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ORIGINAL ARTICLE

"Three horse shoe-like incision" holmium laser enucleation of the prostate: first experience with a novel en bloc technique for anatomic transurethral prostatectomy

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Abstract

Objective To demonstrate the performance of a novel holmium laser enucleation technique in patients with lower urinary tract symptoms (LUTS).

Materials and methods Between September 2015 and August 2017, 114 consecutive patients underwent modified HoLEP [3 horse shoe-like incision HoLEP (3 HSI HoLEP)] for LUTS performed by an experienced urologist (A.M.). The surgical intervention and short postoperative course were analyzed. International Prostate Symptom Score (IPSS), quality of life score, maximum urinary flow rate (Q max), postvoid residual urine (PVR), and clinical and sociodemographic data were assessed preoperatively. The patient cohort was compared with existing data regarding clinical outcome parameters after surgical LUTS therapy.

Results The mean size of the prostatic gland was 86.3 ± 46.5 mL. The mean total operative time was 49.6 min (15–280 min). IPSS, Q max, and PVR were 20.7, 10.8, and 112.7 mL, respectively, prior to the intervention in the 3 HSI HoLEP group. The complication rate for Clavien category-III complications was 4.4%; no category IV complications were recorded. Seven of 114 patients experienced urinary retention after catheter removal during the hospital stay.

Conclusions The presented procedure provides several improvements over the standard modality. The prostatic gland is enucleated en bloc in an anatomical manner without longitudinal incisions of the urethra. This method is fast, safe, and may be easier to learn. However, this is the first description recorded. Future multicenter, controlled studies should clarify the long-term outcomes and surgical performance of 3 HSI HoLEP.

Keywords Benign prostatic obstruction, BPO · Holmium · Laser therapy/methods · Lower urinary tract symptoms, LUTS · Prostatic hyperplasia/surgery · Minimally invasive surgical procedures/methods

Introduction

Lower urinary tract symptoms (LUTS) due to benign prostatic hyperplasia (BPH) are a common health problem in men with a significant impact on quality of life (QoL) [1]. With a low mortality rate of 0.1% [2], transurethral resection of the prostate (TURP) has been widely accepted as the standard of care in the surgical therapy for this disease [3]. However, with increasing weight of the resected adenoma tissue, in particular in glands > 80 ccm, the rate of perioperative complications and related morbidity is considerable [2]. Since its introduction in 1995 by Gilling and Fraundorfer [4], the Holmium Laser Enucleation of the Prostate (HoLEP) has become popular and in many medical centers has replaced TURP as the standard treatment approach for LUTS due to bladder outlet obstruction (BOO). With a lower complication rate in terms of blood loss and a shorter hospital stay for patients undergoing HoLEP [5] compared to TURP, this new approach has significant advantages. Furthermore, laser prostatectomy seems viable for larger prostate glands with a size-independent, low complication rate [6–8]. The surgical approach for this procedure, as described by Gilling

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et al. [9], has remained largely unchanged. Although various methods have been suggested [10–15], mostly motivated by the difficult process of mastering the HoLEP procedure [16] and the desire to shorten the long learning curve, the traditional three-lobe technique is still the most frequently used approach. In contrast, a skilled HoLEP surgeon achieves results equal or better to those of TURP and comparable to those of open prostatectomy. This has been proven in numerous randomized controlled trials (RCTs). However, as mentioned above, the standard three-lobe method requires three longitudinal incisions of the prostatic urethra to reach the plane of the surgical capsule. This step is considered as one of the most difficult to learn. In addition, difficult intraoperative orientation regarding the zonal prostate anatomy is a key factor keeping HoLEP from becoming more widely and rapidly adopted. In our medical center, we have been mastering and modifying the three-lobe technique to overcome these obstacles. After initially applying the traditional technique by Gilling et al., we intentionally altered our approach to increase the efficiency and decrease the operation time of the procedure. In this study, we present for the first time "3 horse shoe-like incision" HoLEP (3 HSI HoLEP) for bladder neck-sparing, en bloc, totally one-lobe HoLEP and report our initial clinical results of using this novel procedure, which quickly became the standard procedure at our institution. Although multiple en bloc techniques have been described, this is to our knowledge the only one-lobe technique not requiring a longitudinal incision of the prostatic urethra.

