New techniques for laser prostatectomy: an update

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Abstract: Traditionally, the gold standard for treatment of BPH has been the electrocautery-based TransUrethral Resection of the Prostate (TURP). However, the number of laser techniques being performed is rapidly increasing. Potential advantages of laser therapy over traditional TURP include decreased morbidity and shorter hospital stay. There are several techniques for laser prostatectomy that continue to evolve. The main competing techniques are currently the Holmium Laser Enucleation of the Prostate (HoLEP) and the 80W 532nm laser prostatectomy. The HoLEP, using the Holmium:YAG laser, has been shown to have clinical results similar to TURP and is suitable for patients on anticoagulation as well as those with large prostates. Disadvantages of this technique are the high learning curve and requirement of a morcellator. When used to treat BPH, studies have demonstrated that, like the HoLEP, the 80W KTP laser is safe and effective in patients with large prostates and in those taking oral anticoagulation. Several studies have compared these two techniques to TURP. Frequently reported advantages of the HoLEP over the 80W laser prostatectomy are the availability after the procedure of a pathology specimen and ability to remove a higher percentage of prostate tissue during resection. However, the transurethral laser enucleation of the prostate addresses these concerns and has shown to have durable outcomes at 2-year follow-up. Two new laser systems and techniques, the thulium laser and the 980nm laser, have emerged recently. However, clinical data from these procedures are in their infancy and large long-term studies are required.

Keywords: surgical therapy and new technology, benign prostatic hyperplasia (BPH), prostate cancer, medical and hormonal therapy

Introduction

Lasers have undergone an evolution from theory to practical application. One application is the treatment of symptomatic benign prostatic hyperplasia, or BPH, via laser prostatectomy. Traditionally, the gold standard for treatment of BPH is the electrocautery-based TransUrethral Resection of the Prostate (TURP). TURP, however, is associated with complications and side effects, including fluid absorption, electrolyte imbalance, intraoperative and postoperative bleeding, and inadequate resection. Laser therapy has several advantages over standard TURP, including technical simplicity and the absence or minimization of complications such as intraoperative fluid absorption and bleeding. Laser therapy may also result in a shorter hospital stay and shorter recovery. Less bleeding and irrigant absorption theoretically allows laser

prostatectomy to treat larger glands with less physiologic stress, suggesting a role for laser therapy in patients with a high burden of coexisting medical disease. Recent estimates suggest an increasing number of practicing urologists are in fact already performing laser prostatectomies on patients with symptomatic BPH, and this number is certain to keep increasing. Furthermore, the techniques and lasers used for laser prostatectomy are constantly evolving. This review is an update on current and new techniques for laser prostatectomy.

Evolution of laser therapy

A variety of lasers have been developed to treat benign prostatic hyperplasia (BPH). Each has its own unique optical characteristics that

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have resulted in significantly different clinical outcomes.

Nd:YAG laser

During the early 1990s, the 1064 nm wavelength Neodymium Yttrium Aluminum Garnet (Nd:YAG) laser was used for a technique known as Visual Laser Ablation of the Prostate (VLAP). Close to the infrared portion of the electromagnetic spectrum, the Nd:YAG wavelength is poorly absorbed by both water and hemoglobin and is transmitted as a free beam through the liquid endoscopic environment with little or no diminution of energy. Because it is poorly absorbed by tissue water, it has a very long absorption length in tissue, penetrating more deeply into tissue than other laser wavelengths used in surgery. The predominant laser-tissue interaction in surgical applications is absorption of laser light energy and subsequent conversion to heat or thermal energy. The relatively slow and nonselective absorption of Nd:YAG laser energy by melanin, pigmented tissues, and proteins translates into a relatively gradual transfer of thermal energy to tissues, producing slow tissue cooking or coagulation as the predominant effect. The Nd:YAG laser was an excellent tissue coagulator.

VLAP became popular among urologists because it represented a low morbidity procedure compared to electrocautery-based transurethral resection of the prostate (TURP). Early data demonstrated good short-term subjective and objective outcomes. Despite low initial morbidity, the VLAP procedure developed a reputation for long-term dysuria and urinary retention requiring extended postoperative catheterization. While the Nd:YAG laser was capable of reaching power outputs as high as 120 W in continuous wave mode, its predominant coagulative effect on tissue, leading to slough and resorption, resulted in prolonged postoperative catheterization and dysuria. As a result, early during the VLAP era, it became evident that this coagulative laser could not unseat the gold standard of care, the electrocautery TURP (Te 2004).

