RESEARCH PAPER

Comparative Study of Holmium laser Enucleation of the Prostate Versus Bipolar Transurethral Enucleation for Treating Large Prostatic Adenomas

Hosam Mohammed Mahmoud[1], Mohammed Abd Elmalek Hasan[2], Ehab Rifat Tawfiek[3], Mohamad Salah El badry[4], Mohammed Gamal Sayed[5]

[1-5] Department of Urology, Faculty of Medicine, Minia University, Minia, Egypt

***Corresponding author:** urology.im25@gmail.com*

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ABSTRACT

Objective(s): To critically review and compare the efficacy, safety, and perioperative outcomes of holmium laser enucleation of the prostate (HoLEP) and bipolar transurethral enucleation of the prostate (B-TUEP) in the surgical management of large prostatic adenomas.

Data Sources: A structured search of PubMed, Web of Science, and Google Scholar was performed to identify randomized controlled trials, comparative cohort studies, systematic reviews, and meta-analyses published on HoLEP and B-TUEP, with emphasis on studies addressing prostates exceeding 80 mL.

Study Selection: Studies directly comparing HoLEP and B-TUEP in terms of perioperative parameters, functional outcomes, and complications were prioritized, alongside technique-description papers and guideline statements relevant to endoscopic enucleation of the prostate (EEP).

Summary of Contents: This review outlines the surgical principles of EEP, the technical evolution and equipment requirements of HoLEP and B-TUEP, and provides a critical comparative analysis of energy source and tissue interaction, operative efficiency, perioperative and functional outcomes, complication profiles, learning curve, and cost/availability between the two techniques.

Conclusion: HoLEP and B-TUEP are both safe and effective anatomical enucleation techniques for large prostatic adenomas, achieving comparable functional outcomes with low retreatment rates. HoLEP offers advantages in hemostasis, catheterization time, and hospital stay, particularly in larger glands, while B-TUEP offers a shorter learning curve for TURP-experienced surgeons and lower equipment cost, making it a valuable alternative where laser technology is unavailable.

Keywords: Holmium laser enucleation; bipolar transurethral enucleation; benign prostatic hyperplasia; endoscopic enucleation of the prostate; large prostate adenoma

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INTRODUCTION

Benign prostatic hyperplasia (BPH) is one of the most common urological conditions affecting aging men, with prevalence rising with age to affect up to 80-90% of men over 80, representing a considerable healthcare burden worldwide [1,2].

Medical therapy with alpha-blockers and 5-alpha reductase inhibitors remains first-line, but surgery becomes necessary for refractory symptoms, recurrent retention, recurrent urinary tract infection, bladder stones, obstructive renal impairment, or failed conservative management. Open simple prostatectomy was long the standard for prostates exceeding 80-100 mL, but carries significant morbidity, including greater blood loss, longer hospitalization, and prolonged recovery [3,4].

TURP has historically been the gold standard for moderate enlargement, but its limitations in large glands - prolonged operative time, bleeding risk, incomplete removal - stimulated development of anatomical endoscopic enucleation (EEP), which mimics open prostatectomy by removing the entire adenoma along the surgical capsule, offering more complete removal and durable outcomes irrespective of gland size [5].

HoLEP has emerged as one of the most effective and extensively studied EEP techniques, using the holmium:YAG laser to dissect the adenoma along its natural plane before morcellation and removal, with numerous studies demonstrating excellent, durable improvement in IPSS, Qmax, and PVR and low retreatment rates even in very large prostates [6,7]. It is, however, limited by a steep learning curve and costly specialized equipment, encouraging alternative energy-based enucleation techniques [8].

B-TUEP applies the same anatomical principle using bipolar electrosurgical energy and equipment closely related to standard bipolar TURP. Bipolar technology permits isotonic saline irrigation, eliminating transurethral resection syndrome risk, and is widely available, making B-TUEP a more accessible and potentially cost-effective alternative [9].

Comparative studies of HoLEP and B-TUEP in large prostatic adenomas generally report comparable functional improvement and safety, while some suggest HoLEP offers shorter catheterization time and hospital stay, and B-TUEP a shorter learning curve and wider equipment availability [10]. This review critically synthesizes the published evidence comparing efficacy, safety, and perioperative outcomes of HoLEP and B-TUEP in large prostatic adenomas, to inform surgical decision-making.

