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INTEGRATED STUDY MASTER'S THESIS

Contemporary Surgical Treatment of Benign Prostate Hyperplasia, Advantages of Different Surgical Methods. Literature Review

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1. ABBREVIATIONS:

BPH – Benign prostatic hyperplasia; LUTS – Lower urinary tract symptoms; TUMT/PLFT – Transurethral microwave therapy; TURP – Transurethral resection of the prostate; M-TURP –; Monopolar transurethral resection of the prostate; B-TURP – Bipolar transurethral resection of the prostate; IPSS – International Prostate Symptom Score; QoL – Quality of life; Qmax – maximum urinary flow rate; Rezūm – Water vapor thermal therapy; UTI – Urinary tract infection; Aquablation – Waterjet ablation therapy; TRUS – Transrectal ultrasound scan; PSA – Prostate-specific Antigen; PVR – Post-void residual volume; PUL – Prostatic Urethral Lift (UroLift); OML – obstructive middle lobe; MSHQ-EjD – Male Sexual Health Questionnaire; VAS – Visual analogue scale; PAE – Prostate artery embolization; CT – computerized tomography; cPAE – conventional microcatheter prostatic artery embolization; bPAE – balloon occlusion prostatic artery embolization; PVP – Photoselective Vaporization; IIEF-5 – International Index of Erectile Function; B-TUVP – Bipolar transurethral vaporization; C-BPVP –Continuous bipolar plasma vaporization; S-BPVP – Standard bipolar plasma vaporization; HoLEP – Holmium laser enucleation of the prostate; AUA – American urological association; ThuLEP – Thulium Laser enucleation of the prostate ; LSP – Laparoscopic simple prostatectomy; RASP – robotic simple prostatectomy; MISP – Minimally invasive simple prostatectomy; PVEP – Photoselective vapo-enucleation of the prostate; TUR – Transurethral Resection; PKRP – Plasmakinetic TURP; mL – milliliter; mL/s – milliliter per second; ng/mL – nanograms per milliliter, cm^3 – cubic centimeter

2. SUMMARY:

Benign prostatic hyperplasia is a common condition among older men that leads to lower urinary tract symptoms and a reduced quality of life. This literature review compared the efficacy, safety and practical aspects of multiple minimally invasive and surgical techniques. Transurethral resection of the prostate is still a good option for patients with small prostates (<30 mL). Comparative studies of holmium laser and conventional electrocautery have shown comparable improvement in symptoms. However, holmium laser incision of the bladder neck provides better hemostasis but carries risks such as retrograde ejaculation. For patients with slightly larger prostates or when minimally invasive treatment is preferred, transurethral microwave therapy and prostatic laser focal therapy offer effective symptom reduction with fewer serious complications than transurethral resection of the prostate, although with slightly lower improvements in urinary flow rates and higher re-treatment rates. Water vapor thermal therapy (Rezūm) showed long-term effectiveness in symptom relief and improvement of quality of life. This improvement of symptoms and of maximum urinary flow was significant and its adverse events only mild and temporary. The review also analyzed other methods such as Aquablation, a robotic waterjet ablation procedure that

provides symptom relief comparable to transurethral resection of the prostate while having advantages in operative time, preservation of sexual function and patient recovery, making it a good choice for medium-sized prostates. The prostatic urethral lift improved urinary symptoms and quality of life. Also, it preserved ejaculatory function, which is an important factor for many patients. However, its overall symptom improvement was slightly lower than after transurethral resection of the prostate. Prostate artery embolization, vaporization and laser enucleation methods were analyzed as well. Prostate artery embolization is safer and less invasive than transurethral resection of the prostate. However, transurethral resection of the prostate has better long-term results. Laser vaporization (both diode and bipolar) led to improvements in symptoms with shorter recovery times and less blood loss. Enucleation methods, particularly holmium laser enucleation of the prostate and thulium laser enucleation of the prostate led to stable long-term results. Holmium laser enucleation of the prostate showed lower reoperation rates and thulium laser enucleation of the prostate had better hemostasis. Although this literature review concludes that transurethral resection of the prostate should still be considered the gold standard as far as symptom relief and prostate volume reduction are concerned, individual patient factors such as prostate size, concomitant disease, or desire to preserve sexual function must be considered when choosing the optimal treatment option.

3. KEYWORDS:

BPH Operation, Holmium laser enucleation, ThuVARP, Transurethral incision of prostate, Open prostatectomy for BPH, Bipolar transurethral enucleation of prostate, ThuLEP, Bipolar transurethral vaporization of the prostate, PVP prostate, Diode laser vaporization of prostate, Aquablation OR AquaBeam, PAE, Rezum Prostate, Transurethral ethanol ablation of prostate

4. METHODS:

Using the PubMed scientific database, a systemic literature search was conducted on the various aspects of surgical methods for the treatment of benign prostatic hyperplasia with the above-mentioned keywords. The search was limited to articles in English. The articles were not restricted to a specific time period. 451 publications were reviewed and discussed to compare the surgical methods perioperatively and postoperatively and their advantages and disadvantages were extracted. 298 records were deleted during the initial screening of records. 52 reports could not be retrieved. 15 reports were excluded as these were older than 2015, because more recent studies were available. 9 reports were deleted due to lack of information and inappropriate studies on the specific topic and 14 reports due to incorrect study type.

5. INTRODUCTION: (1)

Benign prostatic hyperplasia (BPH) is a condition that often affects men with rising age with up to 90% over the age of 70. It is a benign enlargement of the prostate that leads to lower urinary tract symptoms (LUTS) (2). BPH is caused by the proliferation of prostate cells and leads to compression of the urethra and obstruction of the urine flow (3). Symptoms are frequent urination, nocturia, a weak urine stream and the feeling of an incompletely emptied bladder (4). If BPH is not treated, it can lead to chronic urinary retention and damage to the bladder. Predisposing factors are age, genetics and obesity. BPH can be treated in multiple ways, starting with lifestyle changes and escalating to the use of medication and surgery (1). This literature review aims to compare different surgical approaches for different prostate volumes for the treatment of BPH by comparing their peri- and postoperative outcomes. This is important as benign prostatic hyperplasia (BPH) is common among ageing men. Due to side effects of the gold standard methods, it is important to find new data to achieve the best effective result for patients with BPH, as quality of life (QoL) is compromised. Continuous evaluation can ensure that the chosen procedures provide the best outcomes for patients. It is also essential to find surgical methods that are low risk and have fewer unwanted effects. This significantly improves overall patient safety and minimizes the risk of serious complications. Surgical methods should have a faster recovery and less post-operative discomfort in order to improve the patient´s QoL in general. Less invasive procedures or procedures with less postoperative complications are important, because older patients with multiple health problems can be able to return to their everyday lives as quick as possible.

6. MINIMAL INVASIVE PROCEDURES FOR PROSTATE <80 mL Volume:

6.1 Transurethral incision of the prostate (TUIP):

Definition: Transurethral incision of the prostate (TUIP) is a surgical procedure in which an incision is made at the bladder outlet without moving any specific prostate tissue. This technique is usually done with a Collins knife in combination with electrocautery, while alternative procedures such as the use of holmium laser are also possible (5). The indication for this method is generally to treat patients with a prostate size less than 30 mL and without a pronounced middle lobe.

Efficacy: The main results were related to operation time, which was significantly shorter for C-BNI (12.8±4.6 minutes) compared to HoBNI (16.4±5.3 minutes, p=0.0001). Both methods showed similar efficacy in regards of significant improvement in American Urology Association (AUA) symptom scores and maximum urine flow (Qmax) at 3, 6 and 12 months postoperatively ($p < 0.05$), with no significant differences between the two groups. PVR also changes significantly from baseline (HoBNI 95.6±34.7 mL vs. C-BNI 101.3±28.6 mL) to 6 months (HoBNI 15.7±4.5 mL vs.

14.9±4.9 mL) follow-up in both groups (p = 0.0001) but they do not differ significantly between each other (p = 0.32).

Tolerability and safety: HoBNI had better hemostatic properties, resulting in slightly less postoperative hematuria and a slightly lower need for blood transfusions compared to C-BNI. However, retrograde ejaculation was significantly more common in patients who underwent HoBNI treatment (22.9%) than in patients who received C-BNI treatment (6.1%, p = 0.02). Other complications such as acute urinary retention, erectile dysfunction, submeatal strictures and the need for reoperation were similar between the two patient groups and did not differ significantly.

Practical considerations: C-BNI compared to HoBNI had similar hospitalization (p = 0.09) and catheterization times (p = 0.10).

6.2 Transurethral microwave therapy (TUMT/PLFT):

The prostatic laser focal therapy technique uses a probe with three temperature sensors to measure the temperature inside the prostate. At about the two o´clock position, the probe is inserted into the prostate via a special catheter. A transrectal ultrasound scan may be used to determine the position of the probe if necessary. This ensures that it is in the correct position. During the treatment, the measured temperatures are continuously displayed on a computer. This data is used to calculate the magnitude of tissue damage or coagulation necrosis using the heat equation. This procedure allows the treatment to be personalized and stopped as soon as enough tissue has been destroyed. The treatment cessation is achieved based on the device´s automatic calculations and direct observation of temperature in one part of the prostate reaches about 55°C. This procedure is usually performed on an outpatient setting. Patients generally tolerate the treatment well and only need light sedation and/or local anesthesia. The duration of the treatment depends on the individual patient and lasts between 27 and 80 minutes, with the average time being around 57 minutes. One of the most common side effects during treatment is a sense of urgency. To treat this side effect, drugs such as diazepam, ketorolac or ketobemidone are given, if necessary, sometimes in combination. At the end of the treatment, a Foley catheter is inserted and remains in the patient for an average of 14.8 days (median 12 days, range 7 to 56 days) (6).

Efficacy: A non-significant reduction of the symptoms of BPH was achieved after TUMT/PLFT and TURP after 60 months. All studies showed a decrease in IPSS score from 21 points to 8.3 points at 36 months and even more reduction to 7.4 points at 60 months after TUMT/PLFT. For TURP the baseline of the IPSS score was 20.4 points, decreasing to 5.0 points at 36 months and further to 6.0 points at 60 months (7,8). TUMT/PLFT showed an improvement in QoL from 4.3 points to 1.3 points at 36 months and to 1.1 points at 60 months, while TURP resulted a reduction from 4.2 at baseline to 1.0 points at 36 months but the score increased to 1.1 after 60 months (p =

0.841) (6),(7),(8). The peak urinary flow rate (Qmax) in TUMT/PLFT was 7.6 mL/s at baseline, improving to 11.9 mL/s at 36 months and even more to 11.4 mL/s at 60 months. For the TURP group the baseline was 7.9 mL/s at the beginning, after 36 months 13.5 mL/s and after 60 months 13.6 mL/s. Therefore non-significant changes between both groups (6),(7),(8). The PVR volume was not significantly better in one or another. In TUMT/PLFT the baseline was at 106 mL, while it was 94 mL in TURP, at 36 months follow up TUMT/PLFT improved to 47 mL and TURP to 54 mL and after the 60 months TUMT/PLFT increased to 70 mL while TURP further decreased to 51 mL (6),(7),(8). The reduction of prostate volume in both groups was visible. In TUMT/PLFT the reduction was from 49 cm^3 at baseline to 45 at 60 cm^3 at 60 months. In TURP the improvement was from baseline 53 cm^3 to 30 cm^3 at 60 months (6),(8). All these outcomes were not significantly in favor for one of these techniques (6),(7),(8).

Tolerability and safety: TUMT/PLFT showed a higher degree of safety than TURP. Serious adverse events were less frequent in patients after TUMT/PLFT (2%) than in patients after TURP (17%) (6,7). Patients had non-serious adverse events, e.g., urinary retention or urgency, after TUMT/PLFT more often than after TURP (6,7). Also, in long term, serious adverse events were less frequent after TUMT/PLFT (7).

Practical Considerations: One major benefit of TUMT/PLFT is that it is minimally invasive. While TURP requires post-treatment hospitalization and general anesthesia, it can be performed in an outpatient setting. For many patients, this increases the convenience and accessibility. Patients who had TUMT/PLFT had longer post-procedural catheterization duration (14 days on average) than those who had TURP (3 days for TURP) (6). Perhaps as a result of less extensive tissue removal, patients who received TUMT/PLFT also had higher re-treatment rates (10%) compared to those who underwent TURP (4.3%) (8).

