

SHORT THESIS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY (PhD)

**Assessment of the efficacy and effectiveness of transurethral bipolar prostate
enucleation**

by Zoltán Kiss MD

Supervisor: Tibor Flaskó MD, PhD



UNIVERSITY OF DEBRECEN
DOCTORAL SCHOOL OF CLINICAL MEDICINE

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Supervisor: Tibor Flaskó MD, PhD
Doctoral School of Clinical Medicine, University of Debrecen

Head of the **Examination Committee**: Árpád Illés, MD, PhD, DSc

Members of the Examination Committee: Endre Holman, MD, PhD
László Kardos, MD, PhD

The Examination takes place at Library of Bldg. B, Department of Internal Medicine, Faculty of Medicine, University of Debrecen, at 11 a.m., on 21 of May 2026.

Head of the **Defense Committee**: Árpád Illés, MD, PhD, DSc
Reviewers: Árpád Szántó, MD, PhD
Péter József Molnár, MD, PhD

Members of the Defense Committee: Endre Holman, MD, PhD
László Kardos, MD, PhD

The PhD Defense takes place at the Lecture Hall of Bldg. A, Department of Internal Medicine, Faculty of Medicine, University of Debrecen at 1 p.m., on 21 of May 2026.

1. Introduction

Lower urinary tract symptoms caused by benign prostatic hyperplasia (BPH) are one of the most common health problems among older men. Due to the aging of European societies, BPH has become a widespread disease, placing an increasing burden on healthcare systems. Several minimally invasive surgical procedures have been developed for the surgical treatment of BPH, among which transurethral resection of the prostate (TURP) has retained its clinical relevance despite its 100-year history and continues to be considered the gold standard procedure. For decades, TURP was one of the most frequently performed urological surgeries worldwide. Although the number of TURP procedures is gradually declining in some countries, it continues to play a significant role in everyday urological practice. However, the high morbidity of the procedure was a clear motivation for the development of promising alternative surgical techniques, such as anatomical endoscopic enucleation of the prostate (AEEP). AEEP is a safe, durable procedure that can be performed on prostates of any size and adapts the principles of open adenectomy to a transurethral setting. Thanks to its many advantages, AEEP has revolutionized the surgical treatment of BPH and may become the new gold standard procedure in the future. AEEP consists of two distinct surgical stages: first, the transitional zone of the prostate is completely enucleated using laser or bipolar energy, and then the avascularized tissue is removed. The gold standard procedure for the latter is morcellation, but in the absence of a morcellator, an alternative solution is the mushroom technique, in which the adenoma is removed by high-speed resection in the prostate loge. On November 2, 2017, I performed the first transurethral bipolar prostate enucleation (TUEB) in Hungary at the Urology

Department, University of Debrecen. In our work, we assessed the efficiency and effectiveness of TUEB surgery.

2. Literature review

2.1 Historical overview of AEEP

The development of medicine is the result of cumulative selection processes, and AEEP is no exception. A historical overview of enucleation is essential for a comprehensive understanding of the surgery, as it presents the evolutionary milestones that led to the development of today's modern, minimally invasive techniques. The development of the new procedure was prompted by the limitations of TURP surgery. TURP is considered the gold standard surgical treatment for BPH, which has stood the test of time, but the risks and limitations of the surgery are not negligible, such as TUR syndrome, bleeding, and size limitations. Hiraoka and Akimoto attempted the first endoscopic enucleation in Japan in 1989. In their study involving 200 patients, they described the technique of monopolar enucleation (MEP) using a resectoscope, in which the adenoma was separated from the prostate capsule and then removed using a special loop. The next milestone was the advent of holmium laser technology in the mid-1990s. Peter Gilling performed the first holmium laser prostate ablation (HoLAP) in New Zealand in 1994, and it was later recognized that the laser could be used to identify the layer between the capsule and the adenoma in a similar way to open prostatectomy. This process led to the first holmium laser prostate enucleation (HoLEP) in 1998. HoLEP provided excellent hemostasis and a short hospital stay, but its widespread use was hampered by the high purchase cost of the laser and morcellator. In 2002, Hochreiter

