Endoscopic enucleation vs endoscopic vaporization procedures for benign prostatic hyperplasia: how should we choose
A protocol for systematic review and meta-analysis

Xinbao Yin, MD, PhD, Jun Chen, MD, PhD, Hui Sun, MD, Ming Liu, MD, Zehua Wang, MD, Benkang Shi, MD, PhD, Xueping Zheng, MD, PhD*

Abstract
Objective: To assess the safety and efficacy of different endoscopic procedures of the prostate techniques, by comparing endoscopic enucleation (EEP) and endoscopic vaporization procedures (EVP) of the prostate; and laser enucleation procedures (L-EEP) vs laser vaporization procedures (L-EVP) surgeries for benign prostatic hyperplasia.

Methods: A systematic literature review was performed in December 2019 using PubMed, Embase and the Cochrane Library to identify relevant studies. Two analyses were carried out: (1) EEP vs EVP; and (2) L-EEP vs L-EVP. Efficacy and safety were evaluated using perioperative data, functional outcomes, including maximum urinary flow rate (Qmax), quality of life (QoL), international prostate symptom score (IPSS), postvoiding residual urine volume (PRV), and rate of complications. Meta-analyses were conducted using RevMan5.3.

Results: Sixteen studies (4907 patients) evaluated EEP vs EVP, and 12 of them (4392 patients) evaluated L-EEP vs L-EVP. EEP showed improved functional outcomes compared with EVP. EEP was always presented a better Qmax at various follow-up times. EEP also associated with a reduced PRV and IPSS at 12 months postsurgery, an increased Qmax, and reduced IPSS and QoL score at both 24 and 36 months postsurgery. In addition, EEP was associated with less total energy utilized and retreatment for residual adenoma, but a longer catheterization time. Among other outcomes, there was no significant difference. L-EEP favors total energy used, retreatment for residual adenoma, and functional outcomes. L-EEP was associated with reduced PRV at 1, 6, and 12 months postsurgery, a greater Qmax at 6 and 12 months postsurgery, a lower IPSS at 12 months postsurgery, and higher Qmax and lower IPSS and QoL scores at 24 and 36 months postsurgery. However, there was no difference at 3 months postsurgery. No significant differences were observed for other perioperative data and complications.

Conclusions: Both EEP and EVP displayed sufficient efficacy and safety for treating benign prostatic hyperplasia. EEP and L-EEP were favored in perioperative data, rate of complications, and functional outcomes. However, the clinical significance of those statistical differences was unclear. Hence, higher-quality randomized controlled trials may be needed to provide a clear algorithm.

Abbreviations: BNC = bladder neck contracture, BPH = benign prostatic hyperplasia, CI = confidence interval, EEP = endoscopic enucleation, EVP = endoscopic vaporization procedures, HoLEP = holmium laser enucleation of the prostate, IPSS = international prostate symptom score, IQR = interquartile range, L-EEP = laser enucleation procedures, L-EVP = laser vaporization procedures, LUTS = lower urinary tract symptoms, OR = odds ratios, PRV = postvoid residual urine volume, Qmax = maximum flow rate, QoL = quality of life, RCTs = randomized controlled trial, TURP = transurethral resection of the prostate, UTI = urinary tract infection.

Keywords: BPH, enucleation, lower urinary tract symptoms, vaporization

How to cite this article: Yin X, Chen J, Sun H, Liu M, Wang Z, Shi B, Zheng X. Endoscopic enucleation vs endoscopic vaporization procedures for benign prostatic hyperplasia: how should we choose: A protocol for systematic review and meta-analysis. Medicine 2020;99:46(e22882).

Received: 5 May 2020 / Received in final form: 27 August 2020 / Accepted: 23 September 2020
http://dx.doi.org/10.1097/MD.0000000000022882
1. Introduction

Benign prostatic hyperplasia (BPH) is ubiquitous in the aging male with prevalence increasing with age\textsuperscript{[1]} and affecting 50% of those older than 50 and 80% of those older than 80.\textsuperscript{[2]} Elderly males are frequently complaining of lower urinary tract symptoms (LUTS) which are due to bladder outflow obstruction secondary to BPH.\textsuperscript{[3]} There are many long-term complications due to untreated bladder outflow obstruction, such as detrusor failure, renal failure, recurrent urinary tract infections (UTIs), urinary retention, bladder diverticula, and bladder stones.\textsuperscript{[4]} If prostate tissue was removed in men with suspected BPH, symptoms and obstruction are reduced and resolved substantially.

