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REVIEW

Contemporary review of the 532 nm laser for treatment of benign prostatic hyperplasia



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Abstract Benign prostatic hyperplasia (BPH) is a condition that occurs increasingly with age. The established gold standard treatment for BPH has been the electrocautery-based transurethral resection of the prostate (TURP). TURP, however, is associated with several complications and side effects. Therefore, there is an increasing interest in a number of emerging minimally invasive therapies as alternative treatment options. Laser therapy using the Greenlight laser is a promising alternative to the traditional TURP. Selective absorption by hemoglobin allows rapid, hemostatic vaporization of prostate tissue. Additional advantages include avoidance or minimization of complications such as intraoperative fluid absorption, and bleeding, retrograde ejaculation, impotence, and incontinence, as well as its use in treating high volume BPH. We review the use of the Greenlight laser in the treatment of BPH, when comparing complications and advantages in relation to TURP.

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1. Introduction

The established gold standard treatment for benign prostatic hyperplasia (BPH) has been the electrocautery-based transurethral resection of the prostate (TURP). TURP, however, is

associated with several complications and side effects. Therefore, there is an increasing interest in a number of minimally invasive therapies as alternative treatment options. Laser therapy using the Greenlight laser has shown promising alternative to the traditional TURP. The greenlight allows for selective absorption by hemoglobin and hemostatic vaporization of prostate tissue. Other advantages include avoidance or minimization of complications such as intraoperative fluid absorption, and bleeding. An additional benefit of laser therapy may be shorter hospital stay and

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recovery time in comparison to TURP. Laser prostatectomy also has allowed for the treatment of larger prostate glands with a reduced risk of complications.

2. Evolution of 532 nm wavelength laser

2.1. *In vitro* studies

The first experiments with the higher powered (80 W) potassium titanyl phosphate (KTP) laser began with the use of *ex-vivo* animal models [1]. Twenty perfused porcine kidneys were used as a model for human prostatic tissue. High power KTP laser resection was compared to high frequency current, i.e., TURP-like, resection. The 80 W KTP laser technique showed a statistically significant decrease in hemorrhage ($p < 0.0001$) compared to traditional TURP-like resection, demonstrating the fact that an essentially bloodless operative field could be achieved.

In addition several animal studies have been performed with the 120 W 532 nm laser. Lee et al. [2] investigated the use of the 120 W laser in five male beagles. The 120 W laser system was compared to lower watt settings, the 120 W setting vaporized more tissue per unit time while maintaining a depth of coagulation between 1.2 and 2.5 mm. Kang et al. [3] compared the use of the 120 W high-performance system (HPS) laser to the 80 W HPS laser and the 80 W KTP laser from 96 specimens of bovine prostate tissue. The 120 W HPS laser vaporized bovine prostate tissue more efficiently than the 80 W KTP laser and coagulation was equivalent.

2.2. Human studies

2.2.1. Safety studies

The safety of the 80 W KTP laser prostatectomy has been studied in patients with high cardiopulmonary risk. Reich et al. [4] performed 80 W laser prostatectomy on 66 patients with an American Society of Anesthesiologists (ASA) Score of 3 or greater. Of these patients, 29 were being treated with ongoing oral anticoagulation or suffered from a severe bleeding disorder. No major complications occurred during or following the procedure and no blood transfusions were required.

Another safety aspect of the 80 W KTP laser to be studied in detail was its use in anticoagulated patients. A series of 24 anticoagulated patients who underwent a laser prostatectomy using the 80 W KTP laser were studied [5]. No patients developed clinically significant hematuria postoperatively and none developed clot retention. No transfusions were required and there were no thromboembolic events that followed the procedure. Few studies have been published on the safety and efficacy of the 120 W 532 nm laser prostatectomy in humans. In a multi-center prospective study, 305 patients with BPH underwent laser prostatectomy with the 120 W HPS laser [6]. Complication rates of those on anticoagulation were comparatively low to those not on anticoagulation, although this population had many patients with large volume glands and or had signs and symptoms of urinary retention.

