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Photoselective Vaporization of the Prostate: The Basel Experience after 108 Procedures

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Abstract

Objectives: This study aims to investigate safety and efficacy of 80 watt high-power potassium titanyl phosphate (KTP) laser vaporization of the prostate in men with lower urinary tract symptoms (LUTS) secondary to benign prostatic hyperplasia (BPH).

Methods: 108 patients underwent 80W KTP laser vaporization. Functional follow-up included measurement of maximum urinary flow rate (Qmax), postvoid residual volume (Vres) and International Prostate Symptom Score (IPSS) within a 12 months period.

Results: The average prostate volume was 52.2 ± 24.3 ml and the preoperative PSA value was 3.6 ± 3.6 ng/dl. Mean operation time was 54.5 ± 25.0 min. Qmax increased highly significantly ($p < 0.001$) by 111% (+7.9 ml/s) at discharge, 212% (+15.1 ml/s) after three months, 201% (+14.3 ml/s) after six months and 252% (+17.9 ml/s) after 12 months. Correspondingly, Vres, IPSS and Bother Score improved to an extent that was statistically highly significant ($p < 0.001$) immediately after surgery. The observed complication rate within one year was low.

Conclusions: 80 W KTP laser vaporization is a virtually bloodless, safe and effective procedure for surgical treatment of LUTS secondary to BPH. A significant improvement of objective and subjective voiding parameters was observed just after surgery. KTP laser vaporization is associated with a low rate of complications.

Keywords: KTP; Laser vaporization; TURP alternatives; LUTS due to BPH

1. Introduction

Surgical resection of obstructive hyperplastic prostatic tissue is the most effective method of treating patients suffering from lower urinary tract symptoms (LUTS) secondary to benign prostatic hyperplasia (BPH).

Although transurethral resection (TURP) has been established as a highly effective alternative surgical treatment, it remains subject to substantial morbidity [1,2]. Research to find surgical alternatives associated with a low rate of perioperative complications and a comparable efficacy to that of TURP has been ongoing for the past 15 years.

Up to date, there has been only scanty data on clinical experience with the new 80 W KTP laser. This paper presents data on peri- and postoperative morbidity as well as efficacy with a follow-up of up to 12 months.

2. Materials and methods

Since September 2002, we have used an 80W KTP laser (GreenLight PV™, Laserscope®, San Jose, CA) to operate on patients suffering from LUTS secondary to BPH. Inclusion criteria for surgery comprised maximum urinary flow rate (Qmax) ≤ 15 ml/s or transvesically measured postvoid residual volume (Vres) $>$ 100 ml in conjunction with the International Prostate Symptom

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Score (IPSS) > 7. In patients with LUTS suspicious of BPH and a accompanyied prostate-specific antigen (PSA) value > 3 ng/dl or a digital rectal examination suspicious of prostate cancer (PCA), a minimum of two 8-fold prostate core biopsy cycles were performed. If biopsies were negative for prostate cancer, the patients were included in this study.

Patients with evidence of acute urinary tract infection (UTI) or a history of acute or chronic urinary retention requiring an indwelling catheter were excluded from this study. There were no exclusion criteria in terms of prostate volume, presence of large median lobes or age.

Antibiotic prophylaxis (ciprofloxacine 500 mg p.o./0.2 g intravenous) was administered both preoperatively and for 10–14 days postoperatively. No additional preoperative preparation was required. Normally, patients were admitted one day before surgery and underwent routine preoperative evaluation. The operation was usually performed on the following day.

The laser fiber (ADDStat™) was introduced via a 22.5 French laser cystoscope with a separate fiber channel. We prefer to use an automatic suction–irrigation pump system (Endo FMS® Urology) which guarantees continuous irrigation and suction to provide an excellent view during operation. A sterile sodium solution is used for irrigation.

