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ORIGINAL ARTICLE

Comparison of thulium laser enucleation and plasmakinetic resection of the prostate in a randomized prospective trial with 5-year follow-up

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Abstract The aim of this study was to compare the clinical outcomes between thulium laser enucleation of the prostate (ThuLEP) and plasmakinetic bipolar resection of the prostate (PKRP) for treating benign prostatic hyperplasia (BPH) in a prospective randomized trial with 5 years of follow-up. One hundred fifty-eight consecutive patients with BPH were randomized to receive operation of either ThuLEP ($n = 79$) or PKRP ($n = 79$). All cases were evaluated preoperatively, and a part of them were evaluated at 3–5 years postoperatively by the International Prostate Symptom Score (IPSS), quality of life score (QoLS), maximum flow rate (Q_{max}), and postvoid residual (PVR) urine volume. Eighty patients completed the 5-year follow-up. Each study arm showed no significant difference in preoperative parameters. Compared with PKRP, ThuLEP required longer operation time (65.4 vs 47.4 min, $p = 0.022$) but resulted in less hemoglobin decrease (1.5 vs 3.0 g/L, $p = 0.045$), catheterization time (2.1 vs 3.5 days, $p = 0.031$), irrigated volume (12.4 vs 27.2 L, $p = 0.022$), and hospital stay (2.5 vs 4.6 days, $p = 0.026$). During the 60-month follow-up, both procedures demonstrated no significant difference in terms of Q_{max}, IPSS, PVR urine volume, and QoLS. ThuLEP was statistically superior to PKRP in blood loss, catheterization time, irrigated volume, and hospital stay but inferior to PKRP in operation time. However, both procedures showed no significant difference in terms of Q_{max}, IPSS, PVR urine volume, and QoLS through the 60-month follow-up.

Keywords BPH · TURP · PKRP · Thulium laser

Introduction

Benign prostatic hyperplasia (BPH) increases with age, and therefore with an aging society, the incidence will continue to increase significantly. BPH is extremely common but can cause significant harm [12]. The objective of surgical therapy for BPH is to eliminate bladder outlet obstruction with the lowest possible morbidity and the highest possible durability of improvement of symptoms and urinary flow.

Transurethral resection of the prostate (TURP) has been the gold standard endoscopic surgical treatment for BPH for over 30 years. Although significant technical improvements during the past 15 years have reduced intraoperative and postoperative adverse events, there are still concerns regarding complications such as TURP syndrome (TURPS), bleeding, and urethral stricture. Reich et al. demonstrated in a contemporary large-scale multicenter evaluation of 10,654 men a 30-day mortality rate of 0.1 % and an immediate morbidity rate of 11.1 % [14].

Several effective treatments, by using various thermal energy sources to ablate or coagulate prostate tissue, are available for BPH. One of such technical modifications of TURP is bipolar technology. Bipolar TURP technology, including plasmakinetic bipolar resection of the prostate (PKRP), addresses a fundamental flaw of traditional monopolar TURP by allowing performance in normal saline, permitting a longer resection time, and providing an improved hemostasis, thus enabling the surgeon to resect larger prostates without compromising safety [6]. Since the initial series by Starkman and Santucci [15], several randomized clinical trials have shown that bipolar TURP is as effective as monopolar

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TURP in improving micturition parameters, with no increase in the incidence of urethral strictures [4, 7, 18].

Another technical modification is laser therapy, which is increasingly marketed as a replacement for TURP. Published improvements of laser therapy over traditional TURP include lower blood loss [2], ability to treat larger glands [5], and elimination of the risk of TURPS [1]. The thulium laser is a new surgical laser, with a tunable wavelength of between 1.75 and 2.22 μm. Thulium laser enucleation of the prostate (ThuLEP) is almost a bloodless procedure with high efficacy for treating BPH and little perioperative morbidity [16, 17, 21].

