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ORIGINAL ARTICLE

Prostate Disease

# Can the lower urinary tract storage symptoms be completely resolved after plasmakinetic enucleation of the prostate?

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The aim of this study was to determine whether the lower urinary tract storage symptoms of benign prostatic obstruction (BPO) could be completely resolved after plasmakinetic enucleation of the prostate (PKEP) and the possible predictors of persistent symptoms. Two hundred and sixty-seven cases of BPO performed PKEP from July 2008 to June 2009 were retrospectively analyzed. Five-year postoperative data were collected and compared with the preoperative data. According to the urodynamic results, the patients were divided into involuntary detrusor contraction (IDC) group ( $n = 95$ ) and no IDC group ( $n = 172$ ) preoperatively; the patients with IDC were divided into IDC-persistent group ( $n = 33$ ) and IDC-resolved group ( $n = 62$ ) after PKEP. The predictors of persistent IDC were analyzed. Compared with the preoperative data, the 5-year postoperative data showed that the IDC rate was lower ( $P = 0.000$ ), Overactive Bladder Symptom Score (OABSS) was lower ( $P = 0.000$ ), maximum cystometric capacity (MCC) was larger ( $P = 0.000$ ), Prostate volume (PV) was smaller ( $P = 0.000$ ), and prostate-specific antigen (PSA) was lower ( $P = 0.000$ ). Compared with the no IDC group, the IDC group showed that the age was older ( $P = 0.016$ ), MCC was smaller ( $P = 0.004$ ), PSA was higher ( $P = 0.016$ ), and Chronic Inflammation rate was higher ( $P = 0.004$ ). Compared with IDC-resolved group after PKEP, IDC-persistent group showed that the age was older ( $P = 0.019$ ), MCC was smaller ( $P = 0.000$ ), PSA was higher ( $P = 0.013$ ), and Chronic Inflammation rate was higher ( $P = 0.032$ ). The present study shows that the storage symptoms are still needed to be focused on after PKEP. The advanced patient age, MCC, PSA, and chronic inflammation may be the important clinical predictors of persistent IDC.

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**Keywords:** age factors; benign prostatic obstruction; lower urinary tract storage symptoms; plasmakinetic enucleation of the prostate; urodynamic parameter

## INTRODUCTION

Benign prostatic obstruction/the lower urinary tract storage symptoms (BPO/LUTS) is a common disease in aged men. Transurethral resection of prostate (TURP) represents the gold standard in the operative management of BPO/LUTS.<sup>1</sup> Many novel endoscopic technologies have been proposed to replace TURP as the new reference standards. Plasmakinetic enucleation of the prostate (PKEP) is a novel alternative technique that can remove prostatic adenoma anatomically and also may offer comparable results to open surgery with minimally invasive endoscopic surgery.<sup>2</sup> Transurethral enucleation of prostate using a plasmakinetic (PK) device, so-called plasmakinetic enucleation of the prostate (PKEP), was first described in 2005 in China by our center.<sup>3</sup> At that time, there was still no uniform nomination for PKEP in China, so that we just called this procedure intraluminal enucleation of prostate. We have used the PKEP technique to relieve BPO for more than 10 years. The difference in the PKEP procedure in this study from others is that the adenoma was removed by loop electrode resection but not the morcellator. We defined this procedure as transurethral enucleation

and resection of prostate (TUERP), and a retrospective report of 1100 patients who were treated by TUERP in our center with a mean of 4.3-year follow-up has demonstrated its safety and effectiveness.<sup>4</sup> Compared with traditional TURP, the adenoma of prostate enucleated by retrograde transurethral anatomical enucleation is considered to be more complete. Retrograde transurethral anatomical enucleation of the prostate is gaining momentum as a new concept in transurethral surgery of benign prostatic hyperplasia, no matter which energy source is used for the operation.<sup>2</sup>

In this study, we intended to determine whether the lower urinary tract storage symptoms of BPO could be completely resolved after PKEP and the possible predictors of persistent symptoms.

