JOURNAL OF ENDOUROLOGY
Volume XX, Number XX, XXXX 2014

Pp. ■■■–■■■
DOI: 10.1089/end.2013.0715

Technology

Vaporization of the Prostate with 150-W Thulium Laser: Complications with 6-Month Follow-Up

César Vargas, MD, Alejandro García-Larrosa, MD, Santiago Capdevila, MD, and Ainhoa Laborda, MD

Abstract

Purpose: To analyze the efficacy and safety of vaporization of the prostate (VP) with the 150-W thulium:yttrium-aluminum-garnet (Tm:YAG) laser.

Patients and Methods: In a prospective series of 55 patients with small- and medium-size prostates undergoing major outpatient surgery (MOS), the primary objectives were to analyze changes in maximum flow (Q_{max}) and International Prostate Symptom Score (IPSS) after 6 months. Immediate (<30 days) and late (>30 days) complications were subsequently recorded.

Results: An increase in mean Q_{max} of 9.33 mL/s (95% confidence interval [CI] of the mean difference 6.73–11.93; $P<0.001$) was recorded, and mean IPSS was reduced by 16.88 points (95% CI 14.22–19.54; $P<0.001$). The immediate complications recorded were acute urinary retention (one patient), urinary tract infection without fever (two patients), and macroscopic hematuria (two patients). The only late complication observed was bladder neck sclerosis (one patient).

Conclusion: After 6 months, VP with 150-W Tm:YAG presents promising results in the clinical improvement of patients with small- and medium-size prostates. Its complication rate is low and it offers excellent hemostasis. The data from our study provide the basis for the design of clinical trials to compare this technique with other procedures.

Introduction

The use of lasers in urology was based in the neodymium-yttrium-aluminum-garnet laser[1] in the beginning. Vaporization of the prostate (VP) with potassium-titanyl-phosphate (KTP) laser was first reported in 1998.[2] Two meta-analyses have recently been published comparing the functional results of transurethral resection of the prostate (TURP) with those of VP with 80-W KTP and 120-W lithium borate (LBO) lasers.[3,4] These outcomes were achieved with a shorter catheterization time, shorter hospital stay, and fewer complications (bleeding, need for transfusion, and clot retention).

Other types of laser that reproduce the same vaporization technique have been developed. These include the thulium:yttrium-aluminum-garnet (Tm:YAG) laser that, because of its physical properties (wavelength and continuous laser energy emitting mode), combines the best features for performing VP techniques. Only one study on VP with Tm:YAG has been published to date,[5] although its conclusions are limited because the results of two surgical procedures (vaporization and vaporesection) are presented together. No clinical trials comparing VP using Tm:YAG with other techniques have been published.

The objective of this study was to assess the functional results and complications obtained after VP with 150-W Tm:YAG.

Patients and Methods

A prospective clinical case series was performed using VP with 150-W Tm:YAG on 55 patients on a major outpatient surgery (MOS) basis between January 2011 and December 2012.

The inclusion criteria were prostate volume (abdominal ultrasonography) <80 cc, International Prostate Symptom Score (IPSS) >16, and maximum flow rate (Q_{max}) <15 mL/s.

The exclusion criteria were serum prostate-specific antigen (PSA) value >10 ng/mL, suspicious digital rectal examination, history of urethral stricture or prostate surgery, bladder calculi, neurogenic bladder dysfunction, anticoagulant treatment, and American Society of Anesthesiologists score of IV or higher.

The primary study objectives were to assess functional outcomes after 6 months measured with Q_{max} and IPSS, and to record possible immediate- and late-onset complications. These complications were reported following the recommendations of the European Association of Urology,[6] and the modified Clavien-Dindo classification was used.[7]

In addition to the patients' baseline demographic characteristics, the variables analyzed were duration of surgery and laser use (minutes), amount of energy used (kilojoules), and

Department of Urology, Hospital de Viladecans, Viladecans, Barcelona, Spain.

bladder catheter removal date. In patients with a bladder catheter at the time of surgery, the last flowmetry, postvoid residual volume, and IPSS performed before presenting urinary retention were recorded.