Recommendation:	**Level of Evidence:**	**Strength rating:**
A convenient alternative for patients who want safety and outpatient treatment. The choice of treatment should be individually chosen for each patient.	Ia	Conditional (Grade B)

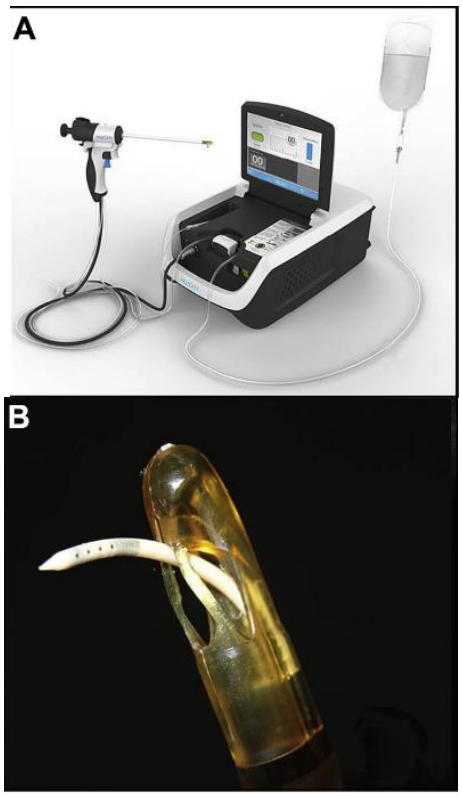
6.3 Water vapor thermal therapy (Rezum):

The Rezūm system is a device that uses sterile water vapor to remove excess tissue. This system consists of a generator and a special single-use transurethral device attached to a rigid 30° cystoscope lens. This is necessary to allow direct visual control during the procedure.

Before the procedure, the patient is placed in a lithotomy position to provide easier access to the urethra. Then the device is inserted into the urethra. A special 18-gauge polyetheretherketone

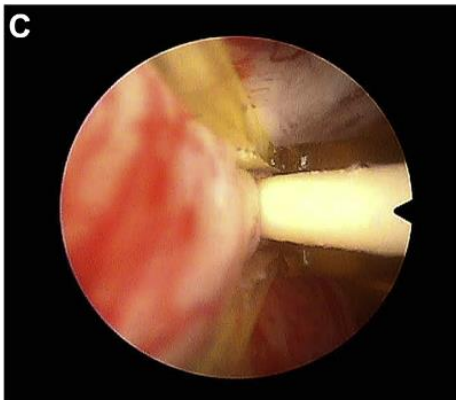
needle is used to introduce water vapor into the prostate. This is inserted into the transition zone of the prostate at a depth of approximately 10 mm. The needle is made with twelve small openings to ensure even distribution of the vapor. The vapor is released circularly through the openings. The vapor is delivered in short injections lasting an average of nine seconds. These injections begin approximately one centimeter below the neck of the bladder and are made in specific positions within the prostate to achieve an optimal effect. Additional injections are made at 0.5 to 1.0 cm intervals along the length of the prostatic urethra, extending to the proximal end of the verumontanum. If a middle lobe is present, it is treated with additional injections. The total number of injections is determined by the size of the prostate adenoma and the length of the prostatic urethra (9).

The primary goal of this treatment is to generate overlapping ablative lesions that extend along the natural course of the urethra. These lesions are designed to remove excess tissue that interferes with the normal function of the prostate. To achieve this, a cystoscopy is first performed when planning the procedure to determine the contours of the prostate and identify the areas that need to be treated. During the procedure, a saline solution is used to improve visualization and provide cooling to the urethra. This helps to prevent possible damage to the mucous membrane of the urethra. After injection, the needle is gently withdrawn and repositioned to ensure that all affected areas are treated. This process continuous until all the affected tissue is properly covered (10). The Rezūm system has been developed to provide a precise, targeted method of treating prostate enlargement that is minimally invasive and helps to restore prostate function by removing excess tissue through targeted heat treatment (11).

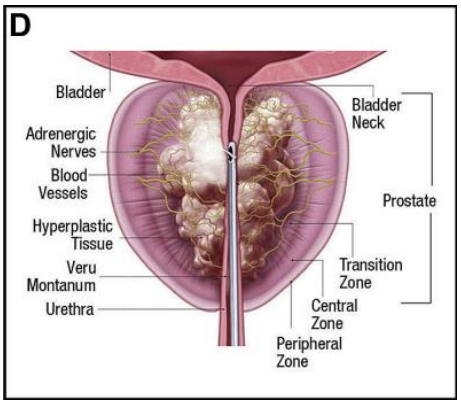


(A) Rezūm System generator and transurethral delivery device. The generator delivers radiofrequency power into the delivery device, where sterile water is converted into water vapor

(B) The tip of the delivery device contains an 18-gauge polyether ether ketone needle where 12 small holes allow for water vapor to be circumferentially emitted



(C) Transurethrally, the needle is deployed at 90° into the prostatic tissue, where vapor is dispersed



(D) 1 to 3 injections of water vapor are delivered into each lateral lobe and 1 to 2 injections into a median lobe, if present.

Figure 1: taken from the article "Efficacy and Safety of Rezūm System Water Vapor Treatment for Lower Urinary Tract Symptoms Secondary to Benign Prostatic Hyperplasia" by Dixon C, Cedano ER, Pacik D, Vit V, Varga G, Wagrell L, Tornblom M, Mynderse L, Larson T., published in Journal of Urology on July 2015. (9)

Efficacy: Patients with lower urinary tract symptoms due to BPH profited by Rezūm water vapor therapy, significantly improving symptom severity and urinary function also in the long term. The IPSS decreased significantly by around 56% from 21.6 ± 5.5 points at baseline to 9.2 ± 6.5 points after 12 months (9). The improvement of symptom severity also stayed in the long term. After 4 years, IPSS decreased significantly from 22.0 ± 4.8 points at baseline to 11.4 ± 7.4 points (10,11). 88.9% of patients who were catheter dependent before surgery, were catheter free after three years (12). After 3 years, Qmax increased significantly from 7.9 ± 3.2 mL/s to 12.8 ± 6.3 mL/s. This is a 87% improvement (9). After 3 years, Qmax increased by a median of 257.6% (12). After 4 years, Qmax increased significantly further from 9.9 ± 2.2 mL/s to 13.7 ± 5.7 mL/s (10). After one year, post void residual volume (PVR) decreased significantly from 92.4 ± 77.3 mL to 63.1 ± 72.2 mL (9). QoL of patients improved significantly after Rezūm water vapor therapy by 61% after one year. From 4.3 ± 1.1 points at baseline to 1.7 ± 1.4 points at 12 months (9). Also, in the long term after 4 years there was a 42.9% significant improvement of QoL scores (10,11).

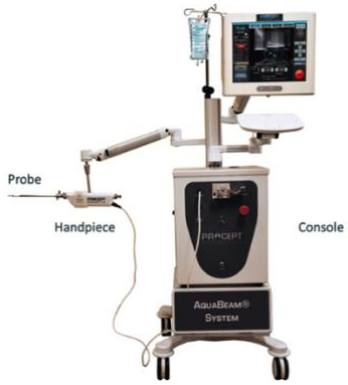
Tolerability and safety: Patients who received Rezūm water vapor therapy generally experienced mild, short-term adverse events. The most prevalent adverse events included urinary retention (33.8%), dysuria (21.5%), urinary urgency and suspected urinary tract infection (each 20%). Serious adverse events, such as hematuria (13.8%), were observed less frequently (9). Post-treatment, catheter-dependent patients experienced dysuria (25.9%), urinary retention (51.9%) and urinary tract infections (25.9%). No cases of sepsis were reported (12). A parallel study revealed comparable rates of dysuria (16.9%), hematuria (11.8%) and urinary retention (5.9%). However, the study also reported two adverse outcomes: one patient developed urosepsis and another patient experienced a bladder neck contracture following the treatment (10,11). The collective findings indicate that Rezūm water vapor therapy is generally safe, with only transient adverse effects being reported (9–12).

Practical considerations: The Rezūm vapor therapy is a minimally invasive, office-based procedure which uses convective water vapor energy to ablate excessive tissue of the prostate (11,12). Operation time is short with a mean of 4.4 to 13.0 minutes (12). Oral sedation or local anesthesia are sufficient for analgesia. Furthermore, Rezūm vapor therapy can be adapted to different morphologies of the prostate (10). For example, median lobe enlargement (11). It is appropriate for patients with prostate volume of 30-80 cc (10),(11),(12). Patient satisfaction was high, with over 90% of patients stating minimal regret after the treatment with the Rezūm system (12).

Recommendation:	**Level of Evidence:**	**Strength rating:**
Provides long-term improvements in LUTS, Qmax and QoL with a very good safety profile. Therefore, a suitable minimally invasive option.	Ia	Strong (Grade A)

6.4 Waterjet ablation therapy (Aquablation) (13,14)

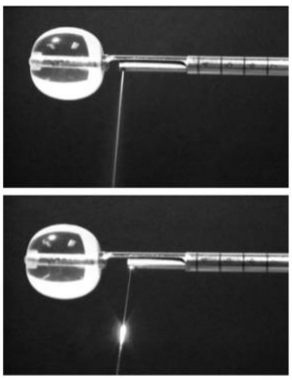
Aquablation is a surgical technique which uses AQUABEAM system consisting of a console, a robotic handset and a single-use probe.



AQUABEAM system, including console, handpiece and probe.

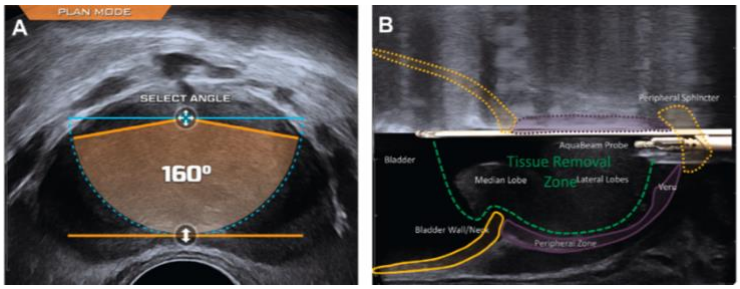
Figure 2: taken from the article “Aquablation of the Prostate for Symptomatic Benign Prostatic Hyperplasia: 1-Year Results” by Gilling P, Anderson P, Tan A., published in Journal of Urology on June 2017. (14)

The Aquablation procedure is performed under anesthesia. A 22-F rigid cystoscope is inserted through the urethra into the bladder. The plug is removed from the cystoscope so that the end of the shaft is flat against the bladder neck. The AQUABEAM handpiece is then inserted and removed again. The handpiece is inserted into the bladder through the shaft and a 15 mL balloon at the end of the device is filled with saline and withdrawn to the bladder neck to prevent the flow of fluid. The handpiece is then fixed to the prostate with an articulated arm. In addition, the transrectal ultrasound scan (TRUS) probe, which produces 2D images, is inserted into the rectum and positioned using a stepper.



Active AquaBeam probe in Aquablation mode (top) and AquaBeam probe in cauterization (waterjet-guided laser) mode (bottom).

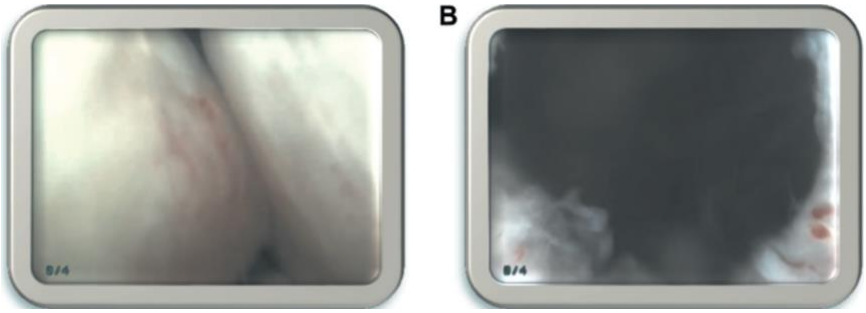
Figure 3: taken from the article “Aquablation - image-guided robot-assisted waterjet ablation of the prostate: initial clinical experience” by Gilling P, Reuther R, Kahokehr A, Fraundorfer M., published in BJU International on November 2015. (13)



TRUS image is integrated into AquaBeam console for surgical mapping of resection plane in transverse (A) and sagittal (B) views. Veru, Verumontanum.

Figure 4: taken from the article “Aquablation of the Prostate for Symptomatic Benign Prostatic Hyperplasia: 1-Year Results” by Gilling P, Anderson P, Tan A., published in Journal of Urology on June 2017. (14)

These TRUS images are required to recognize a prostate contour and mark the areas to be removed. Once the mapping procedure is complete, the Aquablation is started. Now the surgeon uses a foot pedal that activates a console to activate a pump. Once the pump is running, a high-speed jet of saline solution is generated at a 90-degree angle. The console also controls the rotational and longitudinal movements of the handset to precisely remove the prostate tissue according to the previously defined contours.



