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Review Article

Laser Prostatic Surgery: An Update

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ABSTRACT

This review presents an overview of the current state of the art of laser prostatic surgery. Several types of lasers have been used in the treatment of benign prostatic hyperplasia (BPH) over the past 15 years. Vaporization techniques have recently gained popularity and have been widely accepted by many urologists. Short-term results show that vaporization of a prostatic adenoma with higher-power potassium titanyl phosphate and holmium lasers is safe and effective in the treatment of symptomatic BPH. However, well designed randomized comparative trials with long-term follow-up are still needed. Holmium laser is a multi-purpose surgical tool and has multiple applications in urology. In the treatment of symptomatic BPH, holmium laser can be used in ablation, resection and enucleation of the prostate. Holmium laser enucleation of the prostate (HoLEP) is the most investigated laser procedure used in the treatment of symptomatic BPH. Several randomized controlled trails confirmed the safety, efficacy, and durability of HoLEP regardless of the prostate size.

Keywords : Laser, Holmium, KTP laser, Thulium, prostatic hyperplasia, prostatectomy

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INTRODUCTION

Over the last decade several minimally invasive treatments (MITs) have been introduced to challenge the standard TURP in the treatment of symptomatic benign prostatic hyperplasia (BPH). MITs such as transurethral needle ablation (TUNA), transurethral microwave therapy (TUMT), and interstitial laser coagulation (ILC) have been reported to improve voiding symptoms and quality of life (QoL) equivalent to that following TURP, however, urodynamic relief of obstruction is less evident following MITs, which are also associated with higher re-treatment rates compared to TURP[1].

The real challenging alternative to TURP is the procedure that allows immediate complete removal of obstructing tissue in a reasonable operative time with low morbidity and good symptomatic relief. Laser therapy of symptomatic BPH is a promising less invasive alternative to the traditional BPH surgery.

Techniques using lasers gained wide acceptance and popularity based on their favorable safety profile, shorter hospital stay and economic reasons. However, drawbacks of the initial laser techniques included a longer catheterization than with standard TURP, and significant dysuria attributable to coagulative necrosis. The medium-term durability has also been a concern. During the last decade some types of recently introduced laser procedures have become a well-documented treatment alternative, are considered as a true challenge to TURP and are even promoted as new standard treatment.

Several types of laser have been used for treatment of BPH, mainly Neodymium: Yttrium Aluminum Garnet (Nd: YAG), Holmium: YAG (Ho: YAG), Potassium Titanyl Phosphate: YAG (KTP: YAG) and diode laser. Each type is unique in its tissue effect, and consequently in its applications to prostatic tissue. In this article, we present an update of laser procedures for the treatment of BPH.

PHOTOSELECTIVE VAPORIZATION OF THE PROSTATE (PVP)

This procedure is based on the potassium titanyl phosphate (KTP) laser system, in which the Nd: YAG laser light passes through a KTP crystal, which doubles the frequency and halves the wavelength of the emitted laser to 532 nm. The emitted light has different tissue interactions compared to Nd: YAG laser. KTP laser is a visible green light and selectively absorbed by hemoglobin, leading to trapping of the energy in superficial tissues (only 0.8 mm) and rapid vaporization of the tissue; thus this procedure is named photoselective vaporization of the prostate (PVP)[2].

The currently used high-power PVP systems can deliver 80 W. However, the new generation of green light laser (high performance system) can deliver up to 120 W with a dual-mode power pedal feature that allows instant selection of a lower power setting for coagulation without vaporization. This high-power KTP laser is claimed to allow vaporization of large glands in a shorter time. In this new laser system a diode pumped Nd:YAG laser light is emitted through lithium triboride crystal instead of a KTP crystal, resulting in higher power green light laser and potentially more efficient laser PVP[3].

Efficacy and outcomes

The decrease in symptom scores and increase in peak flow rates at 1 year post-operatively were significant in all studies and ranged from 11.2 to 18.9 points, and from 11.0 ml/s to 19.3 ml/s, respectively[4] (Table 1). Te et al. reported on the first US multicenter study of 139 patients with a mean prostate volume of 54.6 cc that underwent 80 W PVP. The mean operative time was 38.7 minutes, the mean catheterization was 14 hours and 32% of patients required no post-operative catheterization. At 1-year follow-up, there was an 82% improvement in symptoms score, 76% in the QoL score, 190% increase in the peak flow rate (Qmax), and 78% decrease in post-void residual volume (PVR). Of 139 patients who underwent PVP, more than 30% of patients were sent home without a catheter; and those with catheters had them removed in a mean of 14 hours[5]. In another study, mean duration of catheterization was 7.59 ± 0.9 hours (range 6 – 13 hours) and hospitalization was 14.4± 1.2 hours (range 10.5–17 hours)[6]. The amount of prostatic tissue removed after KTP laser vaporization was demonstrated by a 30% to 41.7% decrease in PSA and a 27% to 53% decrease in prostate volume as estimated by TRUS[7,8].

