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ORIGINAL ARTICLE

Transurethral thulium laser enucleation versus resection of the prostate for treating benign prostatic hyperplasia: a retrospective study

Ruan Yuan[1] · Yang Boyu[1] · Zhao Fujun[1] · Jiang Chengyi[1] · Jing Yifeng[1] · Wang Xiaohai[1] · Cui Di[1] · Xia Shujie[1] · Han Bangmin[1]

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Abstract

This study aimed to compare the clinical outcomes between transurethral thulium laser enucleation of the prostate (ThuLEP) and transurethral thulium laser resection of the prostate (ThuLRP) for treating benign prostatic hyperplasia (BPH). From May 2014 to August 2015, 212 patients underwent ThuLRP and 188 patients underwent ThuLEP. The ThuLEP group was further divided into two subgroups according to the ways the prostate was taken out. The perioperative parameters were recorded and analyzed. The international prostate symptom score (IPSS), quality-of-life (QoL) score, maximum flow rate (Qmax), and postvoid residual urine volume (PVR) in both groups were estimated and compared 3, 6, and 12 months after surgery. No significant difference was observed between the groups in terms of irrigated time, irrigated volume, catheterization time, and hospital stay. However, the significantly lower hemoglobin drop was observed in the ThuLRP group compared with the ThuLEP group. The ThuLEP group with a morcellator required a shorter operation time for patients with large prostate volume (> 60 mL) compared with the ThuLRP and ThuLEP groups without a morcellator. During 12 months of follow-up, IPSS, Qmax, QoL, and PVR improved significantly without significant differences between the groups. No severe complications were reported; however, the occurrence of transient urge incontinence was higher after ThuLEP compared with ThuLRP, and the proportion of urinary tract infection after surgery was higher in ThuLRP than in ThuLEP. ThuLRP and ThuLEP are safe and efficient for treating patients with symptomatic BPH. ThuLRP offers advantages in terms of minimal blood loss.

Keywords Benign prostatic hyperplasia · Laser surgery · ThuLEP · Thulium:YAG · ThuLRP

Introduction

Benign prostatic hyperplasia (BPH) is a highly frequent disease in aging men. It is the major etiology of lower urinary tract symptoms (LUTS) and bladder outlet obstruction, which have a serious impact on the patients' quality of life (QoL) [1].

Although transurethral resection of the prostate (TURP) is still considered the gold standard of surgical treatment, it is associated with substantial morbidity [2]. A variety of laser systems and techniques for treating BPH have been introduced with decreased blood loss, shorter catheterization, and reduced morbidity to overcome these problems [3]. Due to its accurate thermal effect, the laser promotes the coagulation and hemostasis of tissues and reduces thermal damage range. In recent years, laser has become a pivotal surgical method to relieve moderate-to-severe urinary tract obstruction caused by prostatic hyperplasia. Holmium laser enucleation of the prostate (HoLEP) is strongly recommended for men with moderate-to-severe LUTS due to its higher intraoperative safety and shorter catheterization time and hospital stay compared with TURP and open prostatectomy (OP). Three kinds of 532-nm "Greenlight" laser vaporization of the prostate, including 80-W kalium-titanyl-phosphate (KTP) laser and 120-W and 180-W lithium borate (LBO) lasers, also become alterative options to TURP.

Ruan Yuan and Yang Boyu contributed equally to this work.

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✉ Xia Shujie
xsjurologist@163.com

✉ Han Bangmin
hanbm@163.com

[1] Department of Urology, Shanghai General Hospital, Shanghai Jiao Tong University School of Medicine, 85 Wujin Road, Shanghai 200080, China

The high-power continuous-wave thulium laser was first introduced in 2005 for treating BPH [4]. Thulium laser resection of the prostate (ThuLRP) is a transurethral procedure that uses thulium laser fiber to vaporize and resect the prostate into small pieces, which is small enough to evacuate through the resectoscope sheath without the use of a morcellator. It is superior to TURP in safety and as efficacious as TURP [5]. On the basis of intensively studied HoLEP, which challenges the widely accepted BPH treatment options, thulium laser enucleation of the prostate (ThuLEP) is also a bloodless procedure with high efficacy for treating BPH with little perioperative morbidity [6]. ThuLEP employs the apical incision of prostatic tissue down to the surgical capsule using a thulium laser and blunt enucleation with the resectoscope sheath. A morcellator sometimes is required for removing the prostatic tissue.

