Article

Early Results after Thulium Laser Enucleation of the Prostate in Patients with Urodynamically Proven Detrusor Underactivity

Pawel Trotsenko \(^1,2,3,^*\), Christian Wetterauer \(^2,4,5\), Martin Haydter \(^3\), Lukas Lusuardi \(^6\) and Thomas R. W. Herrmann \(^1,^*\)

\(^1\) Department of Urology, Canton Hospital Frauenfeld, Pfaffenhofenstrasse 4, 8500 Frauenfeld, Switzerland
\(^2\) Department of Urology, University Hospital Basel, 4031 Basel, Switzerland
\(^3\) Department of Urology, State Hospital Wiener Neustadt, 2700 Wiener Neustadt, Austria
\(^4\) Faculty of Medicine, University Basel, 4001 Basel, Switzerland
\(^5\) Department of Medicine, Faculty of Medicine and Dentistry, Danube Private University, 3500 Krems, Austria
\(^6\) Department of Urology and Andrology, University Hospital of Salzburg, 5020 Salzburg, Austria

* Correspondence: pawel.trotsenko@usb.ch (P.T.); thomas.herrmann@stgag.ch (T.R.W.H.)

Abstract: Objectives: Benign prostatic hyperplasia is one of the most common urological diseases. Among these patients, the presence of detrusor underactivity or acontractility represents a challenging condition since no medical treatment is available. Our objective is to evaluate early term outcomes following transurethral anatomical enucleation of the prostate with Tm:YAG support.

Methods: In a retrospective analysis of 115 patients who underwent this procedure between January 2019 and March 2022 due to lower urinary tract symptoms, 8 patients with urodynamic evidence of detrusor underactivity secondary to a non-neurogenic aetiology were identified. Detrusor underactivity was defined as a bladder contractility index of <100.

Results: Median age, prostate volume and bladder contractility index were 73.2 years, 78.5 cm\(^3\) and 63.9, respectively. Median International Prostate Symptom Score/quality of life, Q\(_\text{max}\) and post-void residual volume were 15/3.5 points, 4.4 mL/s and 189 mL, respectively. Postoperatively, immediate catheter-removal success rate was 87.5% (7/8), at 2 months all patients were catheter-free and remained so at 1-year follow-up. Significant improvements for quality of life, Q\(_\text{max}\) and post-void residual volume were detected. Median postoperative International Prostate Symptom Score/Quality of life, Q\(_\text{max}\) and post-void residual volume were 7/2, 21.6 mL/s and 0 mL, respectively.

Conclusions: This surgical approach offers high catheter-free rates, significantly improves functional voiding parameters and increases patient satisfaction in patients with benign prostatic hyperplasia and concomitant detrusor underactivity. Therefore, it can be regarded as an effective approach for such patients.

Keywords: detrusor underactivity; detrusor acontractility; enucleation of the prostate; thulium laser; urodynamics

1. Introduction

As one of the most common urological diseases, benign prostatic hyperplasia (BPH) affects about \(\frac{1}{4}\) of men in the seventh decade and is associated with a major impact on the quality of life (QoL) of patients as well as substantial costs for health care [1,2]. For many patients suffering from lower urinary tract symptoms (LUTS), medical therapy, such as the use of \(\alpha\)-blockers, is initially successful, but surgical therapy becomes necessary when medical therapy fails and results/function remain unsatisfactory. Depending on prostate volume (PV), different surgical techniques are available for treatment [2,3]. For substantially enlarged glands, open prostatectomy dominated as the oldest surgical procedure for many years. However, open prostatectomy is associated with significant complications and is currently recommended by the European Association of Urology (EAU) only in the absence of laser-assisted transurethral enucleation options, such as with the Tm:YAG laser (ThuLEP) [2].
Among these patients, the presence of detrusor underactivity (DU) and detrusor acontractility (DA) represents a particularly challenging condition since no medical treatment is available. Due to this, efforts were focused on a maximal surgical reduction of bladder outlet resistance to ensure efficient bladder emptying. The limited data on this topic showed promising outcomes for patients receiving holmium laser enucleation of the prostate (HoLEP) [4]. Therefore, the aim of this study was to evaluate the efficacy of ThuLEP in terms of early outcomes for patients with DU.

2. Materials and Methods

For this retrospective study, we evaluated the data of 115 patients, who had undergone ThuLEP at the Cantonal Hospital Frauenfeld from January 2019–March 2022 due to LUTS, for the presence of urodynamically proven DU.