Materials and methods

Patients and surgical intervention

Between September 2015 and August 2017, 114 consecutive patients underwent 3 HSI HoLEP at the Department of Urology, University of Freiburg, Medical Center, Germany. The surgical intervention and short-term postoperative course were assessed. International Prostate Symptom Score (IPSS), QoL score, maximum urinary flow rate (Q max), postvoid residual urine (PVR), and clinical and sociodemographic data were assessed preoperatively. The patient cohort data were compared with existing data. The study was approved by our local ethics committee and performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments (number 178/17, Ethics Committee of the University Medical Center Freiburg).

Laser technique and surgical equipment

All interventions (classic and 3 HSI HoLEP) were performed by the same experienced urologist and inventor of 3 HSI HoLEP (A.M.) using a 26-Fr continuous-flow laser resectoscope equipped with 12° optics (SHARK®, RichardWolf GmbH, Knittlingen, Germany) and a mechanical tissue morcellator (PIRANHA®, Richard Wolf, Knittlingen, Germany). The endoscope was connected to a straight fixed camera with a high-definition video system and a flat monitor (KARL STORZ GmbH & Co. KG., Tuttlingen, Germany). We applied a Holmium-YAG laser (Sphinx 100 Watt, LISA laser products OHG, Kattlenburg-Lindau, Germany) equipped with a 520-µm reusable laser fiber at a maximum energy of 3.0 J, frequency of 28 Hz, and pulse duration of 750 µs. These parameters were used for all performed procedures. Normal saline for irrigation was used in all cases. For coagulation of the prostatic fossa, we used a standard monopolar resectoscope device equipped with a cutting loop or a "roller" probe (SHARK®, RichardWolf, Knittlingen, Germany).

3 HSI HoLEP procedure

Step 1: The first intraprostatic horse shoe-like incision: paracollicular incision

A continuous-flow laser resectoscope shaft (26 Fr) was introduced blindly or supported by a Smith obturator when resistance was met or passage was not possible blindly. After initial urethrocystoscopy, the first laser incision was made in a reversed U shape (first horse shoe-like incision) around the seminal colliculus. This allowed the surgeon to easily reach the surgical capsule, partially lift up the middle lobe, and mechanically develop and mobilize both side lobes apically. This step was then continued until a mucosal strip was visible on both side lobes (Fig. 1a).

Step 2: The second intraprostatic horse shoe-like incision: mucosal strip dissection

In the second step, the mucosal strip between the external sphincter and the both lateral lobes was discontinued by a single continuous laser incision, forming another reversed U-shaped cut (second horse shoe-like incision). This allowed full mobilization of the apical part of the prostate. Subsequently, the resectosope shaft was placed between the anterior commissure and the surgical capsule at 12 o'clock. Dissection was then continued towards the bladder neck by laser cutting and mechanical methods. This resulted in the creation of a "channel" between the surgical capsule and the anterior commissure to the bladder neck at 11–1 o'clock (Fig. 1b).