developed the mushroom technique for HoLEP surgery, which offered a suitable alternative for adenoma removal and also reduced the cost of surgery. The next major breakthrough was the advent of bipolar technology, whose main advantage is that the isotonic saline solution used as irrigation fluid minimizes the risk of TUR syndrome. The first bipolar prostate enucleation (TUEB, BipoLEP) was performed by Neill. In 2006, Liu et al. performed the first TUEB surgery combined with the mushroom technique, and in 2010 they published their study involving 1100 patients. They concluded that enucleoresection could be a suitable alternative to TURP and open prostatectomy, and that the surgery was less expensive than enucleation combined with morcellation. It is also important to mention Scoffone Cesare, who performed the first en bloc HoLEP surgery in 2016. Thanks to its many advantages, the en bloc technique is now very popular and is considered the gold standard among enucleation techniques. The development of AEEP continues unabated, with the current focus on reducing the diameter of the laser resectoscopes used for the surgery. AEEP can be performed with any energy source that can be used transurethrally, but the surgical technique used and the experience of the surgeon are much more important than the type of energy source. Nevertheless, it can be said that HoLEP remains the most widely used and best documented method.

2.2 Anatomical background of AEEP

One of the most important advantages of AEEP is that the same basic principle is applied during the operation as in open adenomectomy. In practice, the enucleation performed during open surgery is performed transurethrally. Consequently, the anatomical basis of enucleation differs significantly from that of conventional TURP

surgery. A thorough knowledge of the anatomical background, with particular regard to the structure of the prostate, the exact position of the sphincter, and the vascular relationships, is essential for the safe and effective mastery of the surgical technique. Although the prostate does not have a true capsule in histological terms, the connective tissue fascia layers covering the peripheral zone have become established in terminology as prostatic capsules. From an anatomical point of view, however, the structure referred to as the prostatic capsule during enucleation is actually the layer between the peripheral and transitional zones, which would be more accurately described as a pseudocapsule or surgical capsule. The pseudocapsule is a dense, fibromuscular layer, 1–2 mm thick, the shape and thickness of which can vary significantly from person to person. From a surgical point of view, the capsule of the prostate is one of the most important landmarks during surgery. Several methods have been developed to identify the capsule during the development of enucleation techniques. In the currently popular en bloc technique, no longitudinal incision is made, as the layer between the capsule and the adenoma is opened laterally at 5 and 7 o'clock from the seminal colliculus. The en bloc technique has several advantages: better visibility, faster and easier identification of the capsule, shorter surgical time, easier preservation of the mucosa on the sphincter, less laser/bipolar energy required, and a shorter learning curve. The sphincter consists of two functionally separate, but morphologically continuous components, which are responsible for passive and active continence mechanisms. The smooth muscle component is the lissosphincter, which consists of the inner, longitudinal smooth muscle surrounding the urethral lumen and the outer, wider, circular smooth muscle. The external component of the sphincter is the omega- or horseshoe-shaped rhabdosphincter, which consists of striated muscle. The greatest advantage of enucleation is that, similar to open adenomectomy, it allows for

complete removal of the transitional zone. However, this is also its most significant disadvantage, as the rate of transitional stress incontinence is higher than after TURP surgery. Damage to the mucosa of the lissosphincter and thermal damage to the sphincter play a decisive role in the development of urinary incontinence after enucleation.

2.3. Physical principles of bipolar technology

The advent of bipolar TURP brought about a paradigm shift in transurethral surgical treatment of the prostate, resulting in significant technological and clinical advances. Of course, in addition to preventing TUR syndrome, the bipolar procedure has many other advantages. While electrolyte-free irrigation fluid is used in classic monopolar TURP, preheated physiological saline solution is used in bipolar surgery, which is safe for the patient, well tolerated, has low impedance, and conducts electrical current excellently. The circuit is concentrated between the active and neutral electrodes on the bipolar loop. The electric current generates high temperatures in the vicinity of the loop, which locally boils the isotonic saline solution, forming vapor bubbles. These bubbles merge to form a stable vapor envelope, which creates a plasma zone when a certain threshold voltage is reached. The high temperature of the plasma makes it suitable for effective resection, vaporization, or coagulation of tissue. In a true bipolar procedure, both the active and neutral electrodes are located on the loop, so that the current does not pass through the patient's body. In contrast, in "quasi" bipolar systems, the current emitted from the active electrode flows through part of the urethral tissue and then closes the circuit at the neutral electrode at the end of the shaft. The optimal energy setting is in the range of 130–280 W for resection and 60–110 W for coagulation.