An advantage to the use of the 80 W KTP/532 nm laser is the ability for the surgeon to perform laser prostatectomy

on larger glands with good outcomes and an excellent safety profile. Sandhu et al. [7] detailed large prostate volume resection with the 80 W KTP laser. Sixty-four men with prostate volumes of at least 60 mL and had failed medical therapy previously were taken for vaporization with the 80 W KTP laser. The mean preoperative prostate volume was 101 mL with a mean operative time of 123 min. International Prostate Symptom Score (IPSS) decreased from 18.4 to 6.7 at 12 months; maximum flow rate (Q_{max}) increased from 7.9 mL/s to 18.9 mL/s while postvoid urine residual (PVR) decreased from 189 mL to 109 mL. No transfusions were required throughout the procedure nor was there evidence of postoperative hyponatremia. All 62 patients were discharged within 23 h. This study showed that the 80 W KTP laser could be used as a safe and effective means with durable results for large volume prostatectomy.

In a comparative study performed by Pfitzenmaier et al. [8], vaporization was performed on prostates with volumes greater than or equal to 80 mL and on those with volumes smaller than 80 mL. Out of 173 patients, 39 had prostates ≥ 80 mL. The authors found that the use of photoselective vaporization prostatectomy (PVP) was safe and effective in prostates ≥ 80 mL; however, they also found that the reoperation rate was higher. In another recent study of 150 consecutive patients with lower urinary tract symptoms who underwent laser vaporization with 80 W KTP laser showed a decrease in storage and voiding symptoms by 81.8% and 90.9% at 12 months, respectively [9]. Consistent with other published series, these studies further support the safety, efficacy, and durable improvements on IPSS and quality of life (QoL) of the procedure [7].

While many studies have reviewed the efficacy and outcomes of the 80 W KTP laser, few have reviewed the newer 120 W Greenlight HPS lithium triborate laser. Batura et al. [10] investigated the nature and frequency of complications that are associated with this newer approach. In their study, complications due to the procedure developed in 15.4% of patients over an average follow up time of 20.8 months; urethral strictures and obstruction due to residual prostate tissue were the most frequent complications, at a rate of 3.4% and 4.3% respectively. In addition, their study found an 84% success and durable outcome at 2 years of follow-up. At their center they found that patients who received TURP had an average length of stay and duration of catheterization of 2.5 days each, whereas those observed with laser treatment had stays and catheterizations that lasted 1 day each [10].

High intraoperative safety has been demonstrated for the 120-W LBO-laser with an intraoperative bleeding rate of 1%–2.6%, capsule perforation in 1%, intraoperative blood transfusion in 0.4% and no TUR syndrome reported [11].

The GOLIATH study conducted by Bachmann et al. [12] compared the safety and efficacy of TURP vs. the 180 W XPS GreenLight laser over a 6-month period. Overall 47.8% of patients who received laser treatment compared to 53.4% of patients that received TURP were free of treatment related adverse events. Whereas with earlier laser systems, the reintervention rate was higher when compared to TURP, the GOLIATH study showed that overall numbers of patients free of any adverse events were comparable between these two methods. The two

Table 1 Summary of data collected from included studies.

References	n	Mean age (year)	Pre-operative			Post-operative				
			IPSS	Q _{max} (mL/s)	PVR (mL)	PV (mL)	IPSS	Q _{max} (mL/s)	PVR (mL)	PV (mL)
Malek et al. [13]	10	69	18.7	8.0 ± 1.3	148	38.4 ± 9.7	4.3	19.4 ± 8.4	163	Not available
Hai and Malek [15]	10	64.1 ± 7.6	23.2 ± 4.7	10.3 ± 1.4	137.6 ± 112.2	41.4 ± 18.5	2.6 ± 0.5	30.7 ± 5.8	3.0 ± 4.8	30.3 ± 14.6
Te et al. [16]	139	67.7 ± 8.7	24.0 ± 5.9	7.8 ± 3.8	114.3 ± 122	54.6 ± 31.7	4.3 ± 5.8	22.6 ± 7.6	24.8 ± 44.1	34.4 ± 14.1
Ouyang et al. [19]	40	63.1 ± 4.9	23.7 ± 3.9	7.5	51.6 ± 25.8	88.5 ± 15.3	12.4 ± 2.0	13.8	22.8 ± 12.5	Not available
Altay et al. [20]	68	71.1 ± 9.8	19.9 ± 9.5	7.6 ± 5.4	165 ± 182	104.3 ± 29.7	9.3 ± 4.7	16.0 ± 4.8	61.7 ± 51.4	62.0 ± 43.9