Cystoscopic view of the prostatic urethral lumen before (A) and after (B) Aquablation

Figure 5: taken from the article "Aquablation of the Prostate for Symptomatic Benign Prostatic Hyperplasia: 1-Year Results" by Gilling P, Anderson P, Tan A., published in Journal of Urology on June 2017. (14)

Efficacy: Aquablation and TURP are both effective in the treatment of lower urinary tract symptoms associated with BPH. Aquablation resulted in a significant decrease in the IPSS from 22.8 points at baseline to 6.8 points at 12 months (14), while TURP had a reduction from 22.2 points at baseline to 6.8 points at six months (15). At one year, Aquablation and TURP both resulted in a mean IPSS improvement to 15.1 points, a 93% improvement for Aquablation and an 87% improvement for TURP, this shows the similar efficacy of both methods (16). The long-term results of the WATER trial showed that the benefits were also present in the long-term, with Aquablation reaching a significantly higher IPSS reduction of 14.1 points and TURP a reduction of 10.8 points after five years (17). The improvement in Qmax was also significant with both techniques. Aquablation significantly increased Qmax from 9.4 mL/s to 20.3 mL/s after six months, while TURP increased Qmax from 9.1 mL/s to 18 mL/s in the same period (15). After one year, the two treatments resulted in similar Qmax increases, with Aquablation and TURP showing improvement from 10.3 mL/s to 52 mL/s and 10.6 mL/s to 63 mL/s after 12 months, respectively (16). However, TURP resulted in a significantly higher reduction in prostate volume (44% vs. 31%) and in a similar reduction in prostate-specific antigen (PSA) (36% vs 30%) at six months (15).
Tolerability and safety: Aquablation resulted in fewer complications of Clavien-Dindo Grade 2 or higher (13.3%) than with TURP (30%) (18). Over a five-year period, retreatment rates were lower with Aquablation (1.6%) than with TURP (3.1%). Aquablation has clear benefits in terms of

efficacy, especially with the preservation of sexual function. The rate of anejaculation was significantly lower with Aquablation (6-9%) in comparison to TURP (45%) 17),(18). However, Aquablation had a slightly higher incidence of postoperative bleeding (15.5% in comparison to 15.4% with TURP) (16). After one year, some complications were more common with Aquablation in comparison to TURP. Urinary retention was seen in 8.6% of Aquablation patients, which is greater than 6.2% seen in TURP patients (16). Aquablation was associated with fewer severe complications.

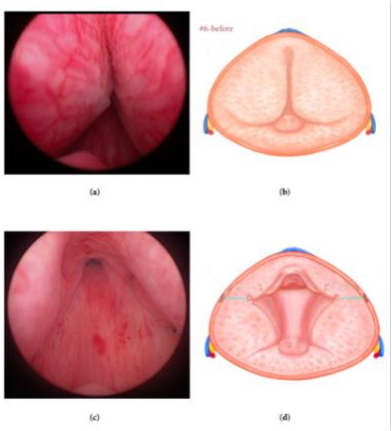
Practical considerations: Patients who want a shorter operation time and a faster recovery may benefit from Aquablation. The mean operative time for Aquablation was 27.6 minutes, which is significantly shorter than 37.4 minutes for TURP. Resection time was also significantly shorter for Aquablation (3.9 minutes compared to 29.8 minutes for TURP) (18). The length of hospital stay was similar for both treatments (on average 1.4 days) (15,18). For patients with a medium-sized prostate (30-80 mL), Aquablation is a good option especially for patients who value their ejaculatory function. TURP and Aquablation resulted in a similar PSA reduction (17). Both techniques improved QoL similarly at one year the mean improvement in QoL score was 3.2 points for Aquablation and 3.5 points for TURP (16).

Recommendation:	**Level of Evidence:**	**Strength rating:**
Provides symptom relief comparable to TURP with good safety, faster recovery and preservation of sexual function, especially in medium-sized prostates (30-80 mL)	Ia	Strong (Grade A)

6.5 Implanted devices (UroLift):

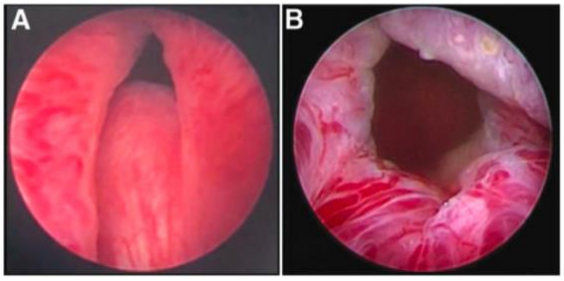
The Prostatic Urethral Lift (PUL) procedure is used to reduce the urethral stricture through the placement of UroLift implants. The prostate tissue is retracted to create a continuous channel through the prostate. In the beginning, a cystoscopy is performed to visualize and identify the prostate. This is an insertion instrument which is placed into the urethra through a 20-FR-protective sheath (19). The surgical sites are then identified, and the insertion instrument is positioned in an anterolateral direction. This allows the affected prostate lobe to be compressed. The UroLift implants are then positioned precisely in the prostate using a 19-gauge needle (20). The implant material consists of a monofilament and is cut to the size of the compressed lobe and then is attached to the urethra with a special end piece (21). Approximately four to six implants are inserted, depending on the size and shape of the prostate. This is necessary to fix the lateral lobe in the retracted position. In this way, a continuous canal through the prostate can be ensured (19). In Patients with an obstructive middle lobe (OML), the protruding tissue is retracted into the prostate

and attached to both sides of the urethra. So that the canal is widened through the prostate to the bladder neck without having to remove all of the protruding tissue (20).



The Prostatic Urethral Lift procedure. (a & b). Before treatment, the enlarged lateral lobes obstruct the urethra. (c & d) After transurethral delivery through a 19-gauge needle, the UroLift implants reshape the prostate to allow for a channel through the anterior aspect of the prostatic fossa.

Figure 6: taken from the article "'prostatic urethral lift' for the treatment of lower urinary tract symptoms secondary to benign prostatic hyperplasia" by Cantwell AL, Bogache WK, Richardson SF, Tutrone RF, Barkin J, Fagelson JE, Chin PT, Woo HH., published in BJU International on April 2014. (21)



Cystoscopic evaluation of median lobe obstruction (A) before and (B) after treatment with the PUL procedure utilizing the UroLift System. PUL = prostatic urethral lift.

Figure 7: taken from the article "Prostatic Urethral Lift for Obstructive Median Lobes: Consistent Results Across Controlled Trial and Real-World Settings" by Eure G, Rukstalis D, Roehrborn C., published in Journal of Endourology on January 2023. (20)

Efficacy: The prostatic urethral lift (PUL) was able to improve lower urinary tract symptoms (LUTS). In the multicenter crossover study, three months after PUL, the IPSS improved significantly higher by 11.1 points from baseline, while only improving by 5.0 points during the control period ($p < 0.001$) (21). During the crossover period, the Qmax improved equally by 2.4 mL/s in control and crossover period (21). In the MedLift study, in which patients with an obstructive middle lobe received PUL, the IPSS improved by 13.5 points at 12 months compared to baseline. This is a 55.1% reduction ($p < 0.0001$). Qmax increased by 6.4 mL/s ($p < 0.0001$) (22). When compared to TURP, PUL led to a significantly lower improvement in the IPSS. In the BPH6 study, PUL improved the IPSS by 11.4 points and TURP by 15.4 points after 12 months ($p = 0.02$) (23). TURP also led to a significantly higher improvement in Qmax. After 12 months TURP

reached an improvement of 13.7 mL/s, while PUL reached 4.0 mL/s ($p < 0.0001$) (23). Both PUL and TURP significantly improved IPSS over two years. PUL by 9.2 points and TURP by 15.3 points. TURP also had a greater improvement in Qmax at two years (24). PUL significantly improved QoL in a crossover study. It led to a 2.0 points improvement at 12 months ($p < 0.001$) (21). In the MedLift trial, PUL improved quality of life by 3.0 points at 12 months ($p < 0.0001$) (22). However, TURP led to a better improvement in QoL in the BPH6 study (24).

Tolerability and Safety: The main advantage of PUL is its tolerability and safety. Only one serious adverse event was reported in the crossover study. The most frequent adverse events were dysuria (35.8%) and hematuria (26.4%). However, they were self-limited (21). Urinary urgency (7.5%) was reported less frequently. No cases of erectile dysfunction or retrograde ejaculation were reported (21). PUL did not produce a significant reduction in PVR after 3 months. Only an insignificant reduction of 13.2 mL ($p = 0.241$) (21). In a comparative study, TURP reduced the PVR by 42.5 mL after 24 months significantly, whereas PUL did not significantly reduced the PVR by 10.6 mL (24). However, with regard to ejaculatory function, 100% of patients treated with PUL maintained ejaculatory function after 12 months, compared to only 61% in the TURP group. This demonstrates that treatment with PUL leads to significantly better preservation of ejaculatory function ($p < 0.0001$) (23). The difference in preservation of erectile function was less pronounced and not significant. 97% in the PUL group compared to 94% in the TURP group maintained erectile function ($p = 0.6$) (23). The L.I.F.T study showed that the maintenance of ejaculatory function after PUL treatment seems to be long-term. According to the MSHQ-Bother score, 27% of patients had a reduction on ejaculation-related discomfort after 3 years. The male sexual health questionnaire (MSHQ-EjD) score continued to improve as well. 36% of patients had a significant improvement after three months and 9% after three years (25).

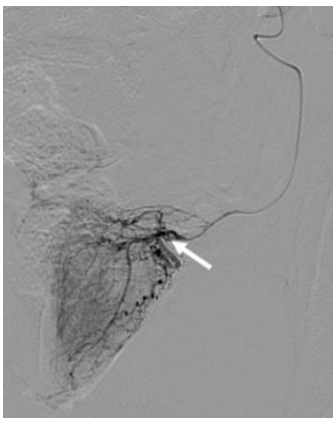
Practical considerations: The BPH6 study demonstrated a significantly higher average recovery improvement visual analog scale (VAS) of 82% in PUL patients after one month as opposed to 53% in TURP patients ($p = 0.008$) (23). Also, PUL does not require general anesthesia, which makes it a good option for patients with significant comorbidities (21). The MedLift study compared PUL with middle lobe obstruction and PUL with lateral lobe obstruction. It showed that more implants were needed for middle lobe obstruction with an average of 6.3 implants compared to 5.1 implants for lateral lobe obstruction ($p = 0.0005$) (22). PUL also did not need any re-intervention for adverse events <30 days, while in TURP group 6% needed re-intervention due to adverse events (23). In delayed (>30 days) stage, 7% in PUL group needed re-intervention due to return of LUTS (3 patients), while 9% in TURP needed re-intervention due to urethral stricture (1 patients) and return of LUTS (2 patients).

Recommendation:	Level of Evidence:	Strength rating:
An effective minimally invasive option that provides significant symptom relief, rapid recovery and preservation of sexual function, with efficacy comparable to TURP.	Ia	Strong (Grade A)

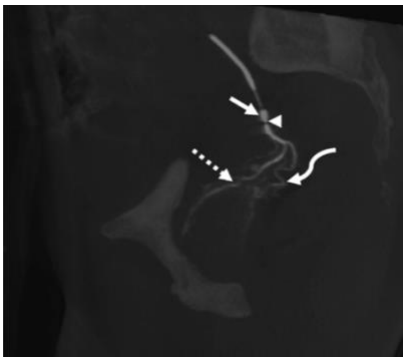
6.6 Prostate artery embolization:

Before prostatic artery embolization (PAE), a transurethral 16-French catheter is inserted to support imaging in all patients (26). Using local anesthesia, a femoral sheath is introduced into the right femoral artery (27). Selective arteriography of the internal iliac artery with a 5-French catheter is then carried out to identify the prostatic arteries. If anatomical features are present, the external iliac artery and its branches are also visualized (26,27). Microcatheters (1.9-3 F) are used to selectively target the prostate arteries and embolize them with 250-400µm microspheres (26),(27),(28). The aim of embolization is to completely cut off the blood supply to the prostate, which is confirmed on angiography by the absence of blood flow. If there are difficult anatomical conditions, a cone beam computerized tomography (CT) is used to prevent misplacement of the microspheres (26,28). The embolization is usually performed on both sides if possible.

Removal of the transurethral catheter is done the morning after the procedure is done (26,27).



Digital subtraction angiography in posteroanterior view with microcatheter tip (arrow) advanced as distally as possible inside the left prostatic artery into the intraprostatic branches.