According to the recent AUA and EAU guidelines, ThuLEP is recommended as a prostate size-independent suitable option to resolve BPH [7, 8]. Moreover, ThuLEP has higher intraoperative safety with regard to hemostatic properties, and its short-term results are similar to those of TURP. Therefore, it can be used as an alternative to TURP.

A few reports comparing ThuLRP with ThuLEP are available. Therefore, it is difficult to choose a surgical method using a thulium laser. This retrospective study was a comparative assessment of the efficacy and safety of these two surgical process in treating BPH.

Material and methods

Patients

Following the institutional review board approval, 212 patients underwent ThuLRP, and 188 patients underwent ThuLEP in a retrospective trial in a single clinical center between May 2014 and August 2015. Both procedures were performed by a single-experienced surgeon. Before surgery, all patients underwent a complete urologic evaluation, including history, physical examination, digital rectal examination, international prostate symptom score (IPSS), QoL, serum prostate-specific antigen (PSA), prostate volume evaluation by transrectal ultrasound, postvoid residual urine volume (PVR), and maximum flow rate (Qmax). The urodynamic test was also performed.

Inclusion criteria were as follows: age < 80 years, IPSS ≥ 12, Qmax ≤ 15 mL/s, and adenoma volume > 30 g. Exclusion criteria were as follows: LUTS resulting from conditions other than BPH, neurogenic bladder, prostate cancer or PSA > 4 ng/mL, and any previous prostatic, bladder neck, or urethral surgery.

Equipment and surgical techniques

All operations were carried out using the RevoLix Thulium:YAG (LISA laser products, Katlenburg, Germany) with a continuous wave of 2 μm. The laser fiber was a multiple-use optical 550 μm fiber (RigiFib, LISA laser products). The energy of the laser used for enucleation and resection was 60 W and 120 W, respectively.

The ThuLRP was performed as previously described [5]. In brief, all patients were placed in the lithotomy position, and general anesthesia was achieved. Thulium lasers with an average power of 120 W, operating in a continuous-wave mode, were used for this procedure. The laser fibers were introduced using a Karl Storz 26F continuous-flow resectoscope. Irrigation with a 0.9% sodium chloride solution was used in all procedures.

The technique of ThuLEP was similar to the previously described operations by Herrmann [6]. The ThuLEP group was divided into two groups according to the different ways the prostate was taken out. In one group, the prostatic adenoma was left connected to the bladder neck and then resected and vaporized using thulium lasers with an average power of 120 W and carried out using an Ellik evacuator. In the other group, the prostatic adenoma was left in the bladder and taken out using a tissue morcellator (YSB-III, Hawk, Hangzhou, China).

At the end of both procedures, a three-way Foley catheter (22 or 24 French) was placed into the bladder to provide intermittent or continuous irrigation. All tissue retrieved from each patient was investigated histologically. According to the Chinese guidelines for the use of antibiotics, patients are recommended to use quinolones 30 min before surgery and one to two times within 48 h after surgery. If a patient shows signs of infection later, appropriate antibiotics should be used based on the results of bacterial culture and drug sensitivity.

Follow-up and assessment

Perioperative outcomes, including operation time, decrease in hemoglobin, irritated time, irrigated volume, postoperative catheterization time, and hospital length of stay, were recorded. Patients were invited for a follow-up visit 3, 6, and 12 months after the surgery and examined for IPSS, QoL, Qmax, PVR, and incidence of complications.

