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ORIGINAL ARTICLE

Prostate Disease

Plasmakinetic enucleation of prostate versus 160-W laser photoselective vaporization for the treatment of benign prostatic hyperplasia

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To evaluate the safety and efficacy of plasmakinetic enucleation of the prostate (PKEP) for the treatment of symptomatic benign prostatic hyperplasia (BPH) compared with 160-W lithium triboride laser photoselective vaporization of the prostate (PVP). From February 2011 to July 2012, a prospective nonrandomized study was performed. One-hundred one patients underwent PKEP, and 110 underwent PVP. No severe intraoperative complications were recorded, and none of the patients in either group required a blood transfusion. Shorter catheterization time (38.14 ± 23.64 h *vs* 72.54 ± 28.38 h, *P* < 0.001) and hospitalization (2.32 ± 1.25 days *vs* 4.07 ± 1.23 days, *P* < 0.001) were recorded in the PVP group. At 12-month postoperatively, the PKEP group had a maintained and statistically improvement in International Prostate Symptom Score (IPSS) (4.07 ± 2.07 *vs* 5.00 ± 2.10; *P* < 0.001), quality of life (QoL) (1.08 ± 0.72 *vs* 1.35 ± 0.72; *P* = 0.007), maximal urinary flow rate (Q_{max}) (24.75 ± 5.87 ml s^{-1} *vs* 22.03 ± 5.04 ml s^{-1}; *P* < 0.001), postvoid residual urine volume (PVR) (14.29 ± 6.97 ml *vs* 17.00 ± 6.11 ml; *P* = 0.001), and prostate-specific antigen (PSA) value (0.78 ± 0.57 ng ml^{-1} *vs* 1.27 ± 1.07 ng ml^{-1}; *P* < 0.001). Both PKEP and PVP relieve low urinary tract symptoms (LUTS) due to BPH with low complication rates. PKEP can completely remove prostatic adenoma while the total amount of tissue removed by PVP is less than that can be removed by PKEP. Based on our study of the follow-up, PKEP provides better postoperative outcomes than PVP.

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INTRODUCTION

In aging men benign prostatic hyperplasia (BPH) is a frequent disease and is associated with bladder outlet obstruction (BOO). Transurethral resection of the prostate (TURP) has been accepted as the reference standard surgical options in the treatment of low urinary tract symptoms (LUTS) due to BPH. However, TURP still has some inherent challenges, including the transurethral resection (TUR) syndrome (1.4%), failure to void (5.8%), and blood transfusion (2.9%),[1] all of which are related to the increase in the resected weight of the tissue.[2,3] Additionally, 10%–15% patients require a second intervention within 10 years.[4] Which has led to a continuous decrease in the number of TURP procedures performed,[2,5] and an increase in the use of other new techniques for the treatment of BPH, including PKEP and PVP.

The plasmakinetic (PK) device has been introduced into urology primarily for the treatment of BPH.[6–8] Intraoperative blood loss was found to be less with the PK device compared with the monopolar resection.[9] Refinement using the PK device to enucleate the prostate with the method just as holmium laser enucleation of the prostate (HoLEP) have proved to be a safe, technically feasible treatment for BPH,[10,11] and the clinical efficacy of PKEP is reliable and favored compared with TURP,[10] no matter what the prostate size is.[11]

One of the other alternatives that have been studied recently is PVP. PVP has been shown to be as effective as TURP in the management of BOO,[12–14] with excellent hemostatic properties and very low intraoperative complication rate, even in patients on oral anticoagulation.[15] The controversial issues concerning PVP in comparison to TURP are the lack of tissue for histologic examination, and the higher cost including single-use fibers, especially in cases of lager prostate adenomas. Both of these new techniques appear to be possible candidates to replace traditional TURP as the gold standard for the surgical treatment of BPH. However, few studies have compared PKEP with PVP. Therefore, we conducted a prospective nonrandomized two-center study with a 12-month follow-up to compare PKEP with PVP in terms of efficacy and safety. The present study, to the best of our knowledge, is the first to compare PKEP V 160-W PVP for the treatment of BPH.

MATERIALS AND METHODS

Patients selection

The present prospective nonrandomized two-center study was performed from February 2011 to July 2012. One-hundred one patients with BOO due to BPH underwent PKEP in Jinan Central Hospital

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Affiliated to Shandong University, and 110 patients underwent PVP in Shandong Provincial Hospital Affiliated to Shandong University. Because of the nonrandomized bi-center nature of the study, different surgeons at the different hospital performed PKEP or PVP. All PKEP and PVP were performed by experienced surgeons. The Ethics Committee approved the protocol.

