High Power Diode Laser Vaporization of the Prostate: Preliminary Results for Benign Prostatic Hyperplasia

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Abbreviations and Acronyms

BPH = benign prostatic hyperplasia

IIEF = International Index of Erectile Function

I-PSS = International Prostate Symptom Score

PSA = prostate specific antigen

PVR = post-void residual urine

Qmax = maximal flow rate

QOL = quality of life

TRUS = transrectal ultrasound

TURP = transurethral resection of the prostate

VLAP = visual laser prostate ablation

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Purpose: Vaporization techniques using lasers have gained wide acceptance for benign prostatic hyperplasia as an alternative to transurethral prostate resection. The high power, 980 nm wavelength diode laser is a new promising alternative with a more rapid ablation rate and excellent hemostatic properties, as shown in ex vivo and in vivo animal models. We prospectively evaluated vaporization efficiency of the high power, 980 nm diode laser for bladder outlet obstruction due to benign prostatic hyperplasia.

Materials and Methods: A total of 47 consecutive patients were included in the study. Inclusion criteria were maximal flow rate 12 ml per second or less with voided volume 150 ml or greater, International Prostate Symptom Score 12 or greater and quality of life score 3 or greater. Patients with a history of neurogenic voiding dysfunction, chronic prostatitis, or prostate or bladder cancer were excluded from analysis. Preoperative maximal flow rate, post-void residual urine, International Prostate Symptom Score, quality of life, International Index of Erectile Function-5, prostate specific antigen and prostate volume were compared with values at 3 and 6 months. Complications were assessed.

Results: Month 3 assessment revealed that the mean $\pm$ SD International Prostate Symptom Score decreased significantly from 21.93 ± 4.88 to 10.31 ± 3.79 ($p = 0.0001$). The mean maximal flow rate increased significantly from 8.87 ± 2.18 to 17.51 ± 4.09 ml per second ($p = 0.0001$). Quality of life score changed considerably compared to baseline. All of these values showed slight improvement at month 6. There was no deterioration in erectile function according to the International Index of Erectile Function-5 short form. Post-void residual urine decreased significantly. Prostate volume and prostate specific antigen reductions were also significant. The most common postoperative complications were retrograde ejaculation (13 of 41 patients or 31.7%) and irritative symptoms (11 of 47 or 23.4%), which subsided in the maximal flow rate at 2 weeks. Recatheterization was necessary in 2 patients due to urinary retention after catheter removal. Two patients had temporary combined urge and stress incontinence for 2 weeks. Late bleeding in 1 patient 4 weeks postoperatively necessitated catheterization and irrigation.

Conclusions: The high power diode laser provided significant improvements in International Prostate Symptom Score and the maximal flow rate with low morbidity. Thus, these results of prostate vaporization with the high power diode laser, representing what is to our knowledge the first clinical study in the literature, are encouraging.

Key Words: prostate, ablation techniques, lasers, prostatic hyperplasia, urinary bladder neck obstruction

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DESPITE being considered the gold standard treatment for BPH, TURP still has relatively significant morbidity.[1–5] Therefore, various lasers have been introduced as alternatives to TURP.[3–12] VLAP using the Nd:YAG laser, which is based on coagulation rather than vaporization, results in long lasting irritative symptoms due to late necrotic tissue sloughing.[8,9] VLAP was followed by resection, ablation and enucleation using the Ho:YAG laser. Holmium laser prostate enucleation is technically challenging with a long, steep learning curve despite high efficacy.[10,11] Vaporization with the 532 nm KTP laser is widely accepted because of the short learning curve due to the ease of the technique.[12,13] However, efficiency decreases as volume (greater than 70 ml) or PSA (greater than 6 ng/ml) increases.[14,15] Moreover, most fibers lose 80% of power during the procedure.[16] Large glands may necessitate more than 1 fiber because of the restricted life span, ie 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.[17,18] We present early results of our experience with the high power 980 nm diode laser in 47 consecutive patients with BPH in what is to our knowledge the first clinical report in the literature.

PATIENTS AND METHODS

A total of 47 consecutive patients who underwent laser prostatectomy with the 980 nm diode laser between September 2007 and April 2008 were included in the study. Preoperative evaluation consisted of medical history, physical examination with focus on neurological status and digital rectal examination. Prostate volume was determined by TRUS. PVR was measured by transabdominal ultrasound after free uroflowmetry. Blood chemistry, including PSA, renal function tests, complete blood count and urinalysis, was also done. Study inclusion criteria were Qmax 12 ml per second or less with voided volume 150 ml or greater, I-PSS 12 or greater and QOL score 3 or greater. Patients with a history of neurogenic voiding dysfunction, chronic prostatitis, prostate and/or bladder cancer were excluded from study.