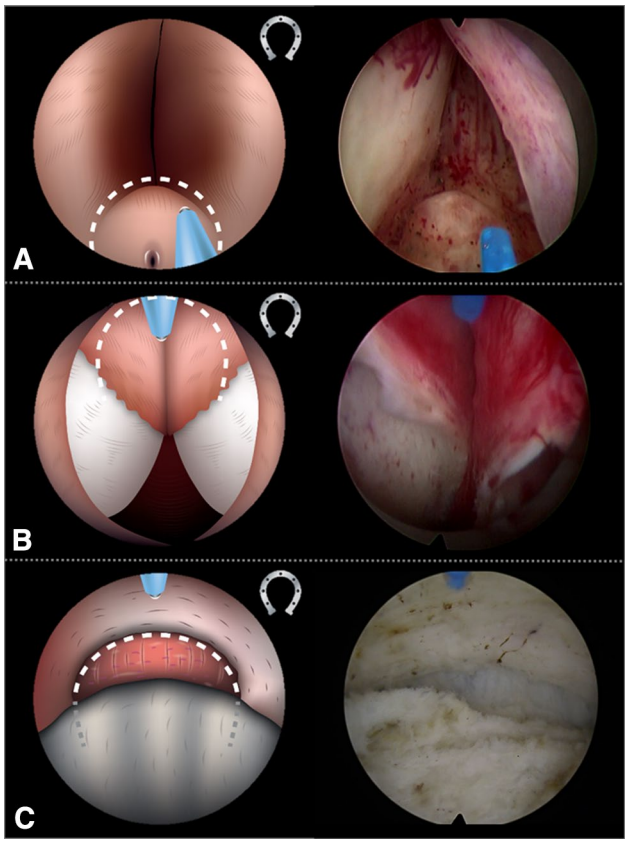

Fig. 1 Schematic overview of the most important steps of the procedure (**a** paracollicular incision, **b** mucosal strip dissection, **c** bladder neck incision)

Step 3: The third horse shoe-like incision: bladder neck incision

Once the surgical preparation reached the bladder neck, an incision was made by the laser that transected the muscle fibers and entered into the bladder lumen. This incision was then continued to both sides, forming another reversed U (third horse shoe-like incision). Through this step, both side lobes were detached from the bladder neck. The lateral sides of both side lobes were then circularly mobilized until the lateral part of the middle lobe on both sides was reached. This dissection was performed strictly along the surgical capsule. After this, the middle lobe was mobilized in a retrograde fashion until the level of the bladder neck. Adenoma tissue was then pushed into the bladder lumen. The remaining attachment at the bladder neck between 4 and 8 o'clock was gently cut by the laser. At this stage, bladder neck modeling was performed (Fig. 1c).

Step 4: Coagulation for hemostasis of the prostatic fossa

After the adenoma tissue was located in the bladder, careful coagulation for hemostasis of the prostatic fossa in areas of increased bleeding was completed. Depending on the intraoperative assessment, we used a monopolar resectosope system equipped with a cutting loop or a "roller" probe for homeostasis. However, the application of a bipolar instrument is also feasible.

Step 5: Intravesical tissue morcellation and retrieval

Intravesical morcellation and extraction by suction of the prostate tissue was then performed. We used a 20-Fr three-way Tiemann catheter blocked in the bladder by 50 mL. Gentle compressing occlusion of the bladder neck was achieved by pulling the catheter and fixation was performed using medical dressing material.

Statistical evaluation

All parameters were evaluated using Wilcoxon's rank sum test (baseline comparison of weight of probes and comparison of all non-parametric endpoints) and Fisher's exact test (binary parameters). All statistical analyses were performed using IBM SPSS Statistics (IBM SPSS Statistics for Windows, Version 23.0. IBM Corp., Armonk, NY, USA). Statistical significance was set at $p < 0.05$.

Results

Patient characteristics

In total, 114 patients were included in this study. We compared outcome parameters to a previously consecutively operated group of 94 who underwent regular HoLEP (classic three-lobe technique) performed by the same surgeon using the same equipment and energy settings. All procedures were performed at a point in time, when the HoLEP procedure was fully established at our institution and > 100 cases were performed previously by the operating surgeon. All data was prospectively recorded and retrospectively evaluated (Table 1).