Statistical analysis

All parameters were presented as mean ± standard deviation. Student *t* test and analysis of variance were used to compare perioperative parameters. The chi-square test was used to compare postoperative parameters, such as IPSS, QoL, Qmax, and PVR. A P value < 0.05 was considered statistically significant. The statistical analysis was performed using SPSS 19.0 (SPSS Inc., IL, USA) analytical software.

Results

Of the 400 patients included in this study, 212 underwent ThuLRP and 188 underwent ThuLEP. The preoperative

characteristics of the two groups were comparable regarding age, IPSS, QoL, prostate volume, PSA, Qmax, and PVR (Table 1). No statistically significant difference was found between the two groups. No apparent difference was found in comorbidities, such as hypertension, coronary heart disease, and so on, between the two groups. The perioperative outcomes are listed in Table 2. The superior effect of vaporization and hemostasis led to a significantly lower hemoglobin drop during ThuLRP than during ThuLEP (0.3 ± 0.04 vs 0.7 ± 0.03 g/dL, $P < 0.01$). Perioperative outcomes of 400 patients who underwent ThuLRP or ThuLEP (with or without a morcellator) stratified by prostate size were further analyzed (Table 3). ThuLEP with a morcellator required a shorter operation time (62.9 ± 5.5 vs 73.3 ± 6.0 or 72.3 ± 5.8 min, $P < 0.01$) for patients with large prostate volume (> 60 mL), compared with ThuLRP and ThuLEP without a morcellator. No statistically significant difference was observed in irrigated time, irrigated volume, catheterization time, and hospital stay.

No patient was lost to the follow-up. The parameters of the operation efficacy measured on IPSS, QoL, Qmax, and PVR revealed improvement at the 3-, 6-, and 12-month follow-ups. No statistical difference was found between the two groups in these parameters (Fig. 1a–d).

Complications during the follow-up included the injury of bladder mucosa, early acute retention, transient urge incontinence, symptomatic urinary tract infection, urethral stricture, and stress incontinence (Table 4). No patients needed a blood transfusion. Bladder mucosa injury occurred in three patients (1.6%) of the ThuLEP group compared with the ThuLRP group, which was usually caused during the morcellation of enucleated tissue. Five patients (2.3%) of the ThuLRP group and one patient (0.5%) of the ThuLEP group experienced acute urinary retention after catheter removal, requiring transient re-catheterization. Further, 32 patients (15.1%) of the ThuLRP group and 15 patients (7.9%) of the ThuLEP group were diagnosed with urinary tract infection. Three patients (1.4%) of the ThuLRP group and two patients (1.1%) of the ThuLEP group developed a urethral stricture, which required urethral dilatation. Transient urge incontinence occurred in 15 patients (7.1%) of the ThuLRP group and 25 patients (13.2%) of the ThuLEP group during the early perioperative period.

Table 1 Patient characteristics and preoperative values

Parameters	ThuLRP ($n = 212$)	ThuLEP ($n = 188$)	P value
Age (year)	54.2 ± 5.2	57.1 ± 5.5	0.334
IPSS	20.8 ± 3.0	21.1 ± 2.8	0.093
QOL	4.3 ± 0.8	4.2 ± 0.7	0.128
Prostate volume (mL)	56.2 ± 24.3	53.7 ± 22.5	0.332
PSA (ng/mL)	3.2 ± 2.1	3.4 ± 1.8	0.288
Qmax (m/s)	9.1 ± 2.8	8.6 ± 3.2	0.365
PVR (mL)	55.4 ± 33.8	60.3 ± 31.4	0.283

Table 2 Perioperative data

Parameters	ThuLRP ($n = 212$)	ThuLEP ($n = 188$)	P value
Operative time (min)	58.3 ± 16.4	52.5 ± 10.3	0.085
Irrigation time (h)	16.3 ± 6.8	15.8 ± 7.0	0.336
Irrigated volume (L)	18.2 ± 2.6	16.9 ± 2.0	0.185
Hb decrease (g/dL)	0.3 ± 0.04	0.7 ± 0.03	< 0.01
Catheterization (h)	56.7 ± 6.3	52.3 ± 5.3	0.093
Hospital stay (d)	6.4 ± 1.2	5.8 ± 1.3	0.144

One case (0.5%) of stress incontinence was observed in the ThuLEP group during the late period.