One of the major advantages of using the bipolar technique is less tissue penetration. In bipolar resection, the depth of the necrotic zone is significantly smaller (0.07 ± 0.08 mm) than in monopolar TURP (0.59 ± 0.27 mm). The temperature increase is significantly greater after monopolar TURP (24.2 ± 3.9 °C) than after bipolar resection (8.1 ± 1.5 °C). The significantly lower temperature increase supports the assumption that bipolar resection causes less tissue damage, which may also explain the milder postoperative urinary irritation symptoms. Another notable advantage of bipolar technology is that it can be used safely in patients with pacemakers, as the risk of electromagnetic interference is minimized. Furthermore, the lower electrical voltage reduces the frequency of obturator spasms, although complete elimination cannot be guaranteed with this technique. The "cut and seal" effect used in the bipolar technique allows for the immediate removal of tissue adhering to the loop, thus preventing interruption of the surgery.

2.4 Physiological background of AEEP – thermoregulation and fluid dynamics

When reviewing the physiological basis of the bipolar technique, it is important to note how the temperature of the irrigation fluid affects the body's thermoregulation, and it is also essential to have a precise understanding of intraoperative fluid dynamics. Scientific research has shown that narcosis significantly impairs central thermoregulation, thereby lowering the temperature threshold required to trigger vasoconstriction and shivering. As a result, most patients undergoing anesthesia develop hypothermia in the absence of active warming. Spinal anesthesia has less effect on central thermoregulation, but it inhibits vasoconstriction and shivering in the blocked areas through peripheral sympathetic and motor nerve blockade. During

transurethral surgery, the use of room temperature irrigation fluid can reduce the patient's core temperature by as much as 1–2 °C. It is important to note that a significant proportion of patients undergoing enucleation are elderly, which is one of the most important risk factors for hypothermia. Hypothermia reduces platelet function, increases fibrinolysis, and reduces vasoconstriction and coagulation factor activity. The use of isothermal irrigation fluids has been shown to reduce heat loss, but large volumes of irrigation fluid are difficult to warm adequately. Excessively heated fluid can cause tissue damage. If isothermal saline solution is not available, preoperative active warming is an alternative solution. In addition to the temperature of the irrigation fluid, ensuring adequate intravesical pressure (IVP) is also a key factor. The spread of AEEP techniques and the integration of morcellation into routine clinical practice has once again drawn attention to the importance of maintaining optimal IVP. This is particularly critical in the context of morcellation, as the nature of the procedure involves higher IVP. Preventing volume overload is crucial, as although isoosmolar hypervolaemia does not cause classic TUR syndrome, it can lead to a condition requiring intensive care following bipolar or laser enucleation. In general, IVP exceeding 20 cmH₂O can be considered elevated, while absorption of irrigation fluid usually becomes significant at values above 40 cmH₂O. Therefore, during morcellation, it is recommended to keep the pressure in the bladder below 40 cmH₂O if possible. The extent of irrigation fluid absorption is influenced by the size of the prostate, the duration of surgery, possible capsule perforation, and the pressure of the irrigation fluid. Direct (intravascular) absorption occurs when the IVP exceeds an average of 15.3 cmH₂O. The critical pressure value for indirect (extravascular) absorption is lower than this and can occur even at the beginning of the operation if the integrity of the prostate is compromised. The type of irrigation system used and the height of the fluid column play a significant

role in the development of IVP. For safe surgical practice, it is advisable to keep the height of the irrigation fluid below 60 cm, which reduces excessive pressure in the prostatic loge and bladder overstretching. The height of the fluid column plays a significant role in the development of hypervolaemia, but bladder compliance and bladder volume are also important factors. Higher IVP (>20 cmH₂O) occurs much more frequently in cases of lower bladder capacity. The increase in IVP during the filling phase of the bladder depends on individual bladder capacity, but on average, a bladder capacity of 500 ml can be considered the critical point above which IVP begins to rise sharply. Absorption of the irrigation fluid is not typical in the initial phase of enucleation, but as the procedure progresses and more veins open, even lower pressure values (15.3 cmH₂O) may be sufficient for the irrigation fluid to be absorbed. The duration of the surgery and the volume of the prostate significantly influence the risk of developing hypervolaemia. Therefore, the concept of low-pressure irrigation, which reduces complications arising from the absorption of physiological saline solution, is increasingly supported. Overall, the bipolar technique represents a significant clinical and technical advance in transurethral prostate surgery. Controlling the pressure of the irrigation fluid, preventing perioperative hypothermia, and maintaining optimal IVP are key to patient safety and surgical success.