Transurethral resection of the prostate (TURP) has been considered the gold standard surgical option for patients with moderate to severe LUTS secondary to BPH, especially for small/medium prostates.\textsuperscript{[5,6]} Substantial improvements on outcomes, including maximum urinary flow rate (Qmax), quality of life (QoL), international prostate symptom score (IPSS), and postvoiding residual urine volume (PRV) have added to its success. However, despite several technical and procedural improvements, TURP is still a potentially dangerous procedure, particularly in patients with larger prostates, indwelling catheters, bleeding disorders, or in patients undergoing anti-coagulation therapy. Therefore, many endoscopic procedures and surgical skills using different energy sources, such as plasmakinetic TURP, plasmakinetic transurethral enucleation of the prostate, holmium laser enucleation of the prostate (HoLEP), and green light laser vaporization or enucleation of the prostate (green laser enucleation of the prostate), have been proposed to replace TURP as the new operative standard. These procedures have a satisfactory evidence base showing an advantage over TURP and a rise in use. Regardless of which kind of energy source is used, each approach of the transurethral procedure can be subdivided into three principles: resection, vaporization, and enucleation.\textsuperscript{[7]}

So far, numerous studies have summarized the growing evidence supporting the use of these new techniques. In the present study, our aim was to perform a systematic review and meta-analysis using data from previously published studies to review the contemporary status of endoscopic enucleation (EEP) and the endoscopic vaporization procedures (EVP) techniques for the treatment of BPH. Moreover, we compared the safety and efficacy of the techniques that take advantage of the laser as energy sources, including laser enucleation procedures (L-EEP) and laser vaporization procedures (L-EVP).

2. Methods

2.1. Study criteria and search strategy

In our present systematic review and meta-analysis, we included the publications focusing on patients treated surgically for symptomatic LUTS utilizing EEP and EVP. Studies using any kind of instrument for EEP and EVP were included, for example, holmium laser, green light laser, bipolar plasma, thulium laser, and transurethral vaporization in saline. When comparing L-EEP and L-EVP, only the holmium laser, green light laser, and thulium laser were included. The language was restricted to English. Studies were selected by searching PubMed, EMBASE, and the Cochrane Library up to December 2019. The search keywords included, but were not limited to, holmium laser enucleation of the prostate, HoLEP, transurethral enucleation, EEP, PVP, photoselective vaporization of the prostate, transurethral vaporization, endoscopic vaporization, GreenLight, transurethral prostatectomy, minimally invasive prostatectomy. We modified the search strategy as required for each electronic database. The bibliographies of included studies and recent reviews were hand-searched.

2.2. Selection of studies, data extraction, and methodological quality assessment

Studies that meet the prespecified inclusion criteria were selected. Abstracts of the identified articles were subjected to independent review by 2 authors. The full-text articles were retrieved for those studies that appeared to meet the inclusion criteria. Two reviewers independently extracted the data. To obtain missing data, the authors of the study were contacted. The methodological quality of randomized controlled trials (RCTs) was assessed according to the Jadad scale and not a RCT according to the Newcastle-Ottawa Scale (NOS) scale.

2.3. Outcome measures

The outcomes assessed included perioperative outcomes, complications, and efficacy of the surgery. The perioperative outcomes were assessed for a decrease in sodium, a drop in hemoglobin (HB) levels, irrigation length, hospital stay, conversion of surgical techniques, the total energy used, operative time, and catheterization time. Complications included capsular perforation, haematuria, clot retention, urge incontinence, stress incontinence, bladder neck contracture (BNC), urethral stricture, transient incontinence, blood transfusions, and urinary incontinence (including urge incontinence, stress incontinence, transient incontinence, and other incontinence not classified). For the efficacy of surgery, the following outcomes were used: maximum flow rates (Qmax), IPSS, QoL, and postvoid residual volume (PRV) at 1, 3, 6, 12, 24, and 36 months postsurgery.

2.4. Statistical analysis

RevMan5.3 was used to perform statistical analysis. Meta-analysis was conducted to generate summary statistics where possible. The weighted mean difference or standardized mean difference were calculated for continuous outcomes along with the 95% confidence interval (CI) and P value. Summary odds ratios (OR) and its 95% CI were calculated for binary outcomes. Statistical significance was defined as P < .05. For articles offering continuous data as median and interquartile range, we calculated the mean and standard deviation using the procedure described by Luo et al\textsuperscript{[8]} and Wan et al.\textsuperscript{[9]} The pooled results were calculated by the fixed-effect model [I\textsuperscript{2} (inconsistency) \textless 50% and P \textgreater .1]. Otherwise, the random effect model was used. Moreover, the effects of pooled results were determined by the z test, and P < .05 was considered statistically significant. Due to inconsistent data reporting, the meta-analysis was not feasible for all studies.

3. Results

3.1. Characteristics of included studies

This systematic review and meta-analysis included 16 studies,\textsuperscript{[10–23]} with a total of 4907 patients (Fig. 1). The characteristics of the included studies are summarized in Table 1. In addition, Table 2...
Table 1
A summary of comparative studies.

