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TOPIC PAPER

Thulium laser enucleation of the prostate (ThuLEP): transurethral anatomical prostatectomy with laser support. Introduction of a novel technique for the treatment of benign prostatic obstruction

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Abstract
Background Transurethral removal of prostatic tissue is the treatment choice for benign prostatic enlargement and benign prostatic obstruction. Urodynamic results are directly linked to the amount of removed tissue which, however, is directly associated with intra- and postoperative morbidity. Transurethral laser operations of the prostate offer the advantage of decreased bleeding complications and the possibility to treat patients with bleeding disorders or anticoagulative treatment. The aim of the article is to present a novel technique of complete transurethral removal of the transition zone (enucleation) with the support of the Thulium laser to combine complete anatomical enucleation and maximum urodynamic efficacy with minimal side-effects.
Materials and methods We present five distinct surgical steps for transurethral complete removal of the transition zone of the prostate (Thulium laser enucleation of the prostate, ThuLEP). Surgical steps are presented in chronological order with the help of intraoperative pictures. Laser energy of 70–90 W is only used for the incision at the verumontanum and bladder neck for removal of the middle lobe, whereas laser energy of 30 W was only used for coagulation of small vessel crossing the surgical capsule towards the transition zone and bladder neck for dissection of the lateral lobes. The lobes themselves are liberated by blunt dissection.
Conclusions ThuLEP offers complete removal of the transition zone no matter what prostatic size. The techniques combine maximum efficacy with minimal side-effects. Clinical results comparing ThuLEP with open prostatectomy or transurethral resection are awaited.

Keywords Benign prostatic enlargement · Benign prostatic obstruction · Treatment · Laser prostatectomy · Thulium · Holmium · HoLEP

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Introduction

Benign prostatic hyperplasia (BPH) is a highly frequent disease in ageing men and associated with benign prostatic enlargement (BPE), lower urinary tract symptoms (LUTS), and benign prostatic obstruction (BPO). Open or transurethral removal of prostatic tissue is the mainstay for the treatment of BPO and BPE. Although transurethral resection of the prostate (TURP) is still considered as the gold standard of surgical treatment, laser prostatectomy has become increasingly popular due to reduced peri- and postoperative morbidity, shorter catheterization and hospitalization time, and possibility to treat patients with bleeding disorders or anticoagulative drugs. A recently published review on urodynamic effects of TURP in comparison to various laser treatment modalities concluded that the degree of BPO reduction is directly linked to the amount of tissue removal [1]. Until now, only open prostatectomy and transurethral Holmium laser enucleation of the prostate (HoLEP) have shown superior efficacy and durability compared to TURP, thereby revealing lower morbidity when using the latter technique [2].

In 2005, the Thulium laser entered clinical practice and has become the most innovative and universally accepted laser armamentarium in urology after introduction of the Holmium laser [3]. The Thulium laser works at a wavelength of two microns in continuous wave (cw) mode. Together with the pulsed Holmium laser, the Thulium laser is the only laser that offers complete absorption of laser energy in water. Furthermore, the Thulium laser offers advanced vaporization and haemostatic features compared to all other lasers [4]. The Thulium laser is not only suitable for transurethral vaporization, bladder neck incision [5] or Vaporesection [6, 7], but also suitable for Vapoenucleation of the prostate [8–10]. All of the aforementioned techniques use the laser energy to dissect between surgical capsule and adenoma. However, no report has yet dealt with the transurethral complete removal of the prostatic adenoma combining the blunt mechanical enucleation of tissue, as done with the index finger, and the advantages of laser energy to reduce bleeding and achieve safe haemostasis using the Thulium laser. We therefore aim to introduce and describe the novel technique of Thulium enculeation of the prostate (ThuLEP).

Material and methods

Laser equipment

The 2-µm cw-Thulium:YAG laser (Revolix™ 120 W surgical laser, LISA laser products, Katlenburg, Germany) was used at two different energy levels, 70–90 W for incision of the lateral margins of the median lobe and at the verumontanum and 30 W for coagulation of capsule-perforating vessels during blunt enucleation of the prostatic adenoma as well as for dissection of the liberated adenomas at the bladder neck for the releasing the lobes into the bladder. Laser energy was applied through a re-usable 550 µm laser fibre (RigiFib™, LISA laser products, Katlenburg, Germany).