3. Objectives

- 1.** Retrospective examination of the clinicopathological characteristics of patients who underwent en bloc TUEB surgery combined with the mushroom technique without a dedicated enucleation loop and with early sphincter incision, assessment of

perioperative surgical outcomes, enucleation efficiency and complications, and summary of one-year follow-up data.

2. Retrospective comparative analysis of morcellation and mushroom technique during en bloc TUEB surgery with early sphincter release in cases of prostate size larger than 80 ml, with particular emphasis on the efficacy and safety of the two methods and the evaluation of complications of the procedures. Examination of factors influencing perioperative blood loss and comparison of six-month follow-up data between the two methods.

4. Patients and methods

4.1 Selection of patients included in the studies and their clinicopathological characteristics

In our first study, we evaluated the effectiveness of en bloc TUEB surgery performed using the mushroom technique and early sphincter release. A total of 252 patients were included in our retrospective study. The surgeries were performed between January 2018 and May 2023 at the Department of Urology, University of Debrecen. Following approval by the Regional and Institutional Research Ethics Committee of the University of Debrecen (ethical approval ID: IRB No. DERKEB/IKEB 6977-2024), data were collected retrospectively. All procedures were performed by a single surgeon. The following were specified as inclusion criteria: prostate volume >30 ml, maximum flow rate (Q_{max}) during uroflowmetry <15 ml/s, residual urine >100 ml, International Prostate Symptom Score (IPSS) >7, and progressive urinary symptoms despite drug therapy. Patients with neurogenic bladder,

urethral stricture, or prostate cancer confirmed during urological examination were excluded. Prior to surgery, all patients underwent a standardized urological examination in accordance with current European urological guidelines. In our second study, we compared the efficacy of the mushroom technique and morcellation in en bloc TUEB surgeries combined with early sphincter release in cases with prostate volumes larger than 80 ml. Between January 2018 and March 2024, we performed surgery on a total of 234 patients with prostate sizes larger than 80 ml. The patients were divided into two groups: 116 patients were assigned to the mushroom technique group and 118 patients to the morcellation group. On March 1, 2021, a Wolf Piranha morcellator (Richard Wolf, GmbH, Knittlingen, Germany) was purchased by the Department of Urology, University of Debrecen, so after this date, morcellation was systematically used in surgeries for prostate volumes larger than 80 ml. Similar to our first study, all procedures were performed by one surgeon. Following approval by the Regional and Institutional Research Ethics Committee of the University of Debrecen (ethical approval ID: IRB No. DERKEB/IKEB 7116-2025), data were collected retrospectively.

4.2 Surgical technique for en bloc TUEB with early sphincter release and mushroom technique

Thirty minutes before the start of surgery, all patients received intravenous antibiotic prophylaxis (usually 2 grams of ceftriaxone). The surgery was performed under spinal anesthesia or narcosis in the lithotomy position. A 27 Ch bipolar resectoscope (Olympus Winter & IBE GmbH, Hamburg, Germany) with 12° optics was inserted transurethrally into the bladder. Preheated (37 °C) physiological saline solution was used as the irrigation fluid. A high-frequency bipolar loop (Olympus Winter & IBE

GmbH, Hamburg, Germany) was used throughout the procedure. En bloc enucleation was performed using the tip of the sheath. A mushroom-shaped pedicle was formed on the bladder neck, which was used to fix the adenoma in the prostate loge. The avascularized adenoma was then resected at high speed. The power setting was 200 W for cutting and 120 W for coagulation.