Morbidity

The reported morbidity after PVP is very low. There is no intra-operative and post-operative blood transfusion or significant electrolyte disturbance reported in any of PVP studies. Volkan et al. reported 11% of uncontrolled bleeding during PVP, with no need for blood transfusion[6]. In a review of pooled results of 7 studies of PVP with 722 patients, Kuntz reported on the short-term post-operative complications including dysuria (13.9%, range 6 to 30%), UTI (4.2%, range 2 to 8%), incontinence (0.4%, range 0 to 1.4%), re-catheterization (5.2%, range 0 to 15.4%), bladder neck contracture (1.1%, range 0 to 3.5%), urethral stricture (1%, range 0 to 4%) and re-operation rate (0.7%, range 0 to 5%)[4]. Retrograde ejaculation was reported in approximately 28% of cases, although there was no evidence of erectile dysfunction in those men who were sexually active pre-operatively[13].

Table 1: Functional results of the recent studies evaluating PVP

Authors	No of patients	Prostate volume (cc)	Symptom score		Peak flow (ml/sec)		Follow-up (Months)
			Preop.	Postop	Preop.	Postop	
Te et al.[5]	139	54.6	23.9	4.3	7.8	22.6	12
Volkan et al.[6]	186	48	18.8	6.7	7.1	14.8	3
Hai and Malek[7]	10	41.3	23.2	2.6	10.3	30.7	12
Sulser et al.[9]	65	49	18.5	7	7.7	18.2	3
Sandhu et al.[10]	64	101	18.4	6.7	7	18.9	12
Bachmann et al.[11]	108	52	18.6	7	7.1	25	12
Reich et al.[12]	66	49	20	6.5	6.7	21.6	12

PVP vs. TURP

In a comparative study of PVP (N=64) and TURP (N=37), the mean prostate volume was lower in the TURP group than in the PVP group (48.9±21.2 vs. 65.1±36.9 cc), however TURP was faster than PVP (49.4 ± 16.0 vs. 59.6 ± 24.4 minutes). The catheterization and hospitalization times were shorter after PVP than after TURP ($p < 0.001$). At 6 months follow-up the degree of improvement of Qmax was comparable in both groups with no statistical difference (TURP, 176%; PVP, 162%). The international prostate symptom score (IPSS) improved by 71% and 72% after PVP and TURP, respectively. No major complications occurred in both groups. The incidence of bleeding-related complications was higher in the TURP group (10.8%)[14].

In another randomized trial of PVP vs. TURP, the duration of catheterization was significantly less ($P<0.001$) in the PVP group (mean 12.2, range 0–24 hours) compared with the TURP group (mean 44.5, range 6–192 hours). The mean hospital stay of the PVP group was 1.08 (range 1–2) days and the mean for the TURP group was 3.4 (range 3–9) days ($P<0.001$). In the TURP group, flow increased from 8.7 to 17.9 ml/s (149%) and in the PVP group from 8.5 to 20.6 ml/s (167%). The IPSS decreased from 25.4 to 12.4 (50.2%) in the TURP group and from 25.7 to 12.0 (49.8%) in the PVP group[15].

In a prospective comparative study between PVP and TURP, the reduction in prostate volume after TURP was significantly larger than after PVP. It decreased from 50.3 to 30.3 cc (39.7%) in the PVP group and from 69.5 to 34.1 cc (51%) in the TURP group[16].

PVP in patients with large prostate

The old laser coagulation and vaporization techniques based on Nd:YAG laser were limited to small to moderate sized prostates, however high-power PVP seems to be safe and effective even in the treatment of large prostates. Rajbabu et al. reported on 54 patients who underwent PVP, the initial mean prostate volume measured by TRUS was 135 (range 100–300) cc, the mean PSA level was 9.6 (range 1.7–51.6) ng/ml, the mean operative duration was 81.6 (range 39–150) minutes. The mean duration of catheterization was 23.0 (range 0–72) hours and the mean hospitalization after surgery was 11.0 (range 0–48) hours. Four patients (7%) had one episode of gross hematuria with clot retention at 2–4 weeks. Four patients (7%) had a UTI. There was transient urgency after surgery in 12 (22%). Three patients (6%) required a repeat PVP due to recurrence of LUTS, one at 4 weeks, one at 16 months and one at 18 months post-operatively. The prostate volume was reduced by 45% and the mean PSA level decreased by 49%. The Qmax increased from 8 to 19.3 ml/s (141%) and IPSS improved from 22.9 to 5.7 (89%) at 24 months post-operatively[17]. In another study of 64 men with a mean prostate volume of 101 ± 40 cc who underwent PVP, 44% of the patients were operated on with intravenous sedation and prostate block

