Efficacy and durability of holmium laser enucleation of the prostate (HoLEP) in the management of acute and chronic urinary retention: A retrospective study

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ABSTRACT

Introduction: Our study aimed to assess the efficacy and durability of holmium laser enucleation of the prostate (HoLEP) in managing acute urinary retention (AUR), neurogenic chronic urinary retention (NCUR), and non-neurogenic chronic urinary retention (NNCUR). We also sought to compare outcomes in patients with preoperative urinary retention (UR) to those without.

Methods: We conducted a retrospective analysis using prospectively gathered data from men who underwent HoLEP at our institution between October 2017 and July 2022. Patient demographics and outcome measures were recorded, including indications for the procedure, median urinary volume drained, or median postvoid residual urine volume (PVR) before catheterization or HoLEP. Chronic urinary retention (CUR) was defined as PVR >300 mL in males able to void and initial catheter drainage >1000 mL in males unable to void, in the absence of pain. NCUR and NNCUR were differentiated based on the presence of any significant illness or injury with a neurologic impact on the bladder. All patients had postoperative followup visits at one, three, six, and 12 months. Our evaluation included the International Prostate Symptom

Score (IPSS), quality-of-life (QoL) assessment, maximum urinary flow rate (Qmax), PVR, and catheter-free status.
Results: Three hundred sixty-eight males who underwent HoLEP were included in our study. The UR group consisted of 189 patients (70 AUR, 42 NCUR, and 77 NNCUR), and the lower urinary tract symptoms (LUTS) group was comprised of 179 individuals. There were no statistically significant differences between the NCUR and NNCUR subgroups regarding demographics and outcomes. At 12 months postoperative, the AUR group had a higher catheter-free rate than the CUR group (p=0.04), and other outcome variables were comparable between the two cohorts. The UR group had a significantly lower QoL score at one month (p=0.01) and a significantly lower IPSS score at one and 12 months (p=0.034 and p=0.018, respectively) than the LUTS cohort. During all followup visits, the UR group had a significantly higher PVR than the LUTS cohort. The successful first trial of void (TOV) rate for the UR and LUTS groups was 81% and 83.2%, respectively. At 12 months postoperative, the catheter-free rate for the UR and LUTS cohorts was 96.3% and 99.4%, respectively.
Conclusions: HoLEP is an effective and durable treatment for UR with a high catheter-free rate and comparable outcomes when performed to manage LUTS.

INTRODUCTION

A paradigm shift in urology makes holmium laser enucleation of the prostate (HoLEP) the new gold standard for men with benign prostatic hyperplasia (BPH)[1,2]. In the last two decades, advanced laser technology has consistently demonstrated durability, size independence, and lower morbidity[2]. Among men undergoing surgery for benign prostatic obstruction, urinary retention (UR) is the primary indication for 24% to 42% of cases[3]. The etiologies of UR are attributed to acute urinary retention (AUR), neurogenic chronic urinary retention (NCUR), and non-neurogenic chronic urinary retention (NNCUR)[4]. While the definition is somewhat controversial, the American Urological Association (AUA) defines NNCUR as an increase in post-void residual volume (PVR) of >300 mL, consistent over six months and confirmed on two separate occurences[5].

Males with coexisting neurologic diseases and BPH are typically believed to develop LUTS due to neurogenic factors instead of BPH-related obstruction. This patient population is underrepresented in the guidelines for the surgical treatment of BPH, as they are thought to experience suboptimal functional outcomes[6,7,8].

Urodynamics (UDS) evaluates the functional state and dysfunction of the lower urinary tract using various physiological parameters[9]. This test is commonly used in the diagnosis of LUTS and overactive bladder[10]. However, its use is somewhat controversial, as some studies indicate that detrusor acontractility does not adversely impact postoperative recovery[11].

Few studies have compared HoLEP outcomes with various subtypes of UR and LUTS[12,13]. Hence, our study aimed to evaluate the efficacy and durability of HoLEP in managing AUR, NCUR, and NNCUR. Additionally, we sought to determine outcomes compared to patients without preoperative UR.

METHODS

Following the approval of the Research Ethics Board, we conducted a retrospective review of a prospectively collected database of patients who underwent HoLEP at our institution from October 2017 to July 2022. Of the 368 males included in the study, 189 were placed in the UR group (70 AUR, 42 NCUR, and 77 NNCUR). The remaining 179 patients were classified under the LUTS group.