A red aiming beam indicates the target area of the high power laser beam. Continuous bubble formation reflects an optimized vaporization effect ones the high power beam is activated. Prostatic tissue is immediately removed by vaporization. The optimal working distance between the laser beam and tissue surface is approximately 0.5–1 mm. If the distance is increased, laser energy is diffused over a larger tissue surface. Tissue heating becomes insufficient. Hence, a temperature of 100 °C required for vaporization is not reached in the tissue layers beneath the surface; instead coagulation occurs wherever the temperature exceeds 65 °C.

Vaporization should start at the bladder neck and be carried out toward the verumontanum by slowly sweeping the laser fiber. The steps of the vaporization technique are comparable to the TURP procedure. A median lobe should be removed first, in order to provide sufficient irrigation. Bleeders are controlled by increasing the working distance of the laser fiber to 3 to 4 mm forcing a coagulation effect. Because of the very localized application of the laser beam, laser vaporization of apical tissue can be performed precisely. However, vaporization should be performed carefully in order to protect the verumontanum and the external sphincter from backward scatter or direct contact of the laser beam.

The end point of the tissue-ablative procedure is a clearly deobstructed TURP-like prostatic fossa that is lined with "coral-like" stromal residues. The prostatic capsule fibers are usually visible after the vaporization of the adenomatous tissue is complete.

Regional anesthesia was mainly performed, making it mandatory to insert a 20 French Tiemann catheter at the end of the procedure. The catheter was usually left in place overnight and removed the next morning.

Follow-up examinations were carried out in our own outpatient department on discharge as well as three, six and 12 months later (up to date). Analysis of outcome includes measurement of Vres and Qmax. All patients were requested to fill in the IPSS questionnaire and Bother Score at these dates.

3. Results

The 80 W KTP laser vaporization was performed successfully in all 108 patients. Detailed patient characteristics are listed in Table 1. Data from 105, 89, 78 and 73 patients was available for analysis after discharge as well as after three, six and 12 months of follow-up, respectively (Table 2). The insufficient period of time after treatment was the main reason for the difference in the number of eligible patients ($n = 20$). Within the observation period four patients were unwilling to participate in the follow-up or did not participate because of logistical reasons ($n = 4$); a few were lost to follow-up ($n = 2$) and morbidity precluded further follow-up in three patients. Two patients died within the follow-up period.

The mean age was 70.4 ± 8.7 years (50–90), average prostate volume was 52.2 ± 24.3 ml (33–150) and preoperative prostatic-specific antigen (PSA) value was 3.6 ± 3.6 ng/dl (0–20). According to our daily clinical practice 27 (25%) patients suffering from LUTS secondary to BPH had a baseline residual volume > 200 ml. Mean operating time was 54.5 ± 25.0 min (15–160). Since regional anesthesia was administered in most cases ($n = 67$), postoperative insertion of an indwelling catheter was therefore mandatory. The catheter was usually removed in the morning following the procedures. The mean time up to

Table 1
KTP laser vaporization of the prostate: perioperative data ($n = 108$)

Time	Characteristic	
Preoperative	Age (years)	70.4 ± 8.7 (50–90)[a]
	ASA category I + II (n)	74
	ASA category III + IV (n)	34
	Preoperative PSA (ng/dl)	3.6 ± 3.6 (0–20)
	Total prostate volume (ml)	52.2 ± 24.3 (33–150)
Intraoperative	Operating time (min)	54.5 ± 25.0 (15–160)
	Applied energy (kJ)	184 ± 80 (2–438)
Postoperative	Transurethral catheter removal on postoperative day	1.7 ± 1.2 (0–6)
	Total hospitalization (days)	5.2 ± 2.3 (3–16)
	Discharged with transurethral/suprapubic catheter (n)	11/2

[a] Data presented as mean ± standard deviation (range) or absolute numbers.

