Original Article

Diode Laser Treatment of Human Prostates

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Abstract

Introduction: Laser-assisted vaporization of prostate tissue by means of the potassium-titanyl-phosphate (KTP) laser is in clinical use. Alternative laser sources are available but are lacking clinical experience.The 980 nm wavelength diode laser provides good hemostasis, in addition to a more rapid ablation rate. The aim of this study is approving the capability, feasibility, and good post-operative outcome of vaporization of prostate by means of a diode laser in a long-term follow up.

Methods: The light (980 nm, 100 W) of a diode laser was transmitted to prostate tissue. The study included 70 men suffering from bladder outlet obstruction due to benign prostatic hyperplasia (BPH). The prostatic lobes were vaporized within the prostatic capsule. Post-operative outcome and voiding were evaluated during a follow-up period of 24 months.

Results: During surgery, no significant blood loss or any fluid absorption occurred. Catheters were removed in the 20.1±4.6 hours. All patients except two were satisfied with their voiding outcome. After removing the catheter, the mean peak urine flow rate significantly increased from 6.8±2.5 ml/s pre-operatively to 15.6±3.1 ml/s post-operatively. No evidence of urgency, dysuria, hematuria, or incontinence was observed. Four patients required re-catheterization, and two of them needed consecutive TURP. After a 1- month, as well as after a 6-month, a 12-mouth, and a 1-year follow-up, all patients were still satisfied with the outcome.

Conclusion: This long term experience showed that 100 W-980 nm-diode-laser vaporization prostatectomy was feasible and appeared to be safe and effective for quickly relieving bladder outlet obstruction due to BPH.

Keywords: BPH; laser, semiconductor; diode laser; ablation

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Introduction

Among the surgical techniques, transurethral resection of the prostate has been applied with great success for decades as the "gold standard" treatment for BPH related diseases, such as obstruction of the urethra. It significantly improves urinary symptoms and urinary flow. Despite its general acceptance and widespread application, complications are seen in up to 20% of patients following a successful intervention (16,17). Currently, a number of minimally invasive procedures are available as effective alternatives entailing less morbidity and shorter hospital stays. Among these, promising surgical techniques are any kind of laser ablation procedures, such as Potassium Titanyl Phosphate – Photoselective Vaporization of the Prostate(KTP–PVP), holmium laser enucleation of the prostate (HoLEP) and others (15-18).

The development of lasers began in earnest with

Einstein in 1917, when he proposed the concept of extremely focused light beams and stimulated emission of microwaves (1). The acronym for laser (light amplification by the stimulated emission of radiation) was coined in 1957 by Maiman who produced the first visible light laser in 1960 (2). The frequency of lasers is determined by the active medium, and some media can be stimulated for laser usage in various wavelengths; however, one wavelength is usually optimum for this purpose. (3)

In a search for potential therapeutic methods for benign prostatic hyperplasia (BPH) that would be associated with less morbidity than transurethral resection of the prostate, the Neodymium-Doped Yttrium Aluminium Garnet(Nd: YAG)laser was introduced for laser ablation (4), as well as for interstitial laser coagulation (5) in the early 1990s. Although having hemostatic features, the remaining necrotic tissue caused bladder outlet obstruction and related symptoms for several weeks after treatment. The lack of immediate tissue ablation combined with good hemostasis was eliminated at the time the (Potassium-Titanyl-Phosphate) KTP laser (60W) was clinically introduced for the treatment of vaporization of hyperplastic obstructive prostate tissue (6). The ability to vaporize tissue with a minimal coagulation rim of underlying structures is a feature that makes KTP-laser therapy an ideal tool for immediate transurethral removal of prostatic tissue in a haemostatic environment (7-8). Vaporization with the 532 nm KTP laser is widely accepted, because of the short learning curve due to the ease of the technique (9-10). However, efficiency decreases as volume (greater than 70 ml), or prostate-specific antigen (PSA) (greater than 6 ng/ml) increases (10-11). Moreover, most fibers lose 80% of power during the procedure (12). Large glands may necessitate more than 1fiber, because of the restricted life span, i.e. 275,000 J.

As a recently proposed alternative, the 980 nm wavelength diode laser provides good hemostasis, in addition to a more rapid ablation rate, as shown in animal models (13- 14). We present early results of our experience with the high power 980 nm diode laser in 70 consecutive patients with BPH.

Methods

This study included 70 men suffering from LUTS due to BPH from 2008 to 2010 in Shohada-e Tajrish Medical Center. All patients (mean age: 68.2±7.8years) underwent physical examination and evaluation of symptoms according to the International Prostate Symptoms Score (IPSS), and a Quality of Life Score (QOL). Additionally, post-void residual urine volume (PVRUV), and the peak urinary flow rate (Qmax) were measured. All patients underwent trans-rectal ultrasound (TRUS) to evaluate prostate size (mean: 59.6±14.1 cm3). Blood tests included blood cell count, serum chemistry, serum prostate-specific antigen (PSA), and urine analysis including urine culture. Criteria for inclusion in the study were moderate to severe obstructive symptoms, as determined by IPSS (Score≥8), and a peak urinary flow rate (Qmax) of less than 15 ml/s with or without residual urine in patients. Since the detailed histories along with the urinary flow rate were adequate for the assessment of Bladder Outlet Obstruction (BOO), pressure-flow studies were not performed in these patients. The exclusion criteria were urethral stricture, previous prostatic surgery, prostate cancer, and neurogenic bladder dysfunction.

