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Minimally Invasive Surgical Treatments for Benign Prostatic Hyperplasia

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Abstract

Although transurethral resection of the prostate (TURP) is considered to be the reference standard for minimally invasive surgical treatment (MIST) of lower urinary tract symptoms (LUTS) due to benign prostatic obstruction (BPO), it is associated with a noteworthy rate of complication. Transurethral microwave thermotherapy (TUMT), transurethral needle ablation (TUNA), and laser prostatectomy (including holmium laser enucleation of the prostate [HoLEP] and potassium titanyl phosphate [KTP] laser) represent the best studied and most accepted MISTs. TUNA and TUMT are simple and safe techniques that can be performed under local anaesthesia in a significant number of patients. Both MISTs significantly improve functional outcomes with respect to baseline values, but they do not reach the same level of efficacy and long-lasting success as TURP. They are, however, superior to TURP in terms of associated morbidity and anaesthetic requirements. HoLEP and KTP have demonstrated similar efficacy and anaesthetic requirements to TURP. Additionally, both lasers are prostate-size independent and seem to have better safety profiles, including shorter catheterisation and hospitalisation time. Yet HoLEP is associated with a steeper learning curve, a higher initial purchase cost, and difficulty in tissue removal. KTP is characterised by longer operative time, lack of tissue for histologic evaluation, and cost including single-use fibres, especially in cases of larger adenomas. High-quality long-term data on the durability of KTP are still missing.

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1. Introduction

The aim of the surgical treatment for lower urinary tract symptoms (LUTS) due to benign prostatic obstruction (BPO) is the removal of as much of the benign prostatic adenoma as possible with minimal peri- and postoperative morbidity and short hospitalisation and catheterisation time.

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Minimally invasive surgical treatment (MIST) is defined as any surgical procedure less invasive than open surgery that is used to achieve the same purpose. Transurethral resection of the prostate (TURP) is currently considered to be the reference-standard MIST; however, it is associated with a 10% complication rate due to bleeding, transurethral resection (TUR) syndrome, urethral stenosis, bladder neck contractures, and sexual dysfunction [1]. Additionally, 10–15% of patients require a second intervention within 10 yr, and a mortality rate of 0.2–2.5% has been reported [2]. For these reasons, less invasive techniques have been advocated, challenging TURP.

Transurethral microwave thermotherapy (TUMT), transurethral needle ablation (TUNA), and laser prostatectomy (including holmium laser enucleation of the prostate [HoLEP] and potassium titanyl phosphate [KTP]) represent the best studied and most accepted MISTs [3,4]. This review will provide an update on the clinical outcomes of the above-mentioned modalities.

2. Transurethral microwave thermotherapy

TUMT uses a special transurethral catheter with an antenna that emits microwave radiation to deliver heat within the prostate, with the eventual goal of destroying tissue by achieving temperatures exceeding the cytotoxic threshold (>45 °C) and inducing cell death (coagulation necrosis). It has also been suggested that TUMT causes denervation of α-receptors, thereby decreasing the smooth-muscle tone of the prostatic urethra [5]. Heat-induced apoptosis in human prostatic stromal cells has also been investigated [6]. Several devices operating at either 915 MHz or 1296 MHz and using different microwave antenna designs have been introduced. The design of the antenna seems to affect the heating pattern more than does the wave frequency [7]. Other differences between the available devices include cooling systems, treatment time, and monitoring of TUMT effect [8]. Presently, the primary tools in the field of microwave thermotherapy are the Prostatron (Urologix, Minneapolis, MN, USA), the Targis (Urologix), the CoreTherm (ProstaLund, Lund, Sweden), and the TMx-2000 (TherMatrx Inc, Northbrook, IL, USA).