IPSS, international prostate symptom score; Q_{max}, maximum flow rate; PVR, postvoid urine residual; PV, prostate volumes.

treatment arms were similar with respect to reintervention; however within 30 days of treatment reintervention was three times higher after TURP [12].

2.2.2. Clinical studies

2.2.2.1. Short-term studies.

The first human trials with the 60 W KTP laser were conducted in a series of 10 patients described by Malek et al. [13] in 1998. Patients experienced a significant improvement in Q_{max} (142%) by 24 h postoperatively, although the follow-up was only 3 months (Table 1). This was followed by a larger series of 55 patients in 2000 [14]. The 2-year experience with the higher powered KTP laser again corroborated initial findings.

Hai and Malek [15] presented the first human experience with 80 W KTP laser prostatectomy. Ten patients were followed for 1 year after their prostatectomy in a pilot study. Patients experienced statistically significant improvements in AUA symptom score (23.2 to 2.6), QoL scores (4.3 to 0.5), Q_{max} (10.3 to 30.7 mL/s), and PVR (137.6 to 3 mL). Te et al. [16] presented the first large, multicenter series on the use of 80 W KTP laser in laser prostatectomy for 145 patients with long-term follow-up. Significant and durable improvements in AUA Symptom Index (AUA SI) scores, QoL scores, Q_{max}, and PVR were demonstrated up to 12 months postoperatively (Table 1).

In a trial by Bouchier-Hayes et al. [17], 120 patients were randomized to TURP or PVP. Maximum urinary flow rate improved by 154% in the TURP and 136% in the PVP group. Other outcomes had similar improvements in both arms. They also found that PVP was 22% less expensive due to decreased length of stay. Another randomized study was done by Horasani et al. [18] randomized 76 patients with prostates larger than 70 mL. They found a significant difference in IPSS, Q_{max}, and PVR in favor of TURP and a larger volume reduction as well. The PVP group had an 18% reoperation rate. Although, it must be remembered that both these studies were conducted with the 80 W KTP laser.

Ouyang et al. [19] explored the impact that the 160 W laser had on erectile dysfunction. Patients were randomly assigned to treatment with either the 80 W or 160 W laser, and erectile dysfunction was evaluated based on IIEF-5. In their study the results showed that IIEF-5 scores of the 80 W and 160 W groups both significantly decreased at 3 month follow-up compared to the patients pre-operative baseline; however, by 6 and 12 months IIEF-5 scores were not significantly different (Table 1). Ultimately, it was concluded that the 160 W laser vaporization of the prostate will not increase the risk of erectile dysfunction, whereas it can greatly increase the efficiency of vaporization [19].

An important consideration is the treatment of large prostates. Altay et al. [20] studied the 12 month safety and efficacy of the 180 W XPS GreenLight laser with the MoXy fiber in prostates larger than 80 mL. Sixty-eight patients with a mean age of 71.1 ± 9.8 were evaluated and outcomes were assessed at 3, 6, and 12 months post-operatively. Subjective parameters such as IPSS and IIEF-5 were assessed as were objective parameters such as Q_{max}, PVR and transrectal ultrasound (TRUS) volume [20]. Mean prostate volume was (104.3 ± 29.7) mL with a range of 81–185 mL [20]. Significant improvements were seen in IPSS, Q_{max}, and PVR ($p < 0.001$) at all-time points [20]. A

reduction of prostatic volume by 40.5% was seen at 12 months (Table 1). The authors concluded that the use of the 180 W GreenLight laser system was effective and safe in the treatment of large prostates [20].