## MATERIALS AND METHODS

### *Patients and clinical data collection*

This study was approved by the Ethics Committee at Zhujiang Hospital, Southern Medical University. We retrospectively reviewed our

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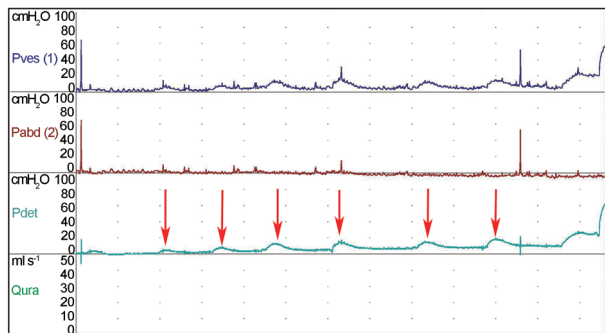
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collected database. The patients accepted PKEP routinely underwent multichannel urodynamic examination as objective data on the effectiveness before operation from 2008 in our department and 5 years after operation is a proper medium-term period for effective follow-up. Therefore, we chose the patients with 5 years after PKEP as the follow-up subjects. Between July 2008 and June 2009, a total of 324 men who underwent PKEP for BPO by two doctors skillful in PKEP were reviewed. The inclusion criteria of the study included that all patients underwent a baseline evaluation with transrectal ultrasonography (TRUS) and multichannel urodynamic study (MMS UD-2000, Medical Measurement System, Enschede, The Netherlands) in addition to a general standard evaluation for LUTS/BPO including medical history, physical examination including digital rectal examination, International Prostate Symptom Score (IPSS), Quality of Life (QOL), Overactive Bladder Symptom Score (OABSS),<sup>3</sup> frequency-volume chart (FV chart), urinalysis, serum prostate-specific antigen (PSA), and postvoid residual urine volume (PVR).

Subjective and objective outcomes of the treatment for BPO were assessed at 5 years postoperatively using the IPSS, QOL, OABSS, FV chart, uroflowmetry, PVR, multichannel urodynamic study, PSA, the occurrence of incontinence, and TRUS. The type of incontinence was specified as being stress, urge, or of a mixed nature according to patient response to the questions. If a patient responded positively to both stress- and urge-related questions, he was considered to have mixed urgency incontinence (UI). Urodynamic investigation was performed according to the standards proposed by Abrams, used to compare the objective data with preoperative situation. Involuntary detrusor contractions (IDC) defined as a condition that the detrusor contracted involuntarily during the filling phase of urodynamic cystometry, either spontaneous or provoked. **Figure 1** shows the involuntary detrusor contractions during the filling phase (Red arrows pointed). **Figure 2** shows the resolution of involuntary contraction after PKEP during the filling phase.

Seventeen patients received medication such as anticholinergic drug for OAB symptoms, but no patient received medication for urination difficulty. The patients who received medication for OAB symptoms stopped the medicine for 3 days before subjective and objective assessment. All definitions corresponded to recommendations of the International Continence Society. The exclusion criteria of the study in 5 years postoperatively are shown in **Table 1**. Fifty-seven patients were excluded in 5 years postoperatively because of death and/or lack of urodynamic results and/or other diseases influencing the urodynamic results. After strict screening, 267 cases were included in the 5-year follow-up research group.



**Figure 1:** The urodynamic cystometry before PKEP showed that there were multiple involuntary detrusor contractions during the filling phase (red arrows pointed). PKEP: plasmakinetic enucleation of the prostate; Pves: intravesical pressure; Pabd: abdominal pressure; Pdet: detrusor pressure; Qura: urinary flow rate.

According to the urodynamic results, the patients were divided into IDC group ( $n = 95$ ) and no IDC group ( $n = 172$ ) preoperatively, and the patients with IDC were divided into IDC-persistent group ( $n = 33$ ) and IDC-resolved group ( $n = 62$ ) after PKEP. The predictors of persistent IDC were analyzed.

#### Data analysis

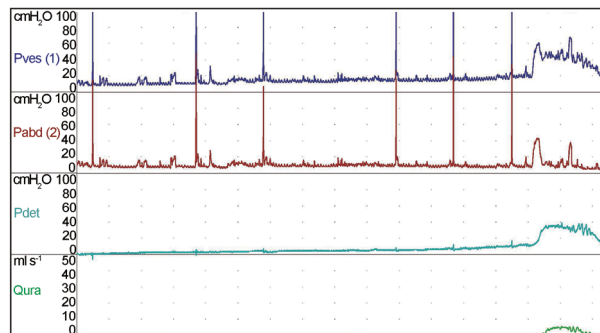
Data were shown as means  $\pm$  s.d. The variables were evaluated for statistically significant differences between the baseline measures and measures obtained at 5 years after PKEP using the paired *t*-test. A 5% level of significance was used for all statistical testing, and all statistical tests were two-sided. The Statistical Package for the Social Sciences (SPSS for Windows, release 18.0, SPSS, Inc., Chicago, USA) software was used for the data analysis.