The inclusion criteria for both groups were Q_{max} <15 ml s^{-1}, IPSS >12, medication failure. The criteria for patient exclusion were neurovesical dysfunction, prostate carcinoma, and a previous history of prostatic or urethral surgery. All patients were evaluated preoperatively by physical examination, digital rectal examination (DRE), and laboratory studies, including the determination of the serum PSA level, Q_{max}, and PVR. The prostate size was measured using transrectal ultrasonography (TRUS).

Surgical procedures

The PKEP procedure was performed with a 26 Fr resectoscope with the PK system. The PK system uses 280 W for cutting and 80 W for coagulation. Physiologic saline served as irrigation fluid. All patients received either spinal anesthesia or general anesthesia. The patients were placed in a lithotomy position and under video control. The ureteral orifices, bladder neck and verumontanum were identified. PKEP started an inverted U-incision close to the verumontanum and making marks at the distal edge of the prostate lobes. The urethral mucosa close to the verumontanum was incised deeply to the level of the surgical capsule. Along the surgical capsule, either side of the lateral lobes was detached clockwise or counter-clockwise from the 5 or the 7 o'clock position of the prostatic apex to the 12 o'clock position, the mid lobe and lateral lobes were dissected in retrograde fashion toward bladder neck by the tip of the resectoscope sheath combined with a loop. The loop was used to cut off the adenoma and the adhesive fibers between the lobe and the surgical capsule when necessary, and to coagulate the denuded supply vessels and hemorrhage spots on the capsule surface. When the mid lobe and the lateral lobe were detached to the bladder neck, the other lateral lobe was detached in the same way. Thus, the prostatic lobes were subtotal enucleated and devascularized but still connected to the bladder neck by a narrow pedicle. The enucleated adenoma attached to the bladder neck was fragmented into pieces very rapidly and bloodlessly with the PK cutting loop.

The PVP procedure was performed with the patients under spinal anesthesia. PVP was carried out with a PVP Green Laser Surgical System. The LBO laser energy was delivered by a 6 F side-deflecting fiber with a 23 F continuous-flow cystoscopy; physiologic saline was used for irrigation. The power setting used at the start of the procedure was 160 W. The bladder neck, median lobe, lateral lobe, and apical portion of the enlarged prostate were vaporized consecutively. The apical prostatic portion was vaporized very precisely, and the power setting used was reduced to 100 W. At the end of the procedure, the capsular fibers were visible, and a "TUR-like" cavity was obtained.

At the end of both procedures, a 20 F three-way Foley catheter was inserted into the bladder with a closed drainage system. Bladder irrigation was continued until hematuria had decreased sufficiently. The perioperative parameters for both groups, including operative time, postoperative changes of hemoglobin and serum sodium, the duration of catheterization and hospitalization, and intra- and post-operative complications were recorded. The resected tissue weight for the PKEP group was measured. We determined preoperative, and postoperative IPSS, Q_{max}, PSA, PVR, and QoL score in 1, 3, 6 and 12 months postoperatively.

Statistical analysis

Statistical analysis was performed using the SPSS 19.0 for Windows (SPSS Inc., Chicago, IL, USA). The data are presented as the mean ± standard deviation. The baseline characteristics and perioperative data of the two groups were statistically analyzed with the Mann–Whitney U-test. The postoperative adverse events were evaluated using the Fisher's exact test. P <0.05 was considered statistically significant.

RESULTS

The baseline characteristics of both groups are shown in **Table 1**. No significant difference was found between the two groups in terms of the studied variables.

It was found that the mean operative time in the PKEP group was 5.4 min shorter than that in the PVP group (P < 0.001). In the PKEP group, a mean amount of 50.84 ± 8.90 g of prostatic tissue was resected. In PVP, the mean energy delivered was 251.07 ± 109.27 kJ. **Table 2** also shows that the longer catheterization and hospitalization times were seen in the PKEP group (P < 0.001). No significant difference was found between the two groups in terms of hemoglobin loss and sodium decrease.