Additionally, individuals with uncontrolled diabetes displaying evidence of diabetes-related neuropathy, cerebrovascular accidents (CVA), supranuclear palsy, or Parkinson's disease were also included in the study. Uncontrolled diabetes was defined by a sustained elevation in the A1C, exceeding 9, over the last 12 months, accompanied by evidence of diabetes-related complications, including neuropathy, as observed through medical history and physical examination. Patients who met any of the following conditions were excluded: previous surgery for bladder outlet obstruction (BOO), prior history of prostate cancer, presence of a urethral stricture, or an active urinary tract infection (UTI).

Study population

Patient demographics and outcome measures, including indications for the procedure and the median urinary volume drained or median PVR before catheterization or HoLEP, were documented. AUR was defined as painful UR of any volume with pain relief after catheterization. Although there is no standardized definition for NNCUR, CUR is commonly characterized in males able to void as PVR >300 mL and, for those unable to void, as initial catheter drainage >1,000 mL in the absence of pain [4,5,12]. UDS were not considered in the patient selection process before performing HoLEP on men with UR.

Patients were given various questionnaires to evaluate their International Prostate Symptom Score (IPSS) and Quality of Life (QoL). A comprehensive physical examination was conducted, encompassing a digital rectal exam (DRE) and a focused neurological assessment. Every patient underwent basic laboratory tests, which included measurements for prostate-specific antigen (PSA) levels, uroflowmetry, PVR, and transrectal ultrasound (TRUS) to estimate prostate volume.

If the patient's PSA level was above the normal range or there were abnormal findings in the DRE, a preoperative biopsy was conducted to rule out prostate cancer. When medically feasible, patients were instructed to temporarily discontinue their anticoagulant and antiplatelet medications 3 and 7 days prior to surgery, respectively. Data related to intraoperative parameters, postoperative outcomes, patient disposition, and readmissions were collected and analyzed.

Surgical technique

From October 2017 to December 2020, we utilized a 100-W holmium:YAG laser (VersaPulse PowerSuite™, Lumenis, Yokneam, Israel). Subsequently, from December 2020 to July 2022, we transitioned to a 120-W MOSES™ laser (Lumenis, Yokneam, Israel). A 550 µm laser fiber and a 28-F continuous flow resectoscope (Karl Storz SE & Co., KG, Tuttlingen, Germany) were utilized. The primary laser configurations for enucleation were set at 2 J and 40 Hz, while the secondary laser foot pedal was adjusted to 2 J and 20 Hz for hemostasis. The enucleated tissue was morcellated using a Karl Storz DrillCut™ (Germany) morcellator. All procedures were performed by a single urologist (H.E), a HoLEP expert. In a previous publication, we reported our top-down enucleation techniques with the holmium laser[14].

Intraoperative parameters were recorded, including enucleation time, laser energy, morcellation time, resected weight, and intraoperative complications, as well as the need for blood transfusion.

All patients had a three-way Foley catheter (22 F) with 75 mL of sterile water in the balloon placed in the operating room. They were kept on mild traction with continuous bladder irrigation (CBI) for 2 hours, which was then stopped for an additional hour if no hematuria was present.

Until December 2020, our standard practice was to perform 100-W HoLEP and admit the patient for an overnight hospital stay, followed by a next-day trail of void (TOV) within a 24-hour period. However, after procuring MOSES™ technology in December 2020, we transitioned to offering same-day discharge and same-day TOV for patients undergoing MOSES™ HoLEP.

Patients who met predetermined discharge criteria, including medical fitness, having a caregiver, not being on anticoagulant or antiplatelet medications at the time of surgery, and meeting Post Anesthesia Care Unit (PACU) discharge criteria, were eligible for a same-day TOV[15,16].

All eligible individuals were offered a same-day TOV 3 hours postoperatively after undergoing an assessment by the operating surgeon for discharge. Patients with preoperative factors such as an unfit medical condition, including a cognitive disorder, anticoagulant therapy, and uncontrolled cardiovascular disease, were ineligible for early discharge. Patients without a caregiver and those who lived beyond city limits were also excluded.

Patients were not excluded based on the presence of an indwelling catheter, PVR, or subjective criteria. They were advised that they could refuse discharge without a catheter at any point if they felt uncomfortable. In cases where patients declined a same-day TOV, they were discharged with a Foley catheter, and a TOV was arranged for the following day.