Table 2
Subjective and objective follow-up after 108 KTP procedures

	Preoperative	Follow-up			
		Discharge	3 months	6 months	12 months
Number of patients available for follow-up.	(n = 108)	(n = 105)	(n = 89)	(n = 78)	(n = 73)
IPS score	18.6 ± 6.3 (8–31)	9.9 ± 6.7† (1–32)	7.7 ± 6.4‡ (0–25)	6.4 ± 5.4 ns (0–15)	7.0 ± 7.0 ns (0–8)
Bother score	3.6 ± 1.6 (0–6)	1.8 ± 1.5† (0–6)	1.4 ± 1.4§(0–4)	1.2 ± 1.2 ns (0–3)	1.1 ± 1.2 ns (0–1)
Qmax (ml/s)	7.1 ± 3.2 (1–14)	15.0 ± 9.7† (4–56)	22.2 ± 11.5† (5–64)	21.4 ± 9.2 ns (10–49)	25.0 ± 8.8 ns (10–40)
Vres (ml)	157 ± 158 (20–800)	88 ± 112† (0–600)	23 ± 32† (0–103)	24 ± 47 ns (0–250)	36 ± 45 ns (0–135)

Data presented as mean ± standard deviation (range). Statistical comparison to the previous control, Wilcoxon test, SPSS 11.5 (SPSS Inc., Chicago, IL) statistical software package.; p value of less than 0.05 was considered to be statistically significant. ns = not significant.
† $p < 0.001$.
‡ $p = 0.004$.
§ $p = 0.047$.

catheter removal was 1.7 ± 1.2 postoperative days (0–6) (Table 1).

Functional parameters improved immediately after catheter removal (Table 2). Compared to the preoperative data, Qmax increased highly significantly ($p < 0.001$) by an average of 111% (+7.9 ml/s) at discharge, 213% (+15.1 ml/s) after three months, 201% (+14.3 ml/s) after six months and finally 252% (+17.9 ml/s) after 12 months (Table 2). The irritation symptom scores, IPSS and Bother Score also improved highly significantly ($p < 0.001$) just after surgery. The improvement of Qmax, Vres, IPSS and Bother Score was sustained throughout the 12-month follow-up period (Table 2).

According to our inclusion criteria, we did not observe statistical differences in terms of improvement of urinary peak flow rate between patients with with high and low baseline residual volumes (Fig. 1). Up from the 3rd months post-operatively, outcome showed no differences with regard to postvoid residual volume among both groups.

We did not detect intraoperative complications such as severe bleeding necessitating transfusion, absorption of irrigation solution (TUR syndrome) or bladder neck perforation. Bladder washout to deal with clot retention was not required postoperatively in any case. Irrigation was usually not necessary on the regular ward. An average of 757 ± 355 ml (500–1500) Ringer lactate infusion was applied intravenously during anesthesia. The mean hemoglobin value changed from 14.6 ± 1.9 mg/dl (9–18) preoperatively to 12.8 ± 2.5 mg/dl (9–16) postoperatively and to 13.3 ± 2.1 (9–16) on discharge. At the same time, the mean sodium level remained unchanged after 1 hour at (−0.9%) 140.5 ± 2.2 U/l (135–145 U/L) and on discharge at 139.3 ± 2.4 U/l (134-144 U/L) and 139.3 ± 2.6 U/L (136-144 U/L) respectively.

After catheter removal, transient urinary retention requiring recatheterization was detected in 11 (10%) patients during the hospital stay and in one (1%) patient after discharge (Table 3). After an additional three to five days, the catheter was successfully removed in all but one (removal after 14 days) of these patients. Patients with an indwelling catheter on discharge were significantly older (68.8 ± 8.1 vs. 66.2 ± 8.6 years;