Discussion

BPH is the main cause of lower urinary tract obstruction in elderly men, and surgical treatment is still the most effective method to treat BPH. Although TURP is still considered the gold standard of surgical treatment, laser prostatectomy has become increasingly popular due to reduced morbidity, shorter catheterization, and decreased hospitalization time [9]. The thulium laser works in a continuous-wave mode at a wavelength of 2013 nm, close to the peak absorption of water, resulting in reduced damage to surrounding tissues. Furthermore, it offers efficient vaporization and hemostatic features, which can reduce blood loss and provide relatively clear vision during operation [5, 10]. The thulium laser has been used in prostate surgery for nearly 10 years, and the main mode of operation currently used involves ThuLRP and ThuLEP [5, 6, 10, 11].

Fried first reported thulium laser vaporization of canine prostates in 2005 [4]. The thulium laser resection of the prostate tangerine technique (ThuLRP-TT) was introduced by Xia et al. [5]. The ThuLRP-TT technique is designed to join the incision by making a transverse cut from the level of verumontanum to the bilateral bladder neck, making the resection deep enough to the surgical capsule and resecting the prostate into small pieces, similar to peeling a tangerine. The pieces of the prostate were vaporized small enough to be flushed out through the resectoscope sheath directly without the need for a tissue morcellator. All the patients of the ThuLRP group in this study used the ThuLRP-TT technique. Compared with TURP, ThuLRP-TT demonstrates reduced hemoglobin loss, decreased catheterization time, and decreased hospital stay, while with the same treatment effect [5, 10, 12]. The ThuLRP-TT is still a safe, effective, and minimally invasive treatment for patients with large prostates or acute urinary retention [13, 14].

The HoLEP has been studied intensively and challenges the widely accepted treatment options such as TURP or open prostatectomy [15]. The ThuLEP, as pioneered by Bach et al.

Table 3 Perioperative data stratified by prostate size

Parameters	Prostate volume < 60 mL ($n = 248$)				Prostate volume ≥ 60 mL ($n = 152$)			
	ThuLRP ($n = 144$)	ThuLEP with morcellator ($n = 46$)	ThuLEP without morcellator ($n = 58$)	*P* value	ThuLRP ($n = 68$)	ThuLEP with morcellator ($n = 52$)	ThuLEP without morcellator ($n = 32$)	*P* value
Operative time (min)	38.2 ± 5.8	42.8 ± 4.7	40.6 ± 5.4	0.058	73.3 ± 6.0	62.9 ± 5.5	72.3 ± 5.8	< 0.01
Irrigation time (h)	13.6 ± 3.8	14.2 ± 3.6	13.8 ± 3.3	0.108	19.2 ± 5.7	18.5 ± 6.0	18.2 ± 5.5	0.225
Irrigated volume (L)	16.5 ± 2.2	15.2 ± 1.8	16.1 ± 2.0	0.325	20.2 ± 3.2	18.7 ± 2.9	19.7 ± 3.1	0.089
Hb decrease (g/dL)	0.23 ± 0.18	0.37 ± 0.10	0.35 ± 0.31	< 0.01	0.6 ± 0.4	1.1 ± 0.6	1.0 ± 0.6	< 0.01
Catheterization (h)	52.2 ± 6.0	51.5 ± 5.3	48.9 ± 5.2	0.396	62.5 ± 6.5	57.5 ± 5.8	58.9 ± 5.7	0.118
Hospital stay (d)	6.0 ± 1.5	5.4 ± 1.2	5.6 ± 1.5	0.185	6.9 ± 2.1	6.2 ± 2.0	6.1 ± 2.1	0.077