In our former study, ThuLEP and PKRP both relieve lower urinary tract symptoms equally in short- to middle-term follow-ups [19]. The current study focuses on the efficacy and safety of ThuLEP and PKRP in treating BPH during long-term results.

Patients and methods

Patients

From May 2009 to June 2010, 158 BPH patients received surgical treatment with either ThuLEP ($n=79$) or PKRP ($n=79$), respectively. The study was approved by the Ethical Committee of Wuhan University and complied with the Code of Ethics of the World Medical Association (Declaration of Helsinki 1964 revised in 2003 and Declaration of Tokyo 1975 revised in 2006).

All participants had given informed consent before their inclusion in the study. Inclusion criteria were age <85 years, maximum urinary flow rate ($Q_{\max}$) <15 mL/s, postvoid residual (PVR) urine volume <150 mL, failure of medical therapy, and transrectal ultrasound (TRUS) volume <100 mL. Exclusion criteria were prostate volume <30 mL, documented or suspected prostate cancer, neurogenic bladder, bladder stone or diverticula, urethral stricture, and maximal bladder capacity >500 mL.

All patients were evaluated preoperatively by scoring subjective symptoms with the International Prostate Symptom Score (IPSS) and quality of life score (QoLS), a physical examination with digital rectal examination, laboratory analysis with total serum prostate-specific antigen, and TRUS measurement of prostate volume, PVR urine volume, and $Q_{\max}$ (with a volume voided >250 mL).

Equipment and techniques

The ThuLEP operations were performed according to the procedure described by Xia et al. [17]. In brief, all patients were in the lithotomy position, and epidural anesthesia was achieved. Thulium lasers with an average power of 100 W (LISA Laser Products OHG, Germany), operating in continuous-wave mode, were used for this procedure. The energy was delivered by way of 550-μm end-firing PercuFib fibers. 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 PKRP operations were performed with the Gyrus PlasmaKinetic (PK) System (Gyrus Medical Ltd., UK) according to a standard procedure. The irrigation fluid was also 0.9 % sodium chloride solution. The cutting setting was 160 W, and the coagulating power setting was 80 W. At the end of both procedures, a standard 22-F three-way catheter was inserted and connected to straight drainage. Bladder irrigation was necessary until hematuria sufficiently resolved. Procedures were performed or supervised by an experienced surgeon who had performed more than 500 cases of both procedures.

Follow-up and assessment

Perioperative outcomes, including operation time, decrease in hemoglobin, postoperative catheterization time, irrigation volume, hospital length of stay, and complications were recorded. The catheters were removed once the color of the urine was clear. The postoperative urinary parameters, including IPSS, QoLS, $Q_{\max}$, and PVR urine volume, were evaluated at 1, 3, and 5 years.

Statistical analysis

Changes in preoperative, perioperative, and postoperative outcome parameters are presented as mean ± standard deviation. Statistical analysis was performed using Student's t test to compare the preoperative and perioperative parameters, with p value <0.05 taken as statistically significant. Two-way repeated-measure analysis of variance was used to compare postoperative parameters, such as $Q_{\max}$, PVR urine volume, IPSS, and QoLS within each group. SPSS 11.5 software (SPSS Inc., Chicago, IL) was used for the statistical analysis.

Results

As shown in Table 1, the baseline characteristics in the two groups were comparable with regard to patient age, prostate-specific antigen level, adenoma volume, IPSS, $Q_{\max}$, and PVR urine volume. The perioperative data are listed in Table 2. The procedures were successfully performed in all patients. No TURPS occurred, and no patients needed a blood transfusion. During the first postoperative week, three PKRP patients and one ThuLEP patient experienced urinary retention caused by blood clot from the wound surface of prostate, which was managed by cystoscopy. Urethral and bladder neck stricture