In addition to meeting the PACU discharge criteria[15], patients were required to have an acceptable urine colour without CBI, absence of clots, and PVR <300 mL. Other discharge criteria included acceptable postoperative laboratory values, the ability to tolerate a diet, and independent ambulation.

Followup
Patients were followed up at intervals of 1, 3, 6, and 12 months. Follow-up visits involved clinical examination, IPSS, QoL, maximum urinary flow rate (Qmax), bladder scan for PVR, catheter-free status and cystoscopy if indicated. A PSA blood testing was conducted at 3 months. Postoperative complications included persistent hematuria, clot retention, bladder neck contraction, and urethral strictures. Stress urinary incontinence (SUI) was evaluated by a detailed history of involuntary urine leakage while sneezing or coughing and the use of pads to prevent wetting. Moreover, SUI was assessed by instructing patients to cough while having a full bladder and observing the passage of urine.

Statistical analyses
The data was collected and analyzed using the Statistical Package for the Social Sciences (SPSS®) version 26.0 (Chicago, IL, USA). Medians and ranges were utilized to present continuous data, which were compared with the Mann-Whitney U Test. Categorical data were described using numbers and percentages and were compared with the Chi-Square test. A p-value <0.05 was deemed statistically significant.

RESULTS
Our study included 368 males who underwent HoLEP. Among them, 189 were categorized into the UR group (70 AUR, 42 NCUR, and 77 NNCUR). The remaining 179 patients were assigned to the LUTS group. The baseline clinical characteristics are presented in Table 1. There were no significant differences between the AUR and CUR cohorts, except for the initial urinary volume drained or PVR. Among the 42 patients in the NCUR group, 32 had uncontrolled diabetes, 6 had a previous history of stroke, 3 were diagnosed with Parkinson's disease, and 1 was known for supranuclear palsy.

The cohorts exhibited comparable intraoperative and early postoperative findings, as shown in Table 2. Postoperative catheter duration and length of hospital stay were the same across all groups (0.5 days). The success rates of the first TOV were comparable across cohorts: UR (81%) versus LUTS (83.2%) (p=0.567), AUR (80%) versus CUR (81.5%) (p=0.433), and NCUR (81%) versus NNCUR (81.8%) (p=0.546).

Postoperative complications, assessed using the modified Clavien classification system, were not statistically significant between the groups. There was also no observed difference in the number of patients requiring readmission. Eleven participants experienced Clavien I postoperative complications attributed to gross hematuria: seven patients (3.7%) from the UR group and four (2.2%) from the LUTS group. Seven of the 11 patients required readmission: 6 (3.2%) in the UR group and 1 (0.6%) in the LUTS group. All cases of gross hematuria were managed with CBI (Clavien I). One patient from the LUTS group had a febrile UTI (Clavien II), leading to a hospital admission and was managed with intravenous antibiotics. There was a significant difference in postoperative recurrent retention in the CUR and AUR groups (5.9% and 0%, respectively, p=0.039). However, there was no significant difference in postoperative

recurrent retention between the NCUR and NNCUR cohorts or between the UR and LUTS groups.

Postoperative follow-up (Table 3)

The UR group had a significantly higher PVR than the LUTS group at 1, 3, 6 and 12 months (p=0.000, 0.000, 0.000 and 0.012, respectively). Additionally, comparable PVR measurements were observed among the AUR, CUR, NNCUR and NCUR groups at 1, 3, 6 and 12 months. IPSS scores were significantly higher in the LUTS group compared to UR at 1, 3, and 12 months (p=0.034, 0.034 and 0.018, respectively). However, there was no significant difference in IPSS scores among the CUR, AUR, NNCUR and NCUR groups.

QoL measurements were significantly better in the UR group compared to the LUTS group at 1- and 3-months follow-up (p=0.01 and 0.01, respectively), with comparable results at 6 and 12 months postoperative (p=0.753 and 0.077, respectively). There was no significant difference in QoL among the CUR, AUR, NNCUR, and NCUR groups. Stress incontinence rates were similar across cohorts.