High power 980 nm laser

One new laser system with similar wavelength characteristics to the Nd:YAG laser is the diode powered 980 nm laser system. The current system has power characteristics capable of up

to 150 W and the systems available (Biolitec, Inc, NJ) allow a continuous wave mode to a flexible and customizable pulsing regime. This system allows either a side- or endfire fiber to be utilized. The 980 nm wavelength is not in the visible spectrum and has an aiming beam to allow visualization of target tissue. While it is commercially available for application with laser prostatectomy and data in animal studies suggest it may be useful, clinical data regarding this technology is scarce (Johnson *et al.* 1992).

Holmium:YAG laser

The next step in the evolution of laser therapy, the 2140 nm wavelength holmium:YAG solid state laser, appeared poised to better achieve an electrocautery TURP-like result (Kabalin 1995; Johnson *et al.* 1992a; 1992b). In contrast to the Nd:YAG laser's deep tissue penetration, the holmium laser wavelength penetrates less than 500 μ m into tissue. It is highly absorbed in water, and can be used for tissue cutting and vaporization. The high absorption of the Ho:YAG laser beam in the aqueous irrigant means that close contact between the optical fiber and the tissue must be constantly maintained for efficient tissue vaporization.

Gilling *et al.* first described the use of the Ho:YAG laser in a side firing mode (Gilling *et al.* 1995). The first studies of Holmium Laser Ablation of the Prostate (HoLAP) described successful early removal of catheters and good clinical outcomes with this 'vaporizing' wavelength, either alone or combined with the Nd:YAG laser. While the laser was able to achieve vaporization, removal of large tissue volumes was tedious and time-consuming since true vaporization only occurred in thin layers with a relatively thin underlying coagulation zone. Recently, a 100 W side firing holmium laser system has been released and promoted as an ablative treatment for small glands.

The Holmium laser technique was further refined by directly incising and mobilizing the prostatic lobes in a manner familiar to resectionists, with clinical results in fact rivaling those of electrocautery TURP (Mackey *et al.* 1998). The Holmium Laser Enucleation of the Prostate (HoLEP) approach takes advantage of the cutting capabilities of the Ho:YAG laser. The Ho:YAG laser is used to make precise incisions in prostate tissue to separate lobes of adenoma

from the prostatic capsule. Next the lobes are pushed into the bladder. The tissue is then extracted by an evacuator or by pulling pieces out manually. To save time, special morsellators cut and aspirate pieces of prostate tissue. Average operative times typically range from 60 to 80 minutes in the hands of well-experienced surgeons and are comparable to TURP. Hemostasis is well controlled.

The major disadvantage of the HoLEP technique, however, lies with the associated high learning curve; a surgeon must perform an estimated 20 to 25 procedures in a short period of time to gain proficiency. Prostatic perforations may occur during the first few cases or even over an extended period of time if infrequently performed. There is also a small but finite risk of bladder perforation requiring open cystotomy closure due to the need for a morcellator. As a result, the HoLEP procedure has had lower acceptance in the urology community than other systems. However, it is a new technology that will still require scrutiny and long-term assessment. The largest series to date was reported by Vavassori *et al.* who described 3-year data on 330 consecutive patients (Vavassori *et al.* 2008). They found the procedure to be safe, effective, and durable at 3 years. Gilling *et al.* published the series with the longest follow-up to date (Gilling *et al.* 2008). Thirty-eight patients were evaluated with a mean follow-up time of 6 years. One patient required reoperation and overall 92% of patients were still satisfied or extremely satisfied with their outcome.

One advantage of HoLEP is that the procedure can be performed safely on patients on anticoagulant therapy or with bleeding disorders. Elzayat *et al.* performed the procedure on 83 patients with bleeding disorders or on oral anticoagulant therapy and found the procedure to be safe and effective (Elzayat *et al.* 2006). However, one patient required intraoperative platelet transfusion and seven required blood transfusion early in the postoperative period due to hematuria coinciding with restarting oral anticoagulant therapy. Overall, however there were no major operative or postoperative complications or thromboembolic events.

As mentioned previously, for surgical treatment of BPH, TURP remains the gold standard. Comparative studies have been done to compare the outcomes of HoLEP to those of TURP.

Montorsi *et al.* looked at outcomes of 100 patients randomized to HoLEP and TURP (Montorsi *et al.* 2008). HoLEP and TURP were equally effective for relieving obstruction and lower urinary tract symptoms. HoLEP was associated with shorter catheterization time and hospital stay. At 1 year of follow-up complications were similar in the 2 groups. Ahyai *et al.* randomized 200 patients with prostate size less than 100 cc to either HoLEP or TURP. After 2 and 3 years of follow-up, AUA symptom score and post-void residual were similar in the two groups and late complications were equally low. The authors concluded that at 3 years of follow-up, outcomes were similar (Ahyai *et al.* 2007).