Table 2: Published studies on PVP in patients on anticoagulants

Reference	No of patients	Catheterization time (day)	Hospital stay (day)	Clot retention	Blood transfusion
Ruszat et al.[18]	116 patients (71 on aspirin, 9 on clopidogrel; 36 on warfarin)	1.8	3.8	0	0
Sandhu et al.[19]	24 patients (2 on clopidogrel; 8 on warfarin; 14 on aspirin)	na	0.7	0	0
Reich et al.[12]	26 patients (10 on clopidogrel; 16 on warfarin)	1.8	na	0	0
Fu et al.[20]	28 patients (oral anticoagulants are not specified)	1.6	1.6	1 patient	0

na = not available

only. The mean operative time was 123 ± 69 minutes and 62 out of 64 patients were discharged within 23 hours. At 12 months, the Qmax increased from 7.9 to 18.9 ml/s, whereas the symptom score decreased from 18.4 to 6.7 (P<0.001). The early re-catheterization and re-operation rates were 5% each[10].

PVP in high-risk patients

One of the important advantages of laser prostatic surgery is the high safety profile, thus it is considered a suitable procedure for the treatment of BPH patients with high surgical risk and patients on oral anticoagulants. Several studies have demonstrated the safety and efficacy of PVP in anticoagulated and high surgical risk patients (Table 2). No significant bleeding or thromboembolic events and no blood transfusions have been reported in the literature. Ruszat et al. reported on 116 patients (71 on aspirin, 9 on clopidogrel and 36 on warfarin) who underwent PVP. No blood transfusions were required of any of them, and the catheterization time and hospital stay were 1.8 and 3.6 days, respectively[21].

In this study slight hematuria was encountered in 2.8% in the aspirin group, 41.7% of the warfarin group, and 33.1% in the clopidogrel group. However, in the control group (non-anticoagulated patients) 5.4% of the patients developed post-operative hematuria. The average post-operative decrease of hemoglobin was 8.6% for patients on anticoagulants versus 8.8% for control[18].

PVP in patients with urinary retention

In a comparative study of 70 patients with refractory urinary retention (RUR) compared to 113 men with no urinary retention (NUR), there was no significant difference in the functional outcomes of both groups. Postoperative complication rates were comparable for the two groups. UTI developed in 4.3% and 4.4% of patients in the RUR and NUR groups, respectively. Re-catheterization and re-operation rates were 12.9% vs. 10.6% and 2.9% vs.2.7% in the RUR and NUR groups, respectively[21]. Pre-operative urodynamic parameters predict the outcome in men with urinary retention undergoing PVP. Post-operatively, men with detrusor overactivity (DO) had higher IPSS than men without DO and were twice as likely to require anticholinergics. Men without impaired detrusor contractility (IDC) had better IPSSs, flow rates, and PVR urine volumes than did the men with IDC. Men with IDC also had a 38% re-operation rate within the first year post-operatively[22].

Durability

There are limited data on the durability of PVP, but the available long-term follow-up results demonstrate sustained improvement in voiding parameters. Malek et al. reported on a 5-year follow-up of 94 patients who underwent PVP. Only 14 patients were actually evaluated at 5 years and their data demonstrated an 80% improvement in symptom score, 170% improvement in Qmax and none of these patients required re-operation[23]. In a 3-year follow-up of the first US multicenter study of PVP, the re-treatment rate was 4.3%[24].

Ruszat et al.[19] reported a cumulative incidence of secondary endoscopic intervention after PVP of 8.2% including 5.9% re-treatment within the observation period of 24 months. In another study, the re-operation rate after PVP was 3% within 1 year postoperatively[17].

Learning curve and cost effectiveness of PVP

Two important issues are concerned with introducing any new technology in the medical field: the learning curve and cost effectiveness. From our experience the vaporization techniques using either KTP or holmium laser are simple and easy to learn.

Currently, the cost data on PVP are limited, but in an Australian comparative study of TURP and PVP, Bouchier-Hayes et al.[11] found that despite the high cost of the equipment and disposables, PVP performed as a day-case procedure was less expensive than TURP (AU$ 3368 vs. AU$ 4291). This was mainly owing to a much shorter duration of hospital stay and catheterization and lower complication rates. Stovsky et al. examined the cost characteristics of the various surgical treatment alternatives for BPH. For a hypothetical cohort of 10,000 patients, the expected costs of PVP, TUMT, TUNA, ILC, and TURP were modeled at 3 and 24 months. The expected total cost of PVP was found to be lower than all other therapies and would only approximate TURP when the cumulative probability of re-operation in PVP-treated patients was 52%[25].

