INTRODUCTION

The famous phrase Rome wasn't built in a day only appeared for the first time in English by Richard Taverner in 1539 translating the work of Desiderius Erasmus in the "Adages" (Erasmus, 1539). However, the original phrase was attributed to a cleric in the court of Phillippe of Alsace, the Count of Flanders in 1,190 uttering Rome ne fue pas faite toute en un jour (Tobler, 1895). In the world of Endourology, the fact that good things need time to ripen was fully proven by evolution of Endoscopic Enucleation of the Prostate (EEP). This term was introduced in the 2016 update of the EAU Guidelines on Management of Non-Neurogenic Male Lower Urinary Tract Symptoms (LUTS) with the reception of two meta-analysis (Gratzke et al., 2015; Li et al., 2015; Lin et al., 2015), promoting EEP for the first time as the preferred treatment of choice for the treatment Benign Prostatic Obstruction (BPO) of large volume prostatic glands. This resulted in the change of
scientific reception away from highlighting the impact of a single energy source (back) to the overarching principle of the common ground of enucleating techniques: anatomical enucleation (AEEP), what began with the publication of Yasunori Hiraoka and monopolar transurethral detachment prostatectomy technique (TUE) in 1983 (Hiraoka, 1983) in Japanese and 1989 in English (Hiraoka & Akimoto, 1989).

### 1.1 Historical context of Thulium:YAG-based enucleating technologies

But, the honour for the historical achievement of exposing transurethral enucleation to a broader readership and surgical peers is due to Peter Gilling and Mark Fraundorfer for their work and publication on ‘Holmium:YAG laser enucleation of the prostate combined with mechanical morcellation: preliminary results’ in 1998 (Fraundorfer & Gilling, 1998). In the wake of HoLEP, transurethral plasmakinetic (i.e. bipolar) enucleation of the prostate (PkEP) followed in 2006 (Neill et al., 2006). In the second half of the 2000s, all other transurethral laser-based enucleation techniques led by Tm:YAG vapo-enucleation (ThuVEP) (Bach, Wendt-Nordahl, Michel, Herrmann, & Gross, 2009) and transurethral anatomical enucleation with Tm:YAG support (ThuLEP) (Herrmann et al., 2010), later diode laser enucleation of the prostate (DiLEP) (Lusuardi et al., 2015) and finally Lithium-Borate ‘Greenlight’ enucleation of the prostate (GreenLEP) (Gomez Sancha et al., 2015) entered the endourological stage to finally replace open prostatectomy (OP) and TURP.

### 1.2 The concept of transurethral anatomical prostatectomy with Tm:YAG laser support (ThuLEP)

There is a plethora of acronyms today claiming to stand for ‘ThuLEP’. However, some rather represent approaches to vapo-enucleate (Iacono et al., 2012) or vapo-resect the prostate (Yang, Liu, & Wang, 2016). The header of original description of the technique published in 2010 outlined the fundamental principle of the concept: ‘transurethral anatomical prostatectomy with laser support’ (Herrmann et al., 2010). The novelty of this approach was neither transurethral enucleation nor marketing of the new Tm:YAG laser. The novelty laid in the focus on blunt mechanical anatomical dissection of the whole transitional zone using the laser energy solely for incising of the mucosa, dividing the adenoma into three lobes and cutting of adhesions or ingrowing centripetal vessels. The principle of thulium-assisted transurethral anatomical enucleation was first demonstrated at a laser meeting at Kairo University in 2009 and triggered one of the finest teacher of HoLEP, the late Mostafa El Hilali, to comment with the words ‘I did not know that you could do it [...]anatomical dissection [...] with Thulium [...]YAG...’ (Herrmann, 2009).