Endoscopy equipment

A 26 F continuous-flow resectoscope (Karl Storz GmbH, Tuttlingen, Germany) with a separate working channel allowing for the 550 µm laser fibre was used. A 30° lens system visualized the lower urinary tract. A camera (Karl Storz GmbH, Tuttlingen, Germany) was connected to the lens for image enlargement and video documentation of the procedure. Physiological saline solution as irrigation fluid was used throughout the entire procedure.

Morcellator

A mechanical tissue morcellator ((Piranha©, Richard Wolf GmbH, Knittlingen, Germany) was used for fragmentation of the prostatic adenoma in the bladder lumen. The morcellator unit consists of a mechanical hand-piece, control unit, rotating blades with a diameter of 5 mm, foot pedal, and a suction pump. The morcellator has to be guided through a long nephroscope that is connected to the outer sheath of the resectoscope through an adapter (Karl Storz GmbH, Tuttlingen, Germany). A double inflow was used to keep the bladder distended during morcellation in order to avoid bladder wall injuries.

Surgical technique

The ThuLEP procedure can be divided into five distinct steps which should be followed meticulously for complete and safe removal of the entire prostate adenoma and for adequate haemostasis.

Preparation of the patient

The patient is placed in the lithotomy position with the legs moved laterally. After sterile preparation and draping, the urethra is irrigated with sterile gel. The 26 F continuous-flow resectoscope is inserted into the bladder under vision in order to avoid urethral or prostatic trauma. The camera should be fixed in a loose position. Finally, the 550 µm laser fibre is inserted through the working channel of the resectoscope. It might be helpful to guide the loose part of the laser fibre through a mosquito clamp, thereby fixing the fibre to the draping and keeping it out of the working area of the surgeon. The outflow channel should always be open during the enucleation procedure for prevention of bladder overdistension. Cystoscopy is performed to exclude concomitant bladder pathologies and visualize the ureteral orifices. The resectoscope is then pulled back into the prostatic urethra, the bladder neck and the extent of lobar protrusion is assessed. Finally, the positions of the verumontanum (Fig. 1a) and the borders of the external urethral sphincter are determined.

Step 1: Circumferential incision of the verumontanum

An inverted U-incision close to the verumontanum is carried out using the 70–90 W power setting of the laser. The incision of prostatic tissue reaches until the distal third of the verumontanum. After incision of the mucosa, the

Fig. 1 **a** Visualisation of the anatomy. **b** Inverted "U"-like circumcision of the verumontanum. **c** Bilateral Turner Warwick-like bladder neck incisions (5 o'clock) in three lobe technique. **d** The surgical capsule. **e** Enucleation of the middle lobe. Middle lobe lifted with the beak of the resectoscope. **f** Lifted middle lobe. Incisions are deepend, but not extended into the peripheral zone

incision is deepened till the surgical capsule of the prostate is reached (Fig. 1b).

Step 2: Removal of the prostatic median lobe

The prostatic median lobe is removed separately before enucleation of the lateral lobes. Bilateral bladder neck incisions close to the lateral margins of the prostatic median lobe are made approximately at the 5 and 7 o'clock positions (Fig. 1c). This incision is extended until the hemi-circumferential incision at the verumontanum (step 1) and then deepened till the surgical capsule becomes visible which can clearly be identified as a white layer with superficial vessels (Fig. 1d). At this level, blunt retrograde enucleation of the prostatic median lobe is started while the laser energy is switched to 30 W. The resectoscope is moved under the edge of the median lobe and bluntly shifted towards the 12 o'clock direction, thereby mechanically disrupting the plane between surgical capsule and prostatic adenoma (Fig. 1e). During blunt disconnection, visual control of the surgical capsule and laser coagulation of perforating vessels at 30 W is necessary. Shifting and disconnection of the adenoma from the surgical capsule and coagulation of crossing vessels is continued until the bladder neck is reached (Fig. 1f). After complete disconnection of the median lobe from the surgical capsule, the liberated lobe is pushed into the bladder.