HOLMIUM LASER PROCEDURES FOR SYMPTOMATIC BPH

The wave length of the holmium laser (2140 nm) is highly absorbed by tissue water, which is heated and vaporized with coagulation of small blood vessels. The depth of tissue penetration is superficial (only 0.4 mm), and allows precise cutting and vaporization of prostatic tissue without charring, with subsequently short catheterization time and minimal irritative voiding symptoms. As in all laser prostatic surgery, the use of normal saline eliminates hyponatremia and electrolyte imbalance (no TUR syndrome). The excellent hemostatic properties of holmium laser results in a mostly bloodless field, decreases blood loss and nearly eliminates the need for bladder irrigation[26,27]. Holmium laser has multiple applications in urology, such as incision of ureteral and urethral strictures, lithotripsy of urinary calculi, ablation of superficial urothelial tumors and surgical treatment of BPH. Several procedures based on holmium laser are used in the treatment of BPH, such as bladder neck incision, prostate ablation, resection and enucleation.

Holmium Laser Ablation of the Prostate (HoLAP)

HoLAP is a simple procedure and suitable for small to medium sized prostates and comparable to PVP. Initially, the Ho:YAG laser was used in combination with the neodymium (Nd:YAG) laser to facilitate coagulation and ablation of prostatic tissue in a technique known as combination endoscopic laser ablation of the prostate. Unfortunately, the addition of the Ho:YAG laser did not improve the longer catheterization time, greater irritative symptoms, delayed symptomatic and flow rate improvement, and the high re-catheterization rate caused by the Nd:YAG laser[28]. The hemostatic effect of the holmium laser was soon noted to be sufficient on its own, allowing elimination of the Nd:YAG component. Now, with more clinical experience, the high-power Ho:YAG laser has been used alone for prostate ablation. Gilling et al. reported on 79 patients who underwent HoLAP. The prostate volume was 40.5 (range 14-133) cc and the operative time was 30.8 (range 5 to 90) minutes. The complication rates were very low and the re-catheterization rate was 9% of HoLAP patients. The AUA symptom score improved from 18.8 to 8.3 (56%) and Qmax increased from 9.2 to 14.5 ml/s (58%) at 3 months after HoLAP[29]. In the 7-year extension of this study, the improvement in symptom score and Qmax proved durable after HoLAP. At 7 years post-operatively, the AUA score, QoL score and Qmax were 10, 2.1 and 16.8 ml/s, respectively[30].

In a randomized trial comparing HoLAP and TURP in men with a prostate size <60 cc, the subjective and objective improvement in both groups was similar at 1-year follow-up. In addition, the advantages of HoLAP over TURP included less dysuria and bleeding, shorter hospital stay (1.6 vs. 3.1 days) and duration of catheterization (1.7 vs. 2.1 days) without need for any irrigation. The IPSS improved from 21.7 to 6.5 (70%) and from 23.7 to 4.7 (80%) in the HoLAP and TURP groups, respectively. In the HoLAP group, the Qmax increased from 8.8 to 19.9 ml/s (126%), and in the TURP group the Qmax increased from 7.7 to 17.6 ml/s (128%). The prostate volume decreased from 36.7 to 22.5 cc (38.7%) after HoLAP and from 34 to 18 cc (47%) after TURP[31].

HoLAP provides durable relief of symptomatic BPH. At 7 years follow-up of 34 patients who underwent HoLAP, there was an 83% improvement in Qmax and a 47% decrease in symptom score with a re-operation rate of 15%. HoLAP is an easy and effective technique with a short learning curve, but the procedure is rather time-consuming[30].

Recently, HoLAP was reintroduced in an effort to appeal to urologists not wishing to learn more advanced techniques, or as a useful starting point when first learning holmium prostatectomy.

Holmium Laser Enucleation of the Prostate (HoLEP)

With more understanding of the surgical planes of the prostate and its identification endoscopically acquired during many cases of holmium resection of the prostate, the technique of HoLEP was developed. It was conceptually the endoscopic equivalent of open prostatectomy. The Ho:YAG laser used to enucleate a large prostate in much the same way as the surgeon's finger does during open prostatectomy. The technique allows peeling the median and lateral lobes off the surgical capsule and then pushing it back into the bladder. A transurethral soft-tissue morcellator allows the enucleated lobes to be evacuated from the bladder[32]. In contrast to TURP, HoLEP is equally suitable for small, medium-sized and large prostates with a similar clinical outcome that is independent of the prostate size[33].