The Surgical Procedure

The procedure was performed under spinal anesthesia. All patients showed sterile urine and were treated with ciprofloxacine during, and for 5 days after surgery.

The laser treatment technique consisted of a side-firing flexible fiber. The laser fiber was introduced through a 22F continuous flow laser cystoscope. Irrigation fluid was normal saline at0.9%. During the procedure, the height of the irrigation fluid bottle was maintained at 60 cm above the patient’s level.

The diode laser emitted light of 980 nm which was coupled into the fiber having a light deflecting mechanism at the distal tip.Vaporization was performed delivering at least 80W light power in continuous mode to the tissue surface both in non-contact and contact modes. The light application process showed a more longitudinal moving than the sweeping technique, starting in the 6 o’clock lithotomy position towards the apical region vaporizing tissue between the bladder neck and the paracollicular region, and repeated on both lateral lobes removing obstructive tissue of the prostate, until the achievement of an adequate TURP-like cavity. The mean exposure time was 60.6±22.6 minutes. A three-way 20F urethral catheter was inserted post-operatively.

All patients had completed the 1-month, 6-month, 1-year and 2-year of follow-ups, postoperatively.

As efficacy measures, mean changes from baseline in the IPSS, QOL, Qmax, PVRUV, and TRUS prostate volume measurement were assessed.

Results

A total of 70 male suffering from intravesical obstruction due to BPH were included in this study. Demographic data were listed with details in Table 1.

All patients showed good conditions after the laser procedure. None of the post-operatively inserted three-way urethral catheters required irrigation. All were removed within 20.1±4.6 hours. Patients stayed in the hospital for 25.8±9.2 hours. There were neither intra-operative complications, nor intra-operative bleeding. There was nosignificant immediate post-operative hematuria. None of the patients required blood transfusion after diode laser prostatectomy. Four patients needed re-catheterization (Table 2)

Mild dysuria that developed in patients resolved within 4.8±2.7 days without any treatment.No patient had urinary incontinence. Two patients (those who required re-catheterization) were not satisfied with the outcome, and underwent the conventional

TURP within 2 months of initial laser therapy, and consequently fell out of the study (Table 3).

Outcome in terms of increase in Qmax, decrease in IPSS, and decrease in post-void residual urine (PVR) urine are shown in Table 4.

There was a dramatic improvement in the three parameters compared with preoperative values at all-time points of follow-up. Compared with the preoperative values, there were significant reductions in PSA level and prostate volume after TURP and PVP at all-time points of follow-up.

Table 1. Demographic data

Diode laser	
Patients, No.	70
Median age, yr ± SD	68.5 ± 8.8
Mean prostate volume, ml ± SD	61.1 ± 16.1
Mean PSA, ng/ml ± SD	2.3 ± 1.9
Mean IPSS ± SD	23.6 ± 7.3
Mean Qmax, ml/s ± SD	6.8 ± 2.5
Mean PVR ,ml ± SD	57.2 ± 59.7

Table 2. Surgical data

Diode laser	
Patients, No.	70
Mean operative time, min ± SD	60.6 ± 22.6
Mean serum sodium, mmol/l ± SD	
Preoperative	136.6 ± 4.0
Postoperative	135.9 ± 4.1
P value	0.16
Mean hemoglobin, g/l ± SD	
Preoperative	13.0 ± 1.8
Postoperative	12.9 ± 1.8
P value	0.321
Mean hospital stay, h ± SD	25.8 ± 9.2
Mean catheterization time, h ± SD	20.1 ± 4.6
Mean irrigation fluid, L ± SD	19.5 ± 3.3

Table 3. Complication of diode laser

Diode laser	
Patients, No.	70
Intraoperative complications	
Blood transfusion	0 (0)
Capsule perforation (%)	0 (0)
TUR syndrome (%)	0 (0)
Early (<30d) post operative complications	
Clot retention (%)	1 (1.4)
Re-catheterization	4 (5.7)
Urge incontinence (%)	0 (0)
UTI (%)	1 (1.4)
Epididymo-orchitis (%)	1 (1.4)
Late (>30d) post operative complications	
Redo TURP (%)	2 (2.8)
Urethral stricture (%)	0 (0)
Bladder neck contracture (%)	0 (0)
De novo sexual dysfunction (%)	0 (0)
Mean time of dysuria, d ± SD	4.8 ± 2.7

Discussion

The clinical results of laser prostatectomy depend on a number of physical factors, such as wavelength, the power, the energy applied, as well as the surgical technique.The Ho:YAG wavelength is absorbed more strongly by water resulting in an increased cutting, but less hemostatic property. With respect to that transurethral HOLEP became accepted as a safe and effective alternative treatment option with reduced blood loss, short catheterization time and hospital stay (19-20).