Oblique sagittal reformat of cone-beam CT depicting the balloon occlusion microcatheter tip placed in the middle third of the left prostatic artery (arrowhead). Note the inflated occlusion balloon (arrow) proximal to the micro-catheter tip. Central gland prostatic artery branch (dashed arrow) and peripheral gland prostatic branch (curved arrow) are also seen.

Figure 8 + 9: taken from the article “Randomized Clinical Trial of Balloon Occlusion versus Conventional Microcatheter Prostatic Artery Embolization for Benign Prostatic Hyperplasia” by Bilhim T, Costa NV, Torres D, Pisco J, Carmo S, Oliveira AG., published in Journal of Vascular and Interventional Radiology on October 2019. (29)

Efficacy: Studies have demonstrated that TURP is superior to PAE (conventional microcatheter prostatic artery embolization (cPAE) and balloon occlusion prostatic artery embolization (bPAE)) in terms of improving the primary symptoms of benign prostate hyperplasia. TURP resulted in a higher improvement in the IPSS score from 17.59 points to 6.82 points, compared to 19.38 points to 10.15 points with PAE. TURP improved PVR from 230.7 mL to 33.7 mL after 12 weeks, while 169 to 70.3 mL after 12 weeks achieved with PAE. In addition, the prostate volume was reduced from 56 mL to 27.16 mL with TURP and a reduction with PAE from 52.8 mL to 40.67 mL in the same study (26). In another study, an improvement in IPSS of 20.0 points at baseline to 12.5 points at follow up was observed with cPAE and a change of 20.6 points to 12.3 points with bPAE (29). TURP also showed a greater improvement in Qmax, which after two years was 17.9 mL/s in comparison to 11.6 mL/s with PAE (28). All in all, TURP provided more rapid and longer-lasting symptom relief when compared to PAE (26,28,29).

Tolerability and safety: PAE was safer with fewer serious complications than TURP. In comparison to TURP, PAE resulted in less cases of mild (3 PAE vs. 9 TURP) and severe hematuria (1 PAE vs. 2 TURP) and fewer serious adverse events such as ejaculatory dysfunction (14 PAE vs. 21 TURP) (26). Less patients in the PAE group had urinary tract infections (UTI) (n = 14) than in the TURP group (n = 19). The same was true for postoperative discomfort, irritation and pain which was experienced by 16 patients in the PAE group and 29 in the TURP group. However, 21% of patients in the PAE group needed TURP two years because there was not enough symptom improvement or recurrence (28). The safety profile of cPAE and bPAE were quite similar, however, bPAE had slightly lesser complications, such as penile skin lesions (3 cPAE vs. 0 bPAE) and rectal bleeding (2 cPAE vs. 0 bPAE) (29). Strictures and urinary retention happened more often in the TURP group, than in the PAE group. For strictures, it were 2 in the TURP and 0 in the PAE group and for urinary retention it were 3 in the TURP group and 1 in the PAE group (26). Altogether, these results indicated that PAE is a safer alternative for patients who are concerned about surgical complications (26,28,29).

Practical considerations: PAE is less invasive than TURP. It does not require general anesthesia. This makes it a good option for elderly or high-risk patients. Research has also reported shorter hospital admissions with PAE, with an average of 2.2 days in comparison to 4.2 days with TURP (26). Also, PAE has been associated with less blood loss during the procedure (30). However, PAE

is more procedurally time-consuming with a mean procedure time of 122.2 minutes opposed to 69.5 minutes for TURP (26). PAE requires special equipment and trained radiologists. This means that it cannot be performed in all hospitals or clinics (30). TURP is a procedure that is widely available.

Recommendation:	**Level of Evidence:**	**Strength rating:**
The procedure is safer and less invasive. Therefore, a good option for patients with a higher surgical risk or for patients who want a faster recovery. A disadvantage of this procedure is poorer long-term efficacy than TURP.	Ia	Conditional (Grade B)

6.7 VAPORIZATION:

6.7.1 Photoselective Vaporization (Green Light Vaporization):

For the procedure a 23 F laser cystoscope, which has a 30° lens, is used. The power of the laser can be changed. For vaporization either 120 Watt for the GL-HPS system is used or 180 Watt for the GL-XPS system. For coagulation 30 Watt is used. Saline solution is used for irrigation to keep the field of view clear and to clean up the operating field. Laser fibers are replaceable in case they are damages (31). Initially, a laser fiber, which fires laterally at 80 Watt, is moved back and forth between the bladder neck and the area next to the verumontanum to create a working channel up to the capsule. This leads to partial enucleation of the adenoma, which remains attached anteriorly for reasons of stability. Then, the power is increased to 180 Watt and by using vapo-enucleation the operator inserts the endoscope through the space created under the lateral lobe. First, the lateral lobes are ablated at the 3 and 9 o`clock positions. Then, at 12 o`clock the adenoma is further reduced. In case of a pronounced middle lobe, the working channel is created beginning at the deepest point of the bladder neck which is usually at 5 or 7 o`clock. First the lateral lobe is removed and then the middle lobe is enucleated. During this process, the tissue is detached from the capsule. Finally, the apical tissue is vaporized (32). After surgery, the patient is catheterized for six hours. If the patient still cannot urinate after that time, the catheter is placed again and another try is done the next day (31).

Efficacy: The IPSS improved from 25 points to 5 points within 1 month and slightly increased to 6 points again after 24 months in the TURP group. In the PVP group, the baseline IPSS was 22 points and improved to 7 points within 1 month and remained the same after 24 months (33). Qmax improved in both the TURP and the PVP group. In the TURP group baseline was 6.4 mL/s and after 12 months it rose to 18.0 mL/s. After 24 months it further increased to 18.6 mL/s. In the PVP group, there was also an increase from 10 mL/s at baseline to 22.2 mL/s after 12 months. However, after 24 months there was a slight decrease to 20.5 mL/s (33). In another study at 6 months follow

up, IPSS improved from 25.4 points to 6.2 points with the HPS laser system and from 24.2 points to 6.4 points with the XPS laser system. Qmax increased from 7.2 mL/s to 18.4 mL/s with the HPS laser system and from 7.0 mL/s to 23.2 mL/s with the XPS laser system (31). In another comparison, which was categorized by prostate size, patients with a prostate size of 20-50 cc had an IPSS of 7.25 points after M-TURP, 7.11 points after B-TURP and 7.23 points after PVP at 12 months follow-up with no significance. Qmax reached 21.64 mL/s, 21.70 mL/s and 22.49 mL/s respectively. Patients with a prostate size of 50-80 cc had IPSS scores of 6.90 points after M-TURP, 6.76 points after B-TURP and 6.82 points after PVP at 12 months also not significant changes between the groups. The Qmax reached 16.42 mL/s, 18.02 mL/s and 16.97 mL/s, respectively (34). QoL improved with a decrease in the mean score from 4.8 points in the HPS group and 4.5 points in the XPS group preoperatively to 1.1 points and 1.3 points at 6 months (31). The PVR volume decreased significantly from the mean values of 177 mL in the TURP group and 150 mL in the PVP group preoperatively to 2.5 mL and 2 mL respectively at 12 months but increased to 6 mL and 4 mL at 24 months (33). When considering HPS and XPS laser system, the PVR volume decreased from 280 mL versus 308 mL preoperatively to 39.3 mL versus 5 mL postoperatively at 6 months with no significant difference between those procedures (31).

Tolerability and safety: No blood transfusions were required in either group, while bladder irrigation was only necessary in the TURP group (33). A 30-day complication rate of persistent hematuria in 18% of cases and urinary retention in 16% of cases was reported with HPS laser system, while hematuria was reported in 12% and urinary retention in 6% of cases with the XPS laser system (31). The frequency of blood transfusion in the 50-80 cc group was 19.35% for M-TURP, 3.70% for B-TURP and 0% for PVP. Other complications such as TUR syndrome happened rarely in M-TURP and were absent in B-TURP and PVP. Clot formation happened in 16.12% for M-TURP and 7.40% in B-TURP and none for PVP. In total, complications happened in 26/60 of M-TURP patients, in 17/57 of B-TURP patients and in 16/58 of PVP patients (34). Erectile function measures with the International Index of Erectile Function (IIEF-5) remained stable in both groups both pre- and postoperatively with mean values around (33). The number of re-treatments was minimal, only 1% of patients with HPS laser technology required re-treatment compared to 0% with XPS laser system (31).

Practical considerations: While TURP had a shorter operation time of 40 minutes on average than PVP with 45 minutes on average, PVP had shorter catheterization and hospitalization times with 48 hours compared to 72 hours after TURP (33). While HPS system had an operation time of 79 minutes, the XPS system had a shorter operation time of 43 minutes. Also, the total laser application time was shorter in the XPS group with 22 minutes than in the HPS group with 37 minutes (31). The hospitalization time was shorter in the XPS group as well with 0.3 days, while it

was 1.5 days in the HPS group. The laser fiber use was 1.5 in HPS group and 1.0 in XPS group per procedure. All these results are significant (31). For prostate sizes of 20-50 cc, an operation time of 32.34 minutes was required for M-TURP, B-TURP required a slightly longer operation time of 32.53 minutes, as well as PVP with 45.62 minutes. For 50-80 cc prostates it was 58.25, 61.03 and 72.58 minutes for the three techniques, with PVP having a postoperative catheterization time of around 24 hours, M-TURP and B-TURP around 33 hours. For prostate sizes of 50-80 cc catheterization time was around 40 hours in B-TURP, 37 hours in M-TURP and 24 hours in PVP (34).

Recommendation:	**Level of Evidence:**	**Strength rating:**
The long-term improvement in symptoms is similar to TURP. The advantages are less blood loss and shorter catheterization, as well as a shorter hospital stay. However, with longer operation times for larger prostates.	Ia	Strong (Grade A)

6.7.2 Diode Laser Vaporization:

An Evolve 980 diode laser system is used for this procedure. It has a wavelength of 980 nm and a maximum power of 120 Watt. To vaporize tissue without direct contact, a flexible 600 mm laterally firing laser fiber is used. A 24F laser cystoscope which has a 30° lens is used and continuously flushed with saline solution to keep the field of view clean (35). In the beginning of the procedure the laser fiber is pushed through the cystoscope and the bladder is filled with a 0.9% saline solution (35,36). Vaporization starts at the bladder neck and continues along the lateral lobes in the area between the 1 and 11 o`clock positions (35). To prevent damage to the sensitive areas, such as the bladder neck or the sphincter area, the power of the laser is reduced to 80 watt there (35,36). Also, in these sensitive areas, the continuous mode of the laser is switched to pulse mode. This increases the precision and is gentler on the sensitive tissue (35). When the cavity is expanded, the power is increased to 120 watt again, which allows effective and rapid tissue ablation (36). To avoid direct contact and effective vaporization the tip of the laser fiber is kept at least 0.5 mm from the tissue. Mostly, the reflected laser beam is enough to vaporize the upper fibromuscular stroma. Larger glands might need more intensive treatment (35). Occurring bleeding can be stopped with the laser beam. After the lateral lobes have been treated sufficiently, the middle lobe, if it is present, is vaporized. The goal of the procedure is to create a channel, like during TURP, which is wide enough to allow urinary passage. To provide post-operative bladder decompression, a urinary catheter is placed at the end of the procedure (36).

Efficacy: Regarding the IPSS, after 3 months, TURP resulted in a significant improvement from the baseline value of 21.36±4.81 points to 8.31±3.32 points. Diode laser treatment also resulted in a

similar significant improvement from 22.6±5.23 points to 8.38±2.89 points (35). In another study with a 24-month follow-up period, TURP resulted in a significant improvement in IPSS from the baseline value of 24.6±6.3 points to 7.7±2.5 points. Diode laser treatment resulted in a significant improvement from 23.6±7.3 points to 10.4±8.7 points as well (36). Regarding Qmax, after 3 months, TURP resulted in a significant improvement from the baseline value of 8.41±4.50 mL/s to 18.5±3.99 mL/s. Diode laser treatment resulted in a significant improvement from 9.63±3.18 mL/s to 16.34±6.9 mL/s as well. Each group improved significantly (35). In another study with a 24-month follow-up period, TURP resulted in an improvement of Qmax from the baseline value of 6.3±1.7 mL/s to 21.1±2.6 mL/s. Diode laser treatment resulted in an improvement from 6.8±2.5 mL/s to 18.5±2.2 mL/s as well. These results differ significantly between both groups (36). Regarding QoL, after 3 months, TURP resulted in a significant improvement from the baseline value of 4.84±0.89 points to 1.43±0.75 points. Diode laser treatment resulted in a significant improvement from 4.44±1.21 points to 1.34±0.61 points as well (35). Regarding PVR volume, after 24 months, TURP resulted in a non-significant reduction from the baseline value of 61.6±63.3 mL to 23.4±16.2mL. Diode laser treatment resulted in a non-significant reduction from 57.2±59.7 mL to 25.4±20.2 mL, there weren't any significant changes seen (36).