<u>Efficacy and outcomes</u>

Gilling and colleagues pioneered the technique of holmium resection and introduced the prostatic tissue morcellator, which allowed the development and use of the HoLEP technique. In 1998 they reported their preliminary results of 64 patients with a mean prostate volume of 75 cc, who underwent HoLEP combined with tissue morcellation. At 1 month post-operatively, the symptom score improved from 23 to 8.6 and Qmax increased from 8.9 to 23 ml/sec. The mean laser time and morcellator time were 46.9 and 10.5 minutes, respectively[34]. Since the development of HoLEP, several case series and randomized trials have been reported, demonstrating the high efficacy and safety of this procedure in the treatment of BPH.

Similarly, Hurle at al. reported on 155 patients with a pre-operative mean prostate volume of 53 ± 39 cc. The mean operative time was 87 ± 44 minutes, the weight of the resected tissue was 37 ± 26 g, and the morcellation efficiency was 1.9 ± 1.6 g/min. The catheter time was 18 ± 13.5 hours and the hospital stay 1.5 ± 1.0 days. The IPSS improved from 26.5 ± 5.3 to 1.2 ± 1.0 (95%) and the Qmax increased from 9.3 ± 3.0 to 21.9 ± 7.0 (135%) at 18 months post-operatively[35]. In our experience with more than 750 HoLEP patients we were able to enucleate the enlarged prostate regardless of the gland size. In our series the catheterization time and hospital stay were 1.4 and 1.5 days, respectively. At 1 year after HoLEP there were 75% and 201% improvements in symptom score and Qmax, respectively[36]. The prostate volume and PSA reduction after HoLEP ranged from 62 to 77% and from 83 to 91%, respectively. This dramatic reduction of PSA after HoLEP confirms nearly complete removal of the adenoma[37].

Morbidity

Very recently, Shah et al. reported on the peri-operative complications of their first 280 HoLEP patients. The morcellation device and laser malfunctioned in two patients each. Blood transfusion was required during HoLEP in one patient; other complications included capsular perforation (9.6%), superficial bladder mucosal injury (3.9%) and ureteric orifice injury (2.1%). Blood transfusion was needed after HoLEP in 1.4% of patients and cystoscopy with clot evacuation in 0.7%. Transient urinary incontinence was the commonest complication after HoLEP (10.7% of patients), but resolved spontaneously in all except two (0.7%). Other rare complications were re-catheterization (3.9%), UTI (3.2%), epididymitis (0.7%), meatal and submeatal stenosis (2.5%), bulbar urethral stricture (2.1%) and bladder neck contracture (0.35%)[38].

In another report on the morbidity of 206 patients who underwent HoLEP, the rate of transfusion was 1%, capsular perforation occurred in 1.5% and bladder mucosal injuries in 1.9% of patients. Re-catheterization, bladder neck contracture and urethral stricture occurred in 7.8%, 3.9% and 2.4% of patients, respectively[39]. In a recent review of HoLEP in 1847 patients, the reported complications were transfusion (1%, range from 0 to 1.8%), re-catheterization (2.7%, range from 0 to 7.7%), UTI (2.7%, range from 1.1 to 6%), urethral stricture (1.9%, range from 0 to 7%), bladder neck contracture (1.5%, range from 0 to 3.8%) and re-operation (1.8%, range from 0.3 to 4.2%)[4].

HoLEP vs. TURP and open prostatectomy

Several randomized trials have shown comparable results of HoLEP and standard surgery (Table 3). In a study comparing HoLEP with TURP, the IPSS improved from 26.0 ± 1.1 to 4.6 ± 0.7, and from 23.7 ± 1.2 to 4.7 ± 0.9, the QoL improved from 4.8 ± 0.2 to 1.5 ± 0.5, and from 4.7 ± 0.2 to 1.4 ± 0.3, the Qmax increased from 8.4 ± 0.5 to 21.3 ± 2.1 ml/s, and from 8.3 ± 0.4 to 18.9 ± 2.8 ml/s in the HoLEP and TURP groups, respectively, at 1-year follow-up. There was no blood transfusion needed in the HoLEP group, but in the TURP group the transfusion rate was 3.3%[40]. In another comparative study, HoLEP and TURP were equally effective with similar complication rates at 1-year follow-up. In the HoLEP compared with TURP groups, respectively, the mean PDetQmax significantly decreased from 77.3 (range 41–145) to 36.2 (range 18–95) and from 81.8 (range 41–147) to 38.5 (range 16–75), and the Schäfer grade of obstruction significantly decreased from 3.4 (range 2–6) to 0,9 (range 1–4) and from 3.5 (range 2–6) to 1.2 (range 0–4)[41].