Step 3: Apical incision of the lateral lobes

The distal margin of the adenoma at the 12 o'clock position is marked and incised by the Thulium laser using 30 W (Fig. 2g). From the incision next to the verumontanum, two superficial incisions towards the 4 and 8 o'clock positions are carried out using the Thulium laser at 30 W. Superficial incision with low laser energy prevents mucosal bleeding and ensures good visualisation for the next steps (Fig. 2h).

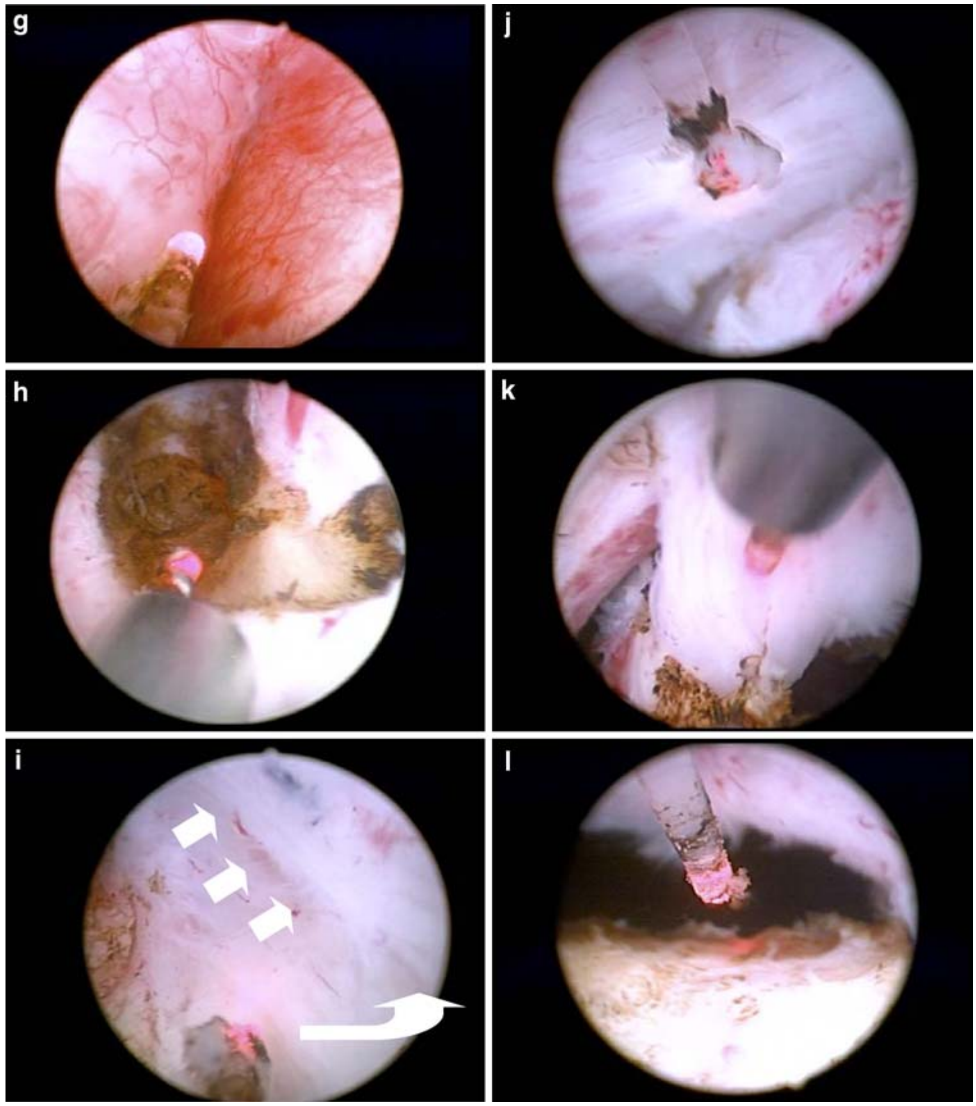

Fig. 2 **g** Incision at 12 o'clock position in between the kissing lobe insertion. **h** Hook-like incision to the mucosa up to 8 (*right*) and 4 o'clock. **i** Exposure of the correct plane (*small arrows*) via blunt shear (*curved arrow*) at the incision aside the verumontanum. **j** Peeling off the capsule like the finger in the retropubic prostatectomy fashion—only from below—exposing the surgical capsule plane bluntly, the lobe medially, surgical capsule laterally. **k** Anteral ventrocaudal fixation. Dissection of the broad band to prevent strain from the apex of the prostate and the surrounding sphincteric region using the low power cut. **l** Released lobe after dissection at the bladder neck from 12 o'clock down and from 5 or 7 o'clock up, respectively

Step 4: Removal of the lateral lobes

The lateral lobes are removed separately, beginning with the left lobe. The apical edges of the lateral lobes are then bluntly exposed by moving the resectoscope under the adenoma and pulling these towards the 2 o'clock position, thereby exposing the apical border of the surgical capsule (Fig. 2i). After the apical plane is opened, the entire lateral lobe is bluntly and progressively released towards the bladder neck (Fig. 2j). Because of the blunt dissection of the lateral lobes, the prostate is often ventro-caudally attached. This attachment appears like a broad mucosal band and must be dissected with low laser energy and not bluntly disrupted to prevent tearing at the apex and surrounding sphincter (Fig. 2k). Again, the surgical capsule can be easily identified by visualizing the small vessels which run in a parallel fashion next to the dissection plane. These vessels remain untouched unless they perforate the capsule and, in such cases, coagulation of capsule-perforating vessels is performed with low laser energy in no-touch technique. The released lobe is then dissected from the bladder neck from the 12 to the 4 o'clock position and, afterwards, from the 6 to 4 o'clock position (Fig. 2l). After complete release from the surgical capsule, the left lateral lobe is pushed into the bladder. The identical procedure is then identically repeated on the right side.

Step 5: Morcellation and removal of the prostatic tissue