Table 1 Patient characteristics and preoperative values of the two groups

Parameters	PKRP ($n = 79$), mean ± SD (range)	ThuLEP ($n = 79$), mean ± SD (range)	p value
Age, years	61.4 ± 6.9 (52–85)	62.4 ± 7.2 (51–85)	0.322
TRUS prostate volume, mL	69.2 ± 23.1 (41.2–96.5)	72.4 ± 21.2 (45.7–94.7)	0.081
Serum PSA, ng/mL	2.36 ± 1.24 (0.21–4.00)	2.45 ± 1.24 (0.31–4.07)	0.135
IPSS	23.4 ± 3.7 (11–35)	22.7 ± 4.3 (11–35)	0.081
Q_{max}[a], mL/s	9.1 ± 3.2 (4–14)	8.7 ± 2.8 (5–14)	0.143
PVR urine volume, mL	72.4 ± 28.1 (48–145)	79.5 ± 29.3 (51–140)	0.123

The results represent the mean ± SD

TRUS transrectal ultrasound, *PSA* prostate-specific antigen, *IPSS* International Prostate Symptom Score, *PVR* postvoid residual, *SD* standard deviation

[a] Maximum flow rate

were absent in both groups during follow-up. No patient had permanent urinary incontinence.

Compared with PKRP, ThuLEP required a longer operation time (65.4 vs 47.4 min, $p < 0.05$) but resulted in less hemoglobin decrease than PKRP (1.5 vs 3.0 g/L, $p < 0.05$), demonstrating the relatively lower volume of blood loss. ThuLEP also needed shorter catheterization time (2.1 vs 3.5 days, $p < 0.05$), less irrigation volume (12.4 vs 27.2 L, $p < 0.05$), and shorter hospital length of stay (2.5 vs 4.6 days, $p < 0.05$).

No patient was lost during the 1-year follow-up. A total of 80 patients completed the 5-year follow-up, 41 from the PKRP group and 39 from the ThuLEP group. Nine patients died of other diseases unrelated to LUTS. The others were lost to follow-up. The follow-up parameters are shown in Table 3. There were significant improvements of both groups in Q_{max}, PVR urine volume, IPSS, and QoLS of 5-year follow-up compared with the preoperative parameters ($p < 0.05$). However, at 1, 3, and 5 years postoperatively, improvement in these parameters between PKRP and ThuLEP groups showed no significant difference. The mean Q_{max} increased from 9.1 and 8.7 mL/s at baseline to 18.9 and 19.4 mL/s, respectively ($p > 0.05$). The mean PVR urine volume decreased from 74.2 and 79.5 mL to 32.6 and 34.9 mL, respectively ($p > 0.05$). The mean IPSS score decreased from 23.4 and 22.7 to 6.5 and 6.9, respectively ($p > 0.05$), and the mean QoL score decreased from 4.9 and 3.9 to 1.5 and 1.4, respectively ($p > 0.05$).

Discussion

Although being the gold standard for treating BPH, major drawbacks of contemporary monopolar TURP remain to be intraoperative and perioperative complications. The most relevant complications include bleeding requiring blood transfusion (2 %; range, 0–9 %), TURPS (0.8 %; range, 0–5 %), acute urinary retention (4.5 %; range, 0–13.3 %), clot retention (4.9 %; range, 0–39 %), and urinary tract infection (4.1 %; range, 0–22 %) [3]. Modern urology faces a tremendous competition between the various modalities of BPH endoscopic treatment in a race for minimal invasiveness, reduced complications, and long-term efficacy.