#### RESULTS

The age of patients before operation was  $68.44 \pm 5.47$  years. The median follow-up duration was 60 months. Among them, 35 cases had combined with chronic inflammation, 17 cases had combined with prostatic intraepithelial neoplasia (PIN), grade I.

Except the incontinence, all 5-year postoperative corresponding indicators including IPSS, QOL, OABSS, FV chart, uroflowmetry, PVR, multichannel urodynamic study, PSA, and TRUS compared with the preoperative ones showed statistically significant difference. The detailed results and *P* values are shown in **Table 2**. Compared with the preoperative data, the 5-year postoperative data showed that the IDC rate was lower ( $13.11\%$  vs  $35.58\%$ ,  $P = 0.000$ ), OABSS was lower ( $2.67 \pm 1.40$  vs  $8.73 \pm 3.01$ ,  $P = 0.000$ ), MCC was larger ( $352.47 \pm 67.68$  vs  $261.34 \pm 66.15$  ml,  $P = 0.000$ ), PV was smaller ( $28.02 \pm 6.54$  vs  $63.32 \pm 22.12$  ml,  $P = 0.000$ ), and PSA was lower ( $1.64 \pm 0.51$  vs  $4.16 \pm 1.83$  ng ml<sup>-1</sup>,  $P = 0.000$ ). Six patients developed OAB symptoms within the postoperative 5 years, and IDC was observed in two patients among them. The percentage changes of the prostate volume and PSA from preoperative values were 55.75% and 60.58%, respectively.

Compared with the no IDC group, the IDC group showed that the age was older ( $69.53 \pm 4.59$  vs  $67.84 \pm 5.83$  years,  $P = 0.016$ ), MCC was smaller ( $245.86 \pm 65.68$  vs  $269.87 \pm 65.58$  ml,  $P = 0.004$ ), PSA was higher ( $4.52 \pm 1.98$  vs  $3.96 \pm 1.70$  ng ml<sup>-1</sup>,  $P = 0.016$ ), and Chronic Inflammation rate was higher ( $21.05\%$  vs  $8.72\%$ ,  $P = 0.004$ ). Compared with IDC-resolved group after PKEP, IDC-persistent group showed that the age was older ( $76.03 \pm 4.70$  vs  $73.73 \pm 4.36$  years,  $P = 0.019$ ), MCC was smaller ( $241.19 \pm 21.91$  vs  $320.82 \pm 32.19$  ml,  $P = 0.000$ ), PSA was higher ( $1.92 \pm 0.53$  vs  $1.62 \pm 0.56$  ng ml<sup>-1</sup>,  $P = 0.013$ ), and Chronic Inflammation rate was higher ( $33.33\%$  vs  $14.52\%$ ,  $P = 0.032$ ). The detailed results and *P* values are shown in **Table 3**.



**Figure 2:** The urodynamic cystometry 5 years after PKEP showed that no involuntary detrusor contraction appeared during the filling phase. PKEP: plasmakinetic enucleation of the prostate; Pves: intravesical pressure; Pabd: abdominal pressure; Pdet: detrusor pressure; Qura: urinary flow rate.

**Table 1: The exclusion causes of the patients in 5 years postoperatively**

Exclusion cause	Number of patients (n)
Death	29
Severe stroke	4
Severe Parkinson's disease	2
Urethral stricture	3
Bladder cancer underwent radical cystectomy	1
Prostate cancer underwent radical prostatectomy	2
Rejected urodynamic investigation	16