Preoperative Qmax, PVR, I-PSS, QOL, IIEF-5 and prostate volume were compared with values at 3 and 6 months. Complications associated with the procedure were documented.

All surgical procedures were performed by the same surgeon (AE) with the patient under spinal (35 or 74.5%) or general (12 or 25.5%) anesthesia. All patients received prophylactic antibiotics before surgery and for 3 days thereafter. Cessation of anticoagulant medicines was recommended 1 week before surgery unless there was a contraindication.

A 23Fr continuous flow laser cystoscope was used with saline irrigation. A 980 nm diode laser generator was used at a power setup of between 80 and 132 W in continuous mode throughout the vaporization procedure. A fusion side firing optical fiber with a 70-degree deflecting angle was used for light transmission. Vaporization started at the bladder neck level with the bladder filled with saline. Starting from the lateral lobes the area between the 1 and 11 o'clock positions was vaporized. Reflected beams were usually enough to vaporize upper fibromuscular stroma, although further vaporization was done when necessary, particularly in large glands. The fiber tip was kept 0.5 mm away from tissue as far as possible for efficient vaporization. Direct contact with tissue was avoided as much as possible. Power was decreased to 80 W at the bladder neck level and around the sphincteric area. The procedure was terminated when a TURP-like cavity was achieved.

An indwelling urethral catheter was inserted and left for a day. All except 2 patients were discharged home the next day. Statistical analysis was done using the paired t test with $p < 0.05$ considered statistically significant.

RESULTS

Mean ± SD patient age was 65.4 ± 8.4 years (range 47 to 85). Three patients older than 75 years with PSA between 4 and 8 ng/ml underwent TRUS guided, 12-quadrant prostate biopsies. Pathological evaluation revealed no tumor. Mean patient PSA was 2.54 ± 1.43 ng/ml.

The procedure was completed successfully in all patients with no intraoperative complications. Blood transfusion was not necessary. Mean operative time was 52.55 ± 13.34 minutes. The mean energy delivered was 242.957 ±. 92.366 J. One fiber was used per patient. Mean preoperative and postoperative hemoglobin and sodium did not differ significantly. The urethral catheter was removed after 24 hours, although in 2 patients urinary retention required recatheterization for an additional 2 days.

Table 1 shows procedure efficacy at 3 and 6 months. Early assessment at month 3 revealed that mean I-PSS significantly decreased from 21.93 ± 4.88 to 10.31 ± 3.79 ($p = 0.0001$). Similarly mean Qmax significantly increased from 8.87 ± 2.18 to 17.51 ± 4.09 ml per second ($p = 0.0001$). The mean QOL score changed significantly compared to baseline (4.19 ± 0.85 vs 2.82 ± 1.16, $p = 0.0001$). These values were slightly improved at month 6. The mean prostate volume reduction at 3 months was also significant on TRUS (51.04 ± 24.14 vs 32.06 ± 11.37 cc, $p = 0.0001$). Baseline PSA was also significantly decreased at followup visits (from 2.54 ± 1.43 to 1.85 ± 1.13 ng/ml at month 3, $p = 0.0001$). PVR decreased substantially from preoperative levels. Mean PVR decreased from 115.28 ± 103.64 to 45.34 ± 27.87 ml and this alteration was significant ($p = 0.0001$).

There was no deterioration in erectile function according to the IIEF short form (mean 17.42 ± 8.86 vs 17.74 ± 8.64, $p = 0.554$). Table 2 lists postoperative complications. Retrograde ejaculation in 13 of 41 sexually active patients (31.7%) and irritative symp-

Table 1. *Three and 6-month results of high power diode laser prostate vaporization in 47 patients with BPH*

	Mean ± SD Preop	Mean ± SD 3 Mos	p Value	Mean ± SD 6 Mos	p Value vs Preop
I-PSS	21.93 ± 4.88	10.31 ± 3.79	0.0001	9.87 ± 3.19	0.0001
QOL	4.19 ± 0.85	2.82 ± 1.16	0.0001	2.15 ± 1.10	0.0001
Qmax (ml/sec)	8.87 ± 2.18	17.51 ± 4.09	0.0001	18.27 ± 3.92	0.0001
PVR (ml)	115.28 ± 103.64	45.34 ± 27.87	0.0001	48.28 ± 29.27	0.0001
Prostate vol (cc)	51.04 ± 24.14	32.06 ± 11.37	0.0001	31.06 ± 10.12	0.0001
PSA (ng/ml)	2.54 ± 1.43	1.85 ± 1.13	0.0001	1.77 ± 1.03	0.0001
IIEF-5	17.42 ± 8.86	17.74 ± 8.64	0.554	17.21 ± 8.72	0.550