| Year, author | Country | Study period | Study design       | Surgical skills | Cases, n. | Inclusion criteria | Follow-up, mo | Study quality |
|--------------|---------|--------------|--------------------|----------------|-----------|--------------------|----------------|---------------|
| 2012, Elhilali et al[10] | Egypt | October 2008 to October 2010 | RCT | HoLEP/PVP | 43/37 | IPSS > 9, PV > 60ml, Qmax < 15ml/s | 12 | 1 |
| 2013, Etterman et al[11] | USA | September 2001 to May 2009 | Retrospective case-control | GreenLEP/PVP | 170/97 | IPSS > 8, Qmax < 10ml/s | 36 | 7† |
| 2015, Jaeger et al[12] | USA | 2009 to 2012 | Retrospective case-control | HoLEP/PVP | 72/21 | PVR of > 300ml | – | 7† |
| 2015, Cho et al[13] | Korea | 2009 to 2012 | Retrospective case-control | HoLEP/PVP | 72/21 | – | 2 |
| 2015, Geavlete et al[14] | Romania | January 2009 to May 2013 | Retrospective case-control | BPEP/TUVis | 80/80 | IPSS > 19, PV > 80ml, Qmax < 10ml/s | 12 | 2 † |
| 2015, Elkoushy et al[15] | Egypt | March 1998 to July 2014 | Retrospective case-control | HoLEP/PVP | 809/291 | – | 12 | 8† |
| 2016, Misrai et al[16] | France | April 2011 to March 2014 | Retrospective case-control | GreenLEP/PVP | 60/60 | PV > 80ml | 12 | 7† |
| 2016, Kim et al[17] | Korea | April 2011 to March 2014 | Retrospective case-control | HoLEP/PVP | 162/176 | IPSS > 7, PV < 40ml, Qmax < 15ml/s, PVR < 100ml | 12 | 7† |
| 2017, Cindolo et al[18] | Italy | July 2012 to November 2015 | Retrospective case-control | GreenLEP/ PVP | 35/139 | – | – | 7† |
| 2017, Xu et al[19] | China | February 2011 to December 2013 | Retrospective case-control | BTUEP/PVP | 39/42 | IPSS < 12, PV < 70ml, Qmax < 15ml/s | 12 | 9† |
| 2017, Wang et al[20] | China | February 2011 to July 2012 | Retrospective case-control | PKEP/PVP | 101/110 | IPSS < 12, Qmax < 15ml/s | – | 7† |
| 2018, Castellan et al[21] | Italy | January 2008 to June 2018 | Retrospective case-control | Thul/VP/VP | 158/93 | IPSS < 7, PV > 40ml, Qmax < 15ml/s, PVR > 100ml | 12 | 7† |
| 2019, Kim et al[22] | Korea | January 2017 to June 2018 | Retrospective case-control | HoLEP/BPVP | 745/49 | – | – | 7† |
| 2019, Prudhomme et al[23] | France | January 1, 2013 to April 30, 2018 | Retrospective case-control | HoLEP/PVP | 179 | IPSS > 10, PV > 10ml, Qmax < 15ml/s, PVR > 100ml | 12 | 7† |

RCT = randomized controlled trial, NRCT = non-randomized controlled trial, HoLEP = holmium laser enucleation of prostate, PVP = photoselective vaporization of prostate, GreenLEP = green laser enucleation of the prostate, BPEP = bipolar plasma enucleation of the prostate, TUN = transurethral vaporization in saline, BTUEP = bipolar transurethral enucleation of prostate, PKEP = plasmakinetic enucleation of prostate, Thul/VP = thulium laser Vaporesection of the prostate, BPVP = bipolar plasma vaporization of prostate, IPSS = international prostate symptom score, PVR = postvoid residual urine volume, PV = prostate volume.

* Using the Jadad scale (a score of 0–5).
† Using the Newcastle-Ottawa Scale (a score of 0–9).

Figure 1. Flow diagram.
Table 2
Baseline demographic and clinical characteristics.

| Year, author | Age (yrs) | PV (ml) | PSA (ng/ml) | Qmax (ml/s) | PVR (ml) | IPSS | QoL |
|-------------|----------|---------|-------------|-------------|---------|------|-----|
| 2015, Elkoushy et al[15] | 71.9 | 9.0 | 94.9 | 25.3 | 5.79 | 9.5 | 7.57 |
| 2016, Misrai et al[16] | 74 | 70 (62–77.75) | 88.5 (57–126) | 4.3 (2.8–4.3) | 9.0 | 7.57 | 9.5 |
| 2017, Cindolo et al[18] | 68.2 | 9.0 | 90 (75–125) | 4.3 (3.7–4.3) | 9.0 | 7.57 | 9.5 |
| 2017, Mu et al[19] | 71.15 | 6.33 | 70.45 | 21.28 | 83.07 | 3.8 | 6.8 |
| 2017, Yoo et al[20] | 69.4 | 6.33 | 70.45 | 33.1 | 63.5 | 4.2 | 4.6 |
| 2017, Wang et al[21] | 69.51 | 6.33 | 70.45 | 7.34 | 68.87 | 4.2 | 4.6 |
| 2019, Kim et al[24] | 70.23 | 5.61 | 69.81 | 7.54 | 36.01 | 25.78 | 37.04 |

shows the baseline demographic and clinical characteristics of each study. All trials were published in English. The median sample size was 192.5 patients (range: 26–1184). The follow-up time ranged from 12 months to 60 months. Among the enrolled studies, 12 studies[10–13,15–18,20,22,23,24] (4392 patients) compared L-EEP and L-EVP.