The rotating inner sheath and the working element of the laser armamentarium is replaced by a long nephroscope attached the adapter and the morcellator with 5 mm blades is inserted through the resectoscope into the bladder. Continuous irrigation and a fully distended bladder are needed to avoid unintentional trauma to the bladder wall. For full distension of the bladder, an additional infusion system with saline solution is connected to the resectoscope. Complete fragmentation of the prostatic adenoma in the bladder is carried out using combined morcellation and suction. The procedure is completed by removal of the instruments and insertion of a 22 F rinsing catheter.

Discussion

We developed a novel technique for complete removal of the transition zone of the prostate using transurethral blunt dissection of the adenoma in combination with sparse use of the Thulium laser. Laser energy is only used for visual incision of the apical border of the adenoma and dissection of the bladder neck as well as punctual coagulation of prostatic vessels. This technique offers the opportunity for maximum deobstruction of the prostatic urethra similar to open prostatectomy but with maximum control of haemostasis. The operation consists of five distinct steps, which includes removal of the prostate median lobe, lateral lobes, and morcellation of the prostatic adenoma in the bladder lumen, and is based on the experience of more than 60 operations at the Hannover Medical School since April 2009 [11].

It is expected that the amount of tissue removal will result in superior urodynamic outcomes with regard to improvement of uroflowmetry, obstruction grade, postvoid residual urine, and re-treatment rate. Because no prostatic tissue of the transition zone is left behind, ThuLEP is expected to deliver the same or even better postoperative results than open prostatectomy or HoLEP. As the surgical capsule is always visible during the entire procedure capsule, perforation is nearly impossible. Erectile dysfunction due to perforation of the surgical capsule at the sites of the lateral lobes and damage of the neurovascular bundles is therefore unlikely. In contrast to HoLEP [18, 23, 24] and Vapoenucleation [8], the laser energy release at the layer of the surgical capsule is reduced to a minimum and thermal coagulation is done precisely at the area of bleeding vessels, rather than performing complete coagulation of the capsule during dissection of the adenoma. Therefore, the surgical capsule is always visible throughout the entire ThuLEP procedure and remains untouched (Fig. 1). Due to the reduced surface of coagulation, ThuLEP is suspected to have significantly less irritative symptoms than previously introduced techniques. Although the amount of removed prostatic tissue during ThuLEP seems to compare with the amount of tissue removed during open prostatectomy, complete removal can always be visually controlled with our technique for prostates of any size.