One advantage of HoLEP over TURP is that the procedure is suitable for large prostates. Outcomes after treatment may rival those of open prostatectomy, the gold standard treatment for BPH in large prostates. HoLEP has been compared in several studies to open prostatectomy. Naspro *et al.* evaluated 80 patients randomized to HoLEP or open prostatectomy 2 years following treatment (Naspro *et al.* 2006). Hospital stay, blood loss, and blood transfusion rate were lower in the HoLEP group but operative time was shorter in the open prostatectomy group. Improvements in urodynamic and uroflowmetry were similar at 24 months. Kuntz *et al.* randomized 120 patients with prostates greater than 100 g to either HoLEP or open prostatectomy (Kuntz *et al.* 2008). At 5 years, improvements in micturition were equivalent and reoperation rates were similarly low. Elzayat *et al.* published a series of 225 patients with prostate size greater than 80 g who underwent HoLEP. The authors found the procedure to be safe and effective (Elzayat and Elhilali 2006).

The HoLEP is a safe and effective procedure for treatment of BPH with durable outcomes. The procedure is also safer than and just effective as effective as TURP and open prostatectomy in patients on anticoagulation and in those with large prostates. Unfortunately the HoLEP is also limited by learning curve and the need for using a morsellator. One may argue that the thulium laser represents the next phase in evolution of the HoLEP procedure.

Thulium laser

The thulium laser is the newest laser to be introduced for treatment of BPH. It is a continuous

wave laser device that emits a wavelength of 2013 nm, close to the peak absorption of water (Bach *et al.* 2007; Fried and Murray, 2005). Because the laser energy is quickly absorbed by interstitial water, which is present in all tissues, the laser effect is not affected by tissue color or vascularization. As the wavelength of the thulium laser is closer to the peak of the absorption spectrum of water than that of the holmium laser, absorption by tissue is theoretically even more pronounced. Compared to the Ho:YAG laser, there should be increased tissue vaporization per unit time (Wendt-Nordahl *et al.* 2008). Hemostasis achieved is comparable to that of the Ho:YAG laser. The technique used with this laser is a combination of vaporization and resection is achieved. Small tissue chips are created then evacuated, without requirement of a morsellator.

Wendt-Nordahl *et al.* conducted a systematic *ex vivo* evaluation of the thulium laser in order to compare the procedure to transurethral resection of the prostate (TURP) and the potassium-titanyl-phosphate (KTP) laser as reference standard methods (Wendt-Nordahl *et al.* 2008). The group found that the 2 μ m continuous wave thulium laser offered a higher tissue ablation capacity and similar hemostatic properties as those of the KTP laser. In comparison to TURP both tissue ablation and the bleeding rate were significantly reduced.

Bach *et al.* demonstrated safety and efficacy of the thulium laser by performing the procedure on 54 patients with BPH (Bach *et al.* 2007). Tissue ablation was 1.5 g per minute. Catheterization time was 1.7 days. Qmax significantly improved from 4.2 to 20.1 ml on average. PVR decreased from 86 to 12 ml. International Prostate Symptom Score (IPSS) and QoL-Score improved from 19.8 to 6.9 and 4 to 1, respectively. No patient required blood transfusion or re-hospitalization.

Xia *et al.* conducted a comparison study to determine safety and efficacy of the thulium laser where 100 patients were randomized to TURP or thulium laser resection of the prostate-tangerine technique (TmLRP-TT) (Xia *et al.* 2007). TmLRP-TT is a procedure that uses thulium laser fiber to dissect whole prostatic lobes off the surgical capsule, similar to peeling a tangerine. In comparison to TURP, TmLRP-TT had decreased catheterization time (45.6 *versus*

87.4 hours), decreased hospital stay (115.1 *versus* 161.1 hours), and caused less of a drop in hemoglobin (0.92 *versus* 1.46 g/dL). Procedure time, improvement in subjective symptom scores, improvement in flow rate, and improvement in PVR were equivalent between the groups. So far the results using the thulium laser are promising. However, more large-scale studies are required to confirm safety and efficacy.