At the end of the 12-month follow-up period, one patient from the NCUR group experienced stress incontinence. The catheter-free rates were 100% among the AUR group and 94.1% in the CUR group (p=0.04), with rates of 92.9% in the NCUR group and 94.8% in the NNCUR group (p=0.476) at 12 months postoperative. Additionally, there was no significant difference in catheter-free rates between the UR and LUTS groups (96.3% and 99.4%, respectively, p=0.087).

Late complications were observed in two patients from the AUR group, including one case of meatal stenosis and one urethral stricture. Additionally, one patient in the NNCUR group experienced bladder neck contracture. Meanwhile, one patient in the LUTS group developed meatal stenosis.

DISCUSSION

UR necessitating catheterization represents the peak of obstruction caused by BPH. It is purported, in part, to be a factor in DUA[6]. There is a debate surrounding the safety and efficacy of surgical treatments for BPH, particularly regarding outcomes in males with DUA[6,11]. Consequently, we evaluated the efficacy and safety of HoLEP in patients with UR versus LUTS, as well as the comparison between AUR and CUR. During the initial postoperative period in our study, the duration of postoperative catheterization and length of hospital stay were consistent across all groups (0.5 days).

Aho and colleagues evaluated the outcomes of HoLEP in patients experiencing AUR, CUR, and LUTS. They reported a median time of one day for the first TOV among all comparison groups[12]. In our study, comparable success rates for the first TOV were observed between UR (81%) and LUTS (83.2%) (p=0.567), as well as among AUR (80%) and CUR (81.5%) (p=0.433), and NCUR (81%) and NNCUR (81.8%) (p=0.546). Conversely, Aho et al.

found that patients with CUR were less likely to pass their first TOV (58.8%) compared to those with AUR (84.6%) or LUTS (87.7%) [12].

The rationale for conducting UDS before endoscopic treatment for BOO is to diagnose concurrent DUA, which is present in 11%–40% of men with LUTS[17]. It has been theorized that the occurrence of DUA in patients experiencing LUTS could be linked to treatment failure postoperatively[17]. The findings of the recent UPSTREAM trial indicate that there is limited evidence regarding the impact of UDS results on symptom outcomes[6].

In their meta-analysis, Wroclawski et al.[17] examined the functional and safety outcomes of surgeries for benign prostatic enlargement in men with DUA compared to those with normal detrusor contractility. Their analysis included 5 prospective non-randomized studies and 12 retrospective studies, two of which focused on HoLEP. They did not observe a statistically significant difference between the DUA and normal contractility groups in terms of postoperative catheterization time, hospitalization time, urinary retention, or the need for re-catheterization. Wroclawski and colleagues' findings demonstrate the comparable safety of prostate surgery in DUA patients and those with normal contractility during the immediate postoperative period[17].

In our study, we also found that a greater proportion of patients with CUR experienced recurrent retention during the early postoperative period compared to those with AUR (5.9% vs. 0%, p=0.039). Notably, there was no significant difference observed in recurrent retention rates between the NCUR and NNCUR cohorts (7.1% vs. 5.2%, p=0.666), nor between the UR and LUTS groups (3.7% vs. 0.6%, p=0.108).

Individuals with neurological diseases (ND) are frequently excluded from research studies due to higher complication rates and poorer perioperative outcomes[18]. In their retrospective study, Krambeck and colleagues compared patients who underwent HoLEP with and without ND. They reported that patients with ND were more likely to fail their first TOV (20% vs. 8.1%, p<0.001) and experience an episode of postoperative AUR (16% vs. 8.5%, p=0.024) [18].

Johnsen et al.[13] conducted a retrospective analysis to investigate differences in postoperative outcomes between patients with and without preoperative UR. They observed that among patients in each group, 3% required temporary re-catheterization after failing initial voiding trials, although none of the patients required long-term catheterization[13].

Throughout the postoperative follow-up period, we observed variations and significant differences in both subjective and objective outcomes between the UR and LUTS groups regarding IPSS, QoL, and PVR. However, we did not observe such differences between the CUR and AUR groups or between the NNCUR and NCUR groups. The variability in postoperative parameters following HoLEP in patients with UR versus LUTS has been documented in previous studies[12, 13, 17].

Johnsen and colleagues reported that while patients without preoperative retention exhibited significantly higher Qmax measurements at 6 and 12 months postoperative, this pattern

did not persist at their latest follow-up visits.[13] Furthermore, Aho and colleagues reported that the UR group demonstrated lower median IPSS and QoL scores than the LUTS group (although the differences were not clinically significant). At 3 months postoperative, they found no significant differences in Qmax and PVR between the UR and LUTS cohorts or within the UR subgroups[12].