For judgment of the completeness of prostatic tissue removal, serum PSA concentration after at least 4 weeks after the operation was suggested. PSA reduction as a proxy parameter for tissue removal for different surgical techniques is shown in Table 1. Preliminary data of the ThuLEP procedure demonstrate a PSA drop of more than 80% on average which is clearly more than TURP, KTP laser vaporization, or Thulium Vaporesection indicating that tissue removal meets the expectations.

Although TURP is nowadays still considered to be the treatment of choice in patients with BPE and BPO, the amount of tissue removal is significantly higher for open prostatectomy when compared to TURP leading to a lower 5-year projected retreatment rate of 2 versus 10%. A review compared the surgical complications of 9,538 patients treated with open prostatectomy and TURP and calculated overall complications in 21% on average for open prostatectomy [95% CI 7.0–42.7] in comparison to 15% for TURP [5.2–30.7]; blood transfusions, epididymitis, postoperative erectile dysfunction and bladder neck contraction/urethral strictures clearly favoured TURP [12]. In a prospective study investigating 10,654 TURP procedures during a 2-year period, Reich et al. [13] confirmed that TURP still has the potential risk of causing major complications which are responsible for an overall mortality rate of 0.1% and an overall morbidity rate of 11.1%. The most frequent complications after TURP were failure to void (5.8%), surgical revision due to bleeding (5.6%), perioperative or postoperative bleeding requiring blood transfusions (2.9%), and transurethral resection (TUR) syndrome (1.4%). Improvement of endoscopic devices, resection technique, anaesthesia, and perioperative care reduced the overall mortality rate of TURP from 2.5% in 1962 [14], 1.3% in 1974 [15], 0.23% in 1989 [16] to 0.1% in 2003 [13]. With the new ThuLEP technique using sodium chloride irrigation fluid and visual coagulation of vessels, it is unlikely that complications such as intra- or postoperative bleeding complications, blood transfusions,

Table 1 PSA reduction after the treatment of BPH

Author	Technique	PSA reduction (%)
Ozden et al. [25]	TURP	70
Aus et al. [26]	TURP	75
Tinmouth et al. [24]	HoLEP	81.7– 86
Elmansy et al. [27]	HoLEP	75.4
van Iersel et al. [28]	KTP	45
Hai and Malek [29]	KTP	41.7
Te et al. [30]	KTP 80 W	37
Hamann et al. [31]	LBO (KTP) 120 W	37
Fu et al. [32]	Thulium Vaporesektion	70
Preliminary data (own series)	ThuLEP	83

or the TUR-syndrome will appear. However, prospective clinical trials have to prove this assumption.

The pitfall of the present description of a new minimally invasive procedure for the treatment of BPE/BPO is that we cannot present any valuable clinical data at this time to confirm the theoretical advantages of ThuLEP. A prospective randomized controlled trial assessing perioperative complications, urodynamic results, and intermediate as well as long-term clinical outcomes is under way in collaboration with the UroThulium Study Group™.

Conclusions

The present article describes a novel treatment technique of BPH using widely blunt dissection of the adenoma from the surgical capsule in combination of Thulium laser use (Thulium laser enucleation of the prostate, ThuLEP). This technique offers the advantages of complete removal of prostatic adenoma similar to open prostatectomy but with transurethral minimal invasive approach. This minimally invasive treatment therefore offers maximum efficacy. Short- and long-term clinical data have to prove this assumption.

Conflict of interest statement There is no conflict of interest.

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