This comment shed light on two aspects: firstly, even the most academic promoters of HoLEP at that time where overestimating the impact of ‘their’ laser, Holmium:YAG (Ho:YAG), in the course of transurethral enucleation of the prostate. At this point of time, it was ‘common sense’ that it was only possible to find or access the correct anatomical plane with a pulsed laser. The spiritedly fought controversy since the advent of Tm:YAG laser was about whether other, in this case Thulium:YAG lasers, could have the potential to ‘enucleate’, although continuous wave lasers were vaporising/vapo-incising lasers in the contrary to the mechanically disrupting Holmium lasers. It culminated when Thulium vapo-enucleation (ThuVEP) was introduced in 2008 (Bach, Herrmann et al., 2009). The demonstration of this novel transurethral technique showed a straightforward transurethral vapo-incising enucleating technique that overcame the obstacles of a rather time-consuming vaporesection technique using the initial 70 Watts generator (Xia, 2009). The vapo-incisions into the prostate to cut out the sample incorporating the transitional zone were aiming at the level of the surgical capsule, thereby emulating the template of conventional HoLEP (Fraundorfer & Gilling, 1998). The orientation in the procedures and the extend of the template based on the surgical experience of the presenting surgeons and was not anatomical in the today-accepted context. However, the major criticism of this technique was that the sealed and carmelised surface of the incisions were violating the viewing habits of the ‘HoLEP community’ (HoLEPcentrism, Gilling & Williams, 2008) and clearly did not match the ‘cotton wool landmarks’ of the surgical plane, or at least what was considered to be ‘the anatomical capsule’ at that time (El-Hakim & Elhilali, 2002; Kuo et al., 2003). Today, it is accepted that both HoLEP and ThuVEP techniques both alter the capsule either with boiling by the vapour bubble (‘white’) or carmelising in the vapoicision ‘brown’. Out of the personal struggle of the author of this article to reproduce the incising ‘ThuVEP’ template with Tm:YAG, ThuLEP was born. Due to the blunt dissection, the surface of the peripheral zone aka surgical capsule remained unaltered and orientation was easily maintained throughout the procedure. The first video publication of ThuLEP in three-lobe technique at the World Congress of Endourology 2009 in Munich was the end point of the discussion whether ‘Thulium could’ and ‘only Holmium can’ find the surgical plane (Imkamp, 2009). It was the starting point of a discussion on what is commonly accepted as anatomical endoscopic enucleation of the prostate ‘AEEP’, today.

Therefore, the surgical twins ‘ThuVEP’ and ‘ThuLEP’ demonstrated the whole spectrum of laser action in enucleating techniques: ThuVEP focusing vaporising features during enucleation and ThuLEP focusing on almost blunt detachment and laser assistance. The principle of the latter on anatomy-focusing approach was mimicked by other continuous wave lasers (LBO/‘Greenlight’ and 980nm diode laser) that had not been found suitable for enucleation at the initial point of the discussion (Gomez Sancha et al., 2015; Lusuardi et al., 2015). Today, the energy source seems to be secondary for the success of EEP and rather a result of institutional resources or personal preferences of a skilled surgeon (Elsal et al., 2015), as transurethral endoscopic enucleations have a same effect given they are anatomical EEP (Herrmann, 2016a; Hiraoka, 2017).
1.3 Surgical and anatomical considerations

In principal, all enucleating techniques can be broken down to two principles. ‘True’ anatomical enucleation by mainly blunt dissection and thereby developing the surgical plane leaving the surface intact for visualisation and orientation and on the other side vapo-enucleation using the vaporising capacity of the energy source to cut and seal the surface at the same time. In vapo-enucleation technique, a high level of experience gains momentum. The cutting plane aims to reach the anatomical plane of the interphase to the peripheral zone. At best, these planes are identical (Figure 1, Kyriazis et al., 2015), but a chance of extra-anatomical preparation with incomplete resection or excess of resection template with the chance of perforation of the capsule is possible (Elshal et al., 2016; Iacono et al., 2012).

The transition from ‘anatomical’ to ‘extra-anatomical’ is fluent (Figure 2). In experienced surgeons, the two approaches are mixed within the procedure depending on speed and anatomical features of the gland. The authors of this publication advocate start with anatomical preparation before moving to ‘vapo-enucleation’ (Herrmann, 2017). Lately, also promoters of vapo-enucleation embraced the anatomical ThuLEP approach for comparative studies of enucleating techniques (Becker, Herrmann, Gross, & Netsch, 2018; Gross, 2019).

A surrogate parameter for ‘complete resection’ is the PSA drop, postoperatively. Given the mainstay of enucleating techniques in total prostate volume larger than 80ml, PSA drop is expected to be around 80% in the absence of concomitant prostate cancer (Gross, Orywal, Becker, & Netsch, 2018; Gross, 2019).