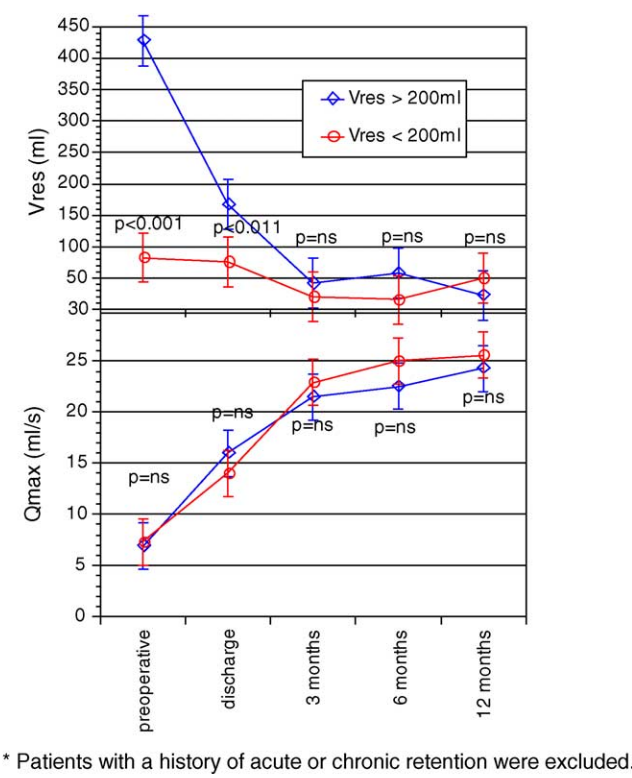

Fig. 1. Comparison of patients with high (>200 ml; n = 27) and low (<200 ml; n = 81) baseline residual volumes (Vres): 12 months follow-up of urinary peak flow (Qmax)- and Vres measurement*. Note: no difference was observed in terms of improvement of Qmax between both groups.

Table 3
Complications after KTP laser vaporization in 108 selected patients with BPH[a]

Type of complication	Follow-up n (%)
Transient hematuria	1 (0.9)
Bladder neck stricture	1 (0.9)
Unexplained fever > 39 °C	2 (1.8)
Transient urinary incontinence[b]	2 (1.9)
Urethral stricture (reoperation)	4 (3.7)
Urinary tract infection	5 (4.7)
Mild to moderate urge	7 (6.5)
Urinary retention	12 (11.1)

[a] Cumulative reporting.
[b] duration > 2 weeks.

$p < 0.05$, Mann-Whitney U test), had larger prostate volumes (51.1 ± 24.4 vs. 41.6 ± 26.9 ml; $p < 0.05$) and had a higher preoperative Bother Score when compared to those patients in whom the catheter had been removed before discharge (Bother Score 4.4 ± 1.4 [catheter] vs. 3.4 ± 1.6 [no catheter]); $p < 0.05$). In addition, we recognized a tendency to larger preoperative residual volumes (151 ± 146 [no catheter] vs. 226 ± 244 ml [catheter]), but this difference has not yet reached statistical significance. Two of these patients with postoperative retention were successfully operated with a bladder neck-sparing technique and four patients had a mean preoperative Vres of 420 ml (260–800) as evidence of a putative chronic retention prior to surgery.

Mild to moderate dysuria was reported by only a few patients $n = 7$ (6%) postoperatively. These patients were usually treated successfully with non-steroid anti-inflammatory drugs and oral analgesics (e.g. metamizole) for a few days. A transient urinary incontinence was reported by four (4%) patients at the time of discharge. In two cases of postoperative incontinence oral medication and active pelvic floor training was necessary. However, urinary incontinence was self-limiting in all patients. Urinary tract infection occurred in five cases (5%), mainly because the prescribed oral antibiotics were discontinued too early. A new incidence of erectile dysfunction was not reported by any patient. In two patients, a successful bladder neck-sparing KTP laser procedure was performed explicitly in order to preserve antegrade ejaculation.

The cumulative complication rate within 12 months is presented in Table 3. A postoperative urethral stricture was observed in four cases (4%). Recurrent urethral strictures, long-lasting transurethral catheterism or a chronic prostatitis were known prior to surgery in these patients.