4.3 Surgical technique for en bloc TUEB with early sphincter release and morcellation

The procedure was performed similarly to the technique described in section 4.2, with the difference that no mushroom-shaped pedicle was formed at the bladder neck. The enucleated adenoma was positioned in the bladder using the tip of the sheath. We then replaced the bipolar resectoscope with a morcellator (Richard Wolf, GmbH, Knittlingen, Germany) and inserted the oscillating morcellator (Richard Wolf, GmbH, Knittlingen, Germany). We used the morcellator at 850 revolutions per minute (rpm) according to the original recommendation of Richard Wolf company. The prostate adenoma was morcellated in the middle of the bladder using the traditional upward technique. At the end of the procedure, both inflows were turned off and the bladder and prostate loge were checked for any residual tissue.

4.4 Measurement of perioperative data

In both of our studies, the surgical time was measured from the insertion of the bipolar resectoscope to the placement of the urinary catheter. The wet weight of the tissue was measured before formalin fixation. The efficiency of the surgery was calculated based on the surgical time and the weight of the removed prostate tissue

(grams/minute). On the first postoperative day, we monitored control laboratory parameters, including Hgb, sodium, and creatinine levels. We recorded the duration of catheter use and hospital stay. We used the Clavien–Dindo classification to evaluate 30-day complications. In our second study, we compared perioperative data between the mushroom technique and the morcellation group. In the morcellation group, we also measured the incidence of the "beach ball" phenomenon.

4.5 Follow-up

The follow-up period was 12 months in our first study and 6 months in our second study. Control examinations were performed at 1, 3, 6, and 12 months, during which PSA testing, uroflowmetry, and ultrasound measurement of residual urine were performed. In addition to these examinations, we used questionnaires (IPSS, QoL, IIEF-5) to objectively assess the patients' urinary and erectile status. We also documented the presence of TSUI and other late complications. In our second study, we compared the data recorded during follow-up between the mushroom technique and morcellation groups.

4.6 Statistical analysis

4.6.1 Statistical analysis of the retrospective study evaluating the effectiveness of en bloc TUEB combined with the mushroom technique

The normality of continuous variables was assessed using the Shapiro–Wilk test. Categorical variables were described as proportions, while continuous variables were given as medians and interquartile ranges. The Wilcoxon test was used to compare

the medians of continuous variables, while Pearson's chi-square test was used to explore the relationships between categorical variables. The threshold for statistical significance was set at $p < 0.05$. All statistical analyses were performed using Intercooled Stata v18.0 software (Stata Statistical Software: Release 18; StataCorp LLC, College Station, TX, USA).

4.6.2 Statistical analysis of a retrospective study comparing the efficacy of the mushroom technique and morcellation in cases of prostate size larger than 80 ml

The distribution of continuous variables was assessed using the Shapiro–Wilk test. In the case of non-normal distribution, the data were presented as median and interquartile range, and comparisons were performed using a non-parametric method (Wilcoxon test). Categorical variables were presented as counts and percentages. Robust regression analysis was performed using the iterative reweighted least squares method to minimize the effect of outliers on the estimated regression coefficients. All statistical analyses were performed using Intercooled Stata v18.0 software (Stata Statistical Software: Release 18; StataCorp LLC, College Station, TX, USA), and statistical significance was set at $p < 0.05$.

5. Results

5.1 Results of a retrospective study evaluating the efficacy of en bloc TUEB combined with the mushroom technique

In our first study, the median age of patients was 70 [65–76] years, while the median BMI was 27.65 [24.7–30.15] kg/m². The ASA score classification was as

follows: ASA 1 score: n=6 (2.38%), ASA 2: n=134 (53.17%), ASA 3: n=108 (42.86%), ASA 4: n=4 (1.59%). Forty-four patients (17.46%) received antiplatelet therapy. The median preoperative prostate size was 60 [40–88.5] ml, while the median preoperative PSA value was 4.17 [1.79–7.81] ng/ml. The median surgical time was 40 [30–70] minutes, and the median weight of enucleated prostate tissue was 34 [16.5–60] grams. The average enucleation rate was 0.76 [0.6–1] grams/minute. There was a significant difference in the enucleation rate between prostate sizes smaller than 80 ml and larger than 80 ml (0.66 [0.53–0.86] grams/minute vs. 1 [0.76–1.11] grams/minute, $p<0.001$). The median postoperative bladder irrigation time was 24 [20–24] hours. The mean decrease in Hgb level was 13.28 g/L ($p<0.001$). Sodium (preoperative: 140 [139–141] mmol/L vs. postoperative: 139 [138–141] mmol/L, $p=0.011$) and creatinine levels (preoperative: 82 [72–95] $\mu\text{mol/L}$ vs. postoperative: 79.5 [68–95] $\mu\text{mol/L}$, $p=0.002$), but these were not clinically relevant. The median catheterization time was 3 [2–3] days, and the median hospital stay was 4 [3–4] days. Clavien–Dindo grade I complications included macroscopic hematuria in 8.33% of cases and capsule perforation in 5.16% of cases, while Clavien–Dindo grade II complications were observed in 3.17% of cases. Clavien–Dindo grade IIIb complications occurred in 2.78% of cases. We did not observe any Clavien–Dindo grade IIIa, IV, or V complications.