Table 4. Follow up data

Diode laser	
Patients, No.	70
Mean prostate volume, ml ± SD	
Before	61.1 ± 16.1
6 Month Follow-Up	25.7 ± 8.5
12 Month Follow-Up	21.2 ± 7.8
24 Month Follow-Up	22.2 ± 6.8
Mean PSA, ng/ml ± SD	
Before	2.3 ± 1.9
6 Month Follow-Up	1.2 ± 0.88
12 Month Follow-Up	0.7 ± 0.5
24 Month Follow-Up	0.8 ± 0.3
Mean PVR, ml ± SD	
Before	57.2 ± 59.7
6 Month Follow-Up	22.9 ± 22.7
12 Month Follow-Up	15.4 ± 16.2
24 Month Follow-Up	17.1 ± 14.2
Mean IPSS ± SD	
Before	23.6 ± 7.3
1 Month Follow-Up	10.6 ± 3.5
6 Month Follow-Up	6.5 ± 2.1
12 Month Follow-Up	6.4 ± 2.5
24 Month Follow-Up	6.7 ± 2.1
Mean Qmax, ml/s ± SD	
Before	6.8 ± 2.5
1 Month Follow-Up	15.6 ± 3.1
6 Month Follow-Up	20.6 ± 4.1
12 Month Follow-Up	22.1 ± 4.2
24 Month Follow-Up	21.8 ± 5.2

Today, KTP-prostate vaporization is a commonly used laser procedureachieving tissue vaporization and hemostasis with aminor coagulation rim, providing good immediate voiding outcomes. Absorption of the 532nm wavelength by hemoglobin causes heat production in small volumes resulting in rapid vaporization of cellular water. The introduction of prostate vaporization using the 532 nm KTP laser led to a new era of BPH treatment. Since then, 532 nm KTP laser photo-selective vaporization of the prostate has been successful for BPH, including in high risk patients.(8-9), compared to TURP efficiency decreases as prostate volume increases, for example for volumes greater than 70 ml an 18% reoperation rate (7 of 39cases) vs. the 0% rate (0 of 37) for TURP(10). Despite symptomatic improvement, which is durable after 3years in all patients, results are significantly better in patients with PSA less than 6 ng/ml (11). This maybe related to the gradual loss of fiber power output, which was measured in 40 cases during the procedure.

Of the fibers, 90% had 80% decreased power at the end of the life span (275 kJ), where as only 10% maintained a stable power output. There was also a significant difference in the quality of individual fibers (12). Power loss may result in coagulation rather than vaporization, which leads to delayed tissue sloughing and irritable symptoms along with an increased risk of urinary retention (12). Therefore, tremendous efforts are ongoing to develop the best laser technology for BPH. The last step in this regard was the introduction of the high power diode laser at980 nm for prostate vaporization.

Wendt-Nordahl et al. compared various characteristics of KTP lasers (532 nm and 80 W vs. diode 980nm and 120 W) in a well established, isolated, perfused porcine kidney model (13). They reported parallel bleeding rates (0.21 vs. 0.14 gm per minute). However, the 980 nm diode laser had a more rapid ablation rate (3.99 vs. 7.24 gm/10 minutes; $p < 0.05$) and a thinner coagulation zone (666.9 vs. 290.1 µm; $p < 0.05$). They suggested the 980 nm diode laser as a novel laser technology for prostate vaporization.

The light weight of the 980 nm diode laser generator (60 pounds) makes transportation easy. It uses regular electrical power (220/110 V and 50 to 60 Hz), together with air cooling. The probe has a hand positioning knob, lines indicating beam direction, and a retraction indicator line for scope safety. Thus, the new generation fusion probes are easy to manipulate, in contrast to the former side firing probes.

The 980 nm wavelength diode laser is invisible and, therefore, the surgeon's vision is more comfortable. An important key to success is to keep the distance between fiber and tissue at 0.5 mm for efficient vaporization. This requires continuous movement of the fiber tip using a sweeping or brushing technique, in accordance with the tissue becoming more distant, as it is vaporized. The red aiming beam indicates the direction of the laser beam throughout the operation.

In this study, improvements in all three key parameters associated with BPH were reported. These results are comparable to the 6-month outcome data reported on other lasers. Bachmann et al. (21) reported percentage of changes in the mean IPSS, Qmax and PVR at 6 months of -71.3, +162.3 and -91.2, respectively, after photo-selective vaporization with the 80W KTP laser. Malek (9) also reported good outcome with this laser, but at the lower power of 60 W; percentage of changes in mean American Urological Association Symptom Index (AUA-SI), Qmax and PVR at 6 months were -79.1, +238, -81%, respectively.

Conclusion

This long term experience showed that 100 W-980 nm-diode-laser vaporization prostatectomy is feasible and appears to be safe and effective for quickly relieving bladder outlet obstruction due to BPH.

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