2.1. *Efficacy and safety*

A systematic review of six randomised controlled trials (RCTs) evaluating the efficacy of microwave thermotherapy in treating men with LUTS and BPO was performed to quantify the therapeutic efficacy [9]. Treatment was offered with different TUMT devices and software including Prostatron (Prostatsoft v.2.0 and v.2.5) and ProstaLund Feedback. Weighted mean differences (WMD) were calculated with a 95% confidence interval (CI) for the treatment differences in pooled means. Overall, 540 participants were randomised in the six trials, including 322 to TUMT and 218 to TURP. The pooled mean symptom score for men undergoing TUMT decreased 65% in 12 mo (from 19.4 to 6.7), compared with a decrease of 77% (from 19.6 to 4.5) in men undergoing TURP. WMD for the symptom score at the follow-up for all six studies was −1.83 (range: −3.09–−0.58), favouring TURP [9]. The authors also found that the mean urinary symptom scores for TUMT patients almost always decreased from the moderate-to-severe symptom range to the mildly symptomatic range. The pooled mean peak urinary flow for the TUMT group increased 70% (from 7.9 ml/s to 13.5 ml/s) compared with an increase of 119% (from 8.6 ml/s to 18.7 ml/s) in men undergoing TURP, with a WMD for maximum flow rate (Q_{max}) at follow-up of 5.44 ml/s (range: 4.22–6.51) [9]. It is noteworthy that the mean Q_{max} after TUMT was usually < 15 ml/s, since only two studies reported a mean post-TUMT Q_{max} >15 ml/s. In contrast, five studies reported that TURP achieved a mean Q_{max} >15 ml/s [5]. No difference could be detected between different devices. Similar clinical outcomes have been reported by a recent meta-analysis of the available RCTs [10]; however, when data were stratified according to the TUMT device, it was indicated that the CoreTherm device demonstrated the most significant improvements in subjective and objective criteria that approximate outcomes with TURP. A pooled analysis of three studies (two RCTs and one open label) of ProstaLund Feedback TUMT (PLFT) with 12-mo follow-up showed that the responder rate was 85.3% and 85.9% in the PLFT and TURP groups, respectively [11]. Analysis, however, showed that PLFT seems to be inferior to TURP in terms of Q_{max} improvement [11]. TUMT has also been applied to patients in retention with a short-term (≤12-mo) success rate ranging from 80% to 93% [12,13].

A randomised study (targeted TUMT against terazosin) evaluated the position of TUMT against medication [14]. It was found that the clinical outcomes of TUMT in terms of International Prostate Symptom Score (IPSS) and Q_{max} were significantly greater than those achieved by terazosin at 6 mo. Subjective and objective improvement was durable at 18 mo for both groups, but it remained significantly greater in the TUMT group

compared with the terazosin group [15]. Additionally, the actuarial rate of treatment failure at 18 mo in the terazosin and TUMT groups was also significantly different (41% and 5.9%, respectively).

Treatment is well tolerated, with most patients experiencing perineal discomfort and urinary urgency. Pain medication needs to be administered to most patients prior to or during therapy. Data from the systematic analysis of published randomised studies comparing TUMT with TURP indicate that the main advantage of TUMT is its low morbidity [8,9,16]. Adverse events including haematuria, clot retention, transfusions, and TUR syndrome generally occurred less frequently following TUMT. The surgical retreatment for urethral strictures and/or bladder neck contracture has also been found to be significantly higher for TURP (5.85 of 100 person-years) than for TUMT (0.63 of 100 person-years) with a relative hazard of 9.76 [8]. Prolonged catheterisation, dysuria or urgency, and urinary retention are the most frequent adverse events after TUMT. The impact of TUMT on sexual function in comparison with TURP has also been studied. Sexually active men undergoing TUMT were significantly less likely to experience retrograde ejaculation (risk ratio [RR]: 0.39; 95% CI: 0.21–0.75) [8]. Pooled data have also shown that erectile dysfunction was less frequent in the TUMT group [8,9,16].

