0.47 (0.16–1.15) g/min, respectively.[24] When specifically looking at the younger staff surgeon, the enucleation efficiency improved 44% from S-HoLEP to 2.21 g/min, which continues to highlight the advancement in the laser efficiency when the pulsed laser energy is optimized for BPH surgery. This improvement in efficiency should not be attributed to overcoming the learning curve, since both surgeons were well past the initial 50 cases and did not change their surgical technique.[24]

Additionally, we observed comparable rates of complications, including those related to bleeding, with the reported literature[14,15,22] regardless of whether the operations were performed with standard or modulated holmium:YAG energy. Generally, holmium:YAG enjoys a good reputation when compared with other energy sources such as bipolar electrocautery for low intraoperative blood loss, low returns to the operating room for bleeding complications, and a low rate of blood transfusion.[14,15,22] Even with robust historic data on the safety profile of S-HoLEP, we were able to transition toward SDD after M_2-HoLEP in almost 70% of cases with only two major complications (3.7%) related to urinary retention. Even with outpatient convalescence, this complication rate was similar to published data on TURP (3.4%–11.4%).[23]

Moses technology was developed to improve laser lithotripsy of urinary tract stones.[4] Creating the Moses effect involves expenditure of a small amount of energy to create a vapor bubble, followed by a second transmission of energy to the target tissue, with the goal of maximizing the percentage of energy delivered to the target tissue during this second transmission.[24] Novel modulation of the pulsed laser energy for prostate tissue ablation and enucleation involves the creation a cavitation bubble, followed by the remainder of the laser energy through a temporary vacuum to the tissue.[24,25] Emiliani and colleagues demonstrated that higher energy settings with a standard holmium:YAG laser increase the depth of tissue penetration when used on veal kidneys.[22] Despite using a smaller fiber, the authors did use energy settings similar to HoLEP (0.5–2.0 J were evaluated). Therefore, the increase in energy directed to the target tissue with pulse modulation optimized for BPH could be enhancing coagulation and therefore explain the more efficient hemostasis we observed. Moses for BPH is the first attempt to optimize modulated laser energy for prostate surgery. M_2-HoLEP has improved the balance between efficient tissue incision and coagulation. These alterations in laser technology has changed the recovery experience for patients after surgery for LUTS/BPH, such that HoLEP can now be performed with same-day catheter removal and same-day discharge to home in appropriately selected patients.

This study does have limitations. First is the retrospective nature of this study design. This is particularly evident with our implementation of the postoperative pathway for SDD between the times when the S-HoLEP and the M_2-HoLEP operations occurred, which most certainly contributed to the significant difference in day of discharge. We do not know how many patients would have been able to be discharged on the same day as surgery using standard holmium:YAG with the clinical pathway in place. However, we did not modify our operative technique for these two cases aside from the technologic change of the optimized pulse modulation laser platform, and so the intraoperative details should be attributable to the laser change. Ideally, a prospective trial would be performed comparing SDD between S-HoLEP and M_2-

HoLEP, but due to the study design, this was impossible. Therefore, we can only reasonably conclude that SDD is feasible using M_2-HoLEP, not that SDD was superior using M_2-HoLEP *vs* S-HoLEP.

Second, we do not have a histologic analysis of how this new laser technology interacted with the target tissue at the different settings used. Such histologic information could provide insights as to why the hemostasis times different between the groups and would be a ripe area for future study. Third, there was a chronologic difference during which these operations were performed, which could potentially allow for a learning curve to not entirely be assessed. While both surgeons were experienced in HoLEP during data collection, there can still be a learning curve both generally for the operation and also a potential for a learning curve with using the new laser technology. Fourth, the exact physics of how the newly modified Moses technology interacts with tissue is not well understood in the literature and is somewhat beyond the scope of this clinical study, but may be better elucidated in a laboratory setting.

Fifth, the scope of this study was to compare two versions of holmium:YAG laser technology and therefore does not compare other energy sources for enucleation or other commercially available versions of holmium:YAG pulse modulation.[21] Additionally, all surgeons subjectively appreciated a higher stability of the laser fiber and very minimal fiber degradation or burnback while performing this operation. However, we did objectively measure this. Further investigation into these observations, perhaps in a laboratory setting or with a validated method of measuring this observation, would indeed be warranted.

Conclusions

The newly optimized Moses pulse modulation technology is safe and efficient for the treatment of BPH. Such technologic improvements in the laser have greatly enhanced the feasibility of same-day discharge of patients undergoing HoLEP.

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Supplementary Material

Supplementary Video S1

References

1. Gilling PJ, Kennett K, Das AK, Thompson D, Fraundorfer MR. Holmium laser enucleation of the prostate (HoLEP) combined with transurethral tissue morcellation: An update on the early clinical experience. *J Endourol* 1998;12:457–459. Crossref. PubMed.
2. Scoffone CM, Cracco CM. High-power HoLEP: No thanks! World J Urol 2018;36:837–838.
3. Rieken M, Bachmann A, Shariat SF. Long-term follow-up data more than 5 years after surgical management of benign prostate obstruction: Who stands the test of time? *Curr Opin Urol* 2016;26:22–27. Crossref. PubMed.

4. Elhilali MM, Badaan S, Ibrahim A, Andonian S. Use of the Moses technology to improve holmium laser lithotripsy outcomes: A preclinical study. *J Endourol* 2017;31:598–604. Crossref. PubMed.

5. Large T, Nottingham C, Stoughton C, Williams J, Krambeck A. Comparative study of holmium laser enucleation of the prostate with MOSES enabled pulsed laser modulation. *Urology* 2020;136:196–201. Crossref. PubMed.