2 SURGICAL RESULTS

The vast amount of data from randomised controlled studies with long-term follow-up longer than 4 years is not available for ThuLEP however, in RCTs ThuLEP versus TURP (Swiniarski et al., 2012) and ThuLEP versus bipolar EEP (Feng, Zhang, Tian, & Song, 2016). ThuLEP demonstrated favourable higher intra-operative safety with regard to haemostatic properties. Applications for Thulium vapo-enucleation (ThuVEP) with the same energy source demonstrated long-term result for complication rates in the range of HoLEP (Cornu et al., 2015) and bipolar enucleation (Li et al., 2015; Lin et al., 2015). No urethral and bladder neck strictures in a RCT ThuLEP with HoLEP were reported during the 18-month follow-up period (Zhang, Shao, Herrmann, Tian, & Zhang, 2012). In addition, ThuLEP seemed to be safer with regard to the development of bladder neck strictures when compared in a RCT with Thulium Vaporesection (ThuVARP, TmLRP-TT, Table 1) (Sun et al., 2019). Two additional studies on ThuLEP versus HoLEP came to the same conclusion that no clinically significant difference could be substantiated in comparison with HoLEP in 6 (Becker et al., 2018)-, or 12- and 18-month follow-up (Zhang et al., 2019). The largest study so far on Thulium:YAG laser in ThuVEP technique (Zhang et al., 2019) with 60-month follow-up reported long-term durability of voiding improvements and overall re-operation rates of 2.4% (Gross, Netsch, Knipper, Holzel, & Bach, 2013; Gross et al., 2017). More studies of randomised controlled trials with long-term follow-up would be ideal to rest the case. However, this topic will become more complicated with the advent of novel Tm fibre lasers that work for both urolithiasis and soft tissue. These lasers have the potential to take over a larger share of new laser devices in clinics in the future. The difference is more or less academical, but sophisticatedly would call for individual evaluation (Becker et al., 2019; Tiburtius, Gross, & Netsch, 2015). Summarising the above, the EAU Guidelines on Management of Non-Neurogenic Male Lower Urinary Tract Symptoms (LUTS), incl. Benign Prostatic Obstruction (BPO) acknowledged that both ThuLEP and ThuVEP are valid alternatives to other transurethral enucleating techniques such as bipolar enucleation or HoLEP (Gratzke et al., 2015).
2.1 Modification of transurethral anatomical enucleation of the prostate with Tm:YAG support

The original concept of ThuLEP as ‘transurethral anatomical prostatectomy with laser support’ was developed in 2009 and published in 2010 (Herrmann et al., 2010). Shortly after that, ThuLEP in two-lobe technique and en bloc enucleation were explored and demonstrated in 2012 (Endoskills, Fortbildungen der Akademie der Deutschen Urologen, 2012). The principle of widely blunt mechanical anatomical dissection of the whole transitional zone using the laser energy solely for incising of the mucosa, dividing the adenoma into three lobes and cutting of adhesions or ingrowing centripetal vessels is present in all variations of ThuLEP. The basic difference between 3 lobe, 2 lobe (Baazeem, Elmansy, & Elhilali, 2010; Dusing et al., 2010; Wolters, Huusmann, Oelke, Kuczyk, & Herrmann, 2016a, 2016b) and en bloc enucleation (Kim, Lee, Kwon, Cho, & Kim, 2015) is the incision into the mucosa ventrally (‘double Ω/ U’, ‘three horseshoe’ (Miernik & Schoeb, 2019) and the incision of the mucosa to dissect the transitional zone in 3 lobe (3), two lobe (2) and entire lobe/ en bloc (0).

Entire transitional zone enucleation aka en bloc AEEP/ EEP like in open prostatectomy has been popularised mainly by 3rd generation HoLEP promoters and has picked up momentum since. The overarching principle of all approaches using either Ho:YAG or Tm:YAG lasers is anatomical preparation, anterior–posterior dissection, early release of the ventral mucosa and apical mucosa sparing incisions in order to reduce early postoperative incontinence (Gomez Sancha et al., 2015; Kim, Lee, et al., 2015; Miernik & Schoeb, 2019; Minagawa, Okada, Sakamoto, Toyofuku, & Morikawa, 2015; Saitta et al., 2019; Scoffone & Cracco, 2016) and ease the learning curve by achieving several reproducible quality markers (Pentafecta) (Peyronnet et al., 2017). However, comparative assessment of effectivity is inconclusive. Enikeev et al. demonstrate in favour of two-lobe technique a faster morcellation in large prostates when compared to en bloc technique AEEP (Enikeev et al., 2019). However, other authors investigated traditional three-lobe HoLEP versus HoLEP en bloc, concluding that en bloc resulted in reduction of total operative time. They supposed that the reason for this result was the easier identification of the surgical capsule in en bloc approach (Rapoport et al., 2018).