Tolerability and safety: Complication rates are generally low and one analysis reported the TURP group experienced 1 capsule perforation, 1 case of TUR syndrome and 1 hemorrhagic event requiring blood transfusion, for a total of 3 complications, while the diode laser group experienced 1 case of urinary retention requiring retreatment, 1 hemorrhagic event leading to conversion to TURP, and no capsule perforation, for a total of 2 complications (35). In another analysis, intraoperative complications of TURP included blood transfusion in 4 patients (7.7%), capsule perforation in 3 patients (5.7%) and TUR syndrome in 2 patients (3.8%), while none of these complications occurred in the diode laser group (36). Early postoperative complications revealed blood clot retention in 7 patients (13.4%) undergoing TURP compared to 1 patient (2%) undergoing diode laser vaporization, recurrent catheterization in 2 patients (3.8%) undergoing TURP compared to 4 patients (8%) undergoing diode laser vaporization and urge incontinence in 2 patients (3.8%) undergoing TURP compared to 4 (8%) undergoing diode laser vaporization (36). Late postoperative complications in TURP included repeat TURP in 1 patient (1.9%), urethral stricture in 2 patients (3.8%), bladder neck stricture in 1 patient (1.9%) and new sexual dysfunction in 2 patients (3.8%), while in the diode laser group no cases of urethral strictures, bladder neck strictures or new sexual dysfunctions were reported and repeat TURP was required in 4 patients (8%). All these results are not significant (36).

Practical considerations: The operation time in the first study was 74.7±25.6 minutes for TURP and 82.6±30.4 minutes for diode laser vaporization (35), while in the second study it was 54.9±15.3 minutes for TURP and 60.6±22.6 minutes for diode laser vaporization with no significance (36). The catheterization time was significant for TURP with 2.63±0.49 days and diode laser vaporization with 1.45±0.75 days and the hospital stay was 2.81±0.58 days in TURP vs. 1.58±0.64 days in diode laser with both p-values <0.01 (35). In the second study, the hospital stay was 59.9±14.4 hours for TURP compared to 25.8±9.2 hours for the diode laser group and the catheterization time was 88.9±22.5 hours for TURP to 20.1±4.6 hours for diode laser group with a p-value of both p = 0.0001. TURP led to a significant reduction in hemoglobin levels (p = 0.002) (36).

Recommendation:	**Level of Evidence:**	**Strength rating:**
Offers effective improvement in symptoms and urodynamics with faster postoperative recovery and less intraoperative complications. This makes it a safe option for selected patients.	Ia	Strong (Grade A)

6.7.3 Bipolar Vaporization:

Efficacy: Regarding IPSS, bipolar transurethral vaporization (B-TUVP) resulted in a significant improvement from the baseline value of 26.36±1.96 points to 2.56±2.58 points. Bipolar TURP resulted in a significant improvement from 26.04±3.02 points to 5.49±3.40 points as well. P <0.001 for both groups and in comparison with these techniques (37). In another study with a 9-month follow-up period, bipolar vaporization resulted in an improvement in IPSS from the baseline value of 19.1±1.2 points to 6.9±1.1 points. Bipolar loop resection resulted in a not significant better improvement from 19.9±1.4 points to 5.2±1.3 points (38). During 6 months follow-up period bipolar plasma vaporization (BPVP) resulted in a significant better IPSS score of 4.2 points for continuous bipolar plasma vaporization (C-BPVP) and 4.4 points for standard bipolar plasma vaporization (S-BPVP) than TURP with 7.5 points (p <0.001) (39). Another study with an 18-month follow-up period showed similar results. BPVP resulted in a significantly lower IPSS score of 5.0 points than TURP with 8.3 points (p <0.0001) (40). Regarding Qmax, B-TUVP resulted in a significant improvement from the baseline value of 8.48±1.04 mL/s to 23.23±1.08 mL/s. Bipolar TURP resulted in a significant improvement from 8.22±1.21 mL/s to 20.79±1.47 mL/s as well. P <0.001 for both groups (37). In another study with a 9-month follow-up period, bipolar vaporization resulted in a non-significant improvement of Qmax to 17.2±6.1 mL/s at 1 month and 18.3±2.1 mL/s at 9 months. Bipolar loop resection resulted in a not significant better improvement to 18.1±7.2

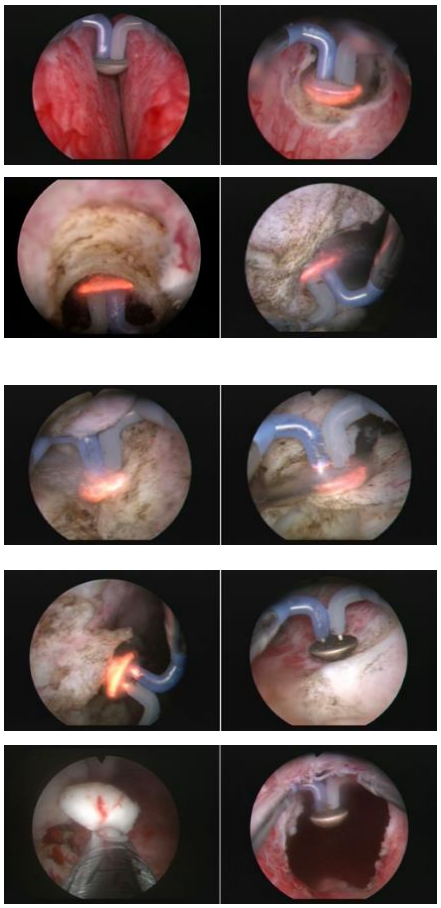
mL/s at 1 month and 19.1±1.3 mL/s at 9 months (38). BPVP resulted in a significantly higher Qmax of 24.8 mL/s at 1 month and 23.7 mL/s at 18 months than TURP with a Qmax of 20.9 mL/s at 1 months and 20.2 mL/s at 18 months (p = 0.0001). Both techniques have significant difference in favor for BPVP (40). Regarding PVR volume, after a 6-month follow-up period, C-BPVP resulted in an improvement from 113 mL baseline to 22.8mL. S-BPVP resulted in an improvement from 94 mL to 21.4mL. TURP resulted in an improvement from 107 mL to 20.9mL. No group was significantly better than the other (39).

Tolerability and safety: In one study, B-TUVP resulted in a significantly lower hemoglobin drop of 0.53±0.29 g/dL than bipolar TURP with a hemoglobin drop of 1.39±0.45 g/dL (p <0.001) (37). In another study, bipolar vaporization resulted in a significantly lower hemoglobin drop of 0.8% than bipolar loop resection with a hemoglobin drop of 1.96% (p <0.001) (38). However, vaporization resulted in a significantly higher incidence of postoperative irritative symptoms than loop resection. 80% at 1 months and 29% at 9 months in vaporization in comparison to 50% at 1 month and 2% at 9 months after loop resection (p <0.001) (38). Also, the incidence of urethral strictures was significantly higher after bipolar vaporization. 11% at 6 months in comparison to none at 6 months after loop resection (p <0.001) (38). C-BPVP resulted in a significantly lower rate of capsular perforation than TURP. 1.7% with B-BPVP and 10% with TURP (p = 0.037). Furthermore, the hemoglobin drop was significantly lower after C-BPVP. 0.4 g/dL after C-BPVP in comparison to 1.4 g/dL after TURP (p <0.001) (39). In the long-term, compared to TURP, BPVP resulted in a significantly lower incidence of postoperative hematuria (2.9% vs. 15.3%, p = 0.0001), fewer blood transfusions (1.2% vs. 6.5%, p = 0.009), lower clot retention (0.6% vs. 4.1%, p = 0.042) and lower rates of re-catheterization (1.8% vs. 7.1%, p = 0.024) (40). Also, after BPVP, there were significantly less cases of the TURP syndrome (0%) than after TURP (1.8%) (p = 0.049) (40). Regarding re-catheterization, B-TUVP had a higher rate of 5.1% than bipolar TURP with 0%. Also, the repeat surgery rate was not significantly higher after TUVP with 2.6% than after TURP with 0% (37). In contrast, readmission rate to the hospital was not significantly higher after TURP with 4.1% than after TUVP with 2.6% (37).

Practical considerations: In one study, B-TUVP had a significantly shorter operation time of 25.92±2.36 minutes than bipolar TURP with 32.63±2.87 minutes (p <0.001). Also, the hospital stay was significantly shorter after B-TUVP with 1.89±0.38 days than after bipolar TURP with 2.10±0.51 days (p = 0.047). Furthermore, catheterization time was significantly shorter after B-TUVP with 4.12±0.33 days than after bipolar TURP with 4.77±0.42 days (p <0.001) (37). In contrast, in another study, the operation time was significantly longer for bipolar vaporization with 81.4±15.3 minutes than for bipolar loop resection with 55.5±9.8 minutes (p <0.001) (38).

Recommendation:	Level of Evidence:	Strength rating:
Relieves symptoms permanently and has less blood loss and a lower complication rate compared to TURP. However, the technique-specific risk should be considered.	Ia	Strong (Grade A)

6.8 Enucleation:



Cysto-urethroscopic assessment of BPH formation and Median lobe enucleation by 5 and 7 o`clock incision.

Lateral lobes separation by 12 o´clock incision and Descendant enucleation from the 1 and 11 o´clock Position.

Ascendant enucleation from the 5 and 7 o´clock incisions and gradual detachment of the lateral lobes.

Plasma vaporization of the remaining adenoma tissue and coagulation of the hemorrhagic sources.

BPH tissue morcellation under a clear endoscopic vision and large prostatic fossa at the end of the procedure.

Figure 10-15: taken from the article “Bipolar plasma enucleation of the prostate vs open prostatectomy in large benign prostatic hyperplasia cases - a medium term, prospective, randomized comparison” by Geavlete B, Stanescu F, Iacoboaie C, Geavlete P., published in BJU International on March 2013. (41)

6.8.1 Holmium Laser Enucleation:

Efficacy: Both Holmium laser enucleation of the prostate (HoLEP) and TURP improved IPSS, QoL, Qmax, PVR and PSA levels in patients with BPH. At 12 months, the AUA symptom score was comparably improved in both groups, with a score of 4.6 ± 0.7 for HoLEP and 4.7 ± 0.9 for TURP, but at 92 months the score degraded to 8.0 ± 5.20 points for HoLEP and 10.3 ± 7.42 points for TURP (42). QoL scores also improved, with HoLEP and TURP patients indicating scores

ranging from 4.8 ± 0.2 points to 1.25±0.2 points versus 4.7 ± 0.2 points to 1.25 ± 0.2 points (43). Qmax was significantly higher in HoLEP patients, with rates varying from 8.4 ± 0.5 mL/s to 21.0 ± 2.0 mL/s at 24 months in comparison to 8.3 ± 0.4 mL/s to 19.3 ± 2.2 mL/s in TURP patients (43). PVR was less in HoLEP patients at 6 months (33.7 ± 5.5 mL) than TURP patients (51.8 ± 14.5 mL) (43). In addition, the decrease in prostate volume on TRUS examination was higher in the HoLEP group, from 77.8 ± 5.6 mL to 28.4 ± 1.8 mL at 6 months, compared to 70.0 ± 5.0 mL to 46.6 ± 4.4 mL in the TURP group (43). Long-term durability was improved with HoLEP, with fewer cases of recurrent BPH requiring intervention after 7 years (0 with HoLEP compared to 3 with TURP) (42).

Tolerability and safety: While both procedures were well tolerated, HoLEP had a lower complication rate compared to TURP. The blood transfusion rate was less in HoLEP patients (0) than in TURP patients (2), which can be explained by the better hemostatic properties of the laser (44). After 24 months, stricture formation was less in HoLEP (1 case) than in TURP (3 cases) (43), and the rate of re-catheterization was higher in the TURP group (9 cases in HoLEP, 16 cases in TURP) (44). Postoperative bladder irrigation was required in 70% of TURP patients, but only in 6.7% of HoLEP patients, pointing to better intraoperative hemostasis in HoLEP (42). Postoperative stress urinary incontinence was lower with TURP (0 cases) than with HoLEP (4 cases), while urge incontinence was more pronounced in the TURP group (5 cases) than in the HoLEP group (0 cases) (44).