DISCUSSION / MAIN BODY

Endoscopic Enucleation of the Prostate: Rationale and Surgical Principles

Endoscopic enucleation of the prostate (EEP) applies the anatomical principles of open simple prostatectomy to a minimally invasive transurethral approach. Unlike TURP's piecemeal tissue removal, EEP achieves complete dissection along the surgical capsule - the plane formed by compressed peripheral-zone tissue and fibromuscular stroma - resulting in near-total removal of the hyperplastic transition zone [11,12]. Early identification of the verumontanum is a key principle common to all EEP techniques, serving as the landmark for distal dissection and sphincter preservation, with dissection typically proceeding apex-to-bladder-neck [13]. EEP may follow a traditional multi-lobe strategy or an en bloc approach dissecting the entire adenoma as one unit; en bloc techniques may improve efficiency, reduce bleeding, and enhance orientation, particularly in large prostates [14]. Enucleated tissue is retrieved by mechanical morcellation [15].

The two dominant energy modalities achieve hemostasis differently: laser systems provide simultaneous cutting and coagulation with shallow penetration and minimal collateral damage [16], while bipolar systems achieve hemostasis through deeper thermal coagulation using saline as a conductive medium, an advantage in anticoagulated patients despite greater coagulative depth [17]. Compared with TURP, EEP provides more complete removal, superior durable symptom relief, and size-independent applicability that has largely replaced open prostatectomy for large glands, with lower blood loss, reduced transfusion, and shorter catheterization and hospital stay [18,19,7,20], though its significant learning curve (20-50 cases for proficiency) remains its principal drawback [21].

Holmium Laser Enucleation of the Prostate (HoLEP)

HoLEP evolved from early Nd:YAG laser coagulation therapy, which improved hemostasis but caused dysuria and unpredictable necrosis from deep energy penetration [12]. The holmium:YAG laser (2140 nm, high water absorption, ~0.4 mm penetration depth) enabled a shift toward anatomical enucleation along the natural adenoma-capsule plane, effectively translating open finger enucleation into an endoscopic technique; parallel development of mechanical morcellators made efficient removal of large tissue volumes feasible [22,23]. Tissue interaction is primarily photothermal, producing rapid vaporization with minimal thermal spread - a key safety feature near the external sphincter [24,25]. Typical settings range from 1.0-2.0 J at 20-50 Hz, with lower settings preferred during apical dissection [26], and saline irrigation eliminates TUR syndrome risk [27]. Refinement from multi-lobe toward en bloc enucleation, with higher-power lasers and more durable fibers, has improved efficiency and established HoLEP as a size-independent technique with robust long-term durability [28].

Several technical variants share the objective of complete anatomical enucleation but differ in how the adenoma is segmented: the classical three-lobe technique remains foundational for training [29,30]; the two-lobe technique reduces mucosal incisions [31]; and en bloc enucleation - now the preferred modern approach - dissects the adenoma circumferentially as a single unit, reducing operative time, bleeding, and transient incontinence [32,33]. Refinements such as early apical release [34], the no-touch technique [35], and the veil technique [36] reflect continued evolution toward better functional preservation, though outcomes depend more on surgeon experience than on the specific variant used [37].

Bipolar Transurethral Enucleation of the Prostate (B-TUEP)

Bipolar electrosurgery emerged in response to the limitations of monopolar TURP - bleeding, TUR syndrome, and suboptimal efficacy in large glands. Confining current between two closely spaced electrodes permits isotonic saline irrigation, eliminating TUR syndrome risk [12,38]. Initially applied to resection (bipolar TURP), bipolar energy was later adapted to anatomical enucleation, inspired by HoLEP, giving rise to B-TUEP [5], now recognized by contemporary guidelines as a valid EEP modality with outcomes comparable to laser enucleation when performed by experienced surgeons [39]. It uses standard equipment - a bipolar generator, continuous-flow resectoscope, and loop/button/spatula electrodes - contributing to wide availability [40,41,42].

The procedure follows the same anatomical sequence as HoLEP: mucosal incisions at 5 and 7 o'clock define entry into the capsular plane, developed using gentle mechanical sweeping combined with controlled bipolar energy applied selectively to fibrous attachments [43,42,44]. The median lobe is typically enucleated first, followed by the lateral lobes; an en bloc alternative reduces repeated plane entry but demands greater expertise [45,46]. Apical dissection near the verumontanum remains the most critical step for continence preservation [47]. Hemostasis uses bipolar coagulation with deeper thermal penetration than laser systems,

requiring careful energy modulation [48]; tissue retrieval by morcellation is increasingly favored, though the more variable, coagulated consistency of bipolar-enucleated tissue can make it somewhat less straightforward than after HoLEP [18,49].