From the inventors’ vast experience in all variations of ThuLEP, the proposed advantage of either one over the other approach is rather subjective. Clear ‘limitations’ of three-lobe technique for example with regard to the applicability for anatomical preparation are unproven and may be related to individual challenges of preparation technique (Pacchetti et al., 2019; Saredi et al., 2017). Clearly, starting with the lateral lobe allows for easier blunt exposure of the surgical capsule than starting with the median lobe. Therefore, the differences or advantages of two lobe or en bloc derive when compared to original three-lobe technique derive rather from the fact that the ‘first lobe’ is a lateral lobe than the fact that it is ‘not three lobe’. Therefore, currently almost all AEEPs at the inventors’ site are carried out in two-lobe technique as displayed in this article, regardless of the energy source used.
The introduction of the mechanical tissue morcellator (Fraundorfer & Gilling, 1998) did not change the basic principle of the enucleating technique but added a tool to facilitate and potentially speed up the evacuation of the dissected tissue. However, the downside is that mechanical morcellation adds a further learning curve to the whole process of adapting AEEP in daily practice (Bae, Oh, & Paick, 2010).

For exit strategy the adoption of ‘mushroom’ technique (Hochreiter, Thalmann, Burkhard, & Studer, 2002) into the ThuLEP concept in the absence or failure of the morcellation device. After ventral release of both lobes, leaving the dorsal part of the transitional zone attached, in situ morcellation is carried out in Nesbit fashion ventrodorsally (Nesbit, 1943), which has been rendered elegantly by Liu et al. for bipolar enucleation of the prostate (Liu, Zheng, Li, & Xu, 2010).

In the evolution of laser generators, 200 Watts power became available. This partially overcame the resection time limitation of effective vapo-resecting approaches like ‘tangerine’ technique (Herrmann, 2016). Like in situ morcellation, the entire transitional zone is vaporised in situ after anatomical detachment inside the fossa. This technique suggested to be favourable for middle size prostate adenomas where histological analysis is not requested. However, precautions must be taken for a reliable turnover of irrigation fluid in order to avoid heat build-up in the surgical field.

2.2 ThuLEP in two-lobe technique. Description of technique and surgical atlas accompanied by instruction video

The five major surgical steps of the ThuLEP procedure in two-lobe technique are:

- Ω-like (Omega) incision with a distance of 5 mm to the verumontanum
- Exposure of the surgical capsule
- Enucleation of the left lobe
- Combined enucleation of the right lobe and median lobe
- Removal of prostatic tissue by mechanical morcellation

3 IRRIGATION

Physiological saline solution (0.9% Saline) as irrigation fluid is used throughout the entire procedure. The continuous intravesical pressure improves visualisation and stops venous bleeding from the level of dissection. In addition, the intravesical pressure is responsible for the absorption of significant amounts of fluid through vessels of the dissection plane in 26% –41% (Bapat et al., 2007; Shah, Kausik, Hegde, Shah, & Bansal, 2006) of the procedures. In healthy patients, fluid absorption of 95–300 ml (Bapat et al., 2007) to 213 to 930 ml (mean 459) (Shah et al., 2006) can be tolerated. As for patients with cardiovascular comorbidities or renal dysfunction, fluid overload can lead to significant challenges both intraoperatively as well as postoperatively (Dodd, Jankowski, Krambeck, & Gali, 2016). Furthermore, influx of physiological saline irrigation can cause haemodilution and acidosis. Haemodilution can cause disturbance of coagulation potential both in vivo and vitro (Bolliger, Szlam, Levy, Molinaro, & Tanaka, 2010). Severe acidosis (pH < 7.2) inhibits the propagation phase of thrombin generation and accelerates fibrinogen degradation (Martini, 2009), which leads to a potential deficit in fibrinogen availability and therefore coagulation disorders.

3.1 Instruments and set-up

Core features of sparing mechanical force to the hypomochlion, the membranous urethra and the ventral bulb urethra in ventral preparation are the rotating inner sheath of the 26 F continuous-flow cliche-resectoscope shaft (Karl Storz GmbH). A passive working element for laser surgery is used to advance the 550 µm laser fibre as retrograde preparation is the mode of action. For visualisation, a Hopkins II lens (30° down) is preferred. A HD pendulum camera is recommended and a HD monitor that can be positioned preferentially straight above the patient in lithotomy position. A bipolar system for backup is kept ready. A third generation bipolar energy generator (Autocon III 400; Karl Storz GmbH) is advised to keep as backup for coagulation not only in the learning curve but also in case of opening of a periprostatic sinus, which needs pressure coagulation to seal the vessel.