All patients were followed up for 12 months. The intraoperative, postoperative, and postdischarge complications are listed in **Table 3**. Neither PKEP nor PVP caused severe intraoperative complications. None of the patients required blood transfusion or developed TUR syndrome in the two groups. Capsule perforation was observed in three patients (2.97%) in the PKEP group, and one (0.91%) in the PVP group (P = 0.351). Three patients (2.97%) in the PKEP group and four (3.64%) in the PVP group were diagnosed with urinary tract infection (UTI), and the irritative symptoms were eased after the sensitive antibiotics were used. Transient, mild to moderate dysuria was seen in two patient (1.98%) in the PKEP group and eight patients (7.27%) in the PVP group. Two patients in each group

Table 1: Baseline characteristics in PKEP and PVP groups

Characteristic	*PKEP (n=101)*	*PVP (n=110)*	*P*
Age (year)	69.51±7.34	68.87±6.40	0.433
IPSS	22.37±5.06	21.74±4.74	0.377
Q_{max} (ml s^{-1})	6.60±2.35	6.79±2.54	0.633
PSA (ng ml^{-1})	3.04±2.79	3.23±3.26	0.792
Prostate size (cm^3)	62.97±14.19	61.98±11.98	0.846
PVR (ml)	92.49±30.49	94.25±33.76	0.847
QoL	4.59±0.95	4.62±0.89	0.972
Hemoglobin (g dl^{-1})	13.28±1.86	13.04±1.61	0.203
Serum sodium (mmol l^{-1})	138.58±2.12	138.69±3.27	0.612

Statistically significant at P<0.05. PKEP: plasmakinetic enucleation of the prostate; PVP: photoselective vaporization of the prostate; IPSS: international prostate symptom score; PSA: prostate-specific antigen; PVR: postvoid residual urine volume; QoL: quality of life

Table 2: Perioperative variables in PKEP and PVP groups

Characteristic	*PKEP (n=101)*	*PVP (n=110)*	*P*
Operative time (min)	60.05±14.24	65.48±13.17	<0.001
Resected tissue (g)	50.84±8.90	-	-
Applied energy (kJ)	-	251.07±109.27	-
Decrease in hemoglobin (g dl^{-1})	0.74±0.36	0.70±0.43	0.097
Decrease in sodium (mmol l^{-1})	1.29±0.80	1.22±0.72	0.666
Catheter duration (h)	72.54±28.38	38.14±23.64	<0.001
Hospital time (days)	4.07±1.23	2.32±1.25	<0.001

PKEP: plasmakinetic enucleation of the prostate; PVP: photoselective vaporization of the prostate experienced slight incontinence after the removal of the urethral catheter and were relieved by pelvic floor exercises. Urethral stricture occurred in two patient (1.98%) in PKEP and three (2.73%) in PVP, and were solved by dilation. One patient (0.99%) with bladder neck contracture requiring transurethral incision was found in the PKEP group, and two patients (1.82%) in the PVP group.

The dramatic symptomatic improvement was observed in both groups (**Table 4**). At the endpoint, the PSA level had decreased to 0.78 ng ml^{-1} in the PKEP group and 1.27 ng ml^{-1} in the PVP group ($P < 0.001$), the IPSS had improved to 4.07 in the PKEP group and 5.00 in the PVP group ($P < 0.001$), the PVR had decreased to 14.29 ml in the PKEP group and 17.00 ml in the PVP group ($P = 0.001$), Q_{max} had increased to 24.75 ml s^{-1} in the PKEP group, and 22.03 ml s^{-1} in the PVP group ($P < 0.001$).

DISCUSSION

In our trial, we dissected the prostate adenoma in a retrograde fashion off the surgical capsule starting at the apex of the prostate and continuing towards the bladder neck. The prostate lobes could be fragmented rapidly into pieces in a nearly bloodless version because the subtotal enucleated lobes were devascularized after the detachment from the capsule. These characteristics helped the PKEP procedure achieve the removal of as much of the benign prostatic adenoma as open operation, and in a very rapid resection speed with a low capsule perforation rate. The mean operative time of PKEP was 5.4 min shorter than that of PVP, but with significant difference ($P < 0.001$). Three patients in the PKEP arm experienced small superficial capsule perforation that happened when we used the loop to cut-off the adherence of the adenoma from the surgical capsule. All was minimal and did not alter the clinical course. At the end of the procedures, a 20 F three-way Foley catheter was inserted into the bladder without any additional intervention, and no severe intra- or post-operation complications happened.

In PKEP, we were very cautious at the apex, so we left some apical tissue to avoid stress urinary incontinence that might occur from the injury to the external sphincter. Two patients (1.98%) in the PKEP group experienced stress urinary incontinence that was resolved by pelvic exercise within 1-month after surgery, and that was comparable to the PVP group.

