Greenlight photoselective vaporization of the prostate: the 21st century prostatectomy

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'..lasers have been used as a novel method of opening a wider channel and improving voiding dynamics in patients with bladder outflow obstruction due to prostatic enlargement'

Symptomatic bladder outflow obstruction due to benign or malignant prostatic enlargement is an extremely common condition in clinical medicine. The gold standard treatment, Transurethral Resection of the Prostate (TURP), has been shown to significantly improve urinary symptoms. However, morbidity associated with this therapeutic modality is around 20%, with the most common complication, hemorrhage requiring blood transfusion, being a very significant problem. Moreover, in the UK, patients are admitted the day before surgery and are usually discharged after a minimum of 3 days as an inpatient. Longer-term sequelae of this procedure includes the regrowth of prostate tissue, thus necessitating repeat surgery. Currently, there are a number of safe and effective alternatives to TURP. One of the most promising techniques is the laser prostatectomy [1,2]. Lasers used to treat bladder outflow obstruction due to prostatic enlargement have included: neodymium:yttrium–aluminum–garnet (Nd:YAG); the holmium (Ho):YAG; the diode and most recently, the potassium titanyl phosphate (KTP):YAG laser. Each of these modalities have their own unique characteristics, with the mechanisms of removing the prostate ranging from tissue coagulation, vaporization, excision of tissue or a combination of these techniques. Importantly, a significant literature base exists on all laser prostatectomy techniques and the primary aim of all studies was to show an advantage, or at least to show comparative success, over TURP. Secondary aims included obtaining significantly less perioperative blood loss, as well as shortened hospital stay, amongst other variables. However, each technique is associated with disadvantages, which have prevented their acceptance as suitable alternatives to TURP. For example, the Nd:YAG laser was infamous for postoperative dysuria and retention requiring re-catheterization due to the coagulated tissue sloughing off up to 3 months after surgery. The diode laser resulted in tissue necrosis as it operates by a mechanism of interstitial coagulation of the prostate rather than a true removal of the adenoma. This led to longer periods of catheterization, more outflow obstruction and dysuria. Finally, the Ho:YAG laser is associated with a difficult learning curve, a long operative period and, because it works by enucleating the prostate, a further step of tissue morcellation is necessary.

The greenlight laser prostatectomy uses a KTP crystal to double the frequency of a Nd:YAG laser, therefore producing a laser with a 532 nm wavelength. It is, however, the delivery of large amounts of energy, which sets it aside from previous laser technology. In the lower powered KTP laser systems (40 W and 60 W), the laser energy was pulsed. In the new high-power system, the generator works using a stream of short micropulses with a duration of 4.5 ms and a peak power of 280 W; 3.5 times the size of a regular 80 W laser. These pulses appear to be almost continuous and are therefore termed quasi-continuous pulses. This new high power KTP laser system is capable of delivering 80 W of power and for the 'average prostate' just under 100 kJ will be delivered in 30 min, as opposed to 12 kJ in the lower power systems. It is this fast delivery of the KTP laser light energy that allows rapid, efficient vaporization of prostate tissue. Furthermore, with the high power laser, there is limited coagulation necrosis because it has a small optical penetration depth in tissue, and therefore energy is confined to the superficial layer of prostatic tissue that is vaporized rapidly and hemostatically with only a 1–2 mm rim of coagulation. Hence, use in vascular organs, such as the prostate gland, is advantageous as the green light from this laser is selectively absorbed by hemoglobin, thus providing excellent hemostasis. This is termed photoselectivity. The small tissue penetration leading to a focused energy to vaporize the prostate with

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small tissue penetration and a small rim of coagulation, as well as its effect on haemoglobin, has led to this type of procedure being coined greenlight photoselective vaporization of prostate (Greenlight PVP™).

The first reported animal studies using the KTP laser (40 W) were performed by Kuntzmann and colleagues [3] and then in human cadavers using a 60 W KTP laser [4]. Subsequently, Malek and colleagues assessed the immediate outcome, within 24 h of this procedure using the 60 W KTP laser in patients with bladder outflow obstruction due to prostatic enlargement [5]. In this study, the mean lasing time was 29 ± 8 min, during which a mean of 104.6 ± 30 kJ of energy was delivered. None of the ten patients had any significant blood loss or any fluid absorption. Foley catheters were removed in all patients within 24 h, and they were all satisfied with their voiding outcome. Objectively, the mean peak urine flow rate increased from 8 ml/s, at baseline preoperatively, (range ± 1.3 ml/s) to 19.4 ml/s, at 24 h postoperatively (range ± 8.4 ml/s). This constituted a 142% increase in peak urinary flow rate, which was statistically significant ($p = 0.003$). The same group then published their results with further follow up at years 2 and 3, using the 60 W KTP laser [6,7]. These series have demonstrated tremendous improvements in qualitative and quantitative parameters associated with bladder outflow obstruction, as well as showing that it is a safe procedure, with minimal morbidity, and that it can be performed satisfactorily in an outpatients setting.