5.2 Results of a retrospective study comparing the effectiveness of the mushroom technique and morcellation in cases of prostate size larger than 80 ml

The median operative time was significantly longer in the mushroom technique group (80 [60–90] minutes) than in the morcellation group (60 [50–70] minutes), ($p<0.001$). There was no significant difference between the two groups in

terms of the weight of the removed adenoma (mushroom technique: 68.5 [50–89.5] grams, morcellation: 65 [55–89] grams; $p=0.572$). Enucleation efficiency was 0.9 [0.76–1.03] grams/minute for the mushroom technique and 1.25 [1.01–1.44] grams/minute for morcellation ($p=0.000$). Based on the linear regression analysis performed, prostate size had a greater influence on surgical duration when using the mushroom technique than when using morcellation. When using morcellation, each gram of prostate tissue prolonged the duration of surgery by an average of 0.41 minutes ($p<0.05$), while with the mushroom technique, it prolonged the duration of surgery by 0.69 minutes ($p<0.05$). Unlike the mushroom technique, the effectiveness of morcellation did not decrease with increasing prostate size. The median Hgb value decreased significantly in both groups, but a greater decrease was observed with the mushroom technique (-25 [-17 to -8] g/L) than in the morcellation group (-11 [-19 to -4] g/L; $p=0.002$). Since there was a significant difference between the two patient groups in the incidence of antiplatelet therapy and urinary retention, we performed multiple robust regression analyses to filter out the possible confounding effects of these variables on surgical time and blood loss. Surprisingly, the results showed that antiplatelet therapy was associated with a near-significant reduction in Hgb (Coef. = -6.53, $p=0.052$, 95% CI [-13.11; 0.05]). In contrast, urinary retention did not significantly affect the degree of Hgb decrease (Coef. = 0.20, $p=0.908$, 95% CI [-3.12; 3.51]). However, the duration of surgery was significantly correlated with increased blood loss, with each additional minute resulting in a further decrease of 0.13 g/L Hgb (Coef. = 0.13, $p<0.001$, 95% CI [0.06; 0.20]). The surgical technique itself had no significant independent effect on Hgb decrease after these factors were taken into account (Coef. = -3.17, $p=0.074$, 95% CI [-6.66; 0.31]). The median catheterization time was shorter in the morcellation group (mushroom technique: 3 [2–3] days vs.

morcellation: 2 [2–3] days; $p < 0.001$), as was the length of hospital stay (mushroom: 4 [3–4] days vs. morcellation: 3 [3–4] days; $p = 0.000$). The rate of Clavien–Dindo I–IIIb complications was similar in both groups, and no blood transfusions were required in either case. As late complications, urethral stricture (0.86%) and bladder neck sclerosis (0.86%) developed in one case each in the mushroom technique group.

6. Discussion

AEEP appeared on the urological surgical scene nearly four decades ago, bringing about a paradigm shift in the surgical treatment of BPH. Endoscopic enucleation is a surgical procedure that can be performed regardless of prostate size, it is safe, reproducible, and provides lasting results. The advantages of enucleation are indisputable when compared to conventional TURP and open adenectomy. While TURP only reduces the volume of the prostate, enucleation completely removes the transitional zone, thereby completely eliminating the obstruction. Another significant difference is that while the effectiveness of TURP does not increase with prostate size, the effectiveness of enucleation improves continuously. It should also be emphasized that with TURP, an increase in prostate size is associated with an increased risk of complications. Although open adenectomy involves shorter surgery time, it is a more invasive procedure, which may be associated with a higher complication rate, and the duration of postoperative catheterization and hospital stay are both significantly longer than those experienced after enucleation. Due to its numerous advantages, some authors already consider enucleation to be the new gold standard in the surgical treatment of BPH. The optimal energy source for AEEP remains a controversial issue in the literature. Enucleation can be performed using a variety of energy sources, such as