Wroclawski and colleagues' meta-analysis[17] investigated functional outcomes in men with DUA compared to those with normal detrusor contractility, yielding similar results for IPSS, Qmax, and PVR at 1 month postoperative. However, when a larger number of patients were evaluated at 3 months postoperative, it revealed that individuals with normal contractility had lower IPSS and QoL scores, as well as better Qmax and lower PVR levels. At 6 months follow-up, these findings remained consistent, except for PVR, which displayed no difference between groups. However, beyond 12 months postoperative, the functional outcomes, IPSS, and QoL became similar once more[17].

Improving patients' QoL and maintaining a catheter-free status are pivotal objectives associated with BPH interventions. Previous studies have demonstrated the variability in catheter-free rates among patients with UR following HoLEP[12,13, 17].

Our study showed no significant difference in catheter-free rates among the UR and LUTS groups at one-year postoperative (96.3% and 99.4%, respectively, p=0.087). Furthermore, the catheter-free rates were 100% in the AUR group and 94.1% among the CUR group (p=0.04), with catheter-free rates of 92.9% and 94.8% in the in the NCUR and NNCUR groups, respectively (p=0.476).

Jaeger et al. investigated patients with BPH and CUR undergoing HoLEP and photoselective vaporization of the prostate (PVP). At 6 months postoperative, men who underwent HoLEP were catheter-free 99% of the time, irrespective of bladder contractility[19]. In Johnsen et al.'s comparison of HoLEP outcomes in patients with or without preoperative UR, including long-term follow-up of up to 14.6 months, none of the patients in either group required prolonged catheterization[13]. Krambeck's group found that at 6 months post-HOLEP, 4.4% of patients in the ND group required persistent catheterization or clean intermittent catheterization (CIC), compared to 0% in the non-neurogenic group (p=0.002)[18].

In this cohort, we reported a unique group previously excluded from literature—neurogenic urinary retention. Hopefully, It will offer insights into the success rate for same-day TOV in CUR and provide percentages of catheter-free status at one-year follow-up, which can be utilized in patient counseling.

Limitations

The limitations of our study include the lack of randomization and its retrospective design, which may introduce the risk of selection bias. Furthermore, our study is based on a relatively small dataset with only a 12-month follow-up period. Moreover, our study did not include UDS; however, it contributes to the growing body of literature suggesting that patients experiencing AUR or CUR are appropriate candidates for de-obstructive surgery, often resulting in positive outcomes and favourable safety profiles. In principle, alleviating the obstruction through surgical

intervention should promote the restoration of spontaneous urination and contribute to the eventual rehabilitation of the detrusor muscle. We were unable to identify any preoperative factors contributing to surgical failure post-HoLEP in the early postoperative period or at one-year follow-up. In our study, we were unable to assess if there is a difference among those with NCUR who progressed to AUR due to the lack of data. Moreover, upon reviewing the literature, there is no standardized definition for CUR.

We acknowledge the limitations of our study and emphasize the need for further research to shed light on the debate regarding the suitability of performing BPH surgeries on this specific patient population. Additionally, there is a need to explore the potential benefits of HoLEP, which maximizes prostate debulking.

CONCLUSIONS

HoLEP is an effective and durable treatment option for patients experiencing AUR or CUR, yielding generally positive outcomes and demonstrating a favourable safety profile. The procedure offers immediate improvements in QoL and voiding parameters, as well as a high catheter-free rate and comparable outcomes when utilized to manage patients without preoperative UR.