Practical considerations: Operative time was significantly prolonged for HoLEP with 96.17 ± 24.86 minutes compared to 81.25 ± 11.85 minutes for TURP (44). However, HoLEP required significantly shorter catheterization time of 17.7 ± 0.7 hours versus 44.9 ± 10.1 hours for TURP, $p < 0.01$), and the hospital stay was significantly shorter for HoLEP as well (27.6 ± 2.7 hours versus 49.9 ± 5.6 hours for TURP, $p < 0.001$) (42). Also, HoLEP provided better maintenance of erectile function compared to TURP as measured by the international index of erectile function (IIEF) (11.6 ± 7.46 points vs. 9.21 ± 7.17 points) (42).

Recommendation:	**Level of Evidence:**	**Strength rating:**
Recommended due to better hemostasis, lower reoperation rates and better preservation of erectile function.	Ia	Strong (Grade A)

6.8.2 Thulium Laser Enucleation:

Efficacy: At follow-up, both HoLEP and thulium laser enucleation of the prostate (ThuLEP) showed improvements in IPSS, QoL, Qmax, PVR and PSA values. At 12 months, IPSS reduction was the same between these techniques, with a mean between 17.9 ± 6.95 points and 7.34 ± 5.43

points for HoLEP and between 18.2 ± 7.31 points and 6.81 ± 4.92 points for ThuLEP, with no statistically significant difference (p = 0.21) (45). Qmax was slightly greater in the ThuLEP group at both 3 and 12 months, with values of 26.12 ± 7.76 mL/s for ThuLEP compared to 19.43 ± 12.56 mL/s for HoLEP at 12 months, although this did not reach statistical significance (p = 0.08) (45). PVR also reduced in both groups, with HoLEP patients reporting a mean PVR of 31.9 ± 20.35 mL, while ThuLEP patients has 42.1 ± 18.99 mL at 12 months, with no significant difference between the groups (p = 0.11) (45). In both techniques, there were improvements in QoL, with HoLEP patients achieving a mean of 45.6 ± 11.59 points and ThuLEP patients 43.6 ± 12.49 points, with no significant difference at 12 months (p = 0.17) (45). PSA levels also dropped comparably in both groups, pointing towards effective removal of the prostate tissue: HoLEP patients had a postoperative PSA level of 1.7 ± 2.45 ng/dL at 12 months versus 1.3 ± 2.41 ng/dL in ThuLEP patients (p = 0.12) (45).

Tolerability and safety: For both procedures complication rates were low and long-term outcomes stable. However, ThuLEP had a better hemostatic profile, which was shown by the significantly lower rate of blood transfusion in the ThuLEP group (1.7%) in comparison to the HoLEP group (6.6%) (p = 0.03) (45). Similarly, another study recorded significantly lower intraoperative blood loss in ThuLEP (130.1 ± 20.3 mL) as compared to HoLEP (166.6 ± 17.1 mL, p = 0.045), reinforcing the improved hemostasis (46). Postoperative urinary retention was less frequent in ThuLEP group (6.1%) in comparison to the HoLEP group (10.7%, p = 0.04) (45). The incidence of stress incontinence was also significantly lower in ThuLEP group, affecting only 1.7%, while 7.4% in the HoLEP group were affected (p = 0.03) (45). One patient in the HoLEP group had temporary incontinence, which disappeared after pelvic floor muscle training, while no patient in the ThuLEP group experienced this (46). Hemoglobin decrease was significantly higher in the HoLEP group (2.77 ± 1.23 g/dL) in comparison to the ThuLEP group (0.45 ± 1.78 g/dL) (p = 0.005).This points towards a superior hemostatic profile of ThuLEP (45). Major electrolyte disturbances happened in neither of the procedures (46).

Practical considerations: ThuLEP had a significantly shorter operation time (72.4 ± 19.4 minutes) than HoLEP (61.5 ± 20.2 minutes) (p = 0.034) (46). Catheterization time was nearly the same for both methods, with HoLEP requiring an average of 2.5 ± 1.0 days compared to 2.4 ± 1.0 days in ThuLEP (p = 0.118) (46). One patient in both groups required re-catheterization for additional three days (46). Patients in the HoLEP group spent on average 2.8 ± 3.89 days, while ThuLEP patients spent on average of 2.2 ± 4.05 days in the hospital. This difference is not statistically significant (p = 0.316) (45).

Recommendation:	Level of Evidence:	Strength rating:
Leads to comparable long-term results with better hemostasis than HoLEP and is therefore more appropriate for patients with a higher risk of bleeding.	Ia	Strong (Grade A)

6.9 Transurethral resection of the prostate (TURP):

Efficacy: Regarding IPSS, bipolar TURP resulted in a not significantly better improvement from 18.8 points at baseline to 10.3 points at the end of the follow-up period of 12 months than monopolar TURP with an improvement from 18.5 points to 10.8 points (47). In another study, with a 36-month follow-up period, bipolar TURP resulted in a significant improvement of QoL from 3.3 points to 0.5 points. M-TURP led to a significant improvement from 3.0 points to 1.0 points as well (48). Regarding Qmax, B-TURP resulted in a significantly higher improvement from 7.2 mL/s to 17.1 mL/s than M-TURP with an improvement from 8.0 mL/s to 16.3 mL/s after 12 months (47). PVR decreased significantly in B-TURP and M-TURP with no technique being significantly better (47). Looking at the long-term improvement of IPSS, B-TURP resulted in a significantly improvement to 2.0 points at 36 months. M-TURP resulted in a significant improvement to 4.0 points as well. No technique was significantly better than the other (48). At 36 months, QoL improved to 0.5 points for B-TURP and 1.0 points for M-TURP (48). Regarding long-term improvements of Qmax, B-TURP resulted in a significant improvement to 23.0 mL/s and M-TURP resulted in a significant improvement to 20.0 mL/s after 36 months as (48). There was no significant difference in long-term QoL or Qmax improvements between B-TURP and M-TURP (47).

Tolerability and safety: After B-TURP, not significantly less blood transfusions were needed with a transfusion rate of 2.1% than after M-TURP after which transfusion rate was 5.6% (47). However, the TUR syndrome happened in no cases after bipolar TURP but in 1.4% of cases after M-TURP (47). Regarding urinary incontinence, B-TURP resulted in a similar amount of cases (5 cases) as M-TURP (6 cases). All cases resolved within 6 months (47). B-TURP resulted in a not significantly higher incidence of complications like urethral strictures or bladder neck contracture than M-TURP with 6.3% after B-TURP and 4.6% after M-TURP (47). Re-catheterization due to clot retention was needed slightly less frequently after B-TURP with 1 case than after M-TURP with 2 cases (47). Blood loss was significantly lower after B-TURP than after M-TURP (48). Erectile function was impaired in both groups, worsening in 17.0% of patients overall. However it improved in 14.3% of patients with pre-existing erectile dysfunction again (47).

Practical considerations: B-TURP had a significantly shorter operation time of 54.0 minutes versus 58.7 minutes for M-TURP (47). The re-catheterization time was also slightly shorter with B-

TURP with 2.4 days compared to M-TURP with 2.6 days (47). The hospital stay was slightly briefer with B-TURP with 2.5 days than with M-TURP with 2.7 days (47). At long-term follow-up, B- TURP continued to demonstrate advantages in terms of hospital stay and catheterization time, underlining its advantages over M-TURP (48).

Recommendation:	**Level of Evidence:**	**Strength rating:**
Still the gold standard for small prostates (<80 mL) with superior symptom relief and prostate volume reduction	Ia	Strong (Grade A)
Bipolar TURP is a safer to monopolar TURP with a lower risk of TUR-syndrome, less blood loss, shorter catheterization times and better long-term urination results.	Ia	Strong (Grade A)

6.10 Plasmakinetic resection (PKRP):

Efficacy: In a study with a 12-month follow-up, plasmakinetic TURP (PKRP) resulted in an improvement of IPSS from the baseline value of 23.8 points to 7.4 points. M-TURP resulted in a similar IPSS score by improving it from 24.7 points to 9.7 points (49). In the same study, PKRP resulted in an improvement of QoL from the baseline value of 4.8 points to 1.5 points at 12 months. M-TURP resulted in a significantly better QoL by improving it from 5.2 points to 2.4 points (49). Qmax improved from 9.3 mL/s at baseline to 19.2 mL/s after PKRP and to a similar level from 10.9 mL/s at baseline to 21.2 mL/s after M-TURP (49). Regarding PVR volume, PKRP lowered it from 93.1 mL to 8.3 mL while M-TURP lowered it to a similar level from 60.6 mL to 14.0 mL (49). In a longer follow-up period of 24 months, IPSS significantly improved to 6.7 points after PKRP and significantly to 7.0 points after M-TURP (50). QoL improved similarly with both techniques. After 24 months, the QoL score was 1.5 after PKRP and 1.6 after M-TURP, both are significant improvements compared to baseline (50). Qmax improved significantly after both techniques and was also slightly higher after PKEP with 18.1 mL/s than after M-TURP with 17.8 mL/s (50).

Tolerability and safety: Overall, the incidence of complications and perioperative morbidity was lower after PKRP than after M-TURP. No cases of the TUR syndrome happened after PKRP while it happened in 2.2% of cases after M-TURP (49). Also, only 0.5% of cases needed a blood transfusion after PKRP, while 2.9% of cases needed them after M-TURP. However, this difference is not statistically significant (50). Urethral strictures and bladder neck contractures happened in a similar percentage of cases after both techniques. 7.1% and 1.2% respectively, after PKRP and 7.3% and 2.4% after M-TURP (50). Clot retention, that was conservatively treatable, happened in a higher percentage of cases after PKRP (15.3%) than after M-TURP (13.3%). However, clot

retention that needed to be treated surgically, happened in a higher percentage of cases after M-TURP (4.4%) than after PKRP (2.5%). Still, this difference is not statistically significant (49). PKRP led to a significantly lower incidence of capsule perforation, happening in 2.1% of patients, than M-TURP during which it happened in 8.1% of patients (50). Both techniques led to a similar incidence of early postoperative urinary incontinence, which happened in 9.8% of PKRP patients and 11.8% of M-TURP patients. Intraoperative and postoperative blood loss was either slightly lower in the PKRP group (51) or significantly lower (50).

Practical considerations: While PKRP had a significantly longer operative time of 47.7 minutes than M-TURP with an operation time of 39.7 minutes. Catheterization time was similar after PKRP with 3.5 days compared to M-TURP with 3.6 days. The duration of the hospital stay after each technique was the same with 1.1 days (49). With both techniques a similar amount of tissue was removed. With PKRP 41.5 ± 15.6 g were resected and with M-TURP 43.3 ± 15.0 g. No technique removed significantly more tissue than the other (50). After PKRP there was a slightly lower rate of recurrence and re-treatment than after M-TURP (49).

Recommendation:	**Level of Evidence:**	**Strength rating:**
A good alternative to monopolar TURP, providing similar or better symptom relief with lower complication rates and shorter catheterization times.	Ia	Strong (Grade A)

MINIMAL INVASIVE PROCEDURES FOR PROSTATE >80 mL Volume:

7.1 Waterjet ablation therapy (Aquablation):

Efficacy: Aquablation leads to a reduction in prostate volume, on average by 42% after six months, which directly correlates with an improvement in urinary symptoms and flow parameters (52). The IPSS score significant improved by an average of 17.5 points after six months and 17 points after 12 months (52,53). Quality of life also improved significantly from a baseline score of 4.6 points to 1.4 points after six months and 1.2 points after 12 months, suggesting a high level of patient satisfaction (52,53). The effectiveness of the procedure is shown by the significant increase in Qmax during the follow up period. At baseline Qmax was 8.7 mL/s, after six months it had increased to 18.8 mL/s and after 12 months it was at 21.1 mL/s (52,53). The PVR also decreased from 131 mL to 47 mL after six months, which represents a decrease of 84 mL, and to 51 mL after 12 months, which is indicative of improved bladder emptying (52,53). PSA levels decreased from 7.1 ng/mL to 4.4 ng/mL after 12 months, pointing to effective tissue resection (52,53).