Permission was provided by the local ethical commission (ID 2022-00582).

Demographic information, data for functional outcome and patient satisfaction were collected and assessed. DU was defined urodynamically as a bladder contractility index (BCI) of <100 [5]. A history of prostate cancer, neuropathic dysfunction secondary to other causes or previous surgery due to BPH led to exclusion. In patients with an established indwelling catheter, the International Prostate Symptom Score (IPSS) before catheterization was determined retrospectively.

The indication for urodynamic studies was determined according to the EAU guidelines (e.g., post-void residual > 300 mL, age < 50 years, void volume < 150 mL, previous unsuccessful surgery, etc.) and performed in accordance with “Good Urodynamic Practice” recommended by the International Continence Society, including 2 consecutive measurements [2,6].

All transurethral enucleations of the prostate were performed by an experienced surgeon (TH) under general or spinal anaesthesia with Tm:YAG laser support. After obtaining the prostate tissue with a morcellator, continuous bladder irrigation was established and then gradually reduced. Catheter removal was performed on postoperative day 2. The detailed technique, including the five major surgical steps of the ThuLEP procedure, has already been described previously [7,8].

The equipment comprised a Tm:YAG laser “Revolix” (LISA Laser Products GmbH, Katlenburg-Lindau, Germany), a 550 µm end-firing fibre, a modified continuous-flow resectoscope (26F) and a tissue morcellator (Drillcut, KARL STORZ SE & Co. KG, Tuttingen, Germany).

The first follow-up, including IPSS, prostate-specific antigen, uroflowmetry and measurement of post-void residual volume (PVR) was performed 2 months after surgery. For patients with a good outcome, the next follow-up was scheduled 1 year after surgery.

The database was created using Excel (Microsoft Corporation, Redmond, WA, USA), and all statistical analyses were performed with SPSS Statistics 24.0 (IBM Deutschland GmbH, Ehningen, Germany). Fisher’s exact test was used to compare nominal data (catheter—free rate). For the determination of significant differences between the samples, the Mann—Whitney test was applied. All tests were performed at a two-sided significance level of $\alpha = 0.05$.

3. Results

ThuLEP was performed successfully in 115 patients between January 2019 and March 2022, and 8 (6.96%) patients with urodynamically proven DU were identified. A detailed flowchart of the study course is presented in Figure 1.
Figure 1. Flowchart of inclusion.

Median age, prostate-specific antigen (PSA), prostate volume, BCI and score (IPSS/QoL) at baseline were 73.2 years, 2.6 ng/mL, 78.5 mL, 63.9 and 15/3.5, respectively. Prior to surgery, acute urinary retention (AUR) with consecutive indwelling catheterization (transurethral/suprapubic) occurred in 3/8 (37.5%) men with a median catheterization time of 19.9 weeks. Detailed baseline and perioperative characteristics are summarized in Table 1.

Table 1. Baseline and perioperative characteristics of patients with DU.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Median (IQR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>73.2 (65.9–77.7)</td>
</tr>
<tr>
<td>Prostate volume (cm³)</td>
<td>78.5 (48.8–105)</td>
</tr>
<tr>
<td>Serum PSA (ng/mL)</td>
<td>2.6 (1.4–4.4)</td>
</tr>
<tr>
<td>Residual Volume (mL)</td>
<td>187.5 (93.8–525)</td>
</tr>
<tr>
<td>BCI</td>
<td>63.9 (47–71.7)</td>
</tr>
<tr>
<td>Q_max (mL/s)</td>
<td>4.4 (0.5–5.9)</td>
</tr>
<tr>
<td>Catheterization duration (weeks)</td>
<td>19.9 (16.5–52.7)</td>
</tr>
<tr>
<td>IPSS</td>
<td>15 (13–19)</td>
</tr>
<tr>
<td>QoL</td>
<td>3.5 (3–4.8)</td>
</tr>
<tr>
<td>Operation time (min)</td>
<td>57 (38.5–61.8)</td>
</tr>
<tr>
<td>Resected volume (mL)</td>
<td>28.5 (21–46)</td>
</tr>
<tr>
<td>Hospitalization (days)</td>
<td>3 (2.8–3)</td>
</tr>
</tbody>
</table>

Patients n (%)

- Preoperative AUR: 3 (37.5)
- Transurethral catheter: 2 (25)
- Suprapubic catheter: 1 (12.5)


After surgery, 7/8 (87.5%) could be discharged without an indwelling catheter; after 2 months, all patients were catheter-free. One year after ThuLEP, 8/8 patients were still catheter-free.