3.2 Use of laser power of Tm:YAG

Vaporisation/ Incision: The vapourising features of laser energy is used to vapo-incise the mucosa, coagulate centripetally ingrowing vessels at low power energy from 5 to 10 Watts or defocusing, and to purge the plane as for example in the fibro-anterior stromal region in high power setting 90 W. To avoid switching of the energy level, repeatedly the use of a double pedal for Incision or coagulation is recommended.

4 STEPS

4.1 Incision around the verumontanum—ejaculation preservation

At first, an Ω-like (Omega) incision around the verumontanum is carried out. The incision starts with a horizontal incision proximal
to the verumontanum followed by an incision of the mucosa laterally on the left and on the right lobe until the distal third of the verumontanum. In ejaculation sparing approaches, a strip of 1 cm on each side of the verumontanum has to be preserved. If the space next to the verumontanum is too narrow or the apical adenoma is too bulky, the Ω-like (Omega) incision is extended 5 mm up from the base of the paracollicular grooves onto the mucosa of the lower part of the side lobe in order to create an untouched plane of mucosa around the verumontanum for ejaculatory hood preservation (Figure 3a,b) as an extended ejaculatory hood template (Wolters et al., 2016) when compared to the ‘original’ ejaculatory hood template of Kim, Song, Ku, Kim, and Paick (2015). In principal, all intended ejaculatory function preserving techniques are based on the findings of Dorschner and Stolzenburg (1994). All attempts need to respect the integrity of the M. ejaculatorious sling in order to allow for pulling down of the verumontanum below the sphincter for ejaculation of semen into the bulbar urethra. Therefore, as the apical portion of the transitional zone is rather ‘untouched’ in the novel extra-anatomical ablative or nonablative MIS antegrade ejaculation rates are gradually higher up to more than 90%. The rate of antegrade ejaculation widely corresponds to the amount of tissue ablated. The highest rate could be achieved in both arms of Water Study above 90% when the volume ablation was at 25% (Kasivisvanathan & Hussain, 2018) and was similarly high in both arms in GOLIATH Study of LOB (Greenlight) versus TURP (PSA reduction 58%) (Bachmann et al., 2015).

4.2 Exposure of the surgical capsule

The cranial end of the mucosal Ω-incision into the lateral lobe is extended anteriorly, also referred to as the hockey-stick incision.

**FIGURE 3** (a) Visualisation of the anatomy and Ω-circumcision of the verumontanum, (b) Endoscopic view of Ω-circumcision (c) Exposure of the left dorsal surgical plane by mechanical shear around the apex of the transition zone (d) endoscopic view during (c), (e) Apical loosing of the transitional zone by circulating around the adenoma, (f) endoscopic view during (e), (g) Incision of broad mucosal band to maintain a ventral mucosal patch, (h) endoscopic view during (g)
(Fraundorfer & Gilling, 1998) or ‘curtain opening incision’ (Kim, Lee, & Oh, 2013). This incision prevents tearing of the mucosa caudally into the sphincteral region and additionally reduces the tearing effect on the caudal mucosa inside the sphincteral region (Dorschner & Stolzenburg, 1994). To expose the surgical capsule, mechanical shearing force is used. The tip of the resectoscopes’ shaft is positioned proximal to the verumontanum facing steep down and is then directed to the left in a shearing movement to circumnavigate the apex of the transitional zone. The correct plane is opened by mechanical and blunt disruption into the zone dorsally below the transitional zone (Figure 3c,d). The surgical capsule can be easily identified by visualising small vessels which run parallel to the dissection plane. Coagulation of capsule perforating vessels is performed in low power setting or defocusing of the laser beam. Like a finger encircling the apical edges of the lateral lobe, the transitional zone is detached from the surgical capsule.

4.3 | Enucleation of the left lobe

Now, the resectoscope is guided into the space between transitional and peripheral zone and the adenoma is loosened circumferentially with the beak of the resectoscope (Figure 3e,f). If the plane is followed thoroughly, the surgical plane can be followed until 12°.

The verumontanum was a very important landmark in traditional HoLEP technique, as the 12° incision was cut down into the mucosa ventrodorsally for the lateral lobe (El-Hakim & Elhilali, 2002; Fraundorfer & Gilling, 1998; Kuo et al., 2003). However, in anatomical anterior–posterior dissection with early release/dissection of the mucosa (Kim, Lee, et al., 2015; Miernik & Schoeb, 2019; Minagawa et al., 2015) (Gomez Sancha et al., 2015; Saitta et al., 2019; Scoffone & Cracco, 2016), the dissection allows to spare the sphincter zone from denudation of mucosa (Dorschner & Stolzenburg, 1994). The time of re-epithelisation of the sphincteral mucosa could be interpreted as the time lag for reversible early stress urinary incontinence.