toms in 11 of 47 (23.4%) were the most common complications. Fortunately irritative symptoms were mild to moderate and gradually resolved in the first 2 weeks of followup. Recatheterization was necessary in 2 patients due to urinary retention after catheter removal. Two patients had temporary combined urge and stress incontinence for 2 weeks. Late bleeding developed in 1 patient 4 weeks later, which was attributable to bicycle riding, in contrast to what was recommended. The patient was admitted to the hospital. A 3-way Foley catheter was inserted for irrigation for a day. The catheter was removed and the patient was discharged home on day 2.

DISCUSSION

When we look at the mortality and morbidity of the gold standard for BPH, that is TURP, the search for new alternatives is appreciated. In 1989 an early postoperative morbidity rate of 18% and 0.2% mortality were reported.[1] Similarly a cumulative short-term morbidity rate of 11.1% and a mortality rate of 0.10% along with a 3% transfusion rate were recently reported.[2] Moreover, there is a 10% to 15% probability of repeat intervention within 10 years.[4] These values clearly indicate the requirement for less invasive procedures for BPH even considering the gradual aging of the population. As an alternative, visual laser ablation of the prostate with the Nd:YAG laser was described in the early 1990s. However, it was later abandoned because of long lasting irritative symptoms due to late tissue sloughing caused by coagulation based efficiency.

Since it is possible to resect, incise, coagulate or vaporize prostatic tissue, many alternative laser techniques have also been described. Interstitial laser coagulation depends on coagulation necrosis created via probes inserted inside the prostate, thereby preserving the urethra. The number of procedures depends on prostate size.[7] Although 63% symptom and 51% Qmax improvements have been achieved, during 2 years of followup the rates of re-treatment and urinary tract infection were 16% and 20%, respectively.[9] The 2,140 nm Ho:YAG laser was first combined with the Nd:YAG laser, as in combined endoscopic laser ablation of the prostate, which was followed by holmium resection of the prostate in 1995 and holmium laser ablation of the prostate in 1996. However, holmium laser enucleation of the prostate is the most efficient of all techniques using the Ho:YAG laser. It also provides a combination with TURP called the mushroom technique or morcellation. Despite its high efficacy it has a long, steep learning curve, in addition to morbidity such as stricture in a remarkably large percent of patients (5% to 10%).[10,11] This may be attributable to the large caliber instruments and to multiple insertions.

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 photoselective vaporization of the prostate has been successful for BPH, including in high risk patients.[12,13] However, compared to TURP efficiency decreases as prostate volume increases, for example for volume greater than 70 ml an 18% reoperation rate (7 of 39 cases) vs the 0% rate (0 of 37) for TURP.[14] Despite symptomatic improvement, which is durable after 3 years in all patients, results are significantly better in patients with PSA less than 6 ng/ml.[15] This may be 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), whereas only 10% maintained a stable power output. There was also a significant difference in the quality of individual fibers.[16] Power loss may result in coagulation rather than vaporization, which leads to delayed tissue sloughing and irritative symptoms along with an increased risk of urinary retention.[16] Therefore, tremendous efforts are ongoing to develop the best la-

Table 2. *Complications of diode laser prostate vaporization in patients with BPH*

	No. Pts (%)*
Retrograde ejaculation	13 (31.7)
Irritative symptoms	11 (23.4)
Temporary urinary retention	2 (4.2)
Temporary urinary incontinence	2 (4.2)
Late bleeding	1 (2.1)

* No patient had urinary tract infection or immediate bleeding.

ser technology for BPH. The last step in this regard was the introduction of the high power diode laser at 980 nm for prostate vaporization.

Wendt-Nordahl et al compared various characteristics of KTP lasers (532 nm and 80 W vs diode 980 nm and 120 W) in a well established, isolated, perfused porcine kidney model.[17] 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) and a thinner coagulation zone (666.9 vs 290.1 μm, each $p < 0.05$). They suggested the 980 nm diode laser as a novel laser technology for prostate vaporization. The literature on laser prostate vaporization using the 980 nm diode laser at high power settings is sparse. To our knowledge we report the first prospective clinical study in the literature of the high power, 980 nm diode laser. Its long-term efficacy for recurrent urethral strictures was reported by Guazzieri et al.[19] The 100 W 980 nm diode laser generator was formerly used for laser vaporization of the prostate at our institution between June 2006 and September 2007, when it was upgraded to the newer 150 W version. It stood the test of time in more than 60 patients. This is virtually a bloodless operation. The excellent hemostatic properties even at low power, ie 23 W, of the diode laser were also described in animal studies.[18]

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, surgeon 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.