bipolar energy, Ho:YAG, Tm:YAG, thulium fiber, or GreenLight laser, but proper surgical technique is more critical to the success of the procedure than the type of energy used. Of the available energy sources, bipolar technology has gained widespread acceptance because it is cost-effective, safe, transmits less heat energy to the tissues, and minimizes the risk of TUR syndrome. In our first study, we evaluated the efficacy and effectiveness of en bloc TUEB combined with the mushroom technique, while in our second study, we compared the mushroom technique with morcellation in cases of prostate size greater than 80 ml. To the best of our knowledge, we are the first to publish a study in the international literature combining en bloc TUEB surgery with the mushroom technique, and we are also the first to report enucleation without the use of a dedicated enucleation loop. The mushroom technique developed by Hochreiter is a cost-effective alternative for prostate tissue removal in institutions where a morcellator is not available. Since both enucleation and resection are performed during the surgery, the term TUERP (transurethral enucleation and resection of the prostate), i.e., enucleoresection, is particularly appropriate. During en bloc TUEB combined with the mushroom technique, the adenoma is fixed in the prostate lobe by retaining a mushroom-like pedicle formed at the bladder neck at 6 o'clock position. This allows the already enucleated and avascularized lobes to be resected quickly and efficiently. Our basic concept was to divide the procedure into two stages, while avoiding the need to replace the loop. In the first stage, we performed en bloc enucleation of the adenoma with the tip of the sheath, and in the second stage, we resected the avascular lobes thus formed. An additional advantage of this method is that the elimination of the enucleation loop results in significant cost savings. According to several urologists, the lack of a morcellator is an obstacle to learning the enucleation technique and introducing it in their own institutions. However, our study confirmed that enucleation can be

performed with satisfactory results even without the use of a morcellator. In my opinion, bipolar technology is the ideal choice for learning enucleation, as most urologists are much more proficient in the use of conventional resectoscopes than in the use of laser resectoscopes. Another important advantage is that if any technical difficulties arise during the operation, it is possible to switch immediately to classic TURP, which guarantees the safe completion of the procedure. It should also be emphasized that the technique we describe is the most cost-effective of the enucleation procedures, as it requires only a bipolar resectoscope, a resection loop, and physiological saline solution. Based on the results of our initial study, patients' urinary parameters showed significant improvement after surgery. The IPSS, QoL, Qmax, Qave, and residual urine values we measured are comparable and consistent with the results reported in the international literature. We also examined the extent of PSA reduction following enucleation. According to the literature, PSA levels decrease by 60-90% after complete removal of the transitional zone, which is supported by our own results. In our second study, we compared the second, somewhat monotonous stage of en bloc TUEB surgery, the removal of the adenoma, in cases where the prostate size exceeded 80 ml, using the mushroom technique and a morcellator. The study was made possible by the fact that in February 2021, our department acquired a morcellator, which made enucleations smoother and faster, as the speed of tissue removal significantly affects the duration of surgery. According to a study by Chen et al., morcellation alone can account for 20-60% of the total surgical time. Although the high purchase cost of morcellators currently hinders their widespread use, morcellation is considered the gold standard technique for tissue removal among urologists performing enucleation. Morcellators are classified based on the blade movement mechanism (oscillating or reciprocating/guillotine) and blade shape (serrated or smooth), and can also be divided into single-use and reusable