**Figure 4** (a) Incision in at 5 o’clock position for medial dissection of the left lobe, (b) endoscopic view during (a), (c) Ascending mobilisation of the left lobe, (d) endoscopic vision during (c), (e) Visualisation of the left empty fossa, (f) mirror-wise shear to the right lobe, (f) Incision of the mucosal band on the right side, (g) the loosened adenoma of right and middle lobe is pushed through the intact bladder neck, (h) empty fossa with intact bladder neck.
(ESUI). The principle of anterior–posterior dissection has been of fundamental importance in Nesbit (Nesbit, 1943) and all contemporary enucleation resection techniques like proposed by Liu et al. (2010). In addition, this approach has been reported to reduce ESUI after AEEP (Endo et al., 2010). However, the learning curve itself has been described as fundamental for the rate of ESUI (Shah et al., 2007). It is striking to see that this concern was already heeded in the 1st publication of EEP in 1983 by Hiraoka (2017).

To loosen the lobe, the tissue first has to be detached apically between 3 o’clock and 12 o’clock position, the dorsal part of the left lobe (from 3 o’clock to 6 o’clock position) has to be kept in situ to avoid bouncing and shaking of the lobe.

After disconnection of the tissue between 3 o’clock and 12 o’clock, the remaining mucosa in the 12 o’clock position has the appearance of a broad mucosal patch (Figure 3g,h). This mucosal attachment has to be dissected with laser energy and should not be bluntly disrupted to prevent tearing at the apex and the sphincter. The apical ventral mucosal patch is dissected under vision from the developed plain ventrally towards the prostatic urethra (from where you know to where you know) on the right lobe in order to maintain a mucosal flap. This apical flap will swing back into the original position after the surgery after it has been mirror-wise dissected on the left side later on where it originally resided before blunt dissection.

After the dissection of the mucosal flap, the resectoscope is moved towards 10° over the midline and the tissue is dissected sloping downward from peripheral towards the lumen until the bladder neck becomes visible by blunt detachment with the sheath and laser dissection where necessary.

During preparation, the laser probe more or less remains inactive, but the probe should be always directed orthogonally to the peripheral zone to dissect tissue or coagulate perforating vessels if necessary. The adenoma is circumferentially detached by the sheath and laser dissection, thereby exposing the surgical capsule.

Before loosening the convexity of the adenoma from 6 o’clock to 3 o’clock position, the medial limit/edge of the left lobe is denoted by an incision from the bladder neck in the 5 o’clock position towards the apex of the prostate (Figure 4a,b). After that, the dorsal part of the left lobe has to be detached. Therefore, the left lobe is loaded up with the beak of the resectoscope and lifted and advanced and pushed into the space between transitional and peripheral zone. Adhesions are cut with laser energy, small vessels sealed with low energy mode (Figure 4c,d). Thereby excellent vision is maintained. The lobe is detached until the bladder neck and finally pushed into the bladder.

4.4 Combined enucleation of the median and right lobe

The median lobe and the right lobe are enucleated en bloc. The resectoscope is placed at the 7 o’clock position next to the dissected edge in a steep angle as on the left side at the beginning of the procedure. The median lobe is lifted with the shaft rolled over to the right side (Figure 4e).

Starting with blunt dissection with the resectoscopes sheath, the right lobe is loosened circumferentially from 7 o’clock to 12 o’clock position.

The remaining mucosal band is cut like on the left side from peripheral towards the midline (Figure 4f). Finally, the detached median lobe and right lobe are pushed into the bladder (Figure 4g,h).

4.5 Removal of prostatic tissue by mechanical morcellation

Once all lobes of the adenoma are deposited into the bladder, haemostasis is either ensured using coagulation of the mucosal edges at the bladder neck in low power setting at 5–10 W or defocused laser in 90 W setting in order to improve visualisation during morcellation or planar bipolar coagulation can be performed using either a resection or vaporisation probe in order to safe surgical theatre time. Irrigation outflow is stopped. The angled 25-cm-long telescope (6° line of vision) is introduced into the working sheath with an adaptor in such a way that the pressure in the bladder does not significantly drop in order to avoid bleeding. In between, the irrigation bags are positioned at a maximum of 80 cm above bladder level in order not to overdistend the detrusor. A second irrigation system is connected to an angled 25-cm-long telescope (6° line of vision). The morcellator blade is introduced in such a way that the pressure in the bladder does not drop significantly to prevent bleeding from venous vessels at low bladder pressure.