Tolerability and safety: Postoperative side effects were mostly mild to moderate, with a complication rate of 22% at six and 12 months of Clavien-Dindo grade 2 which required only

pharmacological treatment (52,53). Bleeding occurred in 5.9% of patients and transfusions were required in 7.9% of cases, with 3% requiring return to the operating room for fulguration. Approximately 2.0% needed both transfusion and fulguration (52). Grade 3 Clavien-Dindo complications necessitating surgical, endoscopic or radiological intervention were noted in 14% of patients at six and 12 months and consisted mainly of bleeding (5.9%) and meatal stenosis (3%) (52,53). Grade 4 with life-threatening complications requiring intensive care, including cerebrovascular events, cardiac complications, multisystem organ failure and hemorrhage, were seen in 5% of patients at both follow-ups, with full recovery observed in all cases (52,53). Ejaculatory dysfunction was present in 19% of sexually active men at three and 12 months, but 81% preserved antegrade ejaculation, emphasizing the potential benefit of Aquablation in maintaining sexual function (52,53). Incontinence occurred in 3% of patients at 6 months and 12 months, and one of them had to undergo an artificial urinary sphincter in the Clavien-Dindo grade 3 (52,53).
Practical considerations: The average operating time for Aquablation was 37 minutes with a resection time of only 8 minutes (54). Other techniques like HoLEP and photoselective vaporization (PVP) have significantly longer operating times of 72 minutes to 129 minutes (54). After Aquablation, patients had to spent on average 1.6 days in the hospital. This is a similar duration to after HoLEP and shorter than after an open prostatectomy, which required a hospital stay of up to 11.9 days (54). Catheterization after the operation was needed for four days on average (52),(53),(54). At 12 months after operation, no subsequent tissue removal procedures were needed. This points towards long-term positive effects (53).

Recommendation:	**Level of Evidence:**	**Strength rating:**
Effective for large prostates (>80 mL) with considerable symptom relief, shorter operation time and preserved ejaculation compared to standard treatment.	Ib	Strong (Grade A)

7.2 ENUCLEATION:

7.2.1 Bipolar plasma enucleation, Electrosurgical Enucleation, Plasmakinetic Enucleation, Bipolar transurethral Enucleation and Resection:

Efficacy: To treat the symptoms of BPH, both bipolar plasma enucleation of the prostate (BPEP) and open prostatectomy (OP) were similarly effective. Both techniques had not significantly different results in symptom scores, Qmax, PVR and PSA levels at all follow-up points up to 12 months (41). In one study transurethral enucleation and resection of the prostate (TUERP) resulted in a significantly lower IPSS score of 6 points at 1 month and 4 points at 3 months than OP with 7 points at 1 month and 5 points at 3 months (55). In the same study, Qmax was also significantly

higher after TUERP with 19.3 mL/s than after OP with 17.7 mL/s (55). However, OP led to a significantly higher improvement of PVR volume than TUERP. The IIEF-5 score was not significantly better in one technique than the other (55). Another study showed no significant changes in the IPSS, Qmax, QoL or PVR in any group between TUERP and OP (56). In a study with a follow-up period of 24 months, B-TUERP resulted in significantly better improvements in IPSS with a score of 6 points and PVR volume with 18.64 mL than B-TURP with an IPSS of 7 points and a PVR volume of 24.74 mL. At 1 month, B-TUERP resulted in a significantly better QoL with a similar improvement after 24 months in both groups (57). Qmax showed significantly higher improvement in B-TUERP than B-TURP at 1 month (19.0 vs. 15.42 mL/s; p = <0.0001) as well as at 24 months (24.9 vs. 20.09 ml/s; p = 0.034, respectively (57). Regarding weight of resected tissue, during OP 75.2 g were resected which is significantly more than the 65.9 g that were resected tissue during PKEP (p = 0.033) (58). Compared to B-TURP, PKEP resulted in a significantly higher weight of resected prostate tissue of 64.2 g than B-TURP of 50.6 g (p = 0.003) (59). In a long-term follow-up period of 60 months, PKEP resulted in a significantly lower IPSS score with a score of 3.32 points, and PVR volume of 4 mL and a significantly higher Qmax with a flow rate of 26.45 mL/s than B-TURP which resulted in an IPSS score of 4.90 points, Qmax of 22.07 mL/s and PVR of 15 mL (59). QoL was similar after both techniques (59).

Tolerability and safety: BPEP resulted in a significantly lower hemoglobin drop of 1.7 g/dL than OP with a drop of 3.1 g/dL (p <0.0001). Hematuria was also significantly rarer in the BPEP group with 2.9% than in the OP group with 12.9% (p = 0.035). Therefore, blood transfusion rates were also significantly lower in the BPEP group with 1.4% than in the OP group with 8.6% (p = 0.059). Short-term complications like acute urinary retention that needed to be treated by re-catheterization were significantly rarer in the BPEP group with 1.4% than in the OP group 8.6% (p = 0.059). Mid-term complications like bladder neck sclerosis, urethral strictures and urinary incontinence happened similar often in both groups (BPEP and OP) (41). TUERP resulted in significantly lower rates of intraoperative bleeding with 22.2% than OP with 57.8%. Hemoglobin drop was also significantly lower with 1.1 g/dL during TUERP and 2.5 g/dL during OP (55). Dysuria was significantly lower at 3 months and pyuria at 1 month after TUERP than after OP. However, at 6 months, there was no significant difference between TUERP and OP (55). Also, in terms of LUTS, bladder neck contracture and urethral stenosis, there was no significant difference between TUERP and OP (55,56). B-TUERP and B-TURP had no significant difference in blood transfusion rates or urethral strictures (57). The hemoglobin drop was significantly lower during B-TUERP with a drop of 1.5 g/dL than during B-TURP with a drop of 2 g/dL (57). Also, during PKEP, the hemoglobin drop was significantly lower with a drop of 1.02 g/dL than during OP with a drop of 1.51 g/dL (p <0.001) (58). Complications like blood transfusions, re-catheterization, urinary tract infections,

temporary incontinence, bladder neck contracture, urethral strictures and retrograde ejaculation were not significantly different between both techniques (58). The drop in hemoglobin was significantly lower during PKEP with a drop of 0.9 g/dL than during B-TURP with a drop of 1.7 g/dL ($p < 0.001$) (59).

Practical considerations: Catheterization time was significantly shorter after BPEP with 1.5 days than after OP with 5.8 days ($p < 0.0001$). The hospital stay was also significantly shorter after BPEP with 2.1 days than after OP with 6.9 days ($p < 0.0001$) (41). Also, catheterization time was significantly shorter after TUERP with 4.3 days than after OP with 7.6 days ($p < 0.05$). Furthermore, the duration of the hospital stay was significantly shorter after TUERP as well with 5.8 days than 9.3 days after OP (56). Operation time was also significantly shorter after TUERP with 77 minutes than for OP with 99 minutes (55). While TUERP resulted in a higher rate of re-operations and re-catheterizations, the difference of OP was not significant (56). Also, in comparison to B-TURP, catheterization time was significantly shorter with B-TUERP 43.89 hours versus 54.03 hours for B-TURP. The duration of the hospital stay was significantly shorter after B-TUERP as well with 52.53 hours than after B-TURP with 60.41 hours. B-TUERP required a significantly longer operation time of 105.09 minutes than B-TURP with 61.09 minutes (57). Meanwhile, PKEP and OP had similar operation times with 111.2 minutes for PKEP and 109.6 minutes for OP. However, in terms of catheterization time and duration of hospital stay, PKEP required less time with 3.3 and 5.4 days respectively while OP required 6.2 and 9.3 days (58). In comparison to B-TURP, PKEP had a significantly shorter catheterization time of 35.5 hours, and a significant shorter duration of hospital stay with 3 days. B-TURP required a catheterization time of 60.1 hours, and a hospital stay of 4 days. Operation time was similar in both groups. 94 minutes for PKEP and 89 minutes for B-TURP (59).

Recommendation:	**Level of Evidence:**	**Strength rating:**
TUERP, B-TUERP and PKEP are not inferior to open prostatectomy in their effectiveness.	Ib	Strong (Grade A)
TUERP, B-TUERP and PKEP have lower morbidity, less blood loss and faster recovery than B-TURP.	Ib	Strong (Grade A

7.2.2 Holmium Laser Enucleation (HoLEP):

Efficacy: One study, with a 3-month follow-up period compared HoLEP to laparoscopic simple prostatectomy (LSP), robotic simple prostatectomy (RASP) and minimally invasive simple

prostatectomy (MISP). All procedures improved the IPSS score, QoL score, Qmax, PVR volume and PSA levels to a similar extend. IPSS scores improved from 24.15 points at baseline to 8.26 points after HoLEP, from 23.42 points to 8.41 points after LSP, from 24.3 points to 8.09 points after RASP and from 23.9 points to 8.35 points after MISP, all procedures improved significant from baseline (60). QoL scores improved from 3.89 points to 1.71 points after HoLEP, from 3.85 points to 1.66 points after LSP, from 3.83 points to 1.69 points after RASP and from 3.84 points to1.67 points after MISP, all procedures improved significant from baseline (60). Qmax increased from 7.05 mL/s to 20.01 mL/s after HoLEP, from 7.11 mL/s to 19.2 mL/s after LSP, from 7.24 mL/s to 19.45 mL/s after RASP and from 7.19 mL/s to 19.31 mL/s after MISP, all procedures improved significant from baseline (60). PVR volume decreased from 130.13 mL to 35.47 mL after HoLEP, from 132.35 mL to 35.78 mL after LSP, from 126.06 mL to 31.21 mL after RASP and from 128.64 mL to 33.85 mL after MISP, all procedures improved significant from baseline (60). PSA levels also dropped similarly after all techniques (60). Another study with a 36-month follow-up period compared HoLEP to B-TURP. The IPSS score improved significantly from 27.01 points at baseline to 4.57 points (an 83% improvement) after HoLEP while it improved significantly as well from 28.32 points to 7.6 points (an 73% improvement) after B-TURP. This is a significant higher improvement after HoLEP, as well as compared to B-TURP (61). Qmax increased significantly from 7.42 mL/s to 29.23 mL/s (an 389% improvement) after HoLEP while it increased significantly as well from 6.88 mL/s to 21.05 mL/s (an 267% improvement) after B-TURP (61). Also there is a significant difference between both (61). After HoLEP, PVR was lower with 27.09 mL than after B-TURP with 36.02 mL. Both have a significant change between preoperative and postoperative results but the difference between both methods is not significant (61). PSA levels decreased from 8.51 ng/mL to 1.72 ng/mL (an 80% improvement) after HoLEP while they decreased from 6.7 ng/mL to 2.79 ng/mL (an 52% improvement) after B-TURP. Although both techniques have significant changes according to preoperative and postoperative outcomes and as well in comparison to both. None the less, HoLEP has a higher reduction (61).

Tolerability and safety: During HoLEP, hemoglobin decreased by 1.14 g/dL, during LSP by 1.43 g/dL, during RASP by 1.22 g/dL and during MISP by 1.31 g/dL (60). Complications of the Clavien-Dindo grade IIIa or higher happened in 4.7% of HoLEP patients, 5.5% of LSP patients, 3.1% of RASP patients and 4.4% of MISP patients. No technique resulted in a significantly higher rate of complications than the other (60). Urethral strictures happened slightly more often after HoLEP (4.7%) than after LSP (2.7%) or after RASP (3.1%) and MISP (2.9%) (60). However, perioperative morbidity was significantly lower after HoLEP than after B-TURP. Blood transfusions were needed in no HoLEP cases while they were needed in 9.1% of B-TURP cases (61). Also, the hemoglobin decrease was significantly lower during HoLEP with 0.6 g/dL than

during B-TURP with 1.63 g/dL (61). The postoperative catheterization period was significantly shorter after HoLEP with 18.68 hours than after B-TURP with 44.2 hours (61). The postoperative complications like urethral strictures happened in 1.8% of HoLEP patients while they happened in 5.5% of B-TURP patients (61).

Practical considerations: All techniques had not significantly different operation times, with 134.32 minutes on average required for HoLEP, 126.55 minutes for LSP, 138.47 minutes for RASP and 133.56 minutes for MISP (60). However, catheterization time was significantly shorter after HoLEP with 2.32 days than after LSP with 5.39 days, RASP with 4.14 days and MISP with 4.72 days. Furthermore, the hospital stay after HoLEP was also significantly shorter with 2.24 days than after LSP with 4.72 days, RASP with 3.84 days and MISP with 4.25 days (60). In comparison to B-TURP, HoLEP had a significant shorter operation time of 71.4 minutes in comparison to 82.61 minutes. Furthermore, the hospital stay was significantly shorter after HoLEP with 22.03 hours than after B-TURP with 42.27 hours (61). Catheterization was nearly half as long after HoLEP with 18.68 hours than after B-TURP with 44.2 hours (61).

Recommendation:	**Level of Evidence:**	**Strength rating:**
Compared to B-TURP for large prostates, the long-term results are better, the perioperative morbidity rate lower and the recovery time faster.	Ib	Strong (Grade A)

7.3 GreenLight Laser vapo-Enucleation:

Efficacy: Photoselective vapo-enucleation of the prostate (PVEP) improved the IPSS score comparable to HoLEP (32). The improvement of QoL was also comparable and not significantly different between both techniques (32). At 12 months, HoLEP increased Qmax significantly higher than PVEP. After HoLEP, Qmax increased from 7.5 mL/s to 26.4 mL/s while it increased from 8.0 mL/s to 18.4 mL/s after PVEP (32). Meanwhile, the reduction in PVR volume was not significantly different between both techniques (32). HoLEP resulted in an 82.6% reduction of PSA levels while PVEP resulted in a significantly lower reduction of 45.9% (32). In a 3 year follow-up, the IPSS score, PVR and QoL remained stable with both techniques (62).