Vaporization is started from the lateral lobes at the bladder neck. The bladder should be kept filled when the bladder neck is being lased. This also helps keep the prostatic fossa opened so that fiber tip-to-tissue contact can be avoided. Vaporization is continued from the 1 o'clock position to the 11 o'clock position or the reverse. We prefer to vaporize the 2 lateral lobes as we proceed distal. The anterior portion remaining between the 1 and 11 o'clock positions is usually vaporized by reflected beams, although it may also be necessary to vaporize this area, particularly when the prostate is large. Since it is a powerful device at high power settings, power should be decreased, preferably down to 80 W, when working close to the external sphincter or at the bladder neck. Nevertheless, absorption in water makes it less dangerous in case of inadvertent firing toward the bladder. The operation should be terminated when a TURP-like cavity is achieved since further attempts may lead to unintended capsular perforation, which is usually identified later. Vaporization close to the external sphincter needs particular attention so as not to cause damage. One should keep in mind that even in the best hands some coagulation necrosis is inevitable. The external sphincter may later heal with scarring as well as muscle loss, which in turn may result in late onset incontinence in cases of extensive vaporization attempts in close proximity. The cavity left after vaporization with the 980 nm diode laser is usually smoother than that achieved with the KTP laser according to our observation and based on our previous experience with the KTP laser. This may be explained by absorption by hemoglobin and tissue water, which in turn assist in achieving even vaporization.

Patients should be informed that usually mild to moderate irritative symptoms may arise during tissue sloughing, which usually lasts no longer than 2 weeks. Unlike the former VLAP technique using the Nd:YAG laser, in which efficiency is based only on coagulation, urinary retention is not common in patients who undergo 980 nm diode laser prostate vaporization. Should this occur, patients may need recatheterization for a couple of days until edema in the prostatic fossa subsides. According to our experience patients usually improve with time. This may be attributable to edema in the early postoperative period and subsequent coagulated zone sloughing, which can be noted when 6-month values are considered.

In our series the most common complication was retrograde ejaculation, as in 41 of 47 sexually active patients (32%) according to patient report, ie less or no semen compared to preoperative status. No further tests were done to better clarify retrograde ejaculation. Dysuria in 23% of patients was probably due to edema in the beginning and necrotic tissue sloughing thereafter. Cessation of anticoagulant medication before the operation is generally recommended but we observed no difference in 4 patients on warfarin or acetylsalicylic acid in terms of perioperative or postoperative bleeding. Only 1 late bleeding episode was seen in 1 patient, which was attributable to bicycle riding. Temporary urinary retention developed in 2 patients after urethral catheter removal. The patients were recatheterized for an additional 2 days, presumably until edema in the prostatic fossa largely resolved. The second attempt at catheter removal resulted in spontaneous micturition.

Incontinence is the most bothersome complication of any prostate operation. It is crucial to pay particular attention to the sphincteric area. Power should be decreased and attempts to vaporize the little tissue remnants close to the sphincter may lead to late onset incontinence due to coagulation necrosis. Temporary combined incontinence in our 2 patients lasted about 2 weeks, given the fact that we decreased power down to 80 W when working close to the sphincter. Lastly, IIEF scores did not change significantly in sexually active patients.

Briefly, we report what is to our knowledge the first study in the literature showing that high power diode laser vaporization of the prostate is safe and effective. In our series the improvement in I-PSS was slightly greater than the improvement in Qmax (53% vs 49%). As the 6-month data indicate, patients improved even more in the long term. Furthermore, some patients completed 1-year followup with sustained clinical success. Nevertheless, longer followup results, particularly vs TURP, are required to determine the exact role of diode laser prostatectomy for the surgical management of BPH.

CONCLUSIONS

The current study in a relatively sufficient number of patients with BPH represents what is to our knowledge the first clinical trial in the literature using the high power, 980 nm diode laser. High power diode laser vaporization of the prostate provided significant improvements in I-PSS and Qmax. Moreover, the complication rate was relatively minimal. The technique was also associated with relatively shorter catheterization and hospitalization times. According to our experience it is a safe procedure that is easy to learn. Therefore, the outcome of the current study is encouraging. Further randomized clinical studies are needed to determine the role of the 980 nm diode laser as an alternative to TURP or other laser techniques for BPH.

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