Surgical technique

The procedures were performed by four different urologists, all experienced in TURP and photovaporization of the prostate with LBO.

Patients were operated on under epidural anesthesia. A 150-W Tm:YAG laser in continuous energy emitting mode was used (Quanta System, Italy; Coupler Medical, Spain). Application was performed with a 23F continous flow cystoscope (Karl Storz, Germany) and a 600-μm side-firing laser fiber with numerical aperture of 0.32. The VP was performed from the basal to the apical area with 0.9% saline irrigation. The procedure began at 80-W.

In the first phase of the surgery, the bladder neck was opened and the median lobe resected. The lateral lobes were then resected until a working channel was created in the prostate. This provided a good irrigation flow to displace the bubbles generated by the vaporization, facilitating vision. A power of 120- to 150-W was used from then on, completing vaporization of the median and lateral lobes. When hemostasis of a specific point was necessary, work proceeded on this area at 40-W. At the end of surgery, a three-way 20F silicone urethral catheter was inserted, and continuous bladder irrigation with saline was maintained.

Patients were discharged the same day of surgery with the urethral catheter, which was scheduled for removal 48 hours later. Treatment was prescribed with tamsulosin 0.4 mg/24 hours and solifenacin 5 mg/24 hours for 4 weeks in combination with diclofenac 50 mg/8 hours for the first 5 days.

Follow-up

Immediate complications were assessed after 1 month. Q_{max}, IPSS, and late complications were assessed after 6 months. The data were collected in a personal interview with each patient, conducted by one of the team physicians.

Statistical analysis

In the descriptive analysis of the quantitative variables, the mean and the standard deviation was used. The absolute frequencies were considered for the qualitative variables. The quantitative variables were analyzed using the Student *t* test if they followed normal distribution and with the nonparametric Mann-Whitney *U* test if they did not fulfil the assumption of normality. For all the tests used to contrast the null hypothesis, *P* value was <0.05. The analysis was performed using SPSS statistical package version 17 for Windows (IBM Corp).

Results

Baseline and perioperative characteristics

Table 1 describes the baseline and perioperative characteristics of the 55 patients. Fifteen (27.3%) of these patients were receiving antiplatelet treatment and eight (14.5%) had bladder catheters at the time of surgery because of acute urinary retention.

Table 1. Baseline and Perioperative Characteristics ($N=55$ Patients)

Variable	*Mean*	*SD*
Age	69.41	9.19
Prostate volume (cc)	42.53	17.41
PVR (mL)	97.11	91.26
PSA (ng/dL)	2.27	1.72
Q_{max} (mL/s)	8.92	3.04
IPSS	25.00	4.54
Operative time (min)	51.62	19.76
Laser time (min)	22.84	9.80
Energy (kilojoules)	177.98	84.59

PVR = postvoid residual; PSA = prostate-specific antigen; Q_{max} = maximum flow rate; IPSS = International Prostate Symptom Score.

No intraoperative complications were recorded. In all cases, bladder irrigation was removed between 3 and 5 hours after the end of vaporization. All patients were discharged on the day of surgery with the urethral catheter (hospital stay less than 8 hours), which was removed 2 days later in all cases.

First follow-up visit (first month)

All patients attended this control. Five (9.1%) patients had presented some type of early complication (<30 days). Table 2 shows these complications, detailing their definition and classification according to the modified Clavien-Dindo classification. None of the patients with hematuria were receiving antiplatelet treatment or required surgical revision or blood transfusion.

Second follow-up visit (sixth month)

Fifty-two patients were assessed, because three were lost to follow-up. Table 3 specifies these late complications, detailing their definition and classification according to the modified Clavien-Dindo classification.