2.2. *Durability*

Available data have shown that objective and subjective improvement after TUMT remain durable [4]; however, studies had different follow-up periods, whereas TURP achieved better clinical outcomes in terms of IPSS and Q_{max} at all times. TUMT patients (7.54 of 100 person-years) were more likely than TURP patients (1.05 of 100 person-years) to require retreatment due to primary treatment failure, with a relative hazard of 10.0 [8].

3. Transurethral needle ablation

The TUNA device delivers low-level radio-frequency (460-kHz) energy to the prostate via a special catheter attached to a generator that enables the system to reach temperatures >100 °C, resulting in localised necrotic lesions in the hyperplastic tissue [17]. At the end of the catheter there are two flexible needles that can be deployed at an acute angle of 40° to each other and at 90° to the catheter. The needles and covering shields at the needle base can be advanced and retracted independently, whereas the teflon shields aim at protecting the urethra from high temperatures [17].

3.1. *Efficacy and safety*

A significant number of clinical studies on TUNA have been published, with different numbers of patients in each study and different follow-up periods. Most of these studies are open single-arm series. In a meta-analysis, Boyle et al analyzed the results from 2 randomised trials, 2 nonrandomised protocols, and 10 single-arm studies conducted on TUNA [18]. There was a significant improvement in symptoms (a 50% decrease of the mean IPSS) and flow rate (a 70% increase of mean Q_{max}) after 1 yr that persisted for at least 5 yr, despite a slight deterioration. When only the two randomised trials were considered, the mean decline in IPSS was 11.6 and 15.7 after TUNA and TURP, respectively (difference was statistically significant). Similarly, a statistically significant difference of 4.6 ml/s in Q_{max} improvement after TUNA (7.0 ml/s) and TURP (11.6 ml/s) was observed [18].

A recent meta-analysis of 26 noncomparative studies and 9 comparative studies, including 4 nonrandomised and 5 randomised studies, was performed [19]. Combined data from the noncomparative studies show that TUNA achieves a significant improvement on both subjective and objective variables over pretreatment values. Mean reduction in symptom index and quality of life (QoL) score was 50–60% compared with baseline across follow-up. The mean increase of Q_{max} was 35% over baseline values. Analysis of studies comparing TUNA to TURP found that initially (at 3 mo), the efficacy of TUNA seems to be equivalent to that of TURP in terms of symptom score, QoL, and postvoid residual (PVR) [19]. Increase in Q_{max} was 57% and 148% for the TUNA and TURP groups, respectively. The degree of improvement, however, in terms of subjective and objective parameters was lower than TURP across time, with differences in objective parameters that were particularly noteworthy [19]. Additionally, no convincing evidence shows that prostate size is significantly reduced following TUNA [19].

The impact of TUNA on bladder outflow obstruction as assessed by pressure–flow studies was determined in several clinical studies that demonstrated a statistically significant decrease in maximum detrusor pressure or detrusor pressure at Q_{max}, yet a number of patients remained in the obstructed range after TUNA therapy. Additionally, urodynamic improvement was less than that achieved after TURP [20–22].

TUNA is usually performed as an outpatient procedure under local anaesthesia, although intravenous sedation is required in some patients [17–19].

The excellent side-effect and safety profile of TUNA has been well documented in several short- and long-term studies. A meta-analysis of the available noncomparative studies showed that the most common posttreatment adverse effect is transient macroscopic haematuria, without requiring any specific treatment [19]. Urinary retention is a common complication with a mean incidence of 23% (range: 13.3–41.6%). Retention is transient (12–48 h) in the majority of patients; within 1 wk, 90–95% of patients are catheter free [17–19]. Irritative voiding symptoms are frequently present, whereas postoperative urinary infection and epididymitis occur rarely (4% and 0.9%, respectively) [19]. Continence status is not affected, and urethral strictures may occur in 0–1.5% of patients and are related to instrumentation of the urethra [20]. Adverse effects on sexual function including erectile function, ejaculation, and diminution in the ejaculated volume were less frequent in the TUNA group [20]. Meta-analysis of the comparative studies showed that TUNA treatment results in a significantly lower number of adverse events than TURP (odds ratio [OR]: 0.14; 95% CI: 0.05–0.41). This indicates that TUNA has an absolute risk reduction of complications of 19.4% [20].