Although TURP remains the gold standard surgical treatment for BPH. Procedure resection time increases the risk of TUR syndrome and other complications.[2,16] PVP is charactered by excellent hemostatic properties and very low intraoperative complication rate.[15] In the PKEP arm, no severe hemoglobin loss and serum sodium loss were observed, and no patient developed TUR syndrome or required a blood transfusion, which were comparable to that in the PVP group. To our best knowledge, there have been no reports of TUR syndrome associated with PKEP and a lack of severe change in the serum sodium postoperatively in patients who undergo PKEP were also found in several studies.[10,11] One reason for the safety of PKEP is that the PK resection has the advantages of being more hemostatic with less risk of hemorrhage using physiologic saline as irrigant fluid.[17] The other reason is that the detachment in PKEP occurs at the level of the capsule so that the vessels are opened only once, during the course of resection of the adenoma, the blood supply of the prostate adenoma is blocked. Which is unlike to TURP, the vessels are opened until the resection is carried down to the surgical capsule. Which may make PKEP a safe choice for patients with heart disease.[10]

HoLEP has been known to be effective and safe for BPH of any size since Gilling *et al*. introduced transurethral enucleation of the prostate using the holmium laser.[18] HoLEP was durable, and most patients were satisfied with the long-term outcome. However, many authorities consider that HoLEP is difficult to learn.[19] In our study, PKEP has the same principle as HoLEP, including identification of the

Table 3: Complications of PKEP and PVP

Complication	*PKEP, n (%)*	*PVP, n (%)*	*P*
CCS grade 1			
Transient incontinence	2 (1.98)	2 (1.82)	1.00
CCS grade 2			
UTI	3 (2.97)	4 (3.64)	1.00
Blood transfusion	0	0	-
Dysuria	2 (1.98)	8 (7.27)	0.104
CCS grade 3			
Clot retention	0	0	-
Urethral stricture	2 (1.98)	3 (2.73)	1.00
Bladder neck contracture	1 (0.99)	2 (1.82)	1.00
CCS grade 4			
TUR syndrome	0	0	-

CCS: the modified Clavien classification system; UTI: urinary tract infection; PKEP: plasmakinetic enucleation of the prostate; PVP: photoselective vaporization of the prostate; TUR: transurethral resection

Table 4: Follow-up data after PKEP and PVP

Variable	*PKEP*		*PVP*		*P*
	Mean±s.d.	*Change (%)*	*Mean±s.d.*	*Change (%)*	
IPSS					
Preoperative	22.37±5.06	-	21.74±4.74	-	0.377
1-month	9.58±3.19	−57.2	10.39±3.21	−52.2	0.054
3 months	7.44±2.23	−66.7	7.97±2.80	−63.3	0.073
6 months	5.20±2.37	−76.8	5.79±2.20	−73.4	0.016
12 months	4.07±2.07	−81.8	5.00±2.10	−77.0	<0.001
QoL score					
Preoperative	4.59±0.95	-	4.62±0.89	-	0.972
1-month	2.53±1.03	−44.9	2.76±1.04	−40.3	0.113
3 months	1.86±0.93	−59.5	2.09±0.91	−54.8	0.052
6 months	1.35±0.71	−70.6	1.68±0.83	−63.6	0.004
12 months	1.08±0.72	−76.5	1.35±0.72	−70.8	0.007
PVR (ml)					
Preoperative	92.49±30.49	-	94.25±33.76	-	0.847
1-month	19.25±7.04	−79.2	20.82±7.09	−77.9	0.054
3 months	17.53±6.94	−81.0	18.90±6.63	−79.9	0.052
6 months	15.50±7.25	−83.2	18.00±6.53	−80.9	0.002
12 months	14.29±6.97	−84.5	17.00±6.11	−82.0	0.001
Q_{max} (ml s^{-1})					
Preoperative	6.60±2.35	-	6.79±2.54	-	0.633
1-month	20.56±6.12	+211.5	20.01±5.45	+194.7	0.364
3 months	21.59±6.13	+227.1	21.11±5.40	+210.9	0.700
6 months	23.98±5.90	+263.3	21.91±5.31	+218.0	<0.001
12 months	24.75±5.87	+275	22.03±5.04	+224.4	<0.001
PSA (ng ml^{-1})					
Preoperative	3.04±2.79	-	3.23±3.26	-	0.792
1-month	1.25±0.89	−58.9	1.51±1.14	−53.3	0.107
3 months	1.13±0.85	−62.8	1.26±1.07	−61.0	0.548
6 months	0.91±0.62	−70.1	1.20±1.05	−62.8	0.186
12 months	0.78±0.57	−74.3	1.27±1.07	−60.7	<0.001