Table 3. Results of randomized trials comparing HoLEP and traditional surgery

Authors	No. of patients	Symptom score		Peak flow (ml/sec)		Follow-up (Months)
		Preop.	Preop.	Preop.	Preop.	
Tan et al.[45]						
HoLEP	31	26	4	8.4	21.8	12
TURP	30	23	5	8.3	18.4	12
Montorsi et al.[46]						
HoLEP	52	21.6	4.1	8.2	25.1	12
TURP	48	21.9	3.9	7.8	24.7	12
Kuntz et al.[43]						
HoLEP	100	22.1	1.7	4.9	27.9	12
TURP	100	21.4	3.4	5.9	27.7	12
Gupta et al. [42]						
HoLEP	50	23.4	5.2	5.1	25.1	12
TURP	50	23.3	5.6	4.5	23.7	12
TUVRP	50	24.9	5.4	4.6	23.6	12
Moody and Lingeman[47]						
HoLEP	10	19	6.3	na	na	8
Open prostatectomy	10	22.4	3.3	na	na	8
Kuntz and Lehrich[48]						
HoLEP	60	22.1	2.4	3.8	29.9	6
Open prostatectomy	60	21	2.8	3.6	27	6
Naspro et al. [49]						
OLEP	41	20.1	7.9	7.8	19	24
Open prostatectomy	39	21.6	8.2	8.3	20	24

na= not available

Gupta et al.[42] compared HoLEP, TURP and TUVP in patients with mean prostate volumes of 57.9 ± 17.6 cc, 59.8 ± 16.5, and 62.6 ± 14.8 cc, respectively. At 1 year post-operatively, the mean IPSS improved from 23.4 to 5.2, from 23.3 to 5.6, and from 24.9 to 5.4 in the HoLEP, TURP and TUVP groups, respectively. The mean Qmax increased from 5.1 to 25.1 ml/s, from 4.5 to 23.7 ml/s, and from 4.6 to 23.6 ml/s in the HoLEP, TURP and TUVP groups, respectively. Patients in all groups had a statistically significant improvement from baseline at 6 months and at 1 year, the maximum being in the HoLEP group ($P<0.001$). However, the differences among the groups compared at both times were not significant.

HoLEP improved the symptom score by 13-fold and TURP improved the symptom score by about 5-fold, whereas the Qmax improved by 5-fold in each group. The mean PVR decreased by 98% in the HoLEP and 88% in the TURP group. Of the sexually active patients, 74% in the HoLEP group and 70.3% in the TURP group had retrograde ejaculation. The operative time of HoLEP was 25% longer than TURP, which is explained by the use of the electrocautery loop to fragment the tissue in most of the HoLEP cases at the beginning of their study until the tissue morcellator became available[43].

In a systematic review of holmium laser prostatectomy Tooher et al. found that, at 6 months post-operatively, there was no significant difference between the holmium laser procedures and TURP, but at 12 months post-operatively the mean Qmax after holmium laser prostatectomy was 4.2

ml/s higher than after TURP. The authors concluded that HoLEP has at least equivalent functional results to TURP in the short term[44].

Comparing HoLEP with open prostatectomy, Kuntz et al. reported equivalence of the procedures in terms of efficacy with less peri-operative morbidity, shorter catheterization time and hospital stay in the HoLEP group. The operative time was longer in the HoLEP group (135 vs. 90 minutes) with a lesser amount of tissue retrieved. The blood transfusion rate was 13% in the open prostatectomy group and none in the HoLEP group[48,50]. Recently, Naspro and associates reported a shorter mean operating time in the open prostatectomy group (72 min vs. 58 min, $p<0.0001$); however, catheter removal (1.5 vs. 4.1 days, $p<0.001$) and hospital stay (2.7 vs. 5.4 days, $p<0.001$) were shorter in the HoLEP group. Blood loss was less and blood transfusions were fewer in the HoLEP group ($p<0.001$). The improvement in voiding parameters and urodynamic findings were comparable between the two groups. Late post-operative complications were similar in the two groups[49].