An increase in mean Q_{max} of 9.33 mL/s was recorded in the remaining 52 patients, which constitutes a change of 104.6% with regard to the initial recording. Mean postoperative IPSS was reduced by 16.88 points (67.5%). Table 4 shows the functional results. Seven (13.5%) of these 52 patients needed treatment with anticholinergics because of the presence of irritative lower urinary tract symptoms (LUTS).

Table 2. Early Complications (<30 Days, $N=55$ Patients)

Complication	n *(%)*	*Management*	*Clavien modified classification*
AUR	1 (1.8%)	Catheterization	I
Hematuria	2 (3.6%)	Catheterization and bladder irrigation	I
Nonfebrile UTI	2 (3.6%)	Antibiotics	II

Irritative LUTS with positive urine culture. Hematuria: Macroscopic hematuria necessitating catheterization and bladder irrigation.

AUR = acute urinary retention (>500 mL after catheterization); UTI = urinary tract infection.

Table 3. Late Complications (>30 Days, n=52 Patients)

Complication	n *(%)*	*Management*	*Clavien modified classification*
Bladder neck sclerosis	1 (1.9%)	Transurethral resection	III

Bladder neck sclerosis: Stricture <16F because of submucosal fibrosis diagnosed by flexible cystoscopy.

Discussion

Existing laser systems can be successfully applied in various prostate surgery procedures. Analysis of their physical properties (wavelength, target chromophore, emitting mode, and power) enables us to understand the effect generated on prostate tissue and their possible clinical application.

KTP laser has a wavelength of 532 nm. Its target chromophore is the oxyhemoglobin molecule. The coagulative necrosis generated on the tissue after the action of the laser alters the characteristics of oxyhemoglobin. As the chromophore is altered, the energy transmitted by the KTP on the tissue will have a lower absorption rate and higher scattering, thereby modifying the vaporizing effect of KTP as of this time.[8]

Tm:YAG has a wavelength of 2013 nm, and its target chromophore is water. The energy of the Tm:YAG has a high tissue absorption rate, producing effective vaporization with scant depth in the remaining tissue. Because the properties of water remain unaltered until water reaches boiling point, the effect of the laser on the tissue remains constant throughout the surgical procedure.[9]

The target chromophore of the holmium:yttrium-aluminum-garnet laser (Ho:YAG) is also water. The main difference with respect to the Tm:YAG is its emitting mode. The Ho:YAG's flash lamp excitation generates a beam of light that is emitted in pulsed peaks. This results in better tearing action on the tissue, which is highly useful in enucleation techniques and permits lithotripsy to be performed. The Tm:YAG is diode-pumped, thus generating continuous energy emission. This wavelength output enables better tissue vaporization.[9]

In animal models, the Tm:YAG 70-W showed a higher tissue ablation rate than the KTP 80-W: 6.56 g/10 minutes *vs* 3.99 g/10 minutes.[10] The ablation rate of both lasers increases with their output power, reaching 16.41 g/10 minutes for the Tm:YAG 120-W[11] and 7.01 for the LBO 120-W.[12] This higher ablation rate is accompanied by less damage to the remaining tissue.

Taking into account its chromophore, wavelength, and diode-pumped continuous emitting mode, we believe that the Tm:YAG laser combines the best physical properties for VP. Only one article analyzing the clinical outcomes obtained with this technique has been published, however.[5] This study describes the results after performing VP with 70-W Tm:YAG (Revolix) on 99 patients with prostates smaller than 35 cc. These results were presented together with those obtained after vaporesection performed on 101 patients with larger prostate volumes. Overall, a 50% improvement in the IPSS score was achieved. Because the results obtained with two different techniques were presented jointly, the specific results of VP with Tm:YAG cannot be assessed. Other different thulium laser technical approaches have been described, such as resection and enucleation of the prostate. None has been evaluated at the 150-W energy level.