The bipolar TURP in general was described as potentially permitting a longer resection time and providing an improved hemostasis, thus enabling the surgeon to resect larger prostates without compromising safety [13]. Systematic review [11] demonstrated that no clinically relevant differences in short-term efficacy exist between bipolar TURP and monopolar TURP, but bipolar TURP is preferable because of a more favorable safety profile, including lower TURPS and clot retention rates and also shorter irrigation and catheterization

Table 2 Perioperative data

Parameters	PKRP ($n = 79$), mean ± SD (range)	ThuLEP ($n = 79$), mean ± SD (range)	p value
Operation time, min	47.4 ± 15.9 (35–75)	65.4 ± 22.2 (47–85)[a]	0.022
Catheterization, days	3.5 ± 1.2 (0.50–4.00)	2.1 ± 0.8 (0.50–3.00)[a]	0.031
Irrigated volume, L	27.2 ± 5.2 (6–30)	12.4 ± 6.4 (6–20)[a]	0.022
Hb decrease, g/L	3.0 ± 0.3 (1.0–3.1)	1.5 ± 0.2 (0.8–2.1)[a]	0.045
Hospital stay, days	4.6 ± 1.4 (3–6)	2.5 ± 1.4 (3–6)[a]	0.026

The values were assayed at the beginning of operation and 1 h postoperatively

Hb hemoglobin

[a] Statistically significant

Table 3 Results during the 5-year follow-up

Parameters	1 year			3 years			5 years		
	PKRP ($n = 65$)	ThuLEP ($n = 69$)	p value	PKRP ($n = 57$)	ThuLEP ($n = 61$)	p value	PKRP ($n = 41$)	ThuLEP ($n = 39$)	p value
Q_{max}[a], mL/s	23.9 ± 12.3 (11.4–37.7)	23.2 ± 13.5 (10.3–37.9)	0.263	22.3 ± 13.2 (9.5–40.3)	22.9 ± 14.3 (10.7–39.8)	0.315	18.9 ± 13.7 (9.7–37.7)	19.4 ± 15.3 (10.3–36.5)	0.631
PVR urine volume, mL	28.3 ± 12.7 (0–57)	27.4 ± 13.1 (0–59)	0.138	24.7 ± 15.3 (0–62)	25.1 ± 11.9 (0–59)	0.235	32.6 ± 17.9 (0–65)	34.9 ± 16.6 (0–63)	0.553
IPSS	4.6 ± 1.8 (1–10)	5.2 ± 1.9 (1–12)	0.086	5.4 ± 2.4 (1–12)	6.1 ± 2.1 (1–12)	0.066	6.5 ± 2.7 (1–12)	6.9 ± 3.2 (1–12)	0.179
QoLS	1.1 ± 0.7 (1–4)	1.2 ± 0.9 (1–4)	0.086	1.3 ± 0.8 (1–4)	1.3 ± 0.6 (1–4)	0.375	1.5 ± 1.1 (1–4)	1.4 ± 0.8 (1–4)	0.431

PVR postvoid residual, *IPSS* International Prostate Symptom Score, *QoLS* quality of life score

[a] Maximum flow rate

duration. During the past decade, PKRP has been accepted as a safer and more effective therapy for the surgical management of symptomatic BPH.

Technologic alternatives, such as laser treatments, may further minimize the risks of this procedure. Several laser devices have been developed to treat BPH. Particularly, green light vaporization and holmium laser enucleation have been studied intensively and represent valid clinical alternatives to TURP [20]. The thulium laser, a new type of surgical laser that recently has been applied in urology and appears to solve many of the limitations of both these devices, has been commonly used in recent decades. The center wavelength of the laser is tunable between 1.75 and 2.22 μm, allowing the wavelength to exactly match the 1.92-μm water absorption peak in tissue. The high density of absorbed energy at the tissue surface leads to instant vaporization and limits the penetration depth from 500 to 2000 μm, which covers the minimum and maximum microvessel diameters of hyperplastic prostates [9], thus resulting in sufficient homeostasis with minimal thermal injury to surrounding tissue.