3.2. Perioperative outcomes in EEP vs EVP

For all included studies, the total energy used was lower in the EVP group by 108.67 minutes compared with the EVP group (95% CI, [−166.29, −51.05]; P = .0002); However, catheterization time was shorter in the EVP group by 0.37 days (95% CI, [0.03, 0.70]; P = .03) (Fig. 2A-B)

3.3. Postoperative complications in EEP vs EVP

In the EVP group, there was no incidence of retreatment for residual adenoma, However, 15 patients required retreatment for residual adenoma in the EVP group (OR: 0.06; 95% CI, [0.01, 0.53]; P = .0007) (Fig. 2C). No differences were noted in capsular perforation, haematuria, clot retention, urge incontinence, stress urinary incontinence, UTI, BNC, urethral stricture, transient incontinence, blood transfusions, and urinary incontinence. (see Supplementary information, http://links.lww.com/MD/F233).

3.4. Efficacy of operation in EEP vs EVP

3.4.1. One month postsurgery. At 1 month postsurgery, IPSS, and QoL data were obtained from 7 studies.[10,14,15,17,20,21] PRV and Qmax were compared in 3[10,14,21] and 4 studies,[10,14,15,21] respectively. EEP presented a better Qmax than EVP at 1 month postsurgery (2.78 ml/s, 95% CI [0.93, 4.64], P = .003) (Fig. 3A). However, there were no significant differences in IPSS, PRV, and QoL. (see Supplementary information, http://links.lww.com/MD/F233).

3.4.2. Three months postsurgery. The studies that reported the efficacy of surgery differed in IPSS, QoL, PRV, and Qmax. We acquired the IPSS data from 6 studies.[10,14,15,17,20,21] The studies that reported QoL at the 1 month postsurgery also reported QoL at 3 months postsurgery.[10,14,15,21] PRV was compared in four studies[10,14,20,21] and Qmax in 5 studies.[10,14,15,20,21] EEP showed significant benefits in terms of Qmax in the third month postsurgery too, (1.85 ml/s, 95% CI [0.13, 3.56], P = .03) but no significant differences were observed in terms of IPSS, PRV, and QoL (Fig. 3B).

3.4.3. Six month postsurgery. Data for IPSS and QoL were obtained from 6 studies at 6 months postsurgery.[10,14,15,17,20,21] The same studies reported PRV at 1 month[10,14,21] and QoL[10,14,15,21] at 3 months. Only Qmax was significantly different between EEP and EVP. EEP was associated with a greater Qmax (3.14 ml/s, 95% CI [2.42, 3.85], P < .00001) in the pooled data analysis (Fig. 3C).

3.4.4. Twelve months postsurgery. Six studies[10,14,15,17,20,21] reported the IPSS and QoL. Five studies[10,12,14,20,21] and 6 studies[10,12,14,15,20,21] compared PRV and Qmax respectively. Our meta- analysis showed no significant difference in QoL between EEP and EVP. EEP procedures, however, appeared to be associated with a higher Qmax (3.23 ml/s, 95% CI [1.83, 4.62], P < .00001), less PRV (6.45 ml, 95% CI [−1.14, −1.49],...
P = .01) and lower IPSS score (−1.39, 95% CI [−2.32, −0.45], P = .004) (Fig. 3D–F).

3.4.5. Twenty-four and 36 months postsurgery. Only the study by Elkoushy et al[15] compared IPSS, QoL, and Qmax between EEP and EVP. The pooled analysis showed that EEP techniques were associated with a higher Qmax (15.20 ml/s, 95% CI [13.93, 16.47], P < .00001 at 24 month after surgery and 11.90 ml/s, 95% CI [9.02, 14.78], P < .00001 at 36 month after surgery), lower IPSS (−3.90, 95% CI [−4.52, −3.28], P < .00001 at 24 month after surgery and −4.10, 95% CI [−5.12, −3.08], P < .00001 at 36 month after surgery) and QoL score (−1.00, 95% CI [−1.18, −0.82], P < .00001 at 24 month after surgery and −1.40, 95% CI [−1.57, −1.23], P < .00001 at 36 month after surgery) at both follow-up times (Fig. 4A–F).

3.5. Perioperative outcomes in L-EEP vs L-EVP
Similar to the results of perioperative outcomes in EEP vs EVP, the total energy used was the only statistically different pooled data in our analysis, L-EEP procedures using less energy in operation (108.67 minutes 95% CI [−166.29, −51.05]; P = .0002) (Fig. 5A). However, no statistical differences were observed between L-EEP and L-EVP in terms of HB level drop, hospital stay, conversion of surgical techniques, operative time, and catheterization time in the pooled data. There were insufficient data to analyze the decrease in sodium, or irrigation length during perioperative periods. (see Supplementary information, http://links.lww.com/MD/F233).