With the introduction of the new high power 80 W KTP laser, the initial experience describing the outcomes in ten patients at 1 year was published in the *Journal of Endourology,* in 2003 by Hai and Malek [8]. In this paper, the prostate volume ranged between 24 and 76 ml, generally larger than the prostate volume in the series with the 60 W KTP laser, and the mean lasing time was 20 min, with an average energy of 68 kJ being applied. Only eight patients were catheterised after the procedure and these were successfully removed within 28 hours of surgery. Interestingly, the two patients who did not have a catheter voided successfully in the recovery room and were discharged home. There were no reports of significant complications, and indeed 1 year follow-up data have revealed significant improvements in the American Urological Association (AUA) symptom score, quality of life score and maximum flow rate.

More recently, at the 2003 AUA conference (IL, USA), Malek and colleagues presented their 5 year follow-up data with the KTP laser (60–80 W) in 84 men [9]. They concluded that significant improvements had been achieved and sustained without deterioration during 5 years of observation in this cohort of patients with minimal complications. Furthermore, at the same meeting there was an informative paper on the safety and efficacy of PVP in men with large prostate volumes by Sandhu and colleagues [10].

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In this selective series of 22 men with prostate volumes greater than 60 ml (mean volume was 103 g; range ± 42 g), the mean operative time needed was 101 mins (range ± 37 mins), with the surgery being predominantly performed using intravenous sedation and prostate nerve block. No blood transfusions were required and all 22 patients were discharged without significant complications within a day of surgery. When reviewed in the clinic at 1 month, there were statistically significant reductions in symptom score (from 19.9 preoperatively to 9.4; $p < 0.01$) and statistically significant improvements in peak urine flow rate (from 6.0 ml/s preoperatively to 18.1 ml/s at follow up; $p < 0.01$). The authors concluded that Greenlight PVP was safe and efficacious for men with symptomatic bladder outflow obstruction due to benign prostatic enlargement and large volume prostates. One clear criticism of these studies is that the data presented are from case series and not randomized controlled studies. In defence however, it has to be stated that the 'gold standard' TURP was accepted as part of our treatment regimen without the constraints of such good quality clinical trials.

However, in this modern era of evidence-based medicine, to accept a new treatment modality, it is necessary to have robust clinical studies from which meaningful data can be extracted. In response to this, the first multicenter prospective trial using the high power Greenlight PVP, was presented at the 2003 AUA annual conference in Chicago (IL, USA) by Te and colleagues [11], where 98 patients were prospectively assessed for qualitative and quantitative variables. The mean operative duration was 36 min and 71% of patients were discharged the same day. Of all the patients, a third were discharged without a catheter and of those catheterized, the mean time to trial without catheter (TWOC) was 14 h. In this abstract presentation, there were significant improvements in symptom and quality of life scores, peak urinary flow rates and even postvoid residual volumes out to 1 year of follow-up. These figures were recently updated and presented at the 2004 AUA in San Francisco (CA, USA) and demonstrated safe and efficacious treatment outcomes with the high power KTP laser [12]. Other presentations at the conference further highlighted the advantages of Greenlight PVP [13,14].

In summary, lasers have been used as a novel method of opening a wider channel and improving voiding dynamics in patients with bladder outflow obstruction due to prostatic enlargement. Many different techniques have evolved that are all grouped under the term laser prostatectomy, but individual techniques vary greatly. The excellent hemostasis that can be achieved means that it is particularly attractive in high-risk patients with bleeding tendency, such as those on the anticoagulants warfarin and aspirin. Indeed, there is a significantly reduced risk of requiring a postoperative blood transfusion following this type of surgery. Furthermore, ongoing studies will look to confirm its quick learning curve as compared with other types of prostatectomy [Shergill et al., unpublished data]. With the presence of 5-year data and ongoing prospective clinical trials, it seems that the KTP laser, in particular the new high power 80 W version (Greenlight PVP), may represent a suitable alternative to the 'gold standard' TURP. Indeed, there appear to be significant advantages of using the Greenlight PVP Laser as compared with other lasers and indeed TURP.

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