Significant improvements in maximal flow rate (Q_max), QoL and PVR were observed at follow-up 2 months after surgery. Median postoperative IPSS/QoL, Q_max, PVR and voided
volume (VV) were 7/2, 21.6 mL/s, 0 and 246 mL, respectively. No significant difference was found for IPSS and VV. Detailed data on functional outcomes and catheter-free rates is displayed in Table 2.

Table 2. Functional outcomes of patients with DU.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Median (IQR) Before surgery</th>
<th>2-month follow-up</th>
<th>p-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>IPSS</td>
<td>15 (13−19)</td>
<td>7 (6−8.5)</td>
<td>0.06</td>
</tr>
<tr>
<td>QoL</td>
<td>3.5 (3−4.8)</td>
<td>2 (1−2)</td>
<td>0.02</td>
</tr>
<tr>
<td>Qmax (mL/s)</td>
<td>4.4 (0.5−5.9)</td>
<td>21.6 (18.3−29.5)</td>
<td>0.001</td>
</tr>
<tr>
<td>PVR (mL)</td>
<td>189 (94−525)</td>
<td>0 (0)</td>
<td>0.003</td>
</tr>
<tr>
<td>VV (mL)</td>
<td>92 (0−178)</td>
<td>246 (281−349)</td>
<td>0.053</td>
</tr>
</tbody>
</table>


4. Discussion

Precision medicine is one of the leading principles in modern oncology and stands for the original ideal in medicine of treating the patient and not the disease. Men with LUTS belong to a particularly heterogeneous group with a multitude of different clinical manifestations. Therefore, a “one-fits-all” solution is not appropriate.

Today, patients expect lower-risk management options with fewer sexual side effects and effective improvement of urgency incontinence and nocturia. For this reason, and in the interest of a holistic approach, the importance of precision medicine in the functional diagnosis and therapy of LUTS is increasing [9,10].

In this context, the popularity of transurethral anatomical enucleation of the prostate (AEEP) for benign prostatic obstruction (BPO) is constantly rising, as it offers a safe and effective treatment for a wide range of patients. Some authors consider AEEP the next gold standard for surgical management of BPO [11–13].

Among these patients, the presence of DU and DA, potentially as a consequence of prolonged bladder outlet obstruction, represents a particularly challenging condition since no medical treatment is available. Therefore, procedures for outlet relief as a compensation for the detrusor’s lack of strength became an important field of research for various studies [4]. This study evaluates the outcomes of maximal subvesical desobstruction with ThuLEP for patients with DU.

The value of preoperative urodynamics in terms of pressure flow studies (PFS) has been a controversial topic in recent years. The objective of the British UPSTREAM study was to determine the utility of preoperative PFS in men with bladder outlet obstruction compared to routine care. The hypothesis was formulated that identification of DU would result in a lower surgery rate.

The results of this study demonstrated that functional outcomes in patients with PFS were non-inferior to routine care but were associated with higher costs for health care. Furthermore, no impact on the rate of surgical procedures could be demonstrated [14].

Notably, no specification of surgical treatments was made, and a large variation of approaches was included. Yet, in both arms, monopolar/bipolar transurethral resection of the prostate (TUR-P) represented the majority (75% and 80%) of treatments [14], but even here, the gold standard approach displays an enormous number of different templates. Therefore, it is difficult to make an accurate statement about the value of a preoperative examination. The situation would be different for AEEP, as there is a clearly defined anatomical template [12] and all anatomical enucleations were shown to be equally effective [15].
Interestingly, the authors of UPSTREAM hypothesized that weakness of bladder contraction would lead to avoidance of surgical therapy [14], but exactly here the value of correct patient selection by PFS is demonstrated. For these men, subvesical de-obstruction of the prostate represents a possible solution for compensating the detrusor’s lack of strength. A general improvement of spontaneous voiding in men with PFS—proven DU due to de-obstruction—was reported by Dobberfuhl et al., although no information on the surgical approach was provided [16]. Mixed results were demonstrated for TUR-P in DU/DA. As there was no significant difference in the success rate of TUR-P for men with urodynamically proven DU, Tanaka et al. concluded, that this condition may not be a contraindication for TUR-P [17]. On the other hand, Thomas et al. argued against TUR-P in patients with DU, because no long-term urodynamic or symptomatic improvement was demonstrated. However, they emphasized the importance of preoperative PFS [18]. Zhu et al. examined the influence of DU severity on patients’ postoperative results and showed limited efficacy of TUR-P in patients with severe DU (BCI < 82) in the 20 ≤ bladder outlet obstruction index < 40 group [19]. These heterogeneous outcomes lead to the question of whether a gold standard with an indefinite template and sizeable discrepancies regarding performance markers, like PSA reduction in large-volume randomized trials, is sufficient for this patient collective [20].