3.6. Postoperative complications in L-EEP vs L-EVP
In the L-EEP group, the rate of retreatment for residual adenoma was lower than in the L-EVP group (OR: 0.06; 95% CI, [0.01, 0.30]; P = .0007) (Fig. 5B). No differences were noted in capsular perforation, haematuria, clot retention, urge incontinence, stress urinary incontinence, retreatment for residual adenoma, UTI, BNC, urethral stricture, transient incontinence, blood transfusions, and urinary incontinence. (see Supplementary information, http://links.lww.com/MD/F233).
Figure 3. A, The forest plot of pooled estimates of the efficacy of operation at 1 month of postoperation in EEP vs EVP. B, The forest plot of pooled estimates of the efficacy of operation at 3 months of postoperation in EEP vs EVP. C, The forest plot of pooled estimates of the efficacy of operation at 6 months of postoperation in EEP vs EVP. D–F, The forest plot of pooled estimates of efficacy of operation at 12 months of postoperation in EEP vs EVP. EEP = endoscopic enucleation, EVP = endoscopic vaporization procedures.
3.7. Efficacy of operation in L-EEP vs L-EVP

3.7.1. One month postsurgery. Only Elmansy et al\[10\] compared PRV between the L-EEP group and the L-EVP group. The pooled data showed less PRV in the L-EEP group at 1 month after surgery (68.8 ml, 95% CI [−11.57, −21.85], \( P = .004 \)) (Fig. 6A). However, no significant differences were noted in IPSS and QoL from 4 studies\[10,15,17,20\] and Qmax from 2 studies.\[10,15\] (see Supplementary information, http://links.lww.com/MD/F233).

3.7.2. Three month postsurgery. This study showed no statistical differences in both groups regarding IPSS,\[10,15,17,20\] Qmax,\[10,15,17,20\] QoL,\[10,15,17,20\] and PRV\[10,20\] at 3 months in the pooled data analysis. (see Supplementary information, http://links.lww.com/MD/F233).

3.7.3. Six month postsurgery. In the pooled data from three studies with 1581 patients, IPSS and QoL showed no statistical differences between L-EEP and L-EVP 6 months postsurgery.\[10,15,17\] However, L-EEP was associated with a greater Qmax (4.25 ml/s, 95% CI [2.96, 5.53], \( P < .001 \))\[10,15\] and less PRV (51.3 ml, 95% CI [−85.8, −16.8], \( P = .004 \))\[10\] in the pooled data analysis (Fig. 6B-C).

3.7.4. Twelve of months postsurgery. In L-EEP group at 12 months post-surgery, PRV(26.5 ml, 95% CI [−40.91, −12.1], \( P = .0003 \))\[10,12,20\] Qmax (3.63 ml/s, 95% CI [0.84, 6.41], \( P = .01 \))\[10,12,15,20\] and IPSS (1.95, 95% CI [−3.44, −0.46], \( P = .01 \))\[10,15,17,20\] (Fig. 6D–F) were better compared with the L-EVP group. However, there was no significant difference between L-EEP and L-EVP for the QoL score of the pooled data.\[10,15,17,20\] (see Supplementary information, http://links.lww.com/MD/F233).

3.7.5. Twenty-four and 36 months postsurgery. Only the study by Elkoushy et al\[15\] compared IPSS, QoL, and Qmax between EEP and EVP at 24- and 36 months postsurgery. The
pooled analysis showed that EEP techniques were associated with a higher Qmax (15.20 ml/s, 95% CI [13.93, 16.47], \(P < .00001\) at 24 month after surgery and 11.90 ml/s, 95% CI [9.02, 14.78], \(P < .00001\) at 36 month after surgery), lower IPSS (\(−3.90\), 95% CI [\(−4.52, −3.28\)], \(P < .00001\) at 24 month after surgery and \(−4.10\), 95% CI [\(−5.12, −3.08\)], \(P < .00001\) at 36 month after surgery) and QoL score (\(−1.00\), 95% CI [\(−1.18, −0.82\)], \(P < .00001\) at 24 month after surgery and \(−1.40\), 95% CI [\(−1.57, −1.23\)], \(P < .00001\) at 36 month after surgery) at both follow-up times (Fig. 7A–F).

4. Discussion

For many years, TURP is still considered gold standard for the small/medium prostates and open prostatectomy\(^{[26]}\) was the most appropriate choice for men with large gland volumes. However, TURP is still accompanied by some life-threatening risks, such as a 2% to 4.8% rate of hemorrhage requiring blood transfusion,\(^{[27]}\) and elevated morbidity occurred in open prostatectomy.\(^{[28]}\) Therefore, diverse transurethral techniques have been adopted in recent years which possess excellent functional outcomes and lower complication rates. Among these new procedures, EEP and EVP seem to be the methods with the most potential since high-quality studies give a demonstration of persistent improvement in the QoL and other functional outcomes, as well as a favorable safety profile.\(^{[1,7,29–31]}\)

Some superb meta-analyses have been published comparing diverse endoscopic procedures\(^{[31]}\) and head-to-head compared specific technologies, such as HoLEP vs bipolar transurethral resection of the prostate,\(^{[32]}\) thulium laser enucleation of the prostate vs TURP.\(^{[33]}\) Although EEP is a widely used surgical procedure, it has never been investigated as a whole and compared with EVP techniques. It is difficult but important to select the best surgical treatment for BPH. Hence, it is worth comparing different surgical procedures, whether it is through direct or indirect studies. As far as we know, our meta-analysis represents the first study to indirectly compare EEP with EVP in terms of the efficacy and safety for the treatment of BPH. Moreover, since laser surgery is a popular procedure today but was rarely used in the last century,\(^{[34]}\) we further analyzed the differences between L-EEP and L-EVP.