The blade consists of a 5-mm-outersh with a rotating inner shearing knife that cuts the suctioned tissue off against the outer sheath. It is inserted through the central channel of the telescope. Rotation speed of the morcellator is adopted to tissue hardness. UNIDRIVE® system controls the rotary frequency of the morcellator and UNIMAT® III system providing the vacuum suction necessary to attach the tissue for morcellation and collect the tissue in the portafilter. 1,000 rotations per minute is the setting for the Unidrive (UNIDRIVE® and UNIMAT® III, Karl Storz GmbH). The system is regularly set at 1,200 rotations for ‘juice tissue’ and 800 rotations for ‘hard balls’ fibrotic tissue.

The sheath does only move as little as possible during morcellation in order to reduce mechanical stress on the membranous and ventral bulbar urethra—the sheath alignment is the centre of the bladder. The blade opening is held upwards and kept relatively close to the user’s field of vision to maintain visual control. A qualified team, good visualisation and reliable irrigation for filling the bladder are essential for swift morcellation.

5 EXIT STRATEGY

The surgical procedure ends with a final inspection of the resection cavity after removal of the morcelloscope and reinsertion of the
working element into the resectoscope sheath. The collapsed bladder now exposes the boundary to the bladder neck mucosa entirely. A final coagulation can be applied if necessary. Residual tissue is captured, and some areas are smoothened via vaporisation. At the end, preservation of the apical mucosa and the integrity of the sphincter zone can be documented. Finally, the instruments are removed under direct vision to assess the integrity of the urethra.

A 20–22 Ch Tiemann catheter is then inserted under digital rectal guidance. The spontaneous instilled drainage from the bladder should be clear, if not a second round of coagulation is advised. The catheter balloon should be inflated at a height that allows the balloon to be positioned on the bladder neck without slipping into the fossa. The fossa is thereby closed and can collapse, and residual bleeding will result in a tamponade of the fossa. At the end, the balloon is fixed to the fossa using a knotted compress (tie). This does not serve for traction purposes but for closing off the fossa. Regularly, the catheter can be removed on the first postoperative day.

6 CONCLUSION

After the successful introduction transurethral anatomical enucleation of the prostate with Tm:YAG support (ThuLEP) has evolved as one of the standard techniques of transurethral anatomical endoscopic enucleations of the prostate (AEEP). The growing body of evidence has proven ThuLEP as a valid alternative for the treatment of BPO and has finally been acknowledged by the EAU guidelines on management of non-neurogenic male lower urinary tract symptoms (LUTS). Regardless of the lobar approach (three-lobe, two-lobe or en bloc) ThuLEP emphasises two principles: widely blunt anatomical dissection and demystification of energy sources as being secondary for transurethral enucleation.

ThuLEP equipment:
- Laser equipment
  - 2-µm Tm:YAG laser generator (Revolix™ 200, 200 W surgical laser, Omnimuide, LISA laser GmbH, Katlenburg, Germany) was used at energy settings of 90 W and 30 Watts
  - Kix Duo double foot switch (Omnimuide, LISA laser GmbH, Katlenburg, Germany)
  - Re-usable 550 lm laser fibre (RigiFibTM, Omnimuide, LISA laser GmbH, Katlenburg, Germany).

Endoscopy equipment
- Hopkins II lens (30° down, 27005BA, Karl Storz GmbH, Tuttlingen, Germany)
- 26 F continuous-flow clic-resectoscope shaft with laser element (Karl Storz GmbH, Tuttlingen, Germany)
- Image 1 S camera system (Image 1 Connect TC200 + H3-Link TC300) (Karl Storz GmbH, Tuttlingen, Germany) with H3-P Full HD Pendulum Camera Head (TH 103) (Karl Storz GmbH, Tuttlingen, Germany)
- Autocon III 400 (UH 400; Karl Storz GmbH, Tuttlingen, Germany)
- OR1 Fusion (Karl Storz GmbH, Tuttlingen, Germany)
- HERRMANN VapoEnucleation Electrode (27.040 VE, Karl Storz GmbH, Tuttlingen, Germany)
- 25-cm-long Morcelloscope with adaptor (Karl Storz GmbH, Tuttlingen, Germany)
- BPO and has finally been acknowledged by the EAU guidelines on management of non-neurogenic male lower urinary tract symptoms (LUTS). Regardless of the lobar approach (three-lobe, two-lobe or en bloc) ThuLEP emphasises two principles: widely blunt anatomical dissection and demystification of energy sources as being secondary for transurethral enucleation.