Our study is the first to analyze the outcomes of VP with 150-W Tm:YAG. In patients with a mean prostate volume of 43.5 cc, we recorded an improvement of 9.33 mL/s in the mean Q_{max} and a reduction of 16.88 points in the mean IPSS. There are no clinical trials comparing the results obtained after VP using Tm:YAG with other techniques, although the results were quantitatively similar to those described in clinical trials analyzing VP performed with KTP, LBO, or Ho:YAG (Table 5).

The short-term VP complication rate with Tm:YAG was similar to the rate described after VP with other laser systems[13–19] and less than that with TURP. Reich and associates[20] specified a rate of acute urinary retention of 5.8% for TURP and bleeding necessitating transfusion of 2.9%. The safety of VP with Tm:YAG allows it to be performed as a MOS procedure.

In our series, 13.7% of the patients remained on anticholinergic treatment, complaining of irritative LUTS 6 months after vaporization. Because of the study characteristics, it is impossible to ascertain whether the symptoms were *de novo* or existed before the surgery. The possible role of the bladder in irritative LUTS in men must be considered. It is estimated that approximately 35% of patients presenting with obstructive LUTS may report concomitant irritative symptoms.[21] Moreover, up to one-third of patients undergoing prostatectomy may present with urgency symptoms up to 11 months postsurgery.[22] Pereira-Correia and colleagues[13] described the appearance of urge urinary incontinence not associated with detrusor hyperactivity in 50% of patients who underwent VP with 120-W LBO, which remitted in the subsequent 3 to 12 months. A smaller coagulated tissue area has been described with Tm:YAG (0.4 mm)[10] than with LBO (0.84 mm) in *ex-vivo* models.[12] It would be interesting to determine whether these differences at tissue level involve changes in the incidence of dysuria and/or irritative LUTS.

The short follow-up time and lack of a comparative group for the technique are two of the limitations of our study. Because it is a quasi-experimental study, in which each subject acts as his own control, the results may be biased by

Table 4. Results at 6 Months (n=52 Patients)

Variable	*Before surgery*[1]	*Follow-up 6 months*[2]	*Mean difference*	*95% CI*[3]	P[4]
Q_{max} (mL/s)	8.92 (3.04)	18.26 (8.24)	9.33	6.73 to 11.93	<0.001
IPSS	25.00 (4.54)	8.12 (6.63)	16.88	14.22 to 19.54	<0.001

[1,2]Mean, standard deviation in parentheses.
[3]95% confidence interval (CI): 95% confidence interval of the mean difference.
[4]Statistical significance.
Q_{max} = maximum flow rate.

Table 5. Vaporizations of the Prostate with Laser: Clinical Trials

Author	*Technique*	n	*PV*	*T*	Q_{max} *a*	Q_{max} *b*	*Dif* Q_{max} *(%)*	*IPSS a*	*IPSS b*	*Dif IPSS (%)*
Bouchier-Hayes et al.[13]	KTP	38	42.4	12	8.8	18.6	9.8 (111.4)	25.3	8.9	− 16.4 (− 64.8)
	TURP	38	33.2	12	8.9	19.4	10.5 (118.0)	25.4	10.9	− 14.5 (− 57.1)
Horasanli et al.[18]	KTP	39	86.1	6	8.6	13.3	4.7 (54.7)	19	13	− 6 (− 31.6)
	TURP	37	88	6	9.2	20.7	11.5 (125)	20	6	− 14 (− 70)
Pereira-Correia et al.[14]	LBO	20	43.4	24	10.0	20.5	10.5 (105)	22	7	− 15 (− 68.2)
	TURP	20	47	24	6.4	18.6	12.2 (190.6)	25	6	− 19 (− 76)
Capitán el al.[15]	LBO	50	51.6	24	8.0	22.6	14.6 (182.5)	23.7	8	− 15.7 (− 66.2)
	TURP	50	53.1	24	8.9	22.0	13.1 (147.2)	23.5	8.6	− 14.9 (− 63.4)
Al-Ansari et al.[16]	LBO	60	61.8	36	6.9	17.2	10.3 (149.3)	27.2	11	− 16.2 (− 59.6)
	TURP	60	60.3	36	6.4	19.9	13.5 (210.9)	27.9	9	− 18.9 (− 67.7)
Lukacs el al.[17]	LBO	69	50.5	12	7.8	16.7	8.9 (114.1)	22	6	− 16 (− 72.7)
	TURP	70	50.1	12	7.8	16.8	9 (115.4)	20	5	15 (− 75)
Elmansy et al.[19]	KTP	52	37.3	36	6.4	18.5	12.1 (189.1)	18.4	5.9	− 12.5 (− 67.9)
	Ho:YAG	57	33.1	36	6.7	17.7	11 (164.2)	20	6.6	− 13.4 (− 67)