KTP or 532 nm wavelength laser

Another laser undergoing continuous evolution is the potassium-titanyl-phosphate (KTP) laser. Doubling the frequency of pulsed Nd:YAG laser energy with a KTP crystal led to the creation of a 532 nm wavelength laser with substantially different tissue interaction properties compared to its parent (Kuntzman *et al.* 1996). Unlike the Nd:YAG wavelength, the KTP wavelength is selectively absorbed by hemoglobin which acts as an intracellular chromophore. KTP laser energy is transparently delivered through a fluid medium, such as water, into the cell where it is absorbed by hemoglobin, then rapidly heated, leading to rapid vaporization of tissue. This in addition to the wavelength's short optical penetration into tissue confines high power laser energy to a superficial layer of prostatic tissue that is vaporized rapidly and hemostatically with only a 1–2 mm rim of coagulation. The thin coagulation zone arises as a result of the quasi-continuous emission characteristics of the KTP laser: typically, continual irradiation of a single point causes heat to diffuse into deeper tissue layers, creating coagulation wherever there is enough convection thermal energy for protein denaturation but insufficient energy for vaporization. These selective characteristics led to the use of the KTP laser in prostatectomy being coined as 'Photoselective Vaporization of the Prostate' (PVP).

Historically, the initial trials involved the comparison of the KTP laser against the Nd:YAG laser in 41 canines (Kuntzman *et al.* 1996). Both techniques were hemostatic in nature, with no irrigant absorption detected. KTP laser vaporization produced a prostatic defect with a mean diameter of 3.0 and 2.4 cm at 2 days and 8 weeks postoperatively, respectively. Statistically smaller defects were produced by Nd:YAG laser vaporization (2.0 and 1.4 cm, respectively) and coagulation (0.5 and 0.9 cm, respectively). No dog treated with KTP laser vaporization was

incontinent or developed urinary retention post-operatively. The use of the KTP laser thus appeared safe and effective in small-scale animal series.

Nd:YAG/KTP laser hybrid

Low power KTP lasers were initially used in conjunction with older Nd:YAG lasers. The former provided ancillary cutting, sculpting, or incising capabilities while the latter induced tissue loss through coagulative necrosis. Studies showed that durable improvements in Qmax, PVR, and AUA symptom score could be achieved (Carter *et al.* 1999; Shingleton *et al.* 1999; Kollmorgen *et al.* 1996). However, a longer period of time was required following surgery to achieve maximum improvement compared to traditional TURP, a reflection of the lack of tissue debulking of the laser. In addition the lower power of the KTP laser limited its utility.

60 W KTP laser

Experiments with a higher power 60 W KTP laser began with both *in vivo* canine studies as well as cadaveric canine and human trials (Kuntzman *et al.* 1997). These studies proved the ability of the KTP laser to vaporize tissue while minimizing accompanying coagulation effects. The first human trials with the 60 W KTP laser came in a series of ten patients described by Malek *et al.* (1998). No patients suffered postoperative TUR syndrome or urinary retention; in fact, all patients were catheter-free in less than 24 hours after the procedure. Patients experienced a significant improvement in Qmax (142%) by 24 hours postoperatively. Though the follow-up described was preliminary in nature, initial results have suggested enduring results in terms of Qmax, mean AUA symptom score, and mean PVR at the 3 month follow-up period. Mean operative time was recorded at 29 minutes.

The first human trials with the 60 W KTP laser were followed by a larger series of 55 patients in 2000 (Malek *et al.* 2000). The 2 year experience with the higher powered KTP laser again corroborated initial findings. Patients experienced statistically significant, enduring improvements in postoperative AUA symptom score (mean = 14.82% improvement), Qmax (mean = 29.1 ml/sec – 278% improvement), and PVR (27 ml, 75% improvement) at 2 year follow-up, comparing favorably with published results for

conventional transurethral resection of the prostate. Mean operative time was 44 minutes. All patients in the series were catheter free 24 hours after the procedure; none required recatheterization and none experienced TUR syndrome. Hematuria was negligible despite the use of anti-platelet agents by many patients. A 9% incidence of retrograde ejaculation at 2 year follow-up was noted, an expected side effect given the authors' deliberate attempt to widely resect the bladder neck. These results demonstrated that prostatectomy with the 60 W KTP laser was as effective as conventional TURP and in fact demonstrated postoperative complications comparable to TURP and even to other laser therapies, such as Ho:YAG.