3.2. *Durability*

Several authors have reported on the long-term efficacy of the TUNA procedure, with most of the studies varying in follow-up duration. A randomised multicentric clinical trial with 5-yr follow-up demonstrated that improvements in IPSS, QoL, Q_{max}, and PVR volume were statistically significant at all time points for TURP and for TUNA after 5 yr [23]. The meta-analysis by Boyle et al revealed that improvements in IPSS and Q_{max} were statistically significant at all time points for TURP and for TUNA after 5 yr, but the overall improvement was superior in the TURP group [18]. Bouza et al found that after 12 mo, both subjective and objective parameters are statistically in favour of TURP, with the differences becoming increasingly greater over time [19].

Combined analysis of the data from 17 noncomparative studies demonstrates that 237 of 1036 patients treated with TUNA required additional treatments due to primary therapy failure, resulting in an overall retreatment rate of 19.07% (95% CI:18.7–39.7) [19]. The combined results of the studies comparing TUNA with TURP indicate that patient benefit from TUNA is less durable than that observed among patients treated with TURP, with a significantly greater number (OR: 7.44; range: 2.47–22.43) of TUNA patients requiring additional treatment for LUTS [19].

3.3. *Patient selection*

It has been reported that patients with prostate volumes >75 ml or with isolated bladder neck obstruction or median lobe enlargement are not ideal candidates to receive TUNA [24]. Other studies have found that prostate size and shape was not related to treatment response [24]. TUNA is not recommended in patients with metallic pelvic prosthesis and pacemaker [17].

4. Laser prostatectomy

Laser technology was applied to treat LUTS secondary to BPO >15 yr ago, with high expectations. Techniques consist of coagulation, vaporisation, resection, and dissection, depending on the wavelength, power, and type of laser emission (continuous or pulsed). Four types of laser have been used for the surgical treatment of symptomatic benign prostatic hyperplasia (BPH): (1) neodymium:yttrium aluminium garnet (Nd:YAG); (2) holmium:yttrium aluminium garnet (Ho:YAG); (3) potassium (*kalium* in German) titanyl phosphate:yttrium aluminium garnet (KTP:YAG); and (4) diode. Described surgical techniques include visual laser ablation of the prostate (VLAP), interstitial laser coagulation (ILC) of the prostate, photoselective vaporisation of the prostate (PVP), holmium laser bladder neck incision, holmium laser resection of the prostate (HoLRP), holmium laser ablation of the prostate (HoLAP), and holmium laser enucleation of the prostate (HoLEP). Since their introduction, the clinical safety, efficacy and durability of lasers in treating BPH have been extensively tested. Consequently, some of the early laser procedures have been abandoned because of the need for long catheterisation time, unpredictable results, and high reoperation rates [25]. Today, only two procedures can challenge the position of TURP as the standard of surgical treatment: HoLEP and, more recently, high-powered KTP [26].

4.1. *Holmium laser enucleation of the prostate*

The holmium laser is a pulsed solid-state laser with a wavelength of 2140 nm, which is strongly absorbed by water. The penetration depth in the prostatic tissue is only 0.4 mm. The resulting energy density is sufficient to heat prostatic tissue to temperatures >100 °C, which creates vaporisation without deep coagulative tissue necrosis.

Gilling et al were the pioneers of such a technique. The end-firing holmium fibre is used at a high power setting of 60–80 W through a continuous-flow, special resectoscope. The procedure starts with bladder neck incisions at 5 and 7 o'clock. The median and lateral lobes are then undermined and resected at the level of the prostatic capsule in a retrograde direction until the bladder neck is reached. Prostatic lobes are then pushed into the bladder, morcellated with a special morcellator, and removed [27].