n = sample size; PV = prostate volume (cc); T = follow-up time (months); Q_{max} a = maximum preoperative flow rate (mL/s); Q_{max} b = maximum postoperative flow rate (mL/s); Dif Q_{max} (%) = change in maximum flow rate after surgery (ml/s). % change in parentheses; IPSS a = preoperative International Prostate Symptom Score; IPSS b = postoperative IPSS score; Dif IPSS (%) = change in IPSS score after the surgery. % change in parentheses; KTP = potassium-titanium-phosphate; TURP = transurethral resection of the prostate; LBO = lithium borate; Ho:YAG = holmium:yttrium-aluminum-garnet.

regression to the mean phenomena. In any case, the intense improvement observed renders it unlikely that the change is because of nonsurgery-related phenomena. Another limitation is the lack of observer and analyst blinding techniques.

Conclusions

VP with 150-W Tm:YAG presents promising results in the clinical improvement of patients with small- and medium-size prostates after 6 months. Its complication rate is low, and it offers excellent hemostasis. The process is safe, enabling it to be performed as MOS. The data from our study could form the basis for the design of studies to compare this technique with other surgical procedures.

Disclosure Statement

No competing financial interests exist.

References

1. Cowles RS 3rd, Kabalin JN, Childs S, et al. A prospective randomized comparison of transurethral resection to visual laser ablation of the prostate for the treatment of benign prostatic hyperplasia. Urology 1995;46:155–160.
2. Malek RS, Barret DM, Kuntzman RS. High-power potassium-titanyl-phosphate (KTP/532) laser vaporization prostatectomy: 24 hours later. Urology 1998;51:254–256.
3. Thangasamy IA, Chalasani V, Bachmann A, Woo HH. Photoselective vaporisation of the prostate using 80-W and 120-W laser versus transurethral resection of the prostate for benign prostatic hyperplasia: A systematic review with meta-analysis from 2002 to 2012. Eur Urol 2012; 62:315–323.
4. Zhang X, Geng J, Zheng J, et al. Photoselective vaporization versus transurethral resection of the prostate for benign prostatic hyperplsasia: A meta-analysis. J Endourol 2012; 26:1109–1117.
5. Mattioli S, Muñoz R, Recasens R, et al. [Treatment of benign prostatic hypertrophy with the Revolix laser.] (Spa) Arch Esp Urol 2008;61:1037–1043.
6. Mitropoulos D, Artibani W, Graefen M, et al. Reporting and grading of complications after urologic surgical procedures: An ad hoc EAU guidelines panel assessment and recommendations. Eur Urol 2012;61:341–349.
7. Dindo D, Demartines N, Clavien PA. Classification of surgical complications: A new proposal with evaluation in a cohort of 6336 patients and results of a survey. Ann Surg 2004;240:205–213.
8. Teichmann HO, Herrmann TR, Bach T. Technical aspects of lasers in urology. World J Urol 2007;25:221–225.
9. Herrmann TW, Liatsikos E, Nagele U, et al. EAU guidelines on laser technologies. Eur Urol 2012;61:783–795.
10. Wendt-Nordahl G, Huckele S, Honeck P, et al. Systemic evaluation of recently introduced 2-microm continuous-wave thulium laser for vaporesection of the prostate. J Endourol 2008;22:1041–1045.
11. Bach T, Huck N, Wezel F, et al. 70 vs 120 W thulium:yttrium-aluminium-garnet 2 microm continuous-wave laser for the treatment of benign prostatic hyperplasia: A systematic ex-vivo evaluation. BJU Int 2010;106:368–372.
12. Heinrich E, Wendt-Nordahl G, Honeck P, et al. 120 W lithium triborate laser for photoselective vaporization of the prostate: Comparison with 80 W potassium-titanyl-phosphate laser in an ex-vivo model. J Endourol 2010;24:75–79.
13. Pereira-Correia JA, de Moraes Sousa KD, de Morais Perpétuo D, et al. GreenLight HPS™ laser vaporization vs transurethral resection of the prostate (< 60 mL): A 2-year randomized double-blind prospective urodynamic investigation. BJU Int 2012;110:1184–1189.
14. Bouchier-Hayes DM, Van Appledorn S, Bugeja P, et al. A randomized trial of photoselective vaporization of the prostate using the 80-W potassium-titanyl-phosphate laser vs transurethral prostatectomy, with a 1-year follow-up. BJU Int 2009;105:964–969.
15. Capitán C, Blázquez C, Martin MD, et al. Greenlight HPS 120-W laser vaporization versus transurethral resection of the prostate for the treatment of lower urinary tract symptoms due to benign prostatic hyperplasia: A randomized clinical trial with 2-year follow-up. Eur Urol 2011;60:734–739.
16. Al-Ansari A, Younes N, Sampige VP, et al. Greenlight HPS 120-W laser vaporization versus transurethral resection of