4. Discussion

Despite the large number of alternative procedures available, TURP remains an effective surgical technique for experienced surgeons with good short-term and long-term functional results [3–5]. Although there have been technical improvements and a dramatic decrease of mortality and morbidity during recent decades, TURP always has been associated with a significant perioperative morbidity [1,2,6–8].

Visual laser ablation of the prostate using a Neodymium:Yttrium-Aluminum-Garnet (Nd:YAG) laser (VLAP) was introduced in the early 1990s by Costello and colleagues to treat obstructive voiding caused by BPH [9]. In contrast to the 532 nm KTP laser, the 1064 nm Nd:YAG laser light is not selectively absorbed by prostatic tissue, i.e. the laser energy is mainly converted into heat and causes a deep coagulation zone. This largely avoids bleeding during the procedure. However, it results in delayed necrosis and sloughing of tissue with consecutive symptoms of irritation.

Based on primary experimental studies, Malek and colleagues inaugurated a 60 W KTP laser in clinical practice, obtaining encouraging results with a 2-year follow-up [10]. In contrast to the 60 W laser formerly employed, we have used an improved 80W power setting with a quasi-continuous pulsing technology. A high-frequency modulation of laser light generates a continuous stream of short micropulses (StarPulse™-Technology). It is postulated that the higher power results in faster tissue heating and a more rapid tissue removal by vaporization. A comprehensive overview article with detailed description of KTP laser vaporization for treatment of obstructive LUTS secondary to BPH has recently been published by Malek and Nahen [11]. KTP laser vaporization is referred to as photoselective vaporization of the prostate (PVP), in which high power KTP laser energy is used to vaporize and, thus, immediately remove obstructive prostatic adenoma [11]. The photoselectivity of the green 532 nm laser wavelength, is given by the fact that this visible wavelength is strongly absorbed within the very superficial layer of tissue by virtue of the fact that blood vessels and hemoglobin (chromophore) contained therein serve as primary and selective absorbers. Consecutively, the process of vaporization carries away heat from the targeted tissue and, thus, prevents deep coagulation [11]. The vaporization process is comparable to the ‘‘resection’’ process during TURP, with immediate removal of tissue. Efficient vaporization also helps prevent the problems associated with earlier Nd:YAG laser treatments (visual laser ablation of the prostate [VLAP]), wherein much deeper tissue coagulation (7 mm) led to early edema and delayed sloughing of necrotic tissue, resulting in prolonged obstruction and severe postoperative dysuria [11].

Our current study shows a favorable perioperative outcome after 80 W KTP laser vaporization in patients with symptomatic LUTS secondary to BPH (Tables 1 and 2). Although our data represent preliminary results with a limited follow-up of 12 months, the efficacy of this procedure seems to be comparable to that of TURP and other primary tissue-ablative procedures (Table 4). Our 12-month results are comparable to those of a recently published prospective multicenter series employing the 80 W KTP laser [12]. Currently, no data from studies comparing TURP and PVP has been

Table 4

Improvement of subjective (IPSS) and objective parameters (Qmax) of different transurethral tissue-ablative prostatectomy procedures after 12 months