[11] and Herrmann et al. [6], is a new type of surgical treatment that recently has been applied in urology and showed stability in Qmax improvement, satisfactory rise in the QoL, and decrease in IPSS. Compared with the plasmakinetic bipolar resection of the prostate, ThuLEP offers advantages in terms of intraoperative safety, minimal blood loss, less irrigation, shorter catheterization, and shorter hospital stay, but needs a longer operation time [16]. Shao et al. reported that the follow-up results of ThuLEP, especially the improvement in Qmax and IPSS, were comparable to those of HoLEP, and with better hemostasis [17]. ThuLEP employs the apical incision of prostatic tissue down to the surgical capsule using the thulium laser and blunt enucleation with the resectoscope sheath. A morcellator was always required for removing the prostatic tissue in previous studies [15–17]. In this study, the ThuLEP group was divided into two groups according to the different ways the prostate was taken out. In one group, the enucleated prostatic tissue was retained connected to the neck of the bladder, vaporized, and resected into multiple small prostate chips, which were subsequently irrigated from the bladder through the sheath. In the other group, the prostatic adenoma was taken out using a tissue morcellator. The superior effect of vaporization and hemostasis led to a significantly lower hemoglobin drop during ThuLRP than during ThuLEP. The thulium laser techniques of removing prostatic tissue by vaporesection efficiently avoid the higher risk of complications caused by morcellation (e.g., bladder mucosa injury and technical troubles with morcellator tightness) and get rid of dependence on a morcellator [6]. Since ThuLEP mainly relies on the mechanical force of the cystoscope sheath, the actual working time of the laser is relatively short, but the laser is activated most of the time during ThuLRP. Therefore, it is believed that it is more meaningful to compare the total operation time rather than the laser activation time of these two methods.

The analysis of significant difference in the operation time between the groups showed that ThuLEP with a morcellator required a shorter operation time for patients with large prostate volume (> 60 mL) compared with ThuLRP and ThuLEP