blade types. The blades of first-generation morcellators performed a reciprocating motion, while the blades of second-generation morcellators perform an oscillating motion, making these devices safer and more efficient. In terms of effectiveness, oscillating morcellators have been shown to be more than twice as effective as reciprocating devices. According to our own results, the effectiveness of morcellation is independent of prostate size, while in the case of the mushroom technique, effectiveness decreases with increasing prostate volume. To the best of our knowledge, this is the second study in the international literature to compare the effectiveness of morcellation and the mushroom technique, but our study involved a higher number of cases. Weerasawin et al. reported better functional results and shorter surgical times with morcellation than with the mushroom technique. Similarly, in our study, the surgical time was significantly shorter in the morcellation group. However, the method of tissue removal did not affect the functional results, which can be explained by the fact that the principles of enucleation are the same for both techniques. AEEP is considered a fundamentally safe procedure for the surgical treatment of BPH. Randomized trials and meta-analyses have consistently demonstrated lower blood loss in AEEP surgeries, resulting in shorter catheterization times and hospital stays, thereby significantly reducing the burden on the healthcare system. Another significant advantage of AEEP is that it achieves an extremely high catheter removal rate of 98.3%. It is also noteworthy that 10 years after HoLEP surgery, the rate of reoperation due to recurrent BPH is only 0.7%, compared to 18% after TURP surgery. The advantages of AEEP are supported by strong evidence. Enucleation alleviates lower urinary tract obstruction to a greater extent than conventional TURP surgery. Urinary parameters (IPSS, Qmax, residual urine) improve to a greater extent after AEEP than after monopolar TURP. The effectiveness of resection and vaporization techniques is

particularly inferior to AEEP in cases of larger prostate size. In my opinion, the most important factor in the surgical treatment of BPH is not the amount of adenoma removed, but the achievement of satisfactory functional results in the long term. I see the greatest advantage of AEEP precisely in this, in the consistently good results, since the reoperation rate due to residual BPH after the procedure is significantly lower than the values experienced after TURP.

7. New findings

1. I was the first to present the results of the en bloc TUEB surgical technique combined with early sphincter release and the mushroom technique without a dedicated enucleation loop in the international literature, confirming its effectiveness and safety as an alternative to classic TURP.

2. The use of en bloc TUEB combined with the mushroom technique can achieve significant cost savings, while the functional results are comparable to those of procedures performed with a morcellator. The mushroom technique may be particularly useful in institutions where a morcellator is not available.

3. I demonstrated that in en bloc TUEB surgery performed on prostate volumes exceeding 80 ml, the use of a morcellator significantly reduces surgical time and consequently reduces perioperative blood loss compared to the mushroom technique.

4. I was the first to confirm that while the effectiveness of the morcellator is independent of prostate size, the effectiveness of the mushroom technique decreases with increasing prostate volume.

5. I demonstrated that perioperative blood loss is not affected by the method of tissue removal, the presence of urinary retention, or the use of antiplatelet therapy. The extent of perioperative blood loss is significantly correlated with surgical time.

8. Summary

With advancements in minimally invasive surgical techniques for BPH, AEEP is becoming increasingly prominent as a safe method providing durable results. AEEP is the only surgical technique applicable to prostates of any size. Among the available energy sources, bipolar technology is well-established and offers several advantages over monopolar systems. In my doctoral dissertation, I examined the effectiveness and outcomes of bipolar-based AEEP. My study was divided into two parts: first, I retrospectively analyzed outcomes of en bloc TUEB performed with the mushroom technique, without using a dedicated enucleation loop and with early sphincter release. In the second part, I compared morcellation with the mushroom technique specifically for prostates larger than 80 ml. According to my findings, TUEB using the mushroom technique could represent an effective and safe alternative to the classical TURP, particularly in institutions where a morcellator is unavailable. This approach can achieve significant cost savings while maintaining similarly favorable surgical outcomes. My comparative study on morcellation demonstrated that using a morcellator significantly reduces operative time and improves perioperative blood loss

in prostates larger than 80 ml. I also concluded that the efficiency of morcellation remains unaffected by prostate size, in contrast to the mushroom technique. Thus, my second study can serve as useful guidance for urologists regarding the limitations of the mushroom technique.

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List of publications related to the dissertation

1. **Kiss, Z.**, Murányi, M., Nagy, A. C., Flaskó, T.: Effectiveness of the mushroom technique versus morcellation in en bloc bipolar prostate enucleation for prostates over 80 mL.
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List of other publications

3. **Kiss, Z.**, Drabik, G., Murányi, M., Nagy, A. C., Goumas, I. K., Flaskó, T.: Single session removal of encrusted double J stent using a simultaneous endourological approach: a case series.
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