At the beginning, HoLEP was proposed as an alternative to TURP for the treatment of small and midsized prostatic adenomas. After the publication of the study by Kuntz and Lehrich [28], in which HoLEP was compared with open prostatectomy (OP), an increasing number of publications showed the safety and the efficacy of HoLEP for the treatment of patients with very large glands. Therefore, HoLEP has been defined as the endourologic alternative to OP [29].

4.1.1. *Efficacy and safety*

4.1.1.1. Holmium laser enucleation of the prostate versus transurethral resection of the prostate. Gilling and colleagues [30] performed the first meta-analysis of four RCTs comparing HoLEP and TURP. They found that urodynamic relief of obstruction (detrusor pressure at Q_{max} and Schaffer grade) was superior with HoLEP compared with TURP but only when prostate volumes were >50 g. A new meta-analysis compared HoLEP with TURP and showed no statistically significant difference between HoLEP and TURP in terms of Q_{max} at 12 mo after treatment [31]. Additionally, no statistically significant differences between pooled estimates were noted between HoLEP and TURP for urethral stricture (2.6% vs 4.4%), blood transfusion (0% vs 2.2%), and reintervention (4.3% vs 8.8%). The overall complication rate, however, was 8.1% in the HoLEP group and 16.2% in the TURP group, with a statistically significant difference in the pooled estimates. Pooled data suggest that HoLEP is superior to TURP in terms of catheterisation time, hospital stay, and blood loss. In contrast, a benefit of TURP over HoLEP has been shown for operation time [31]. Recently, in their meta-analysis of the available RCTs, Lourenco et al reconfirmed the findings of the previous meta-analysis regarding functional outcomes, catheterisation time, hospital stay, blood loss, and postoperative complications rate [32].

4.1.1.2. Holmium laser enucleation of the prostate versus open prostatectomy. Results of two RCTs comparing the outcomes after HoLEP and OP were recently reported. Naspro and colleagues found similar functional outcomes at 2-yr follow-up for prostates >70 g as well as with reduced catheterisation, hospital stay, and blood loss in the HoLEP group [33]. Recently, Kuntz et al reported that their long-term (5-yr) data demonstrated similar durable subjective and objective improvement for both groups, with a reoperation rate of 5% in the HoLEP group and 6.7% in the OP group [34].

4.1.2. *Durability*

Studies evaluating durability of HoLEP are now available. Elzayat and Elhilali [35] found that the objective and subjective improvements after HoLEP remained sustained at 6 yr, with a reoperation rate of 4.2% for recurrent BPH obstruction. Gilling and colleagues [36] reported the results from a series of patients with a mean follow-up of 6.1 yr. HoLEP achieved durable results in terms of Q_{max}, QoL, and IPSS, while the reoperation rate was 1.4%. Similarly, Vavassori et al assessed safety and efficacy of HoLEP in 330 consecutive patients and found that the relief was durable after 3 yr of follow-up [37].

Today, the main drawback contributing to the lack of widespread acceptance of HoLEP, despite the ongoing accumulation of evidence regarding its safety and efficacy, is the significant learning curve (requiring 30–50 cases) and the lack of structured training programmes.

4.2. *KTP laser*

The KTP laser presents considerably different laser–tissue interactions compared with other laser systems. A 1064-nm Nd:YAG laser light is emitted through a KTP crystal, which doubles its frequency and splits the wavelength, making the light visible in the green area of the electromagnetic spectrum (ie, green-light laser) [26]. Green light is selectively absorbed within the tissue by haemoglobin, which acts as an intracellular chromophore. Absorption leads to instant removal of prostatic tissue by a rapid photothermal vaporisation of heated intracellular water (ie, PVP) [38]. Because of the short penetration of the KTP laser into tissue (0.8 mm), the resulting coagulation zone is limited (1–2 mm), which leads to more focused and efficient vaporisation, creating a TURP-like cavity [38].