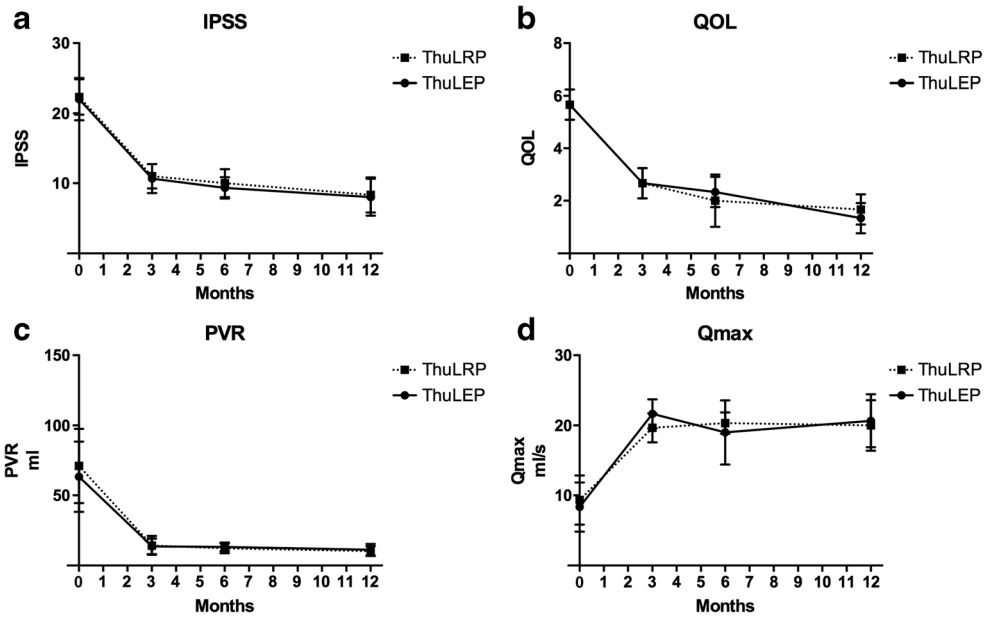

Fig. 1 **a**–**d** Operation efficacy measured on IPSS, QoL, Qmax, and PVR

Table 4 Early and late complications

Complications	ThuLRP, *n* (%)	ThuLEP, *n* (%)	*P* value
Early			
Bladder mucosal injury	0	3 (1.6%)	0.065
Reoperation for bleeding	0	0	1
Early acute retention	5 (2.3%)	1 (0.5%)	0.134
Transient urge incontinence	15 (7.1%)	25 (13.2%)	0.038
Urinary infection	32 (15.1%)	15 (7.9%)	0.027
Late			
Urethral stricture	3 (1.4%)	2 (1.1%)	0.752
Stress incontinence	0	1 (0.5%)	0.288

without a morcellator. However, no statistically significant difference was found between the groups for patients with small prostate volume (< 60 mL). ThuLRP required a longer operation time in patients with large prostate volume because the time of surgery was prolonged by the time of cutting prostatic tissue into small pieces. Although the laser enucleation of the prostate is reported to need a prolonged learning curve of the enucleation technique and prolonged operative time compared with TURP or open prostatectomy, experienced surgeons determining the speed and manner of performance could shorten the operative time [18]. It was presumed that tissue removal time during surgery in patients with ThuLEP without a morcellator was longer compared with ThuLEP with a morcellator in patients with large prostate volume because the enucleated prostatic tissue was resected and vaporized by thulium lasers using an Ellik evacuator instead of a morcellator. The operative time could be saved if a morcellator was applied but with the increased risk of complications.

The statistically significant hemoglobin drop also deserves attention. Whether it was for a large- or small-volume prostate, the superior effect of vaporization and hemostasis led to a significantly lower hemoglobin drop during ThuLRP than during ThuLEP (with or without a morcellator). However, no patient needed a blood transfusion. The 120-W thulium laser in the ThuLRP group used for resection is excellent for controlling bleeding, without special hemostasis during resection [5]. The ThuLEP group depended mainly on the blunt separation with the resectoscope sheath, and the blood vessel in the prostate capsule was easy to bleed, which needed special hemostasis and led to the increased amount of hemoglobin loss during surgery. No statistically significant difference was noted in irrigated time, irrigated volume, catheterization time, and hospital stay between the two groups, which was consistent with the findings of previous studies.

No patient was lost to the 12-month follow-up, and both groups obtained comparable results in the postoperative urinary parameters of IPSS, QoL, Qmax, and PVR, demonstrating great improvement after the surgery. The condition of patients further improved or was sustained during the observation. No serious complications occurred during the follow-up. However, three patients (1.4%) of the ThuLRP group and two patients (1.1%) of the ThuLEP group developed a urethral stricture, mainly the urethral orifice stenosis, which might be related to the conditions of patients' urethra, and the diameter and length of the catheter. The incidence of urinary tract infection was higher in the ThuLRP group than in the ThuLEP group, and was noticed within 2 weeks after the surgery, which may be related to the repair process of the wound. Further RCTs are required to find its specific reasons. Symptoms usually can be controlled using antibiotics and nonsteroidal anti-inflammatory drugs.

Conclusions

In conclusion, this retrospective study showed no significant difference in the clinical outcomes of ThuLEP and THuLRP. Therefore, the choice of a flexible mode of operation depended on different conditions of patients in clinical practice. It seems better to choose ThuLEP with a morcellator for patients with a large-volume prostate, whereas ThuLRP may be more tolerated by elderly and high-risk patients. Whether these inconspicuous differences have a certain clinical significance still requires further verification using RCTs with a long-term follow-up and a large sample size.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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