80 W KTP laser

Despite the effectiveness of the 60 W KTP laser in prostatectomy, its speed of vaporization, which is less than ideal, inherently limited the size of prostate which could be resected given time constraints. The next logical improvement therefore lay in increasing laser power to speed tissue ablation. It is interesting to note that to preserve a thin coagulation zone while still maintaining high vaporization efficiency, a unique laser pulsing technology was incorporated into the 80 W high power KTP laser system. A high frequency modulation of laser light generates a continuous stream of short micro-pulses with a duration of 4.5 ms and a peak power of 280 W, that is, 3.5 times the average laser power of regular 80 W laser. The short duration of the micro-pulses does not allow time for heat to diffuse from the superficial layer, thus confining energy to a small volume of tissue, in a situation referred to as thermal confinement. As each micro-pulse generates a very fast temperature increase inside tissue, the tissue water is not only rapidly vaporized but the surrounding tissue matrix is torn apart, allowing for efficient removal of prostatic tissue. Continuous bladder irrigation is thus required to cool the tissue as well as to provide a clear aqueous medium for laser light to transmit to target tissue without energy loss. Optimal outcome of these effects are technique dependent as well as target tissue composition dependent.

The first experiments with a higher powered (80 W) KTP laser began with *ex vivo* animal models (Reich *et al.* 2004). 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 that essentially bloodless ablation of tissue could occur.

Hai and Malek presented the first human experience with 80 W KTP laser prostatectomy (Hai and Malek 2003). Ten patients were followed for one year after their prostatectomy in a pilot study. Patients experienced statistically significant improvements in AUA symptom score (23.2–2.6), quality of life (QOL) scores (4.3–0.5), Qmax (10.3–30.7 ml/sec), and PVR (137.6–3 ml). No patient experienced postoperative urinary retention, infection, incontinence, or erectile dysfunction; none subsequently developed bladder neck contractures or urethral stricture. Two patients in fact did not require postoperative catheterization at all. Only one patient, on active anticoagulation, experienced mild transient postoperative hematuria requiring recatheterization for 24 hours. The mean operative time was 19.8 minutes.

Te *et al.* have presented the first large, multicenter series on the use of 80 W KTP in laser prostatectomy for 145 patients with long-term follow-up (Te *et al.* 2004). Of note, this experience represented the initial laser experience of this technology with these centers, testing ease of use. Significant and durable improvements in AUA Symptom Index (AUA SI) scores, QOL scores, Qmax, 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, Qmax from 7.7 to 22.8 ml/sec, PVR volume from 114.2 to 7.2 ml. Mean prostate volume, as determined by ultrasound, decreased from 54.6 to 34.4 ml. Mean operative time was 36 minutes, and no patient required a blood transfusion. More than 30% of patients were sent home without a catheter; those with postoperative catheters had them removed in a mean of 14 hours. Reported morbidities were generally minor. Eight per cent of patients experienced mild-to-moderate dysuria lasting more than 10 days. Eight per cent 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.

As a novel procedure, there are growing numbers of reports of long-term outcomes of 80 W KTP laser prostatectomy. Ruszat *et al.* published the largest series of 80 W KTP laser prostatectomies. At a single center, 500 patients underwent PVP, including 45% taking oral anticoagulation (Ruszat *et al.* 2008a). 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% and reoperation rate was 14.8%. Urethral and bladder neck strictures were observed in 4.4% and 3.6% of patients, comparable to the rate in TURP (Ruszat *et al.* 2008a). Te *et al.* reported 3-year multi-center long-term follow-up in 139 patients who underwent 80 W PVP. At 3 years, 33.8% of patients had follow-up and improvements in symptom relief and urinary flow rate were durable (Te *et al.* 2006). Retreatment rate was 4.3%.

One of the advantages of the 80 W KTP/532 nm laser is the ability to perform laser prostatectomy on larger glands with good outcomes and an excellent safety profile. Sandhu *et al.* detailed large prostate volume resection with the 80 W KTP laser (Sandhu *et al.* 2004). Sixty-four men with BPH possessing prostates with volumes of at least 60 ml who had failed medical therapy 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 minutes. IPSS decreased from 18.4 to 6.7 at 12 months; Qmax increased from 7.9 ml/sec to 18.9 ml/sec while PVR decreased from 189 ml to 109 ml. No transfusions were required nor was there evidence of postoperative hyponatremia. All 62 patients were discharged within 23 hours. This was the first evidence that the 80 W KTP laser could be used as a safe and effective means for with durable results for large volume prostatectomy. Of note, since the procedure was very hemostatic and performed under normal saline unlike TURP and open prostatectomy, higher risk patients could be treated due to improved hemodynamic stable safety profile provided by this laser technique. Large prostates, as a result, could be treated safely despite the longer operative times. Of note, hospital stay is short compared to TURP and open prostatectomy.