After the success of the canine and human cadaver studies, the 60-W KTP laser was first used in 10 patients by Malek et al [39]. The procedure was performed using a 22-Ch continuous-flow cystoscope and sterile water irrigant, the energy delivered via the side-firing laser fibre in the noncontact mode. No patients had significant blood loss and

there was not evidence of fluid absorption; the Foley catheters were removed within 24 h. At postoperative 24 h, a significant improvement in Q_{max} was evident and, apparently, no patient complained of dysuria or haematuria or required recatheterisation. A subsequent report from the same institution documented the outcome of 55 men who underwent 60-W KTP vaporisation of the prostate with 2-yr follow-up [40].

4.2.1. *80-W KTP laser*

Despite the good results and its technical simplicity, the 60-W KTP laser had limitations, especially with prostates >60 ml, due to the slow speed of vaporisation. To improve it, a quasi–continuous-wave KTP 532-nm laser was developed, emitting power of 80 W. The first clinical trial of the 80-W KTP laser was published by the same group of authors in 2003 [41].

4.2.2. *Efficacy and safety*

4.2.2.1. *KTP laser versus transurethral resection of the prostate.*

Today, there are only two RCTs comparing KTP laser vaporisation with TURP. Bouchier et al [42] reported that KTP was superior to TURP in terms of catheterisation time, blood loss, and hospital stay, which was lengthier. At 6 mo, results revealed similar improvements in voiding parameters, although prostate volume reduction was significantly greater in the TURP arm. Interim results from the same trial were published showing that improvements in Q_{max} and symptom scores were equivalent for both treatments, and although the number of patients available for evaluation at 1 yr was still suboptimal for drawing conclusions, early reoperation rate was in favour of TURP [43].

Horasansli et al [44] compared the short term outcomes of PVP and TURP for glands >70 ml. Seventy-six patients were assigned for surgical treatment with TURP or KTP. Operation time was significantly longer in the KTP group, whereas catheter removal and hospital stay were significantly longer in the TURP group. Three patients, in the TURP group only, required blood transfusions. At 6-mo follow-up, significant statistical differences in IPSS, Q_{max}, and PVR outcomes were observed in favour of the TURP group. Erectile function and retrograde ejaculation rates were similar in both groups. A significant reduction of postoperative prostate volume and serum prostate-specific antigen (PSA) values were measured; however, the percentage of the reduction in prostate volume was significantly higher in the TURP group (62.9% vs 40.5%). Seven patients (17.9%) required reintervention because of insufficient healing of the coagulated tissue, which obstructed the bladder outlet to a significant extent in the PVP group and not at all in TURP group. Additionally, three patients (8.1%) in the TURP group and two patients (5.1%) in the PVP group underwent internal urethrotomy because of severe urethral stricture within the follow-up period.

4.2.2.2. *KTP laser versus open prostatectomy.*

In the only RCT, Alivizatos et al [45] compared the effectiveness and safety of KTP to OP for the surgical treatment of prostatic adenomas >80 ml. They reported that patients who underwent KTP experienced a longer length of operation time, shorter time of catheterisation, and shorter hospital stay. Adverse events were minor and of similar profiles in both groups, although patients who underwent OP showed a higher transfusion rate. All functional parameters improved significantly compared with baseline values in both groups; however, patients who underwent OP scored better in the IPSS QoL score. No significant differences between the two groups were detected in Q_{max}, PVR, and the five-item International Index of Erectile Function (IIEF-5) questionnaire. The same group of authors reported the same functional results and a small and nonsignificant number of reoperations due to urethral stricture, bladder neck contracture or persistent bladder outflow obstruction at a follow-up of 18 mo, stating that KTP prostatectomy is a highly acceptable treatment alternative to OP [46].