6. Harris PA, Taylor R, Thielke R, Payne J, Gonzalez N, Conde JG. Research electronic data capture (REDCap)—a metadata-driven methodology and workflow process for providing translational research informatics support. *J Biomed Inform* 2009;42:377–381. Crossref. PubMed.

7. Barry MJ, Fowler FJ, O'Leary MP, et al. The American Urological Association symptom index for benign prostatic hyperplasia. The Measurement Committee of the American Urological Association. *J Urol* 1992;148:1549–1557; discussion 1564. Crossref. PubMed.

8. Suskind AM, Dunn RL, Morgan DM, DeLancey JOL, McGuire EJ, Wei JT. The Michigan Incontinence Symptom Index (M-ISI): A clinical measure for type, severity, and bother related to urinary incontinence. *Neurourol Urodyn* 2014;33:1128–1134. Crossref. PubMed.

9. Rosen RC, Cappelleri JC, Smith MD, Lipsky J, Peña BM. Development and evaluation of an abridged, 5-item version of the International Index of Erectile Function (IIEF-5) as a diagnostic tool for erectile dysfunction. *Int J Impot Res* 1999;11:319–326. Crossref. PubMed.

10. Rosen RC, Catania JA, Althof SE, et al. Development and validation of four-item version of Male Sexual Health Questionnaire to assess ejaculatory dysfunction. *Urology* 2007;69:805–809. Crossref. PubMed.

11. Aldoukhi AH, Roberts WW, Hall TL, Ghani KR. Watch your distance: The role of laser fiber working distance on fragmentation when altering pulse width or modulation. *J Endourol* 2019;33:120–126. Crossref. PubMed.

12. Rivera ME, Lingeman JE, Krambeck AE. Holmium laser enucleation of the prostate. *J Endourol* 2018;32(S1):S7–S9. Crossref. PubMed.

13. Dindo D, Demartines N, Clavien P-A. Classification of surgical complications: A new proposal with evaluation in a cohort of 6336 patients and results of a survey. *Ann Surg* 2004;240:205–213. Crossref. PubMed.

14. Cornu J-N, Ahyai S, Bachmann A, et al. A systematic review and meta-analysis of functional outcomes and complications following transurethral procedures for lower urinary tract symptoms resulting from benign prostatic obstruction: An update. *Eur Urol* 2015;67:1066–1096. Crossref. PubMed.

15. Cornu J-N. Bipolar, monopolar, photovaporization of the prostate, or holmium laser enucleation of the prostate: How to choose what's best? *Urol Clin North Am* 2016;43:377–384. Crossref. PubMed.

16. Gabbay G, Bernhard J-C, Renard O, et al. [Holmium laser enucleation of the prostate as a day case surgery: Prospective evaluation of the first 30 patients]. *Progres En Urol J Assoc Francaise Urol Soc Francaise Urol* 2015;25:34–39. Crossref. PubMed.

17. Comat V, Marquette T, Sutter W, et al. Day-case holmium laser enucleation of the prostate: Prospective evaluation of 90 consecutive cases. *J Endourol* 2017;31:1056–1061. Crossref. PubMed.

18. Lee S-M, Gordon K, McMillan R, Crystal F, Acher P. Day-case holmium laser enucleation of the prostate: Feasibility, safety and predictive factors. *Ann R Coll Surg Engl* 2018;100:475–479. Crossref. PubMed.

19. Lwin AA, Zeng J, Evans P, et al. Holmium laser enucleation of the prostate is safe and feasible as a same day surgery. Urology. 2020. Crossref.

20. Emiliani E, Talso M, Haddad M, et al. The true ablation effect of holmium YAG laser on soft tissue. *J Endourol* 2018;32:230–235. Crossref. PubMed.

21. Rodríguez Socarrás ME, Llanes González L, Reinoso J, et al. Pulse modulation for holmium laser: Vapor tunnel–virtual basket–bubble blast. *Videourology* 2020;34. Crossref.

22. Zhong J, Feng Z, Peng Y, Liang H. A systematic review and meta-analysis of efficacy and safety following holmium laser enucleation of prostate and transurethral resection of prostate for benign prostatic

hyperplasia. *Urology* 2019;131:14–20. Crossref. PubMed.

23. Abdul-Muhsin H, Critchlow W, Navaratnam A, et al. Feasibility of holmium laser enucleation of the prostate as a 1-day surgery. World J Urol 2019. Crossref.

24. Ventimiglia E, Traxer O. What is Moses effect: A historical perspective. *J Endourol* 2019;33:353–357. Crossref. PubMed.

25. Dushinski JW, Lingeman JE. High-speed photographic evaluation of holmium laser. *J Endourol* 1998;12:177–181. Crossref. PubMed.

Address correspondence to: Amy E. Krambeck, MD, Department of Urology, Northwestern University School of Medicine, 675 N Saint Clair St, Suite 20-150, Galter Pavilion, Chicago, IL 60611, USA E-mail: gecoots2@gmail.com

*ORCID ID (https://orcid.org/0000-0002-1972-0230).

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Abbreviations Used

BPH =	benign prostate hyperplasia
CBI =	continuous bladder irrigation
ED =	erectile dysfunction
EEP =	endoscopic enucleation of the prostate
GAD-7 =	generalized anxiety disorder 7-item score
HoLEP =	holmium laser enucleation of the prostate
IPSS =	International Prostate Symptom Score
LUTS =	lower urinary tract symptoms
M_2-HoLEP =	pulsed laser modulation optimized for HoLEP
MSHQ-EjD =	Male Sexual Health Questionnaire for Ejaculatory Dysfunction
MISI =	Michigan Incontinence Symptom Index
PVR =	postvoid residual
QoL =	quality of life
S-HoLEP =	standard HoLEP
SDD =	same-day discharge
SHIM =	Sexual Health Inventory for Men
TURP =	transurethral resection of the prostate
VT =	void trial