Pfizenmaier *et al.* conducted a comparative study between vaporization of prostates greater than or equal to 80 ml and those smaller than 80 ml. Thirty-nine of 173 patients had prostates

≥ 80 ml. The authors found that PVP was safe and effective in prostates ≥ 80 ml but the reoperation rate was higher (Pfitzenmaier *et al.* 2008). In another study, Rajbabu *et al.* assessed 54 consecutive patients with prostates >100 ml who underwent 80 W KTP laser prostatectomy. Consistent with other published series, the procedure was found to be safe, effective, and produced durable improvements in IPSS and QOL at 24 months (Rajbabu *et al.* 2007).

The safety of the 80 W KTP laser prostatectomy has been studied in patients at high cardiopulmonary risk, and demonstrated to be excellent due to the excellent hemostatic profile and perioperative hemodynamic stability of the procedure. Reich *et al.* performed 80 W laser prostatectomy on 66 patients with an American Anaesthesiology Score of 3 or greater (Reich *et al.* 2005). Of these patients, 29 were being treated with ongoing oral anticoagulation or had a severe bleeding disorder. No major complications occurred during or following the procedure and no blood transfusions were required. Two patients required reoperation within 12 months due to recurrent urinary retention. Mean improvements in IPSS (20.2–6.5) and peak flow (6.7 ml/s to 21.6 ml/s) were durable at 12 months.

The final safety aspect of the 80 W KTP laser to be studied in detail was its use in anticoagulated patients at high risk for clinically significant bleeding. A series of 24 anticoagulated patients with BPH treated with laser prostatectomy using the 80 W KTP laser was studied (Sandhu *et al.* 2005). Of these, eight were on warfarin; two on clopidogrel; and 14 on aspirin. Eight (33%) of these patients had a previous myocardial infarction; seven (29%) cerebrovascular disease, and seven (29%) peripheral vascular disease. No patients developed clinically significant hematuria postoperatively and none developed clot retention. No transfusions were required and there were no thromboembolic events. One patient had transient postoperative urinary retention requiring discharge with a catheter, two patients developed retrograde ejaculation, and two patients had urinary tract infections postoperatively. Mean operative time was 101 minutes. Follow-up revealed a decrease in IPSS from 18.7 to 9.5 as well as an increase in Qmax from 9.0 to 20.1 ml/sec at 12 months. PVR decreased from 134 to 69 ml at 1 month but were not statistically significant beyond that timepoint.

In this study, all patients underwent PVP safely without any adverse thromboembolic or bleeding events. Significantly, more energy and time was used for lasing per gland size in these patients. Since that time, multiple reports have confirmed this experience (Ruszat *et al.* 2007).

The gold standard comparator of minimally-invasive procedures for BPH is the TURP. For a novel procedure, there is a quickly growing literature comparing 80 W KTP laser prostatectomy to TURP. Currently Ruszat *et al.* is conducting a study with 396 patients randomized to either 80 W laser prostatectomy or TURP (Ruszat *et al.* 2008). Interim 24-month follow-up data of this study was recently published. The rate of intraoperative bleeding (3 *versus* 11%), blood transfusion (0 *versus* 5.5%), capsule perforations (0.4 *versus* 6.3%), and early postoperative clot retention (0.4 *versus* 3.9%) was significantly lower in the laser group. There was no significant difference in IPSS and PVR. After 12 months, size reduction was greater in the TURP group (66 *versus* 44%) and the rate of repeat procedure was greater in the PVP group (6.9 *versus* 3.9%, not significant). Bouchier-Hayes *et al.* reported data on 120 patients randomized to undergo TURP or 80 W laser PVP (Bouchier-Hayes *et al.* 2006). At 12 months equivalent improvements in IPSS and flow rates were demonstrated. Length of hospitalization, length of catheterization, and adverse events were lower in the laser group. In a non-randomized study Bachmann *et al.* studied 101 patients who underwent either TURP or laser prostatectomy. Perioperative morbidity and symptom improvement was equivalent in the groups at 6 months (Bachmann *et al.* 2005). Another randomized study has yielded divergent results. In this study, 76 patients with prostate size >70 ml were randomized to TURP and 80 W laser prostatectomy (Horasanli *et al.* 2008). Procedure time was shorter for the TURP group. Hospitalization stay and catheterization time were significantly shorter in the laser group. There was a significant difference in favor of TURP in terms of improvement in IPSS, PVR, and Qmax as well as volume reduction in the TURP group. In addition, reoperation rate was higher in the laser group.

Clinically the 80 W KTP laser prostatectomy possesses many advantages. Its efficacy appears to be equivalent or nearly equivalent to that of standard transurethral resection of the prostate as an instant tissue defect can be created with

Table 1. PVP and large prostates.