Intraoperative parameters

In both groups, no major intraoperative complications were recorded and all interventions were carried out until full prostate enucleation was achieved. A significant difference was seen in overall surgery time ($p = 0.034$) and surgery time per operated prostate volume ($p = 0.0001$) between the two groups (see supplementary figure 1). The advantage of 3 HSI

Table 1 Summary of patient characteristics and parameters of all included surgical interventions separated by applied surgical technique

	HOLEP	3-horse shoe HOLEP	*p* value
Total no. of patients	94	114	–
Age (years)	72.3 (50–89)	71.6 (52–94)	0.428
Surgery time (min)	58.4 (17–250)	49.6 (15–280)	0.034
Prostate size (ml)	88.3 (35–700)	86.3 (35–280)	0.418
Preoperative IPSS	17.9 (8–30)	20.7 (0–30)	0.024
Hospital stay (days)	3.8 (2–11)	3.5 (2–8)	0.472
Preoperative postvoid residual urine (PVR; ml)	62.3 (0–400)	112.7 (0–2200)	0.065
Preoperative maximum urinary flow rate (Q max; ml)	10.0 (2.2–31.9)	10.8 (0–26.3)	0.0877
Reoperation rate (%) (Clavien grade III complication)	13.8%	4.4%	0.012
Life-threatening complication (%) (Clavien grade IV complication)	0	0	–
Resected weight of prostate tissue (g)	68.7 (10–707)	69.6 (9–220)	0.392
Blood transfusion required (number of patients)	3	0	–
Urinary retention after first catheter removal (number of patients)	12	7	
Discharge without catheter	98%	96.5%	0.134

If not stated otherwise, for each value average and range are given

HoLEP was especially prominent in larger prostates (see supplementary figure 2). In both procedures, a clear correlation between prostate size and operation time was observed [Pearson's correlation coefficient (R) for HoLEP = 0.06; R for 3HSI HoLEP = 0.5].

Perioperative outcomes

The immediate postoperative outcomes were comparable. In both cohorts, no major life-threatening complications were reported. No significant difference was seen in the duration of hospital stay between the two groups. However, the reoperation rate due to prolonged bleeding or clot retention was significantly higher ($p = 0.012$) in the HoLEP group (13.8 vs. 4.4%). Furthermore, while not statistically significant, the 3 HSI HoLEP group also showed a tendency toward a lower rate of urinary retention after catheter removal (12 patients vs. 7 patients). Overall, both procedures provided good functional outcomes, for 98% of patients after regular HoLEP and 96.5% of patients after 3 HSI HoLEP leaving the hospital without catheter.

Discussion

The surgical therapy of BOO-related LUTS has continuously evolved over the recent decades. However, the clinical management of large prostates remains challenging and is associated with considerable morbidity. To overcome these issues, diverse treatment modalities have been proposed. HoLEP is one of the most promising techniques as an alternative to simple prostatectomy. However, mastering the technique requires a long learning curve and substantial experience. This might be hampering the wider acceptance of HoLEP. Some modifications to the initial approach have been published. However, none of them have been able to significantly change the current situation. In parallel, several RCTs demonstrated the undisputed superiority of transurethral enucleation over open prostatectomy and TURP [17].

Several groups have reported en bloc transurethral enucleation methods using different energy sources [14, 18–20]. Our concept most closely resembles the technique of Minagawa et al. However, we believe that our new procedure, 3 HSI HoLEP, has several significant advantages. In contrast to the methods of Minagawa [19], Saredi [21] and Gong [14], no longitudinal incision of the prostatic urethra is necessary in 3 HSI HoLEP and to our knowledge, the 3 HSI HoLEP is therefore the only described approach that preserves the complete anatomy of the adenoma including the prostatic urethra. The application of three anatomy-based incisions might lead to a higher degree of standardization. Complications, arising from performing longitudinal incisions into prostatic tissue, which do not follow anatomical landmarks, can therefore be potentially avoided. Another advantage is that the third horse shoe-like incision can be adapted to match the anatomy of the bladder neck depending on the individual prostate size. The 3 HSI HoLEP method allows tissue dissection following natural anatomical structures as the surgical plane at any time. This is very important for ensuring the quality of the enucleation leaving no tissue behind.