During the entire postoperative follow-up, greater Qmax values were obtained with enucleation methods, including bipolar plasma enucleation of the prostate, plasmakinetic transurethral enucleation, HoLEP, thulium enucleation of the prostate, and green laser enucleation of the prostate. even after 24 to 36 months. Enucleation methods were also associated with better PRV, IPSS, and QoL compared with vaporization methods when the postoperative follow-up period exceeded 12 months. However, when laser techniques were considered, better functional outcomes of Qmax only became apparent 6 months postsurgery. However, the lower PRV seemed to persist throughout the follow-up duration (except 3 months after operation) and the differences with IPSS and QoL could be observed over 12 months following surgical treatment. EEP methods imitate open prostatectomy and remove more tissues using fibreoptic lasers or bipolar loops.\(^{[35]}\) Therefore, it is not surprising that enucleation methods yielded the greatest Qmax values compared with resection and vaporization methods, since more tissues were removed using enucleation methods than vaporization methods.\(^{[36]}\) In a systematic review and network meta-analysis performed by Huang et al,\(^{[37]}\) EEP procedures have been shown to improve Qmax by about 1.71 to 1.98 ml/s and 4.12 to 4.82 ml/s at 6 to 12 and 24 to 36 months postsurgery, respectively, compared with EVP procedures which have been considered clinically significant. In this study, EEP was observed to improve Qmax by 2.78 and 1.85 ml/s than vaporization methods at 1 month and 3 months, and by 3.14, 3.23, 15.2, and 11.9 ml/s more at 6, 12, 24, and 36 months following surgery, respectively. Accordingly, it was clinically
significant for the difference of Qmax between EEP and EVP procedures.

As we compared the perioperative data of EEP and EVP, both showed effective outcomes. On the other hand, based on our meta-analysis, EVP favored significant differences with respect to catheterization time, while there was no significant difference between the L-EEP and L-EVP groups. Our analysis also showed that EVP and L-EVP methods seemed to generate higher total energy used during surgery compared with EEP and L-EEP. EEP is widely believed to increase the risk of urinary incontinence and capsular perforation. Nevertheless, our study did not observe any differences in the rate of implications between groups. A lower rate of retreatment for residual adenoma in EEP and L-EEP was observed. This could be explained by the fact that EEP methods remove whole hyperplastic adenoma of the prostate as open prostatectomy, while EVP methods remove less apical prostate tissue to prevent sphincter injury. Therefore, in order to overcome the
shortcomings of vaporization, some surgeons resect the apex of the prostate after vaporization.\[40\]

A published network meta-analysis of 88 randomly controlled trials with 15 procedures found that HoLEP was the first choice for PRV values, although diode laser vaporization of prostate gave better results in terms of IPSS and Qmax.\[34\] Another network meta-analysis comparing different lasers for surgical treatment of BPH, comprising 36 randomized studies involving 3831 patients found that HoLEP was the most advantageous operative procedure for improving PRV.\[41\] Our results indicated that enucleation technology is more effective than vaporization, regardless of the laser energy that was utilized.

Huang et al\[37\] reported superior functional outcomes and parallel safety when comparing enucleation methods to vaporization methods. Such results were confirmed by our meta-analysis again. Regarding laser energy, the results were similar when comparing L-EEP and L-EVP. However, Zhang et al\[41\] comparing different lasers for the treatment of BPH found that dysuria was the most frequent short-term complication in patients treated with green laser vapo-enucleation of the prostate and HoLEP, but was rarely seen in Nd:YAG laser with vaporization. When long-term complications-related outcomes were considered, BNC or stenosis was oftentimes found in KTP/Nd:YAG with vaporization and HoLEP comparing with green laser vaporization of the prostate and diode laser with vaporization.

Our study included only 2 RCTs. Hence, we must interpret the results within the context of some limitations. First, the follow-up time varied from study to study; data for more than 12 months of follow-up were obtained from only 1 study,\[15\] and the majority of the included studies had a maximum follow-up of up to 1 year.\[10,13,14,16,17,19–22,24,25\] Consequently, we lacked the data to evaluate the differences in long-term efficacy and safety between EEP and EVP. Second, as a result of rare complications and zero events reported by some studies, the pooled ORs were less

Figure 7. A–F The forest plot of pooled estimates of the efficacy of operation at 24 and 36 months of postoperation in laser enucleation procedures vs laser vaporization procedures.
precise. Third, there existed high heterogeneity in most analyses, which could be interpreted as the difference in each trial studied, such as the initial volume of prostate, the degree of urodynamic obstruction, and the level of experience of the surgeons. Fourth, because of a lack of standardized definition and techniques, we did not distinguish vapo-enucleation from enucleation. Hence, further investigations are required to evaluate the differences in outcomes between vapo-enucleation and enucleation or vaporization methods. Nevertheless, this review still enjoys several advantages. To our knowledge, this study is the first comprehensive systematic review and meta-analysis that focuses on comparing EEP and EVP methods for treatment of BPH, and that offers an evaluation of their efficacy and safety, with a view of providing valuable insights and recommendations for clinician surgeons.