the prostate for the treatment of benign prostatic hyperplasia: A randomized clinical trial with midterm follow-up. Eur Urol 2010;58:349–355.
17. Lukacs B, Loeffler J, Bruyère F, et al. Photoselective vaporization of the prostate with GreenLight 120-W laser compared with monopolar transurethral resection of the prostate: A multicencer randomized controlled trial. Eur Urol 2012;61:1165–1173.
18. Horasanli K, Silay MS, Altay B, et al. Photoselective potassium titanyl phosphate (KTP) laser vaporization versus transurethral resection of the prostate for prostates larger than 70 mL: A short-term prospective randomized trial. Urology 2008;71:247–251.
19. Elmansy HM, Elzayat E, Elhilali MM. Holmium laser ablation versus photoselective vaporization of prostate less than 60 cc: Long-term results of a randomized trial. J Urol 2010;184:2023–2028.
20. Reich O, Gratzke C, Bachmann A, et al. Morbidity, mortality and early outcome of transurethral resection of the prostate: A prospective multicenter evaluation of 10,654 patients. J Urol 2008;180:246–249.
21. Coyne KS, Kaplan SA, Chapple CR, et al. Risk factors and comorbid conditions associated with lower urinary tract symptoms: EpiLUTS. BJU Int 2009;103(suppl 3):24–32.
22. Neal DE, Ramsden PD, Sharples L, et al. Outcome of elective prostatectomy. BMJ 1989;299:762–767.

Address correspondence to:
Cesar Vargas, MD
Department of Urology
Hospital de Viladecans
Avinguda de Gavà, 38
08840 Viladecans, Barcelona
Spain

E-mail: urocvb@gmail.com

Abbreviations Used

Ho:YAG = holmium:yttrium-aluminum-garnet laser
IPSS = International Prostate Symptom Score
KTP = potassium-titanyl-phosphate laser
LBO = lithium borate
LUTS = lower urinary tract symptoms
MOS = major outpatient surgery
PSA = prostate-specific antigen
Q_{max} = maximum flow rate
Tm:YAG = thulium: laser
TURP = transurethral resection of the prostate
VP = vaporization of the prostate