Kuntz et al. reported a high-quality RCT of HoLEP compared to simple prostatectomy in the treatment of large prostatic glands (> 100 g). Five years after intervention, the functional results were equal between the groups. However, the authors stressed the difficulty in learning and mastering

HoLEP [22]. Jones et al. published a systematic review and meta-analysis illustrating the use of HoLEP and open prostatectomy in LUTS treatment in large glands. Three RCTs including a total of 263 patients from 310 identified publications were included in the analysis. The authors concluded that HoLEP and simple prostatectomy offer similar overall efficacy profiles for both objective and subjective clinical outcome parameters.

The further improvement of surgical treatment of patients with LUTS resulting from BPH will require innovations in equipment and surgical techniques. Transurethral enucleation is considered superior to vaporization and resection. However, it is also the most difficult technique to learn. Therefore, the importance of developing new surgical approaches should not be underestimated. Our initial experience with 3 HSI HoLEP revealed some interesting characteristics. First, the overall resection efficacy (average: 0.47 ml/min) made 3 HSI HoLEP superior to the previously reported methods [23]. Interestingly, some studies did not specify how the efficacy rate was assessed. Second, all procedures were performed by an urologist skilled in the use of the conventional three-lobe technique. This suggests that switching to 3 HSI HoLEP is simple. Also, the 3 HSI HoLEP method can be also executed in patients with large or very large glands. In total, 30% of the patients had prostates > 80 g and 9.6% had prostates > 150 g.

The present study had some important limitations that should be discussed. First, complication rates in the conventional HoLEP group were higher than in the literature. We believe a combination of factors is most likely to be responsible. First, we performed a complete adenoma enucleation, always following the surgical capsule. However, some reports in the literature might refer to vaporesection resulting in a bias in reintervention and recatheterization rate. In addition, our approach to recatherization and reintervention is aggressive. If postvoid residual volume is significantly higher than prior to surgery recatherization is usually performed, since we believe that this will ultimately accelerate patient recovery. However, follow-up investigations have to be performed to examine this issue. Furthermore, the weight of resected prostatic tissue (mean: 68.7 g) was significantly higher in our cohort, than in previously performed studies with this technique [24], although some studies with larger prostates have reported lower rates as well [25]. In addition, our conventional HoLEP group showed a relatively high transfusion rate of 3.1%. However, all 3 patients requiring postoperative blood transfusion had a prostate size > 100 ccm and higher transfusion rates in patients with larger glandes have been reported previously [25]. No elevated complication rate was, nonetheless, seen in the 3 HSI HoLEP group. Our 3 HSI HoLEP technique had been applied for only 1.5 years at the time of the study. Therefore, no long-term data were available for analysis. While a follow-up examination is ongoing and results will be reported, the current manuscript is primarily focusing on the description of the new technique. As mentioned above, all presented cases were treated by a single surgeon (A.M.) who is also the inventor of 3 HSI HoLEP. Therefore, no evidence regarding learning curves in other endourologists was obtained and the evaluation of the learning curve using the 3 HSI HoLEP and the implementation in other centers will be subject of further studies.

Conclusions

Standard HoLEP and our novel 3 HSI HoLEP technique are safe and reliable procedures for the treatment of symptomatic BPO. Our new approach offers a more effective and time-efficient way of enucleation with similar perioperative complication rates and postoperative outcomes. Despite the limitations discussed above, we believe that the findings of this study present sufficient evidence that this new technique should be more widely disseminated. Future multicenter, comparative, controlled trials are needed to assess the benefits afforded by 3 HSI HoLEP.

Authors' contribution DSS: Protocol/project development, data analysis, manuscript, figure writing/editing. AM: Protocol/project development, performance of operations, data analysis, manuscript and figure writing/editing, supervision

Compliance with ethical standards

Conflict of interest None of the other authors has any conflict of interest or financial ties relevant to this work to disclose. No external funding was received for this study.

Ethics approval The study was approved by our local ethics committee and was performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments (number 178/17, Ethics Committee of the University Medical Center Freiburg). For this type of study formal consent was not required. This article does not contain any studies with animals performed by any of the authors.

German Clinical Trial Register ID DRKS00013024 (approved WHO primary register).

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