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FIGURES AND TABLES

Table 1. Baseline clinical characteristics

Parameters		NCUR (42)	NNCUR (77)	p	AUR (70)	CUR (119)	p	UR (189)	LUTS (179)	p
Age median (range), years		76.5 (60–92)	75 (55–95)	0.104	75 (59–96)	75 (55–95)	0.924	75 (55–96)	74 (55–92)	0.218
ASA n (%)	I	–	23 (29.9)	0.000	11 (15.7)	23 (19.3)	0.808	34 (18)	49 (27.4)	0.112
	II	36 (85.7)	51 (66.2)		54 (77.1)	87 (73.1)		141 (74.6)	110 (61.5)	
	III	6 (14.3)	3 (3.9)		5 (7.1)	9 (7.6)		14 (7.4)	20 (11.2)	
	IV	-	-		-	-		-	-	
Initial urinary volume drained or PVR median (range), mL		628 (300–2600)	638 (370–2300)	0.09	900 (700–1100)	657 (300–2600)	0.000	800 (300–2600)	134 (0–285)	0.000
Preoperative IPSS median (range)		22 (11–32)	23.5 (5–35)	0.711	–	23 (5–35)	–	23 (5–35)	23 (7–35)	0.841
Preoperative QoL median (range)		4 (3–6)	5 (1–6)	0.493	–	5 (1–6)	–	5 (1–6)	5 (1–6)	0.525
Preoperative Qmax median (range), mL/s		7.8 (1.4–20)	5.8 (2.2–15)	0.085	–	6.8 (1.4–20)	-–	6.8 (1.4–20)	8.4 (2.4–17.6)	0.238
Preoperative catheter duration median (range), months		4 (1–12)	4 (1–72)	0.108	4 (1–12)	4 (1–72)	0.496	4 (1–72)	–	–
Preoperative size by TRUS median (range), cc		102 (42–250)	113 (60–203)	0.333	120 (60–325)	110 (42–250)	0.298	113 (42–325)	106 (50–273)	0.048

ASA: American Society of Anesthesiologists; AUR: acute urinary retention; CUR:chronic urinary retention; IPSS: Internationla Prostate Symtom Score; LUTS: lower urinary tract symptoms; NCUR: neurogenic chronic urinary retention; NNCUR: non-neurogenic chronic urinary retention; PVR: postvoide residual; Qmax: peak flow rate; QoL: quality of life; UR: urinary retention.

Table 2. Intraoperative parameters and perioperative outcomes

Parameters	NCUR (42)	NNCUR (77)	p	AUR (70)	CUR (119)	p	UR (189)	LUTS (179)	p
Enucleation time median (range), min	55 (28–125)	60 (24–165)	0.464	70 (25–184)	60 (24–165)	0.149	61 (24–184)	60 (19–200)	0.149

Morcellation time median (range), min		10 (3–55)	12 (3–50)	0.345	14 (3–58)	11 (3–55)	0.153	12 (3–58)	10 (1–36)	0.023
Enucleated tissue weight median (range), g		80 (50–242)	76 (25–204)	0.619	100 (20–303)	78 (25–242)	0.014	85 (20–303)	72 (18–238)	0.009
Enucleation efficiency median (range), g/min		1.35 (0.3–2.4)	1.5 (0.5–2.5)	0.681	1.41 (0.48–3)	1.31 (0.3–2.5)	0.076	1.35 (0.3–3)	1.23 (0.38–3.93)	0.226
Intraoperative complications n (%)		1 (2.4)	0	0.352	1 (1.4)	1 (0.8)	0.702	2 (1.1)	1 (0.6)	0.594
Blood transfusion n (%)		0	0	–	0	0	–	0	1 (0.6)	–
Postoperative catheter duration median (range), days		0.5 (0.125–8)	0.5 (0.125–8)	0.617	0.5 (0.125–12)	0.5 (0.125–8)	0.669	0.5 (0.125–12)	0.5 (0.125–14)	0.224
Length of hospital stay median (range), days		0.5 (0.25-2)	0.5 (0.25-8)	0.80	0.5 (0.25-4)	0.5 (0.25-3)	0.073	0.5 (0.25-4)	0.5 (0.25-5)	0.24
Success of first TOV n (%)		34 (81)	63 (81.8)	0.546	56 (80)	97 (81.5)	0.433	153 (81)	149 (83.2)	0.567
Recurrent retention n (%)		3 (7.1)	4 (5.2)	0.666	0 (0)	7 (5.9)	0.039	7 (3.7)	1 (0.6)	0.108
Readmission n (%)		3 (7.1)	1 (1.3)	0.909	2 (2.9)	4 (3.4)	0.848	6 (3.2)	2 (1.1)	0.176
Retreatment n (%)		0	0	–	0	0	–	0	0	-
Early complications n (%)	Clavien I	3 (7.1)	1 (1.3)	0.090	3 (4.3)	4 (3.4)	0.745	7 (3.7)	4 (2.2)	0.637
	Clavien II	–	–		–	–		–	1 (0.6)	
	Clavien III	–	–		–	–		–	–	
	Clavien IV	–	–		–	–		–	–	
Late complications n (%)		0	1 (1.3)	1	2 (2.9)	1 (0.8)	0.284	3 (1.6)	1 (0.6)	0.341