Study	No.	Size (mL)	Duration (months)	Operative time (min)	Blood loss	Transfusion	Delayed bleed	Postop. retention: %	Preop. IPSS	IPSS at 6 mo.	Reoperation rate: %
Sandhu <i>et al.</i> 2004	64	101.3	12	123	Drop in hct by 1.5%	0	0	1.6	18.4	7.2	5
Horasanli <i>et al.</i> 2008	37	86.1	6	87		0	0	15.3	20.2	13.1	17.9
Rajbabu <i>et al.</i> 2007	54	135	24	81.6	Drop in hemoglobin 3%	0	7.4%	4	22.9	7.8	6

Table 2. PVP in patients taking anticoagulation.

Study	No. patients	Duration (months)	Warfarin	Clopidogrel	ASA	Procedure Time	Prostate Volume	Blood transfusions	Postop. complications
Sandhu <i>et al.</i> 2005	24	12	8 [33%]	2 [8%]	14 [58%]	101	82 mL	0	1 postoperative retention 2 UTI
Ruszat <i>et al.</i>	116	24	36 [31%]	9 [8%]	71 [61%]	67	62 mL	0	13 postop retention 9 UTI

Table 3. PVP in comparison to TURP.

Study	No. patients	Duration (months)	Equivalent	Favor PVP	Favor TURP
Horasanli <i>et al.</i> 2008	76	6		Catheterization time* Hospital stay*	Procedure time* IPSS improvement* Qmax improvement* PVR improvement* Volume reduction* Reoperation rate*
Ruszat <i>et al.</i> 2008	396	24	IPSS improvement PVR improvement Rate of strictures Reoperation rate	Hospitalization time* Catheterization time* Intraoperative bleeding* Capsule perforation* Blood transfusions* Early clot retention* Catheterization time* Hospitalization time* Blood loss* Cost*	Procedure time* Improvement Qmax*
Bouchier-Hayes <i>et al.</i> 2006	76	12	Qmax improvement IPSS improvement PVR improvement QoL improvement Sexual function Perioperative morbidity	Catheterization time* Postop urinary retention Blood loss	Procedure time* Urethral stricture rate
Bachmann <i>et al.</i> 2005	101				

*statistically significant

excellent hemostasis, without absorption of hypotonic fluid. The ability to use normal saline solution as irrigation also removes the risk of dilutional hyponatremia. The procedure can be performed with a range of anesthesia from a prostate block with IV sedation to regional anesthetic

to general anesthesia. It can be used in high-risk patients such as those anticoagulated with heparin, coumadin, nonsteroidal anti-inflammatory drugs and aspirin. Often, no postoperative irrigation is required, and catheter time is relatively short. Many patients do not even require

postoperative catheters. However, one criticism is the length of operative time with larger gland prostates and the desire to increase vaporization efficiency.

120 W 532 nm laser system

The 80 W KTP laser system has evolved to a higher power system capable of 80 W to one of 120 W. This new laser emits the same 532 nm wavelength, with the same hemostatic properties as the 80 W KTP (Te 2008). The 532 nm 80 W KTP laser is created by passing a 1064 nm Nd:YAG laser beam through a KTP crystal. In contrast, the 120 W HPS 532 nm wavelength is created by passing a Nd:YAG laser beam through a lithium triborate (LBO) crystal. The 532 nm LBO beam is better-collimated than the KTP beam.

Several animal studies have been performed with the 120 W 532 nm laser. Lee *et al.* investigated the use of the 120 W laser in five male beagles (Lee *et al.* 2008). Photoselective vaporization of the prostate was performed in antegrade fashion through a suprapubic cystotomy at 40, 80 and 120 W settings for three distinct firing periods (5, 10 and 20 seconds) at unique locations in the prostate. One hundred and twenty watts HPS consistently vaporized more tissue per unit time while the depth of coagulation (1.2–2.5 mm) was decreased compared to the lower powered systems. Kang *et al.* compared the use of the 120 W HPS laser to the 80 W HPS laser and the 80 W KTP laser from 96 specimens of bovine prostate tissue (Kang *et al.* 2008). The 120 W HPS laser vaporized bovine prostate tissue more efficiently than the 80 W KTP laser and coagulation was equivalent.