**Table 2: Changes in subjective and objective parameters in 5 years after the operation**

Parameter	Preoperative	Postoperative 5 years	P value
IPSS			
Voiding	9.94±1.85	2.02±0.67	0.000
Storage	13.21±1.61	3.12±0.831	0.000
Total	23.15±2.70	5.14±1.10	0.000
QOL	4.48±0.66	2.01±0.60	0.000
OABSS	8.73±3.01	2.67±1.40	0.000
OABSS >3 (%)	93.63	27.72	0.000
FV chart			
Daytime frequency	8.61±1.06	5.97±1.11	0.000
Nocturia	2.10±0.95	0.68±0.57	0.000
Maximal capacity (ml)	235.67±68.87	331.52±70.85	0.000
Free Flowmetry			
Qmax (ml s <sup>-1</sup> )	7.98±2.50	20.40±3.69	0.000
PVR (ml)	67.40±30.11	19.60±14.90	0.000
Urodynamic study			
Compliance	12.79±5.33	24.96±6.67	0.000
IDC (%)			
No	64.42	86.89	0.000
Yes	35.58	13.11	0.000
MCC (ml)	261.34±66.15	352.47±67.68	0.000
BOOI	63.34±11.56	22.22±6.22	0.000
BOOI level	3.79±0.67	1.60±0.49	0.000
MDP (cmH <sub>2</sub> O)	95.89±9.64	62.88±4.74	0.000
PUP (cmH <sub>2</sub> O)	25.44±6.73	13.75±2.83	0.000
PUL (cm)	4.82±0.49	2.80±0.41	0.000
MUCP (cmH <sub>2</sub> O)	85.33±9.89	70.73±5.53	0.000
PV (ml)	63.32±22.12	28.02±6.54	0.000
Serum PSA (ng ml <sup>-1</sup> )	4.16±1.83	1.64±0.51	0.000
Incontinence	None	None	1.000

Means are expressed as mean±s.d. BOOI: bladder outlet obstruction index; FV chart: frequency-volume chart; IDC: involuntary detrusor contraction; IPSS: International Prostate Symptom Score; MCC: maximum cystometric capacity; MDP: maximum detrusor pressure; MUCP: maximum urethral closure pressure; OABSS: Overactive Bladder Symptom Score; PUL: prostatic urethra length; PUP: prostatic urethra pressure; PV: prostate volume; PVR: postvoid residual urine; Qmax: maximal flow rate; QOL: quality of life; PSA: prostate-specific antigen

**Table 3: Clinical characteristics of patients with and without IDC preoperatively and patients with IDC resolution and with persistent IDC after PKEP**

	IDC (n=95)	No IDC (n=172)	P value	Persistent (n=33*)	Resolved (n=62)	P value
Age (years)	69.53±4.59	67.84±5.83	0.016	76.03±4.70	73.73±4.36	0.019
MCC (ml)	245.86±65.68	269.87±65.58	0.004	241.19±21.91	320.82±32.19	0.000
Qmax (ml s <sup>-1</sup> )	8.49±2.68	7.70±2.36	0.013	20.25±3.86	20.39±4.18	0.878
BOOI	61.85±11.48	64.16±11.55	0.118	21.45±6.15	22.41±6.42	0.486
PV (ml)	61.72±22.84	64.21±21.73	0.379	27.56±6.48	27.90±7.20	0.820
PSA (ng ml <sup>-1</sup> )	4.52±1.98	3.96±1.70	0.016	1.92±0.53	1.62±0.56	0.013
CI (%)	21.05	8.72	0.004	33.33	14.52	0.032
DM (%)	10.53	7.56	0.408	18.18	6.45	0.076

Means are expressed as mean±s.d. \*Two patients without IDC preoperatively developed IDC after PKEP, and the two patients were excluded. BOOI: bladder outlet obstruction index; CI: chronic inflammation; IDC: involuntary detrusor contraction; MCC: maximum cystometric capacity; MDP: maximum detrusor pressure; PKEP: plasmakinetic enucleation of the prostate; PSA: prostate-specific antigen; PV: prostate volume; Qmax: maximal flow rate

**DISCUSSION**

The goal of any treatment for BPO/LUTS is the relief of LUTS symptoms and subsequent improvement in the patients' QOL. In addition, the long-term therapeutic effect is a considered factor for any surgical procedure. The short-term therapeutic effect of TURP was good, but the long-term therapeutic effect of that was questioned due to the recurrence rate.<sup>6</sup> Retrograde enucleation of the prostate similar to the finger-assisted enucleation of the adenoma during OP is a new concept in transurethral surgery of BPO. Because of the promising results, this procedure was diffused rapidly and adapted by more and more urologists. Although the energies used for retrograde enucleation of the prostate by urologists may be different, such as holmium laser,<sup>7-10</sup> thulium laser,<sup>11,12</sup> diode laser,<sup>13,14</sup> or plasmakinetic energy,<sup>4,15</sup> retrograde enucleation of the adenoma possesses several advantages over conventional transurethral resection. First, prostatic enucleation ensures a complete adenoma removal similar to OP ensuring excellent and long-term voiding effect and low recurrence rate. Second, enucleation over surgical prostatic capsule provides a clear anatomical landmark throughout the procedure, assisting orientation, which is mostly important in the cases of large adenomas. Third, adenoma of the blood supply from the surgical prostatic capsule was cut by the energy, so that the bleeding amount was largely reduced. Fourth, the blunt energy-free enucleation diminishes energy scattering to the periphery and the postoperative irritative symptoms or damage to structures in proximity was diminished.<sup>2</sup> Therefore, although it is clinically well known that some of the patients may suffer transient incontinence for a short period after transurethral retrograde enucleation,<sup>9,10</sup> the short- and long-term efficacy for obstructive symptoms is still the confirmative advantage to promote its extensive application.