4.2.3. *Durability*

Malek et al [47] reported excellent clinical outcomes, without necessity of reintervention, and sustained symptomatic and urodynamic improvements with a follow-up of up to 5 yr. Complications are described as mild and rare with transient dysuria (6%), delayed haematuria (3%), bladder neck contracture (2%), and retention (1%). This report, however, has to be judged cautiously, since 79 of the 94 patients were treated with the 60-W laser and only the last 15 received therapy with the 80-W setting. Moreover, of the total number of patients, only 14 (15%) were actually evaluated 5 yr after surgery.

Te et al [48] reported on a series of 139 men undergoing 80-W PVP in a multicentre setting with a maximum follow-up of 3 yr. The overall functional results were improved and sustained up to 3 yr, with a retreatment rate of 4.3%.

Long-term results of a single centre have been published recently [49]. A total of 500 patients, including men in retention, on anticoagulation therapy, and of an advanced age were treated with the 80-W KTP. Patients' mean age was 71.4 ± 9.6 yr

(range: 46–96), mean preoperative prostate volume was 56.1± 25.3 ml (range: 10–180), and mean operation time was 66.4 ±26.8 min (range: 10–160). Despite ongoing oral anticoagulation in 45% of the patients, no severe intraoperative complications were observed. Mean catheterisation and postoperative hospitalisation time was 1.8 ± 1.2 d (range: 0–10) and 3.7 ± 2.9 d (range: 0–35), respectively. All functional parameters were significantly improved. Urethral and bladder neck strictures were observed in 4.4% and 3.6% of the patients, respectively, whereas, the retreatment rate because of insufficient vaporisation or regrowth was 6.8%.

4.2.4. *120-W high-performance system KTP laser*

Despite the proved value of 80-W KTP laser, vaporisation of very large glands remained time consuming. To overcome this limitation, a new KTP laser, the GreenLight High Performance System (HPS) was recently introduced. This diode-pumped solid-state laser system delivers the same 532-nm wavelength within a power setting of 120 W, resulting in increased vaporisation efficacy. One of the differences between this system and the 80-W KTP laser is that the maximum focus of power is now maintained, even within a distance of 3–5 mm, which allows efficient vaporisation despite changes in distance between fibre and tissue [50]. This new technique has some considerable risks, such as the potential of bladder perforation; orifice injury, especially with large median lobes; or perforation of the prostatic capsule with opening of large venous sinusoids at the end of the procedure. The increased vaporisation may also impair vision due to increased formation of bubbles and may result in less efficient haemostasis and increased fibre degradation, with higher cost considerations. Thus, the use of the HPS KTP laser necessitates a longer learning curve [50].

The outcomes were reported from a multicentre study conducted with 305 patients divided into three subgroups; patients in urinary retention, patients on anticoagulants, and patients with prostate volume >80 ml. Observing the changes in American Urologic Association Symptom Score (AUASS), QoL, Q_{max}, and prostate volume from baseline to follow-up, the authors concluded that PVP with the GreenLight HPS laser was safe and effective in all patient subgroups. A limitation of the study was a mean follow-up of only 4.2 mo, with a maximum follow-up of 11 mo [51]. Short-term results (12 mo) have also been recently reported by Spaliviero et al [52]. They included 70 consecutive patients with a median prostate volume of 61.6 ml (range: 20.9–263.0). Mean laser and operative times were 13 min (range: 3–34) and 30 min (range: 6–100), respectively. All were outpatient procedures, with 49 (70%) patients catheter free at discharge. No urethral strictures or urinary incontinence were noted. Median AUASS decreased from 22 to 4, while the median Q_{max} increased from 9.4 ml/s to 20.0 ml/s.

Although GreenLight HPS laser PVP seems promising, intermediate and long-term follow-up data are awaited.

5. Conclusions

Today, a high level of evidence supports TUMT and TUNA for the management of LUTS due to BPO. The emergence of high-power KTP and the maturation of HoLEP have boosted a new interest in laser prostatectomy.

It is well accepted that an increased ablative power results in increased improvement of objective and subjective parameters (Fig. 1), with the expense of increased morbidity. Besides clinical outcomes, a variety of factors may influence the choice of MIST, including availability, cost, and learning curve.