Procedure	Author [Source]	No. of patients (12 m)	Age mean ± SD (years)	Prostate volume mean ± SD preop. (ml)	Improvement of Qmax Δ ml/s (%)	IPS score Δ (improvement %)	Treatment failure n (%)[a]
80 W KTP	Present series	73	70.4 ± 8.7	52.2 ± 24.3	+17.9 (252)	−15.0 (81)	0
	Malek et al. 2000[e] [10]	36	68 ± 7	43 ± 14	+19.0 (255)	−18.1 (82)[d]	0
	Te et al. 2004 [12]	119	67.7 ± 8.7 (n = 139)	54.6 ± 31.7 (n = 139)	+14.8 (190)	−19.7 (82)	0
	Hai et al. 2003 [15]	10	64.1 ± 7.6	41 ± 18.5	+20.4 (198)	−20.6 (88)[d]	0
	Barber et al. 2004[h] [16]	30	66	60	+11.2 (135)	−15.4 (69)	ned.
	Te et al. 2003[f] [17]	12	46–82	55.1 ± 32	+15.1 (196)	−22.2 (93)[d]	0
TURP	Melick et al. 2003 [18]	50[c]	ned.	ned. (20-65)	+10 (78)	−12.5 (75)[d]	2 (4)
	Schatzl et al. 2000 [4,30]	28	ned.	ned.	+12.9 (157)	−14.8 (76)	1 (4)
	Madersbacher et al. 1999[g] [5]	1480	ned.	ned.	+9.7 (125)	ned. (71)	ned. (2.6)[j]
	Gilling et al. 1999 [19]	102[i]	66.8 ± 7.4	44.6 ± 20.7	+11.3 (124)	−18.7 (81)[d]	4 (6.6)[k]
	McAllister et al. 2003[h] [20]	108	69.7	51.1	+11.8 (112)	−13.8 (67)	4 (4)
	Fraundorfer et al. 2001 [25]	59	ned.	ned.	+11.3 (124)	−18.7 (81)	2 (3)
	Mottet et al. 1999 [21]	13			+9.9 (129)	−19 (80)	2 (15.4)
	Chandrasekar et al. 2004 [22]	25	70.1[i]	48.3[i]	+13.8 (173)	−14.3 (75)	ned.
HoLEP	Mottet et al. 1999 [21]	23	ned.	ned.	+11.1 (126)	−15.2 (70)	1 (4.3)
	Hurle et al. 2002 [24]	72	65 ± 7	54 ± 33	+13.2 (141)	−24.5 (92)	4 (2.5)
	Gilling et al. 1999 [19]	102[i]	66.9 ± 6.5	44.3 ± 19.0	+16.3 (183)	−17.7 (81)	1 (1.6)[k]
	Hochreiter et al. 2002[l] [23]	94	69 (47-90)[b]	38 (20-70)[b]	ned. (150)	ned. (85)	ned.
	Fraundorfer et al. 2001[m] [25]	61	ned.	ned.	+16.3 (183)	−17.7 (81)	0
TUVP	Melick et al. 2003[o] [18]	46[c]	ned.	ned. (20-65)	+19 (211)	−15.5 (76)	2 (4)
	Madersbacher et al. 1999[g] [5]	189[c]	ned.	ned.	slightly exceeded 125%	ned. (80)	0[j]
	Reich et Faul 2004[n] [26]	194	ned.	ned.	+9.6 (117)	−14.1 (63)	0
	Schatzl et al. 2000 [4,30]	17	ned.	ned.	+12.4 (139)		2 (12)
	McAllister et al. 2003[h] [20]	109	70.2	54.3	+9.5 (95)	−11.8 (59)	1 (1)
	Michel et al. 2003[p] [27]	84[c]	ned.	46	+15.6 (161)	−20.3 (85)	2 (2)[q]
	Chandrasekar et al. 2004[r] [22]	51	70.1[i]	48.3[i]	+13.3 (150)	−14.1 (75)	2 (4)

ned. = not explicitly specified.
[a] in terms of insufficient tissue ablation.
[b] median (range).
[c] at study-entry.
[d] AUA score.
[e] KTP laser with 60W power setting.
[f] multi-center prospective trial (7 institutions).
[g] meta-analysis of 29 randomized clinical trials, all follow-up > 6 months, pts. Preoperative retention excluded.
[h] 6 month results.
[i] TURP and compared group together, separate number of patients at 12m not explicitly specified.
[j] 2 year period.
[k] any kind of reoperation.
[l] holmium laser enucleation combined with electrocautery resection: mushroom technique.
[m] holmium laser resection.
[n] using Band Electrode.
[o] using Vapodrode®.
[p] using Rotoresect system.
[q] within 4 year follow-up.
[r] using Plasma Kinetic™ energy.