Few studies have been published on the safety and efficacy of the 120 W 532 nm laser prostatectomy in humans (Woo *et al.* 2008). In a multi-center prospective study, 305 patients with BPH underwent laser prostatectomy with the 120 W HPS laser. Changes in maximum flow rate (Q_{max}), postvoid residual urine, IPSS, and prostate volume from baseline to follow-up were significant ($p < 0.001$) in all patients. A subgroup analysis was done in 3 groups of patients: those in retention ($n = 63$), on anticoagulation ($n = 67$), and with prostates ≥ 80 ml ($n = 52$). Complications were comparatively low in all groups.

Transurethral laser enucleation/vaporization techniques with 532 nm laser systems

Frequently reported advantages of the HoLEP over the 80 W laser prostatectomy are the availability after the procedure of a pathology specimen and ability to remove a higher percentage of prostate tissue during resection. This advantage, however, is not unique to HoLEP. We have developed and now routinely apply a new technique of laser prostatectomy with the 532 nm laser. This technique is a variation of enucleation/vaporization/resection that we call transurethral laser enucleation of the prostate (TLEP) and is demonstrated in Figures 1a–e. The procedure allows pathology to be collected and analyzed, provides more improved surgical debulking of obstructive prostate tissue, and increased tissue removal efficiency to shorten operative times. This new advance technique is essentially a hybrid between a HoLEP, a TURP, and laser vaporization techniques utilizing the 532 nm laser. In contrast to the HoLEP, the technique can be quickly learned by those with prior transurethral resection skills. Like the HoLEP, pathology is provided and resection/enucleation is very complete. In our initial experience, 428 patients underwent TLEP utilizing both the 80 W and 120 W 532 nm systems, and the procedure has been shown to be safe and effective. There were no life-threatening complications experienced by any patients. A blood transfusion was required by only one patient for delayed bleeding a few weeks postoperatively. At 24 months, improvements in AUA SI (18.56 to 6.84), Q_{max} (9.46 to 12.54 ml/s), and PVR (161.61 ml to 85.03) are durable (Chung *et al.* 2009).

Conclusions

Laser prostatectomy has become widely accepted by urologists as an alternative to TURP for the treatment of BPH. Laser technology is generally accessible to the practicing urologist and the transurethral endoscopic approach and operative techniques are familiar to practicing urologist. Laser prostatectomy has proved to be a safe and efficacious surgical intervention to relieve symptomatic bladder outlet obstruction. Overall morbidity contrasts favorably with standard surgical approaches. There are several techniques for laser prostatectomy that continue to evolve. The main competing techniques are currently the HoLEP and the 80 W 532 nm laser PVP. There are several advantages of these procedures over traditional TURP. Both techniques can be

Figure 1. Transurethral laser enucleation/vaporization technique (TLEP). View of the prostate through cystoscope; (a) First an incision is made through the median lobe until the bladder neck fibers can be seen. Sweeping motions with the side-fire laser fiber ensure that a wide channel is made that allows for the strong flow of cooling irrigant. Second, incisions are made lateral to the median lobe. It is important at this step to visualize the ureteric orifices; (b) The intervening tissue between the incisions, if large, is divided into smaller chips. The chip is also vaporized to reduce bulk before it is incised and pushed into the bladder; (c) The middle lobe is removed in this manner on both sides to view the ureteral orifice well from behind the bladder neck; (d) An multiple vaporization-enucleation-incisions are made starting at the 11 o'clock position of the lateral lobe down to the fibres of the prostatic capsule. This 11 o'clock incision is continued medial to join the median lobe defect at the 7 o'clock position. Intervening tissue is vaporized, incised, and pushed into the bladder. The same procedure is done to the other side to remove the contralateral lateral lobe starting at the 1 o'clock position to the 5 o'clock position. Apical tissue proximal o the verumontanum is carefully ablated with care to preserve the veru; (e) Anterior tissue at the 12 o'clock position is then incised-vaporized-enucleated as needed to connect the 1 o'clock to the 11 o'clock position. The goal is to achieve a TURP like cavity with removal of tissue to capsule and with view of the Ureteral orifice as well as removal of any intravesical components.

used on patients with high comorbidity and those taking anticoagulation. Furthermore both techniques may be applied to patients with large prostates. The HoLEP is limited by its high learning curve and need for a morselator. Some disadvantages of 80 W 532 nm KTP based PVP technique include lack of tissue specimen and lower

percentage of tissue resection. However, the transurethral laser enucleation of the prostate addresses these concerns and has shown to have durable outcomes at 2-year follow-up. Two new laser systems and techniques, the thulium laser and the 980 nm laser, have emerged recently. However, clinical data from these procedures

Figure 1. Continued.

are in their infancy and large long-term studies are required.

Conflicts of interest statement

None declared.

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