A recent study by Emara and Barber [21] reported on their early experience with the XPS Generator and the Moxy Laser Fiber. One hundred and thirty-one patients, with an average age of 72.6 were treated using the XPS/MoXy system. Subjective parameters such as IPSS as well as objective parameters such as Q_{max} , PVR, and prostate volume were assessed at 3 months post-operative follow-up, and compared to the preoperative data [21]. Patients were divided into three groups based on preoperative prostate size (<40 mL, 40–80 mL, >80 mL). Significant improvements were seen in mean IPSS (18.51 ± 0.8036 vs. 8.529 ± 0.7164 , $p < 0.0001$) and Q_{max} (9.843 ± 0.4188 mL/s vs. 20.10 ± 1.543 mL/s, $p < 0.0001$) postoperatively in all three groups [21]. Mean prostatic volume reduction was 51.2%, 49.8%, and 48.1% for all three groups respectively. Results showed that the XPS generator and MoXy fiber are able to achieve effective results with respect to clinical outcome and prostatic volume reduction [21].

2.2.2.2. Long-term studies. As a novel procedure, there are growing numbers of reports of long-term outcomes of 80 W KTP laser prostatectomy. Ruzsat et al. [22] published the largest series of 80 W KTP laser prostatectomies. At a single center, 500 patients underwent PVP, including 45% taking oral anticoagulation. After 3 years, 26.2% of patients had follow-up and mean AUS SI, PVR, and QoL were significantly improved compared to baseline. At 60 months, retreatment rate was 6.8%. Urethral and bladder neck strictures were observed in 4.4% and 3.6% of patients, comparable to the rate in TURP. Te et al. [16] reported 3-year multi-center long-term follow-up in 139 patients who underwent 80 W KTP laser prostatectomy. At 3 years, 33.8% of patients had follow-up and improvements in symptom relief and urinary flow rate were durable. Retreatment rate was 4.3%.

Te et al. [16] presented the first large, multicenter series on the use of 80 W KTP laser in laser prostatectomy for 145 patients with long-term follow-up. Of note, this experience represented the initial laser experience of this technology with these centers, testing its ease of use. Significant and durable improvements in AUA Symptom Index (AUA SI) scores, QoL scores, Q_{max} , and PVR were demonstrated up to 12 months postoperatively. Mean AUA symptom scores declined from 24 to 1.8 at 12 months; mean QoL scores improved from 4.3 to 0.4, Q_{max} from 7.7 to 22.8 mL/s, and PVR volume from 114.2 to 7.2 mL. Mean prostate volume, which was determined by ultrasound, decreased from 54.6 to 34.4 mL (Table 1). Mean operative time was 36 min, and no patient required a blood transfusion. More than 30% of patients were sent home without a catheter; and for those patients that did require post-operative catheters, they had them removed in a mean time of 14 h post-operatively. Morbidity as reported by the doctors was generally minor. It was found that 8% of patients experienced mild-to-moderate dysuria lasting more than 10 days, 8% had transient hematuria, and 3% had post-operative retention. Among the 56 men who were potent

prior to the procedure, 27% experienced retrograde ejaculation but none of them experienced impotence.

3. Conclusions

TURP has been used as the standard of care for the treatment of BPH, however complications due to its use, such as bleeding, retrograde ejaculation, impotence and incontinence, have led to a growing interest among physicians in the use of minimally invasive therapies as alternatives to the procedure. The Greenlight laser has shown to be favorably comparable to the use of TURP when comparing complication rates. Less bleeding and irrigant absorption has theoretically also allowed laser prostatectomy to treat larger volume glands with less physiologic stress; as such, this suggests a role for laser therapy in patients with a high burden of coexisting medical disease. Moreover, the use of laser technology is generally accessible to the practicing urologist. The transurethral endoscopic approach and operative techniques are fairly simple. These attributes have positioned laser prostatectomy as an accepted and often preferred surgical treatment of BPH, perhaps one day surpassing TURP as the gold standard of care for BPH.

4. Conflicts of interest

The authors declare no conflict of interest.

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