HoLEP in high-risk patients

HoLEP can be safely used in treating critically ill and anticoagulated patients, with low peri-operative complications, regardless of the prostate size. Pedraza et al. reported on 40 critically ill patients with major co-morbidity who underwent HoLEP. There were no significant changes in Hb (8.7 g/L to 8.5 g/L) or Na (135 mmol/L to 137 mmol/L). One patient was returned to the operating room for bleeding, two patients required post-operative blood transfusions[51]. In our HoLEP series we treated 83 patients on oral anticoagulants (warfarin) or with a bleeding disorder. Fourteen of them underwent HoLEP without withdrawal of their anticoagulants, 33 patients temporarily stopped the anticoagulants and 34 were on heparin substitution. No major complications or thromboembolic events were reported, and only 1 patient required intra-operative platelet transfusion and 7 required blood transfusion early in the post-operative period due to hematuria coinciding with restarting oral anticoagulant therapy. The transfusion rate was higher in the anticoagulated group than in the rest of the patients (9.6% vs. 1.9%)[52]. Lower blood loss after HoLEP is owing to the excellent hemostatic properties of the holmium laser and to the nature of the enucleation technique, as it cuts the feeding vessels of the enucleated adenoma only once, whereas during TURP the same vessel is cut several times during resection, leading to more hemorrhage[33].

HoLEP in patients with urinary retention

Peterson et al. reported on 164 patients with urinary retention who underwent HoLEP. The mean prostate volume was 107 cc and all of the patients were able to void post-operatively and remained catheter-free. The post-operative complications were minimal and the catheterization and hospitalization times were 33.7 and 22.5 hours, respectively[53]. In our series of 169 patients with urinary retention, only three patients (1.7%) with a decompensated bladder were unable to void post-operatively. The IPSS had improved from 19.3 (range 8 to 35) to 4.1 (range 0 to 26), the PVR urine volume had decreased from 670 ml (range 132 to 2000) to 35.7 ml (range 0 to 156), and the Qmax had increased from 6.05 to 19.9 m/s at 3 years after HoLEP[54].

Durability of HoLEP

Recently, Gilling et al. reported on the 6-year follow-up of 71 HoLEP patients. The mean IPSS for this group was 8.5 (range: 0-24), the Qmax was 19 (range 6-28) ml/s and the QoL score was 1.8 (range 0-5). One patient (1.4%) had undergone re-operation with HoLEP. Overall, 92% were either satisfied or extremely satisfied with their outcome[55]. At 5 years follow-up of 42 HoLEP and 32 open prostatectomy patients, Kuntz et al. reported a mean AUA symptom score of 3 in both groups ($p=0.98$), and a mean Qmax of 24.4 ml/s in both groups ($p=0.97$). Late complications consisted of urethral strictures and bladder neck contractures; re-operation rates were 5% in the HoLEP and 6.7% in the open prostatectomy group (p=1.0). No patient developed BPH recurrence[56]. This low re-treatment rate after HoLEP is owing to near complete removal of the adenoma, as it follows the plane between the adenoma and the surgical capsule, allowing anatomical enucleation of the prostatic adenoma.

Learning curve of HoLEP

The prolonged learning curve is the main reason for the lack of widespread acceptance of HoLEP. This could be due to a lack of tutoring in HoLEP offered by the manufacturing companies in most countries, and therefore learning the procedure is left exclusively to the interested urologists. Under supervision of an expert, it is generally agreed that about 30 cases are required for a urologist familiar with transurethral surgery to feel reasonably safe performing the HoLEP technique[57]. The beginner should start with enucleation of small to moderate-sized prostates or start with HoLAP to acquire laser surgery skills and gain confidence, and then progress to resection and HoLEP. The surgeon can always switch to TURP, if it is necessary[4]. We believe that if the urologist follows this instruction the learning curve can be accomplished rapidly, and it will certainly be shorter than for other urologic procedures such as laparoscopic surgery.

Cost effectiveness of HoLEP

Several studies showed that laser prostatic surgery provides short hospital stay and low morbidity, so it may be considered more cost-effective than standard surgery.

In a cost analysis study comparing HoLEP and open prostatectomy, the most significant cost factors were the operative time (average 16.1% and 25.1% to the cost of open prostatectomy (n=29) and HoLEP (n=34), respectively), and the length of post-operative hospital stay (average 53.3% and 32.0% to the cost of open prostatectomy and HoLEP, respectively). Overall, the hospitalization cost of HoLEP was 9.6% less than that for open prostatectomy. Cost analysis showed that the mean peri-operative cost per patient is €2868.9 (US$3556.3) for open prostatectomy and €2356.5 (US$2919.4) for HoLEP[58].

A study from New Zealand comparing holmium laser resection of the prostate and TURP in terms of cost-effectiveness concluded that HoLRP offers 24.5% cost saving over TURP, and when 93 procedures are performed annually, this would cover the initial and maintenance costs of the laser equipment[59]. Furthermore, the high-powered holmium laser is a multifunctional endourologic instrument.