Tolerability and safety: The conversion rate was significantly higher after PVEP than after TURP. After PVEP, 24.5% of patients needed conversion due to hemostasis while 15% needed it due to residual adenoma conversion. After PVEP, postoperative hematuria rate was also higher than after HoLEP with 3.7% after PVEP and 2% after HoLEP (32). The hemoglobin drop was similar

between both techniques, averaging at 0.74 ng/dL (32). Still, the need for blood transfusions was higher after PVEP with 1.8% than after HoLEP with 0% (32). Early complications, like clot retention or epididymo-orchitis happened similar often after both techniques (32). Late complications happened more often after PVEP but it was not significantly different between both techniques (32). After PVEP 26.7% of patients needed re-treatment due to recurrent obstruction at 3 years, while it was 5% after HoLEP (62). Also, patients required repeat alpha-blocker therapy significantly more often after PVEP (62).

Practical considerations: PVEP had a significantly longer operation time with 92±32 minutes than HoLEP with 73±30 (62). The duration of hospital stay was similar between both techniques with 1.5 days for PVEP and 1.1 days for HoLEP (32). HoLEP required a catheterization time of 1.2 days while it were 2.3 days for PVEP (32). During HoLEP, 1.7 g of tissue were removed per minute during HoLEP while 1.2 g were removed per minute during PVEP, which shows a significant difference in favor for HoLEP (62).

Recommendation:	**Level of Evidence:**	**Strength rating:**
An alternative with less invasive treatment, but with poorer treatment results and higher recurrence rates compared to HoLEP.	Ib	Conditional (Grade B)

8. DISCUSSION:

For water vapor therapy using the Rezūm system, this thesis had similar results as the current guidelines in terms of efficacy. Improvements in IPSS, Qmax and QoL were significant in both. However, this thesis included also long-term data of 4 years instead of only 12 months in the guidelines. Therefore, this thesis also highlights the long-term benefits of the Rezūm system. Furthermore, the guidelines showed no impact on PVR, while the studies included in my thesis showed significant improvements after 12 months (63). In terms of safety, both this thesis and the current guidelines reported mainly mild and short-term adverse events (63). In terms of efficacy and safety for Aquablation, both this thesis and the current guidelines had similar results. IPSS and Qmax both improved significantly after Aquablation. The current guidelines also showed PVR and QoL improvements after Aquablation. However, the improvements in IPSS, Qmax, PVR and QoL were not significantly different after Aquablation or TURP. Both the current guidelines and my thesis showed that Aquablation was associated with less complications and better sexual function than TURP (63). For UroLift the IPSS, Qmax and QoL all showed significant improvements in the guidelines and my thesis (63). The guidelines had a follow-up of 60 months (63), while my thesis

had a follow-up of 2 years for IPSS and Qmax and 12 months for QoL. However, TURP performed significantly better for IPSS and Qmax and similar for QoL in both papers (63). PVR also improved significantly better after TURP than after PUL (63). In my thesis there is also data which shows that TURP significantly reduced PVR. This outcome was not analyzed in the guidelines. Referring to safety, both papers showed that UroLift is safer than TURP, there were no serious adverse events with PUL and ejaculatory function was significantly better as well (63). The guidelines had mixed results regarding the efficacy of PAE in comparison to TURP. However, there was a trend of TURP being significantly more effective. In this thesis the results were clearer, both PAE and TURP improved the functional outcomes but TURP was always significantly better (63). Regarding safety, the guidelines had inconclusive results again (63), while in this thesis PAE had fewer serious complications than TURP. However, PAE also had more re-interventions than TURP. Both in the guidelines and my thesis the data suggests that PVP is non-inferior to TURP in terms of efficacy and has less complications and less hospitalization and catheterization times (63). Regarding diode laser vaporization both the guidelines and my thesis show that the efficacy of TURP is slightly higher but there is no significant difference between TURP and diode laser vaporization. However, diode laser vaporization had a shorter catheterization (63). In my thesis data also shows that the hospitalization is shorter after diode laser vaporization procedure. While the guidelines say that intraoperative complications are similar, my thesis had data that diode laser vaporization had less intraoperative complications (63). In the data of my thesis IPSS and Qmax improved significantly better B-TUVP in one study, while the improvement was not significantly better in another study. In the guidelines there was no difference between TUVP and TURP. PVR showed similar improvement in both my thesis and the guidelines (63). BPVP had lower need for blood transfusions in comparison with TURP in my guidelines and my thesis (63). While the guidelines had an overall lower rate of complications in B-TUVP, my thesis had a higher rate urethral strictures and postoperative irritation symptoms (63). Both in the guidelines and my thesis TUVP had a shorter catheterization times (63). The data in the guidelines showed no significant difference in short-term according to Qmax and re-intervention rates between HoLEP and TURP, while another study had favorable results for HoLEP (63). A 7 year follow-up showed comparable long-term results in HoLEP and TURP (63). In my thesis IPSS, QoL, Qmax, PVR and prostate volume improved to a higher extend with HoLEP. In my thesis HoLEP had less complications and fewer re-catheterizations and longer operation times. In the guidelines the results were mixed, some studies suggested shorter catheterization, longer operation times and less complications (63). While others had similar rates of complications and a similar operation time (63). In terms of efficacy there was no significant difference between ThuLEP and HoLEP in both the guidelines and the study. For safety the guidelines had similar complication rates between both groups at 18 months, while in my

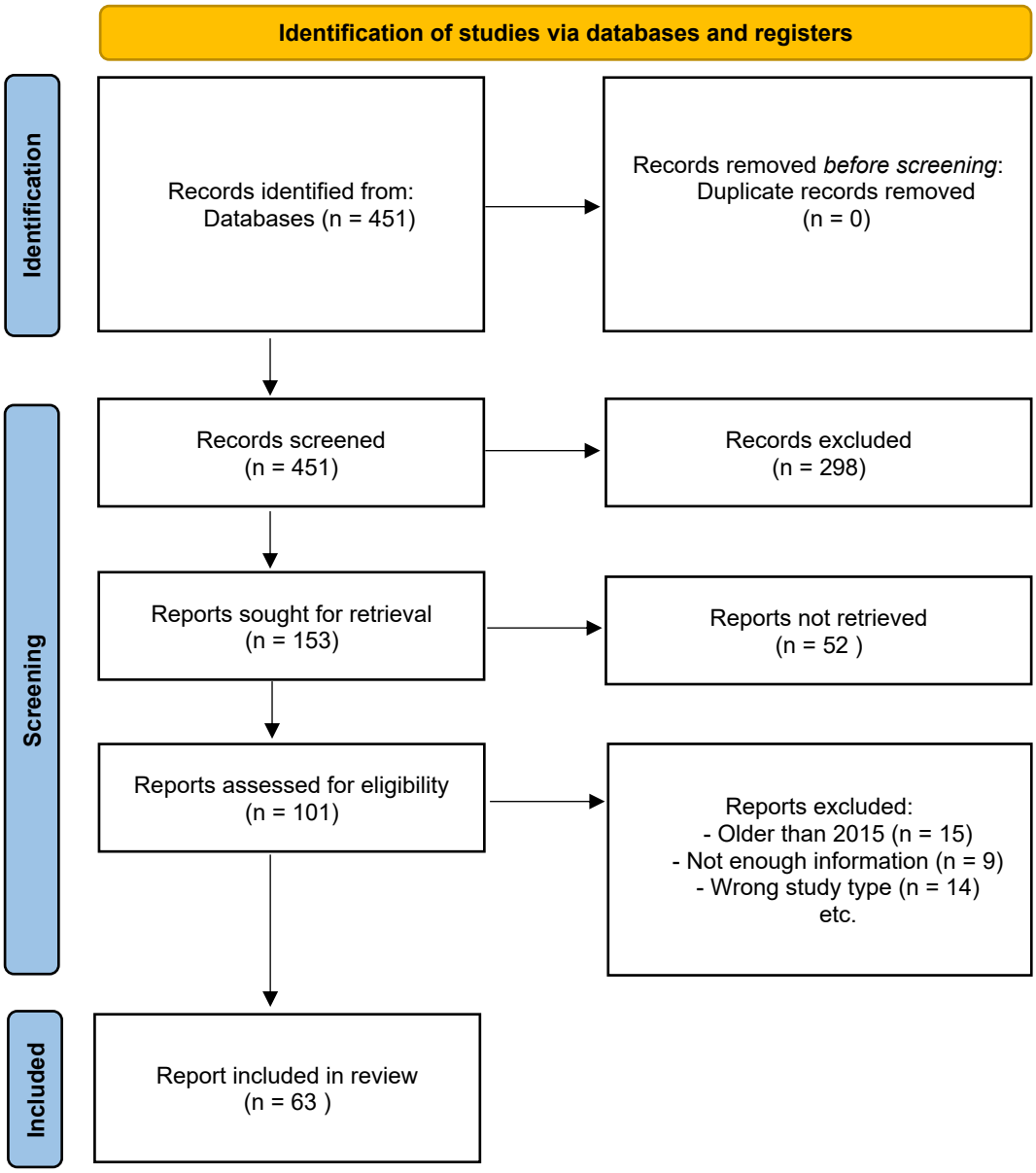
thesis ThuLEP had significantly less blood transfusions and lower hemoglobin drop. Also, significantly less postoperative urinary retention and stress incontinence were shown. My thesis showed a significantly shorter operation time for ThuLEP, while the guidelines showed no such difference. The catheterization time and hospitalization time was not significantly different in either my thesis and the guidelines (63). IPSS and QoL improved significantly after M-TURP and B-TURP with no significant differences between both techniques in the guidelines and in my thesis. However, in my thesis Qmax increased significantly better after B-TURP while in the guidelines there was no significant difference between both (63). In both the guidelines and my thesis, B-TURP is the safer method due to a less complications like the need of blood transfusions or the elimination of the TUR syndrome. Furthermore, catheterization time and hospital stay was shorter after B-TURP (63). When comparing the thesis with the guidelines, both showed significant improvement in IPSS, Qmax, while PVR was also significant in the guidelines and no p-value mentioned in my thesis (63). My thesis also demonstrated improvements in prostate volume after 6 months and QoL and PSA after 12 months. According to operation time, my thesis mentioned it to be shorter than other techniques. Also, a shorter hospitalization was required. In both my thesis and the guidelines PKEP had a significantly better efficacy compared to TURP (63). As well PKEP was superior in operation time, catheterization time and hospitalization (63), while in my thesis the operation time was longer for PKEP. For large prostates, HoLEP improved to be non-inferior to OP in the guidelines (63) and also non-inferior to LSP, RASP and MISP in my thesis. In comparison to TURP, my thesis showed significantly better results with HoLEP. Regarding safety and operation time HoLEP was similar to LSP, RASP and MISP. The catheterization time was significantly shorter with HoLEP than the other techniques. In comparison to TURP, HoLEP was safer and had shorter catheterization operation and hospitalization times. According to the guidelines the operation time for HoLEP was longer, while the catheterization and hospitalization times were shorter compared to OP (63). Also, the guidelines mentioned that OP is not the gold standard but a good alternative if there is no excess to the endourological techniques for larger prostates.

9. CONCLUSION:

TURP stays the gold standard for small prostates. It results in a superior symptom relief as well as a higher reduction in prostate volume. Still, many minimally invasive alternatives, like PLFT/TUMT, Rezūm, Aquablation, PUL, PAE, PVP, diode laser vaporization, BPVP, HoLEP/ThuLEP and PKRP, result in similar long-term improvements. They are usually safer and result in less blood loss, shorter catheterization and hospital stays, as well as a better preservation of sexual function. When deciding what treatment should be offered to a patient, clinicians should take into account the patient´s comorbidities, risk factors and goals in terms of recovery and outcomes. Minimally

invasive alternatives result in similar or even better outcomes for patients with prostates over 80 mL in comparison to standard treatment. Symptoms improved significantly after Aquablation with a shorter operation time. Also, it preserves antegrade ejaculation. Enucleation techniques such as TUERP (including B-TUERP and PKEP) achieve similar efficacy to open prostatectomy but with lower morbidity, less blood loss, and faster recovery compared to conventional B-TURP. HoLEP has a better long-term efficacy, reduced morbidity and re-treatment rates. PVEP is less effective but might still be an alternative for patients who want a less invasive treatment.

10. PRISMA FLOW CHART:



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