published. A meta-analysis of results for Qmax after 12-month follow-up reveals that holmium laser procedures, transurethral electrovaporization and TURP are equally efficient [13,14]. A comparison of this accumulated data with the results from our KTP laser vaporization study as well as other trials using this technique show that PVP is comparable to aforementioned primary tissue-ablative transurethral procedures (Table 4) [15–27]. In patients with high baseline residual urine volumes debulking of the obstructive tissue is of utmost concern. Thus, even in these patients laser vaporization is a suitable tool for improvement of Qmax and Vres parameters (Fig. 1).

PVP has the potential to reduce health care expenses for the treatment of obstructive BPH. Although capital investment for the laser generator (100.000–120.000 €) and disposable costs for the single use laser fiber (1000–1200 €) are significant, cost savings for insurers become evident ones shorter hospital stay, lower incidence and less severity of post-operative complications for PVP compared to TURP are taken into consideration [28]. Although vaporization of very large prostates is feasible, it remains a technically demanding procedure. Access to tissue can be challenging in complex gland geometries with very large lobes. Moreover, the effectiveness of power delivery by the laser fiber is limited. Vaporization efficiency is impaired after applying energy of approximately 150 kJ, as indicated by a reduction in vapor bubble formation, owing to a functional deterioration of the laser fiber. Therefore, usually more then one fiber needs to be used on big glands. Added disposable costs for the PVP treatment of large glands must be weight against the costs for open prostatectomy considering the minimally-invasive approach of the laser treatment and the shorter convalencence. Compared to the standard transvesical adenoma enucleation, the superior safety of the PVP procedure combined with the unequivocal tissue-ablative effect indicates that it is suitable for treating a large prostate, especially in elderly or polymorbid patients.

The 80W KTP laser vaporization is a user-friendly technique in conjunction with a low overall complication rate (Table 3). Although our data represents the entire learning curve of two surgeons, neither severely bleeding TUR-syndrome nor clot retention was observed. With TURP urinary retention, urinary tract infection and severe hemorrhages with subsequent clot retention remain the most frequent bleeding complications within 4–6 weeks post-operatively [28]. Additionally, fluid absorption during TURP occurs in more than 50% and is a clinical problem in up to 12% of cases [29]. Based on meta-analysis data, transfusion rate and postoperative clot retention is nowadays reported in 7–8.6% and 5.5–7% after TURP, respectively [5,13]. We have not seen any of these complications in our KTP laser series.

The rate of postoperative urinary tract infection we observed is comparable to TURP. Continuation of oral antibiotics for approximately 10–14 days should be mandatory after KTP laser vaporization. We observed a prevalence for UTI in patients with higher baseline Vres and in patients who had discontinued the oral antibiotics before the prescribed time. The overall retention rate in our series was 11% (Table 3). Eleven patients were discharged with an indwelling catheter, mainly because of persistent large residual volumes at the time of discharge. The retention rate we observed is a little higher than after TURP, but stayed in an acceptable range [2,13,28]. Additionally, the retention rate must been seen in light of very brought inclusion criteria that did not exclude very old patients, patients with high preoperative residual volume or patients with co-morbidities.

5. Conclusions

High-power (80 W) KTP laser vaporization of the prostate is a new virtually bloodless and effective procedure for surgical treatment of LUTS secondary to BPH. Our results showed an immediate and highly significant improvement of objective voiding parameters just after surgery, which is sustained during a follow-up of 12 months. Additionally, patients typically experienced relief from obstructive voiding immediately after surgery. KTP laser vaporization of the prostate is associated with a low rate of perioperative complications. These results have to be corroborated by studies comparing KTP laser vaporization with the golden standard TURP.

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