5. Conclusion

Our study showed that EEP and EVP provide efficacy and safety for the treatment of BPH. Most perioperative data existed no significant difference between both groups, but EVP favors total energy used and retreatment for residual adenoma and reduces catheterization time. EEP shows better functional outcomes than EVP. Compared with L-EVP, L-EEP provides greater total energy used and retreatment for residual adenoma with the same complications and better functional profiles. However, the clinical significance of these findings remains unclear. Therefore, more long-term, larger-scale, and well-designed head-to-head RCTs are needed to provide a clear direction as to which techniques to select in clinical conditions.

Acknowledgments

We are grateful to the participants and researchers of the primary studies identified for this meta-analysis and the editors and the anonymous reviewers for the comments provided and the valuable inputs. We thank our institutions for allowing us to perform this study.

Author contributions

Data curation: Jun Chen, Ming Liu.
Formal analysis: Hui Sun.
Software: Zehua Wang.
Visualization: Benkang Shi.
Writing – original draft: Xinbao Yin.
Writing – review & editing: Xueping Zheng.

References

[1] Foster HE, D’Amico P, Kohler TS, et al. Surgical Management of lower urinary tract symptoms attributed to benign prostatic hyperplasia: AUA Guideline Amendment 2019. J Urol 2019;202:592–8.
[2] Lokedawar SD, Harper BT, Webb E, et al. Epidemiology and treatment modalities for the management of benign prostatic hyperplasia. Trans Androl Urol 2019;8:529–39.
[3] Chapple CR. Lower urinary tract symptoms suggestive of benign prostatic obstruction—Triumph: design and implementation. Eur Urol 2003;39 Suppl 3:51–6.
[4] Thangasamy IA, Chalasani V, Bachmann A, et al. Photoselective vaporisation of the prostate using 80-W and 120-W laser versus transurethral resection of the prostate for benign prostatic hyperplasia: a systematic review with meta-analysis from 2002 to 2012. Eur Urol 2012;62:315–23.
[5] Lourenco T, Pickard R, Vale L, et al. Alternative approaches to endoscopic ablation for benign enlargement of the prostate: systematic review of randomised controlled trials. BMJ 2008;337:a449.
[6] Ahvay SA, Gilling P, Kaplan SA, et al. Meta-analysis of functional outcomes and complications following transurethral procedures for lower urinary tract symptoms resulting from benign prostatic enlargement. Eur Urol 2010;58:364–7.
[7] Netch C, Bach T. Vaporization vs. enucleation techniques for BPO: do we have a standard? Curr Opin Urol 2015;25:45–52.
[8] Luo D, Wan X, Liu J, et al. Optimally estimating the sample mean from the sample size, median, mid-range, and/or mid-quartile range. Stat Methods Med Res 2018;27:1785–805.
[9] Wan X, Wang W, Liu J, et al. Estimating the sample mean and standard deviation from the sample size, median, range and/or interquartile range. BMC Med Res Methodol 2014;14:135.
[10] Elhilali MM. Holmium laser enucleation versus photoscopic vaporization for prostatic adenoma greater than 60 mL: preliminary results of a prospective, randomized clinical trial. J Urol 2012;188:216–21.
[11] Eltermann DS, Chughtai B, Lee R, et al. Comparison of techniques for transurethral laser prostatectomy: standard photoselective vaporization of the prostate versus transurethral laser enucleation of the prostate. J Endourol 2013;27:751–5.
[12] Jaeger CD, Mitchell CR, Myndseres LA, et al. Holmium laser enucleation (HoLEP) and photoselective vaporisation of the prostate (PVP) for patients with benign prostatic hyperplasia (BPH) and chronic urinary retention. BJU Int 2015;115:295–9.
[13] Cho MC, Ha SB, Oh SJ, et al. Change in storage symptoms following laser prostatectomy: comparison between photoselective vaporization of the prostate (PVP) and holmium laser enucleation of the prostate (HoLEP). World J Urol 2015;33:1173–80.
[14] Gevleve B, Balai C, Ene C, et al. Bipolar vaporization, resection, and enucleation versus open prostatectomy: optimal treatment alternatives in large prostate cases? J Endourol 2015;29:323–31.
[15] Elkousy MA, Elhal AM, Elhilali MM. Postoperative lower urinary tract storage symptoms: does prostate enucleation differ from prostate vaporization for treatment of symptomatic benign prostatic hyperplasia? J Endourol 2015;29:1159–65.
[16] Misrai V, Kerever S, Phe V, et al. Direct comparison of greenlight laser XPS photoselective prostate vaporization and greenlight laser en bloc enucleation of the prostate in enlarged glands greater than 80 ml: a study of 120 patients. J Urol 2016;195(4 Pt 1):1027–32.
[17] Kim KS, Choi JB, Baek WJ, et al. Comparison of photoselective vaporization versus holmium laser enucleation for treatment of benign prostatic hyperplasia in a small prostate volume. PLoS One 2016;11:e0156133.
[18] Cindolo L, Ruggera I, Destefanis P, et al. Vaporize, anatomically vaporize or enucleate the prostate? The flexible use of the GreenLight laser. Int Urol Nephrol 2017;49:405–11.