Indeed, in the few studies on AEEP in DU/DA, very promising results were observed. According to Lomas and Krambeck, HoLEP appears to be an effective and durable solution for patients with BPO and DU/DA (follow-up > 24 months) with postoperative catheter free-rates of 88.9% (8/9) for DU and 62.5% (5/8) for DA, respectively [4]. Similarly, Mitchell et al. demonstrated excellent short- and intermediate-term results for HoLEP in patients with underactive bladders. Besides a catheter-free rate of 100% (5/5 with DU) and 94.7% (18/19 with DA) after a median follow-up of 24.7 months, PFS 6 months after surgery showed a significant return of detrusor function in 15/19 (79%) of men with DA [21]. The effects of preoperative DU on the long-term surgical outcome of HoLEP were assessed by Cho et al. Improvement of functional parameters and QoL appeared to be maintained up to 5 years after surgery, suggesting the benefit of complete removal of the prostatic adenoma in patients with DU [22,23]. The prospective cohort of Carmignani et al. demonstrated the safety and effectiveness of ThuLEP for patients with refractory urinary retention, although unfortunately, no preoperative PFS was performed. Due to the inclusion criteria (refractory urinary retention or PVR > 300 mL, followed by at least two attempts at catheter removal), a certain amount of DU/DA can be assumed [24]. Recently, Aho et al. published their HoLEP results for acute and non-neurogenic chronic urinary retention, showing 3-month catheter-free rates of more than 98.5%. For this retrospectively analysed cohort (July 2004–March 2010), PFS did not play a role in the decision-making process, and the usefulness of PFS for non-neurogenic urinary retention before HoLEP has also been questioned, even discussing a possible disadvantage for the patient due to discouraging invasive diagnostics. Enucleated tissue weight was defined, but no preoperative PV was reported [25]. For many years, the EAU guidelines recommended transurethral enucleation only for PV > 80 mL [3]. Therefore, no clear conclusion for small PV is possible, and so preoperative PFS, as part of precision medicine, could be essential for the selection of the operative approach, offering AEEP also for patients with small PV and concomitant DU or DA. According to UPSTREAM, PFS was acceptable and valuable for patients for its additional information about the cause and selection of the probable best treatment approach [14]. Consequently, it is debatable that PFS has such a discouraging effect on patients and their decisions. A meta-analysis by Kim et al. about the diagnostic value of urodynamics for the selection of patients for transurethral surgery even suggested a significant association between PFS results and better improvements in all outcome parameters for patients with bladder outlet obstruction [26]. For certain indications, ambulatory urodynamic monitoring is an additional diagnostic tool based on the natural filling of the bladder. Specifically, in patients with suspected DA by conventional PFS, Rademakers et al. demonstrated a valuable benefit, as bladder contractions could still be detected in 83.5% of cases [27]. Since its
clinical introduction in 2005, the thulium laser has become the most widely accepted laser device in urology after the holmium laser [7]. The weak spots of the first generation of thulium laser generators, namely being pure soft tissue lasers, have been overcome with the latest generation of generators. Today, pulsed thulium fibre lasers (TFL) and pulsed solid-state Tm:YAG are available. Originally designed to extend the scope of lithotripsy, these novel laser generators have improved their versatility in soft tissue surgery using the mechanical force of the laser’s photothermal effect. In soft tissue surgery, TFL claims momentum in transurethral prostate surgery, as studies could demonstrate no significant clinical and surgical difference towards holmium:YAG. However, the mainstay of TFL is its application in stone therapy, with the advantage of less retropulsion and better dusting abilities [28–30]. Regarding the impact on tissue, Huusmann et al. reported less carbonization by the pulse Tm:YAG than by continuous wave mode and less trauma than by the holmium:YAG laser [31]. According to the EAU Guidelines 2022, thulium-based AEEP is a valid alternative to other enucleation techniques [2].