CONFLICT OF INTEREST

Thomas R. W. Herrmann declares Karl Storz GmbH, Honoraria, Financial Support for attending Symposia, financial support for educational programs, Consultancy, Advisory, Royal ties; Boston Scientific AG Honoraria, Financial support for attending Symposia, financial support for educational programs, Consultancy, Advisory Board; LISA Laser OHG AG Honoraria, Financial support for attending Symposia, financial support for educational programs; Ipsen Pharma Honoraria, Financial support for attending Symposia, Advisory Board. Author declares no conflict of interest.

Mathias Wolters declares no conflict of interest.

ORCID
Thomas R. W. Herrmann https://orcid.org/0000-0003-4493-1301

REFERENCES

Bazzi, A. S., Elmansy, H. M., & Elhilali, M. M. (2010). Holmium laser enucleation of the prostate: Modified technical aspects. BJU International, 105(5), 584–585. https://doi.org/10.1111/j.1464-410X.2009.09111.x

Bach, T., Herrmann, T. R., Ganzer, R., Blana, A., Burchardt, M., & Gross, A. J. (2009). Thulium:YAG vaporesection of the prostate. First results. Der Urologe Ausg A, 48(5), 529–534.

Bach, T., Herrmann, T. R., Ganzer, R., Burchardt, M., & Gross, A. J. (2007). RevolLix vaporesection of the prostate: Initial results of 54 patients with a 1-year follow-up. World Journal of Urology, 25(3), 257–262. https://doi.org/10.1007/s00345-007-0171-x

Bach, T., Wendt-Nordahl, G., Michel, M. S., Herrmann, T. R., & Gross, A. J. (2009). Feasibility and efficacy of thulium:YAG laser enucleation (VapoEnucleation) of the prostate. World Journal of Urology, 27(4), 541–545. https://doi.org/10.1007/s00345-008-0370-0

Bach, T., Xia, S. J., Yang, Y., Mattioli, S., Watson, G. M., Gross, A. J., & Herrmann, T. R. (2010). Thulium: YAG 2 mum cw laser prostatectomy: Where do we stand? World Journal of Urology, 28(2), 163–168.

Bachmann, A., Taburo, A., Barber, N., d’Ancona, F., Muir, G., Witzsch, U., ... Thomas, J. A. (2015). A European multicenter randomized non-inferiority trial comparing 180 W GreenLight XPS laser vaporization and transurethral resection of the prostate for the treatment of benign prostatic obstruction: 12-month results of the GOLIATH study. The Journal of Urology, 193(2), 570–578. https://doi.org/10.1016/j.juro.2014.09.001

Bae, J., Oh, S. J., & Paick, J. S. (2010). The learning curve for holmium laser enucleation of the prostate: A single-center experience.
Scoffone, C. M., & Cracco, C. M. (2016). The en-bloc no-touch holmium laser enucleation of the prostate (HoLEP) technique. *World Journal of Urology*, 34(8), 1175–1181. https://doi.org/10.1007/s00334-015-1741-y

Shah, H. N., Kausik, V., Hegde, S., Shah, J. N., & Bansal, M. B. (2006). Evaluation of fluid absorption during holmium laser enucleation of prostate by breath ethanol technique. *The Journal of Urology*, 175(2), 537–540. https://doi.org/10.1016/S0022-5347(05)00239-9

Shah, H. N., Mahajan, A. P., Sodha, H. S., Hegde, S., Mohile, P. D., & Bansal, M. B. (2007). Prospective evaluation of the learning curve for holmium laser enucleation of the prostate. *The Journal of Urology*, 177(4), 1468–1474. https://doi.org/10.1016/j.juro.2006.11.091

Sun, Q., Guo, W., Cui, D., Wang, X., Ruan, Y., Zhao, F., ... Jing, Y. (2019). Thulium laser enucleation versus thulium laser resection of the prostate for prevention of bladder neck contracture in a small prostate: A prospective randomized trial. *World Journal of Urology*, 33(4), 503–508. https://doi.org/10.1007/s00345-019-02945-x

How to cite this article: Herrmann TRW, Wolters M. Transurethral anatomical enucleation of the prostate with Tm:YAG support (ThuLEP): Evolution and variations of the technique. The inventors’ perspective. *Andrologia*. 2020;52:e13587. https://doi.org/10.1111/and.13587