In our experience, PKRP provided the subjective advantages of remarkable intraoperative visibility caused by a smooth wound surface, reduced bleeding, and detailed visual differentiation of the adenomatous tissue and fibers of the prostatic capsule after resection. With ThuLEP, nearly no bleeding is visualized during the operation, and it provides better intraoperative visibility, although leaving a rough surface and sharp margin on the vaporization area. The superior coagulation obtained during ThuLEP led to a significantly lower mean hemoglobin drop than during PKRP (1.5 vs 3.0 g/L, $p < 0.05$). Furthermore, as assessed by the better coagulation, patients receiving ThuLEP also needed shorter catheterization duration (2.1 ± 0.8 vs 3.5 ± 1.2 days, $p < 0.05$), less irrigation volume (12.4 ± 6.4 vs 27.2 ± 5.2 L, $p < 0.05$), and a shorter hospital stay (2.5 ± 1.4 vs 4.6 ± 1.4 days, $p < 0.05$). Compared with a 550-μm end-firing fiber of ThuLEP, the standard resection loop of PKRP provided higher resecting efficacy and resulted in a shorter operation time (47.4 ± 15.9 vs 65.4 ± 22.2 min, $p < 0.05$).

Saline was used as the irrigating solution for both procedures (ThuLEP and PKRP). As expected, no TURPS occurred and the serum concentrations of sodium chloride preoperatively and postoperatively showed no statistical significance (data not shown). Of cause, position, such as Trendelenburg position, also plays an important role in reducing the rate of TURPS [10]. Trendelenburg position results in lower intravesical pressure which is related to TURPS. However, Trendelenburg position also inhibits the respiratory and circulatory functions of the patient, so specific patients should be chosen with care. Lithotomy position is often chosen for it is easy to operate and, what is more, has no undesirable effect on respiratory and circulatory functions, which is more important for old patients.

No patient was lost during the 18-month follow-up, and both procedures obtained comparable results in the postoperative urinary parameters of IPSS, QoLS, Q_{max}, and PVR urine volume at the intervals of 1, 3, 6, 12, and 18 months. As for the longer follow-up, although a part of patients lost each year, there was no difference in these parameters between the two procedures. As for the sexual satisfaction, only limited patients from each group were willing to accept the questionnaire and reported improved erectile function and sexual satisfaction. So, a definite conclusion is not available.

Compared with the PKRP series performed by Hu et al. [8], an operation time of 36.4 min, a hospital stay of 4.2 days, the mean Q_{max} increase from 6.94 mL/s at baseline to 19.28 mL/s, the mean PVR urine volume decrease from 126.33 to 10.45 mL, the mean IPSS score decrease from 15.79 to 7.51, and the mean QoL score decrease from 4.36 to 1.91, respectively, in our series, including both PKRP and ThuLEP, required similar operation time (37.7 and 47.4 min, respectively), hospital stay (4.6 and 2.5 days, respectively), and Q_{max} (18.9 and 19.4 mL/s) while resulted in larger PVR urine volume (32.6 and 34.9 mL) and a lower IPSS (6.5 and 6.9). These differences might partly be caused by the different surgical preceding and perioperative parameters. Compared with the ThuLEP series performed by Xia et al. [17], an operation time of 43.7 min, a hemoglobin decrease of 0.9 g/dL, and a hospital stay of 4.9 days, in our series, including both PKRP and ThuLEP, resulted in less hemoglobin decrease (1.5 and 3.0 g/dL). No significant difference was seen in postoperative parameters of Q_{max}, PVR urine volume, IPSS, and QoLS in both series.

Conclusions

PKRP and ThuLEP are both safe and efficient procedures for the treatment of patients with symptomatic BPH. Compared with PKRP, ThuLEP offers advantages in intraoperative safety, minimal blood loss, less irrigation, shorter catheterization, and shorter hospital stay but needs a longer operation time. Assessment at mid- and long-term follow-ups showed no difference in urinary parameters.

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Compliance with ethical standards The study was approved by the Ethical Committee of Wuhan University and complied with the Code of Ethics of the World Medical Association (Declaration of Helsinki 1964 revised in 2003 and Declaration of Tokyo 1975 revised in 2006).

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

Informed consent All participants had given informed consent before their inclusion in the study.

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