This study confirms that ThuLEP provides an effective surgical solution for patients with DU, achieving good early outcomes. ThuLEP was performed successfully in eight patients with urodynamically proven DU and a median BCI of 63.9. Before the day of surgery, three patients needed a permanent catheterization. On follow-up, 2 and 12 months after ThuLEP, 8/8 patients were catheter-free. Significant improvements in functional parameters and QoL were achieved. Although no statistically significant improvement in IPSS was found, there was a median improvement of 8 points. In summary, these results support and are consistent with the previously mentioned studies [4,22,25].

To the best of our knowledge, this is the first work to assess the impact of ThuLEP on patients with urodynamically proven DU and one of the few papers examining the impact of AEEP in a population with DU. This study has its limitations due to the single-centre data, the retrospective approach and a small sample size. DU was proven by PFS, but none of the patients underwent urodynamic evaluation after surgery. Therefore, the generalization of the results is difficult.

Despite the given limitations, this study should rather serve as a stimulus to rethink our approach to every single patient suffering from LUTS and how to accomplish the goal of personalized medicine in BPH treatment. A multicenter study with prospective, randomized evaluation of (urodynamic) data would help to evaluate relevant clinical problems with DU and to improve quality of care. In the spirit of the Magna Charta of AEEP [15], the main objective for the future is not to evaluate the success of different enucleation techniques and instruments but rather to consider and establish AEEP as a solid surgical approach for patients with DU/DA. Similarly, as a tribute to holistic medicine and the patient’s values and expectations, the importance of preoperative PFS as a tool for precision medicine in LUTS should be reconsidered, using AEEP as a reference procedure.

5. Conclusions
ThuLEP can lead to high catheter-free rates, significantly improve functional voiding parameters as well as patient satisfaction in patients with BPH and concomitant DU. As such, ThuLEP could be regarded as an effective surgical approach for this special group of patients. In the future, not the instruments for enucleation, but rather AEEP, could be considered as a treatment approach for patients with DU/DA. Well-designed, prospective, randomized-controlled studies are needed to support these findings. The importance of preoperative urodynamics as a tool for precision medicine in LUTS should be reconsidered, using AEEP as a reference procedure.

Author Contributions: All authors have conjointly designed the study, and P.T. interpreted the data and drafted the manuscript. C.W., M.H., L.L. and T.R.W.H. designed and critically revised the manuscript for important intellectual content. P.T. was involved in the statistical analysis. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.
Institutional Review Board Statement: Approval by the local Ethics Committee was granted (Ethikkommission Ostschweiz EKOS; ID 2022-00582).

Informed Consent Statement: All patients signed a general consent.

Data Availability Statement: All data are available from the corresponding author upon reasonable request.

Conflicts of Interest: Thomas RW Herrmann: Company consultant, Speaker bureau, R&D collaboration, Proctor, Speaker-Karl Storz GmbH, Tut-lingen, Germany. The rest of the authors declare that they have no conflict of interest.

Abbreviations
AEEP Anatomical enucleation of the prostate
AUR Acute urinary retention
BCI Bladder contractility index
BPH Benign prostatic hyperplasia
BPO Benign prostatic obstruction
DA Detrusor acontractility
DU Detrusor underactivity
EAU European Association of Urology
HoLEP Holmium laser enucleation of the prostate
IPSS International Prostate Symptom Score
IQR Interquartile range
LUTS Lower urinary tract symptoms
PFS Pressure flow studies
PSA Prostate-specific antigen
PV Prostate volume
PVR Post-void residual volume
TFL Thulium fibre lasers
ThuLEP Laser enucleation of the prostate with Tm:YAG support
TUR-P Transurethral resection of the prostate
Qmax Maximal flow rate
QoL Quality of life
VV Voided volume

References
4. Lomas, D.J.; Krambeck, A.E. Long-term Efficacy of Holmium Laser Enucleation of the Prostate in Patients with Detrusor Underactivity or Acontractility. Urology 2016, 97, 208–211. [CrossRef] [PubMed]
5. Abrams, P. Bladder outlet obstruction index, bladder contractility index and bladder voiding efficiency: Three simple indices to define bladder voiding function. BJU Int. 1999, 84, 14–15. [CrossRef] [PubMed]

11. Gómez-Sanchez, F. The constant search for the greater good: Evolving from TURP to anatomic enucleation of the prostate is a safe bet. *World J. Urol.* 2021, 39, 2401–2406. [CrossRef]


15. Herrmann, T.R.W. Enucleation is enucleation is enucleation is enucleation. *World J. Urol.* 2016, 34, 1353–1355. [CrossRef]


**Disclaimer/Publisher’s Note:** The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.