s.d.: standard deviation; PKEP: plasmakinetic enucleation of the prostate; PVP: photoselective vaporization of the prostate; PSA: prostate-specific antigen; PVR: postvoid residual urine volume; IPSS: international prostate symptom score; QoL: quality of life surgical capsule, detachment of the adenoma along the capsule, and morcellation of the prostate adenoma using a different energy, which is easier to learn. And PKEP does not comprise the higher cost of the laser and requires no additional device to fragment the adenoma into pieces. Neill *et al*. reported that the removed tissue by PKEP is similar to that by HoLEP, and the functional outcomes were also similar at 6 and 12 months follow-up.[20]

The greater degree of peripheral adenoma compression present in larger glands tends to create a more easily identifiable surgical plane.[21] It is much easier to identify the surgical capsule during the course of enucleation in large prostate than in small glands, PKEP allows for complete endoscopic enucleation of prostate adenoma of any size.[11] No residual adenoma tissue leads to decreased postoperative bleeding and postoperative urinary retention. In our PKEP group, no patient required re-catheterization because of acute urinary retention or postoperative clot retention.

The average weight of enucleated tissue in the PKEP group was 50.84 g, and histologic examination was possible in all cases. Since up to 10% of incidental prostate cancers are diagnosed after TURP,[1] many cancer patients may be underdiagnosed for the lack of tissue for histologic examination after PVP.

Our results, showing a quick, dramatic and statistically significant improvement compared with the preoperative data persisted throughout the follow-up period in both groups. As PSA is a surrogate of BPH volume which is easier and cheaper to determine the prostate volume than by TRUS,[22,23] and the PSA reduction correlates directly with the weight of resected tissue.[24] We use PSA instead of TRUS to determine the prostate volume in this study. A decrease in PSA was recognized in both groups, while after PKEP the decline was remarkable. At the 12-month follow-up, the PSA reduction in the PKEP group was 74.3%, whereas 60.7% in the PVP group ($P < 0.001$). The PVR decreased by 84.5% in the PKEP group, and 82.0% in the PVP group ($P = 0.001$), Q_{max} increased by 275% and 224.4% ($P < 0.001$), IPSS improved by 81.8% and 77% ($P < 0.001$), and QoL improved by 76.5% and 70.8% ($P = 0.007$), respectively. Herrmann *et al*. concluded that the degree of BPO reduction is directly linked to the amount of tissue removal by reviewing the urodynamic effects of TURP in comparison to various laser treatment modalities.[25] A possible explanation for the better outcome of PKEP is that during the course of enucleation, the tip of the resectoscope sheath produces the anatomical plane between the surgical capsule and the adenoma in an excellent intraoperative visibility, which results in complete removal of the prostatic adenoma similar to open prostatectomy through a minimally invasive approach. Whereas it is difficult to discern the plane and unlikely to be reached when performing PVP.[26] Humphreys *et al*. also had the same consideration that there is less prostate adenoma removal by ablative procedures compared with transurethral enucleation of the prostate.[27]

This study is the first report to evaluate the safety and efficacy of PKEP versus 160-W PVP for the treatment of symptomatic BPH. Although the follow-up period of our study was relatively short, an assessment of perioperative morbidity and early effective relief of urodynamic obstruction can be made. Zhao *et al*. carried out a study of PKEP with 3-year follow-up and proved PKEP had a sustainable improvement in micturition function during the follow-up.[10] Conclusions about the durability of PKEP relative to PVP need to evaluate long-term outcomes.

Our study had several limitations, including no-randomized nature of the study, relatively short follow-up period, lack of cost-effectiveness and sexual function. Future, multi-center, prospective, randomized study with extended follow-up may be needed to corroborate our findings.

CONCLUSIONS

Both PKEP and PVP relieve LUTS due to BPH with low complication rates. PKEP offers complete removal of the prostatic adenoma while the total amount of tissue removed by PVP is less than PKEP. Based on our study of the follow-up, PKEP provides better postoperative outcomes than PVP.

AUTHOR CONTRIBUTIONS

SJW and XNM has been involved in data interpretation, performed the statistical analysis and drafting the manuscript, CJ and SBZ have been involved in data collections, XBJ and LYZ have made the study design, LYZ has made the critical review. All authors read and approved the final manuscript.

COMPETING FINANCIAL INTERESTS

All authors declare no competing interests.

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