At current prices, a 100-W holmium laser costs about €90,000, a morcellator about €15,000. However, once the system has been purchased, the costs per case are low, because a laser fiber (€400) can be re-sterilised and used in about 20 patients, depending on their prostate size. The re-usable end-firing fiber is considered as one of the advantages for HoLEP over PVP and HoLAP. Although the purchase costs of both lasers are in the same range, the KTP laser fiber (€ 500) is designed for single use only and in large prostates two or even three fibers may be necessary. That means that the HoLEP holmium fiber costs per patient are 5% of the KTP fiber costs[4].

THULIUM LASER (TH: YAG) VAPORIZATION/RESECTION OF THE PROSTATE

Thulium lasers operate at wavelengths between 1.75 μm and 2.22 μm, which is close to the peak absorption of water, making them a good choice for tissue ablation The lasing medium is the thulium-doped silica optical fiber, which is pumped by a diode laser, thus it can operate in continuous-wave/pulsed modes and allows precise incision, vaporization and coagulation of the tissue[60]. One of the advantages of this new laser is the tunable wavelength technology, allowing adjustment of laser output for different tissue depth. In a study that described Th:YAG laser (110 W) ablation of canine prostate, tissue was vaporized at a rate of 0.8 g/min with thermal coagulation zones of 0.5 to2 mm, suggesting a potential for hemostasis[61].

Recently Bach et al. reported a clinical study of 70 Watt Th: YAG laser (RevoLix™ LISA laser products, Katlenburg, Germany) in vaporesection (simultaneous resection and vaporization of the tissue) of the prostate in 54 patients. The mean pre-operative prostatic volume was 30.3 (range 12–38) cc and average resection time was 52 (range 28–72) minutes. Mean catheter time was 1.7 (range 1–3) days, and the authors reported a tissue ablation of approximately 1.5 g/min at the conclusion of their learning curve. At 12 months follow-up the mean Qmax significantly improved from 4.2 to 20.1 ml/s and the mean PVR decreased from 86 to 12 ml. The IPSS and QoL score improved from 19.8 to 6.9 and 4 to 1, respectively. The complication rate was very low, with only six patients showing UTI with irritative symptoms 1–2 weeks post-operatively[62].

In a randomized trial comparing Th: YAG laser prostate resection (n=52) to TURP (n=48), the mean prostate volume was 59 and 55 cc, respectively. Th: YAG laser resection was significantly superior to TURP in terms of catheterization time (45.7 ± 25.8 vs. 87.4 ± 33.8 hours, $p < 0.0001$), hospital stay (115.1 ± 25.5 vs. 161.1 ± 33.8 hours, $p < 0.0001$), and drop in hemoglobin (0.92 ± 0.82 vs. 1.46 ± 0.65 g/dl, $p< 0.001$), whereas it required an equivalent time to perform (46.3 ± 16.2 vs. 50.4 ± 20.7 minutes, $p >0.05$). Both procedures resulted in significant improvement in functional results. One year after the operation, the mean IPSS improved 6-fold in the Th: YAG laser group and more than 5-fold in the TURP group. QoL and Qmax improved about 5-fold and 3-fold, respectively, in each group. The PVR volume decreased by 94% in the Th: YAG laser group and 93% in the TURP group. In the TURP group, one case of TUR syndrome was observed. Blood transfusion was required in two patients after TURP and in one of Th: YAG laser group. At 1 month follow-up 4% of the laser group and 8% of the TURP group were diagnosed with UTI. At 12 months follow-up only one case of urethral stricture was observed in the laser group compared with three cases (6.3%) in the TURP group[63]. These initial results are promising, but further studies of Th: YAG laser prostatectomy and longer-term follow-up are needed to evaluate the procedure.

In conclusion, laser vaporization techniques such as HoLAP and PVP are simple and easy procedures. Both are safe and effective in the treatment of symptomatic BPH. They quickly relieve bladder outlet obstruction symptoms and have a low rate of intra-operative and post-operative complications. Generally, laser vaporization techniques and laser prostatic surgery are ideally suited for the treatment of high surgical risk and anticoagulated patients. Holmium laser has multiple applications in urology and its use in the treatment of BPH is considered a true challenge for TURP as well as open prostatectomy. HoLEP has equivalent or superior results compared with traditional surgery and vaporization techniques, and it is being promoted as the size-independent new gold standard for the treatment of BPH. HoLEP is safe and effective, with low morbidity and short catheterization time and hospital stay. It produces sustained improvement of objective and subjective parameters. The initial results of Th:YAG laser prostatectomy appear promising, but randomized trials with long-term follow-up are required.

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