In this study, the Qmax indicated that the patients still had good voiding function in 5-year follow-up. The PVR, BOO Index, BOO Level, PUL, and PUP, which reflected the urethral resistance, were still normal at 5 years after PKEP. It demonstrated that retrograde enucleation of the prostate had good long-term efficacy for the bladder outlet obstruction due to BPO. The low PSA and PV also demonstrated that the prostate was still in small size at 5 years after PKEP. It meant that PKEP can confirm the complete enucleation of the adenoma and effectively prevent recurrence in 5-year follow-up.

However, the most troublesome symptoms are associated with the storage function, such as urgency, frequency, and nocturia. Although bladder compliance and MCC were normal, the storage function in UDS showed that 13.11% of patients still have detrusor activity in 5-year follow-up. The OABSS and FV chart showed that some of the patients were still suffered storage symptoms. Another study on HoLEP showed that OAB symptoms and urodynamic parameters were improved significantly after surgery, but the involuntary detrusor contraction in UDS was still 36.4% and the bladder compliance did not improve in

6-month follow-up.<sup>16</sup> With this 5-year follow-up study, it demonstrated that the relief of BPO could not relieve all of the storage symptoms for patients. The comparison between IDC group and no IDC group preoperatively and between IDC-resolved group and IDC-persistent group after PKEP demonstrated that age, MCC, PSA, and chronic inflammation may be the important clinical predictors of persistent IDC. The reasons may be those as following: first, the storage function of bladder was impaired seriously due to the bladder outlet obstruction and the longer disease period led to the more serious impairment. Even if the BPO had been resolved for 5 years, the storage function of bladder could not be completely recovered; second, the storage dysfunction of bladder separately existed and unrelated to the BPO; third, some of the patients have BPH with prostatic chronic inflammation, and the chronic inflammation is still persistent after the PKEP. The recent study by Antunes *et al.* also showed that advanced patient age together with low MCC and early and high amplitude uninhibited contractions are the most important clinical predictors of persistent DO after BOO is relieved.<sup>17</sup> The results were similar to our results.

Although the energies used for retrograde enucleation of the prostate by urologists may be different, the principle is similar. The study by Elkoushy *et al.* has proved that storage urinary symptoms significantly improved more after retrograde enucleation of the prostate compared with prostate vaporization and baseline degree of storage symptoms, prolonged operative time, and lower percent of postoperative PSA level reduction negatively predicts postoperative improvement of storage symptoms.<sup>18</sup> However, storage urinary symptoms also cannot be resolved by retrograde enucleation of the prostate. Therefore, it was critically important to perform the preoperative UDS detection for BPO, which can confirm the operative indication and judged the prognosis of bladder function, especially for the storage function of the bladder. Moreover, the storage symptoms were still needed to be focused on during the follow-up even though the bladder outlet obstruction was completely resolved by PKEP.

Our study also had a few limitations. The first limitation was that it was a retrospective study without a comparative group operated with the standard TURP. The second limitation was the absence of some valuable UD data such as the amplitude of detrusor overactivity and timing of DO. The third limitation was the insights on the predictors and the impact of IDC on the clinical outcome measures could be better assessed.

## CONCLUSIONS

PKEP can confirm the complete enucleation of the adenoma and effectively prevent recurrence in 5-year follow-up and had a satisfactory long-term effectiveness on voiding symptoms, but the storage symptoms were still needed to be focused on during the follow-up. The advanced patient age, MCC, PSA, and chronic inflammation may be the important clinical predictors of persistent IDC. However, a study with better design needs to be carried out to confirm the conclusion in future.

## AUTHOR CONTRIBUTIONS

BKL participated in the design of the study, carried out the study, performed statistical analysis, prepared figures and data tables, and wrote the manuscript. BSC and YHX carried out the study and assisted in writing. CXL participated in the design of the study and helped carried out the study. SBZ, YWX, and HLL helped carry out the study. YZ participated in statistical analysis. LPL assisted in writing. All authors read and approved the final manuscript.

## COMPETING INTERESTS

All authors declare no competing interests.

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