Comparative Analysis: HoLEP versus B-TUEP

Both HoLEP and B-TUEP are grounded in the same conceptual foundation - complete anatomical enucleation of the adenoma along the surgical capsule - but differ meaningfully in energy source, tissue interaction, operative handling, and learning requirements, differences that may influence perioperative outcomes, complication profiles, and long-term efficacy [12,49].

Energy source and tissue interaction. HoLEP uses holmium:YAG laser energy (2140 nm, ~0.4 mm penetration depth), enabling precise cutting with excellent coagulation and minimal thermal spread, whereas B-TUEP relies on bipolar electrosurgical current with comparatively deeper thermal penetration, which may increase the risk of tissue charring and marginally more bleeding, though bipolar energy remains highly effective in experienced hands [5,38,25]. HoLEP is therefore often characterized as a "laser-driven" enucleation with superior intrinsic hemostasis and visualization, while B-TUEP is a "mechanically assisted" enucleation offering greater tactile feedback during dissection [42,40].

Operative technique and efficiency. The operative sequence is essentially identical between the two techniques - capsular plane identification, adenoma enucleation, and tissue retrieval - but the continuous cutting efficiency of the laser allows smoother, less interrupted dissection in HoLEP, whereas B-TUEP requires alternating blunt dissection and intermittent energy application, which may prolong operative time early in a surgeon's experience [21]. En bloc techniques improve efficiency in both modalities, but the learning curve for en bloc enucleation is generally steeper for B-TUEP [46]. Tissue retrieval by morcellation is more routinely straightforward in HoLEP owing to the more uniform consistency of laser-enucleated tissue, though B-TUEP morcellation is safe and effective with proper technique [35,50].

Perioperative outcomes. Comparative series generally report reduced intraoperative blood loss, lower transfusion rates, and shorter catheterization time with HoLEP, attributable to the superior hemostatic properties of laser energy, while B-TUEP achieves comparable operative times and hospital stay in experienced hands, with low overall perioperative morbidity for both techniques given the shared use of saline irrigation and elimination of TUR syndrome risk [51,39].

Functional outcomes. Both techniques produce significant, durable improvement in IPSS, Qmax, and PVR, and comparative studies have consistently found no significant difference between HoLEP and B-TUEP in functional outcomes at short- or long-term follow-up, indicating that both approaches are equally effective in relieving bladder outlet obstruction once the learning curve has been overcome [49].

Complications. The complication profiles of the two techniques are broadly similar, with comparable rates of early complications (hematuria, clot retention, urinary tract infection, transient incontinence) and late complications (urethral stricture, bladder neck contracture). HoLEP is associated with somewhat lower intraoperative bleeding and transfusion rates, while B-TUEP may carry marginally higher bleeding risk from deeper thermal penetration, though this is generally not clinically significant in experienced centers [43,52]. Transient stress urinary incontinence can occur with either technique and appears more influenced by surgical technique and experience than by energy modality [47].

Learning curve, cost, and availability. HoLEP is traditionally regarded as having a steeper learning curve, with proficiency typically requiring 40-60 cases due to the need for precise laser control and enucleation-specific anatomical orientation [53]. B-TUEP may offer a shorter learning curve for surgeons already experienced in TURP, since it uses familiar instrumentation, although mastering true anatomical enucleation still requires substantial dedicated training regardless of energy source [54]. HoLEP also requires a dedicated laser generator and morcellator, a substantial capital investment that can limit availability in resource-constrained settings, whereas B-TUEP uses standard bipolar equipment already present in most urological centers, making it a more accessible and cost-effective option of particular relevance in developing healthcare systems [55].

CONCLUSION

HoLEP and B-TUEP both apply the anatomical principle of complete adenoma enucleation along the surgical capsule and, on current comparative evidence, achieve equivalent long-term functional outcomes and comparable overall complication rates in large prostatic adenomas. The techniques diverge mainly in perioperative parameters rather than ultimate efficacy: HoLEP's superior hemostatic properties translate into modest but consistent advantages in catheterization time and, in some series, hospital stay and transfusion risk, while B-TUEP offers a more accessible learning curve for TURP-trained surgeons and substantially lower equipment cost. Rather than one technique being categorically superior, the choice between HoLEP and B-TUEP should be guided by equipment availability, surgeon training, and patient-specific factors such as anticoagulation status and gland size. Further large, adequately powered randomized trials with long-term follow-up - particularly in prostates exceeding 80-100 mL - are needed to clarify whether

HoLEP's perioperative advantages translate into meaningful differences in durability of outcomes or retreatment rates.

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