TUNA and TUMT are simple and safe techniques that can be performed under local anaesthesia in a significant number of patients. Both MISTs significantly improve functional outcomes with respect to baseline values, but they do not reach the same level of efficacy and long-lasting success as TURP. They are, however, superior to TURP in terms of

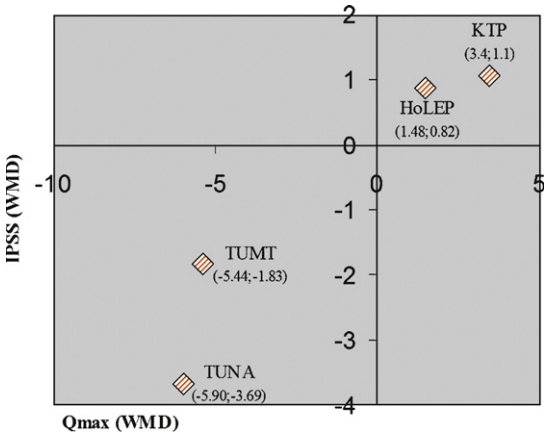

Fig. 1 – Comparative display of the position of transurethral microwave thermotherapy (TUMT), transurethral needle ablation (TUNA), holmium laser enucleation of the prostate (HoLEP), and potassium titanyl phosphate (KTP) laser based on the International Prostate Symptom Score (IPSS) and maximum flow rate (Q_{max}) weighted mean differences (WMDs) between each minimally invasive surgical technique and transurethral resection of the prostate as estimated by meta-analyses (except KTP, only one randomised controlled trial).

Table 1 – Comparison of minimally invasive surgical technique performance to transurethral resection of the prostate

	TUMT	TUNA	HoLEP	PVP
Symptom score	S	S	S	S
Q_{max} (ml/s)	W	W	S	S
Duration of operation	B	B	W	W
Catheterisation time	W	B	B	B
Hospitalisation time	B	B	B	B
Anaesthesia requirements	B	B	S	S
Adverse events*	B	B	B	B
Sexual function**	B	B	S	S
Durability	W	W	S	ID

B = better; S = similar; W = worse; ID = insufficient data; Q_{max} = maximum flow rate; TUMT = transurethral microwave thermotherapy; TUNA = transurethral needle ablation; HoLEP = holmium laser enucleation of the prostate; PVP = photoselective vaporisation of the prostate.
* Significant bleeding, clot retention, transfusions, TUR syndrome.
** Retrograde ejaculation, erectile dysfunction.

associated morbidity and anaesthetic requirements (Table 1). European Association of Urology (EAU) guidelines [53] state that TUMT and TUNA should be reserved for patients who want to avoid surgery or who do not respond favourably to medication. The 6th International Consultation on New Developments in Prostate Cancer and Prostate Diseases [54] concludes that TUMT and TUNA represent an option when instrumental treatment is indicated (except when absolute indication for surgery exists).

HoLEP and KTP have demonstrated similar efficacy and anaesthetic requirements to TURP. Additionally, both lasers are prostate-size independent and seem to have better safety profiles, including shorter catheterisation and hospitalisation times (Table 1). Yet HoLEP is associated with a steeper learning curve, initial purchase cost, and difficulty in tissue removal. KTP is characterised by the longer operative time; lack of tissue for histologic evaluation; and cost, including single-use fibres, especially in cases of larger adenomas. High-quality long-term data on the durability of KTP are still missing.

When clinical practice guidelines were released, data for HoLEP and especially for KTP laser were limited. EAU guidelines [53] state that holmium laser prostatectomy is a viable alternative to TURP, whereas KTP was not discussed. The 6th International Consultation on New Developments in Prostate Cancer and Prostate Diseases [54] suggested that HoLEP is equivalent to TURP/ and adenomectomy, representing a true challenge to both procedures, whereas KTP needs to be better studied.

Conflicts of interest

The authors have nothing to disclose.

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