[19] Mu XN, Wang SJ, Chen J, et al. Bipolar transurethral enucleation of prostate versus photoscopic vaporization for symptomatic benign prostatic hyperplasia (>70ml). Asian J Androl 2017;19:608–12.
[20] You S, Park J, Cho SY, et al. A novel vaporization-enucleation technique for benign prostatic hyperplasia using 120-W HPS GreenLight laser: Seoul technique II in comparison with vaporization and previously reported modified vaporization-resection technique. World J Urol 2017;35:1923–31.
[21] Wang SJ, Mu XN, Chen J, et al. Plasmakinetic enucleation of prostate versus 160-W laser photoselective vaporization for the treatment of benign prostatic hyperplasia. Asian J Androl 2017;19:15–9.
[22] Castellani D, Cindolo L, De Nunzio C, et al. Comparison between thulium laser VapoEnucleation and GreenLight Laser photoselective vaporization of the prostate in real-life setting: propensity score analysis. Urology 2018;121:147–52.
[23] Sun I, Yoo S, Park J, et al. Quality of life after photo-selective vaporization and holmium-laser enucleation of the prostate: 5-year outcomes. Sci Rep 2019;9:8261.
[24] Kim KS, Lee SH, Cho HJ, et al. Comparison of bipolar plasma vaporization versus standard holmium laser enucleation of the prostate: surgical procedures and clinical outcomes for small prostate volume. J Clin Med 2019;8:1007.
[25] Pruholdme I, Marquette T, Pere M, et al. Benign prostatic hyperplasia endoscopic surgical procedures in kidney transplant recipients: a comparison between holmium laser enucleation of the prostate, greenlight photoselective vaporization of the prostate, and transurethral resection of the prostate. J Endourol 2019;34:184–91.
[26] Wroclawski ML, Carneiro A, Tristao RA, et al. Giant prostatic hyperplasia: report of a previously asymptomatic man presenting with gross hematuria and hypovolemic shock. Einstein (Sao Paulo) 2015;13:420–2.
[27] Rassweiler J, Teber D, Kuntz R, et al. Complications of transurethral resection of the prostate (TURP)-incidence, management, and prevention. Eur Urol 2006;50:969–79. discussion 980.
[28] Carneiro A, Sakuramoto P, Wroclawski ML, et al. Open suprapubic versus retropubic prostatectomy in the treatment of benign prostatic hyperplasia during resident’s learning curve: a randomized controlled trial. Int Braz J Urol 2016;42:284–92.
[29] Gilling PJ, Wilson LC, King CJ, et al. Long-term results of a randomized trial comparing holmium laser enucleation of the prostate and transurethral resection of the prostate: results at 7 years. BJU Int 2012;109:408–11.
[30] Gu M, Chen YB, Liu C, et al. Comparison of holmium laser enucleation and plasmakinetic resection of prostate: a randomized trial with 72-month follow-up. J Endourol 2018;32:139–43.
[31] Cornu JN, Ahyai S, Rachmann A, et al. A systematic review and meta-analysis of functional outcomes and complications following transurethral procedures for lower urinary tract symptoms resulting from benign prostatic obstruction: an update. Eur Urol 2015;67:1066–96.
[32] Qian X, Liu H, Xu D, et al. Functional outcomes and complications following B-TURP versus HoLEP for the treatment of benign prostatic hyperplasia: a review of the literature and Meta-analysis. Aging Male 2017;20:184–91.
[33] Jiang H, Zhou Y. Safety and efficacy of thulium laser prostatectomy versus transurethral resection of prostate for treatment of benign prostate hyperplasia: a meta-analysis. Low Urin Tract Symptoms 2016;8:165–70.
[34] Sun F, Sun X, Shi Q, et al. Transurethral procedures in the treatment of benign prostatic hyperplasia: a systematic review and meta-analysis of effectiveness and complications. Medicine (Baltimore) 2018;97:e13360.
[35] Kuntz RM, Ahyai S, Lehrich K, et al. Transurethral holmium laser enucleation of the prostate versus transurethral electrocautery resection of the prostate: a randomized prospective trial in 200 patients. J Urol 2004;172:1012–6.
[36] Placer J, Gelabert-Mas A, Vallmanya F, et al. Holmium laser enucleation of prostate: outcome and complications of self-taught learning curve. Urology 2009;73:1042–8.
[37] Huang SW, Tsai CY, Tseng CS, et al. Comparative efficacy and safety of new surgical treatments for benign prostate hyperplasia: systematic review and network meta-analysis. BJU Int 2019;367:15919.
[38] Wilson LC, Gilling PJ, Williams A, et al. A randomised trial comparing holmium laser enucleation versus transurethral resection in the treatment of prostates larger than 40 grams: results at 2 years. Eur Urol 2006;50:569–73.
[39] Gallucci M, Puppo P, Perachino M, et al. Transurethral electro-vaporization of the prostate vs. transurethral resection. Results of a multicentric, randomized clinical study on 150 patients. Eur Urol 1998;33:359–64.
[40] Tekeli A, Muslumanoglu AY, Baykal M, et al. A hybrid technique using bipolar energy in transurethral prostate surgery: a prospective, randomized comparison. J Urol 2005;174(4 Pt 1):1339–43.
[41] Zhang X, Shen P, He Q, et al. Different lasers in the treatment of benign prostatic hyperplasia: a network meta-analysis. Sci Rep 2016;6:23503.