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Table 3. Postoperative functional outcomes

Parameters		NCUR (42)	NNCUR (77)	p	AUR (70)	CUR (119)	p	UR (189)	LUTS (179)	p
1 month postoperative	IPSS median (range)	5 (0–18)	5 (0–22)	0.151	8 (0–25)	5 (0–22)	0.292	6 (0–25)	8 (0–24)	0.034
	QoL median (range)	1 (0–6)	1 (0–6)	0.377	1 (0–5)	1 (0–6)	0.476	1 (0–6)	2 (0–6)	0.01
	Qmax median (range), mL/s	20.7 (5.2–65)	22.9 (10.2–73.3)	0.326	21.5 (4.3–47.1)	23 (3–54)	0.421	21.5 (4–73)	23.5 (5–64)	0.997
	PVR median (range), mL	53 (0–164)	65 (0–530)	0.964	65 (0–594)	60 (0–530)	0.804	60 (0–594)	38 (0–265)	0.000
	Stress incontinence n (%)	3 (7.1)	4 (5.2)	0.666	3 (4.3)	7 (5.9)	0.635	10 (5.3)	7 (3.9)	0.528
3 months postoperative	IPSS median (range)	5 (0–18)	5 (0–22)	0.151	8 (0–25)	5 (0–22)	0.292	6 (0–25)	8 (0–24)	0.034
	QoL median (range)	1 (0–6)	1 (0–6)	0.377	1 (0–5)	1 (0–6)	0.476	1 (0–6)	2 (0–6)	0.01
	Qmax median (range), mL/s	20.7 (5.2–65)	22.9 (10.2–73.3)	0.326	21.5 (4.3–47.1)	23 (3–54)	0.421	21.5 (4–73)	23.5 (5–64)	0.997
	PVR median (range), mL	53 (0–164)	65 (0-530)	0.964	65 (0–594)	60 (0–530)	0.804	60 (0–594)	38 (0–265)	0.000
	Stress incontinence n (%)	3 (7.1)	4 (5.2)	0.666	3 (4.3)	7 (5.9)	0.635	10 (5.3)	7 (3.9)	0.528
6 months postoperative	IPSS median (range)	3 (0–16)	4 (0–17)	0.187	8 (0–21)	3.5 (3–17)	0.53	4 (0–27)	4 (0–30)	0.108
	QoL median (range)	0.5 (0–3)	1 (0–3)	0.412	1.5 (0–6)	1 (0–3)	0.187	1 (0–6)	1 (0–6)	0.753
	Qmax median (range), mL/s	22.5 (13–49)	25.6 (2.8–76)	0.935	22 (8–42)	23.6 (2.8–76)	0.60	23 (3–76)	25 (1–69)	0.282
	PVR median (range), mL	54 (0–287)	66 (0-480)	0.247	45 (0–1000)	61 (10–480)	0.267	60 (0–1000)	27 (0–250)	0.000
	Stress incontinence n (%)	1 (2.4)	1 (1.3)	0.660	0	2 (1.7)	0.532	2 (1.1)	0	0.499

12 months postoperative	IPSS median (range)	2.5 (0–16)	3 (0–20)	0.84	3 (0–17)	3 (0–20)	0.297	3 (0–20)	4 (0–21)	0.018
	QoL median (range)	0.5 (0–3)	0 (0–3)	0.899	1 (0–4)	0 (0–4)	0.292	0 (0–4)	1 (0–6)	0.077
	Qmax median (range), mL/s	22.5 (5–65)	24 (6–64)	0.418	27 (8–45)	23.8 (5–65)	0.316	24.7 (5–65)	24 (6–51)	0.63
	PVR median (range), mL	69 (0–790)	72.5 (0–445)	0.215	39 (0–185)	60 (0–790)	0.144	50 (0-790)	41 (0–286)	0.012
	Stress incontinence n (%)	1 (2.4)	0	1	0	1 (0.8)	1	1 (0.5)	0	1
	Catheter-free n (%)	39 (92.9)	73 (94.8)	0.476	70 (100)	112 (94.1)	0.04	182 (96.3)	178 (99.4)	0.087

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