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Moses Holmium Laser in Prostate Enucleation: Application and Future Prospects – A Review

Kai Li[1,a,*], Weidong Yang[1,b], Dongqing Wang[1,c]

[1]*Department of Urology, Affiliated Hospital of Hebei University, Baoding, Hebei, China*
[a]*worklk@126.com*, [b]*yangweidong2025@163.com*, [c]*858503298@qq.com*
**Corresponding author*

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Abstract: Moses Holmium Laser technology has emerged as a significant advancement in the surgical treatment of benign prostatic hyperplasia (BPH), particularly in prostate enucleation procedures. This review provides a comprehensive overview of the fundamental principles underlying holmium laser technology and highlights the innovative features introduced by the Moses technique. Current clinical applications of the Moses Holmium Laser demonstrate notable advantages including enhanced surgical efficiency, superior hemostasis, and improved postoperative recovery outcomes compared to conventional methods. The article critically examines recent clinical studies and technological enhancements that have refined the application of this laser system in urological surgery. Furthermore, it explores the evolving role and potential future developments of Moses Holmium Laser within the broader scope of urology, emphasizing its capacity to optimize patient care and surgical precision. By synthesizing existing evidence and emerging trends, this review aims to offer clinicians and researchers a systematic reference framework to facilitate the continued advancement and widespread adoption of Moses Holmium Laser technology in prostate enucleation.

1. Introduction

Benign prostatic hyperplasia (BPH) is a highly prevalent condition affecting middle-aged and elderly men worldwide, characterized by nonmalignant enlargement of the prostate gland. Epidemiological data indicate that approximately 50% of men aged 50 to 60 years exhibit histological evidence of BPH, with prevalence increasing to over 70% in men older than 70 years and up to 90% in octogenarians [1]. The clinical manifestations of BPH primarily involve lower urinary tract symptoms (LUTS), including urinary frequency, urgency, nocturia, weak stream, and incomplete bladder emptying. These symptoms substantially impair patients' quality of life (QoL), affecting physical, psychological, and social domains [2][3]. Moreover, BPH is often accompanied by comorbid conditions such as erectile dysfunction and depressive symptoms, further complicating management and diminishing health-related quality of life (HRQoL) [1][4]. The pathophysiology of BPH is multifactorial, involving hormonal changes, chronic prostatic inflammation, smooth muscle hyperactivity, and stromal proliferation, which collectively contribute to bladder outlet obstruction

and symptom progression [5][6]. Chronic inflammation, in particular, has been recognized as a key factor influencing disease severity and therapeutic responsiveness, highlighting the need for targeted interventions [5].

Conventional surgical treatment for BPH, notably transurethral resection of the prostate (TURP), has been the gold standard for decades due to its efficacy in relieving obstruction and improving symptoms. However, TURP and other traditional prostatectomy techniques are associated with significant drawbacks, including substantial intraoperative bleeding, prolonged catheterization, risk of sexual dysfunction, and relatively lengthy postoperative recovery [7][8]. These limitations have prompted the urological community to explore less invasive alternatives that minimize perioperative morbidity while maintaining therapeutic efficacy. Minimally invasive surgical therapies (MISTs) have emerged as promising options, offering advantages such as reduced blood loss, shorter hospital stays, faster recovery, and preservation of sexual function [9][10]. Examples of such interventions include prostatic artery embolization (PAE), water vapor thermal therapy (Rezum®), prostatic urethral lift (UroLift®), and various laser-based enucleation techniques [11][12][13]. These approaches have expanded the treatment armamentarium, particularly benefiting patients who are unfit for conventional surgery or those prioritizing quality of life and functional preservation.

Among the laser technologies, holmium:YAG laser has established itself as a versatile and effective tool in prostate surgery, combining precise tissue cutting with excellent hemostatic properties. Holmium laser enucleation of the prostate (HoLEP) has demonstrated durable symptom relief and favorable safety profiles, even in large prostates, and is increasingly considered a standard minimally invasive surgical option [14][15]. Nonetheless, ongoing innovations aim to optimize laser energy delivery and procedural efficiency. The advent of Moses™ technology represents a significant advancement in holmium laser application. This pulse modulation technique delivers energy in multiple shorter pulses within a single firing cycle, enhancing laser-tissue interaction, improving fragmentation efficiency in lithotripsy, and reducing operative time during prostate enucleation [16]. Preclinical and clinical studies suggest that Moses™ technology may reduce the learning curve of HoLEP and facilitate outpatient-based procedures, though further high-quality evidence is warranted to confirm these benefits [16].

The introduction of Moses™ technology into holmium laser prostate enucleation marks an innovative upgrade to traditional laser systems, increasing energy transmission efficiency and enhancing surgical safety. By modulating the pulse structure, Moses technology reduces retropulsion and improves cutting precision, which translates into shorter operative times and potentially fewer complications [16]. This evolution aligns with the broader trend in urology towards minimally invasive, patient-centered interventions that prioritize rapid recovery and quality of life. Given the significant burden of BPH on aging male populations and the limitations of conventional surgery, integrating advanced laser technologies like Moses™ into clinical practice holds promise for improving therapeutic outcomes and patient satisfaction.

In this context, a comprehensive review of the current application status and future prospects of Moses holmium laser technology in prostate enucleation is timely and necessary. Such a synthesis will provide clinicians and researchers with an updated understanding of the efficacy, safety, and technical considerations associated with this innovative approach. Additionally, it will identify gaps in evidence and outline directions for future research and clinical implementation. This article aims to systematically summarize the development, clinical utility, and potential advancement pathways of Moses holmium laser in the surgical management of BPH, thereby contributing to optimized patient care and informed decision-making in urological practice.

2. Main Body

2.1. Principles and Characteristics of Moses Holmium Laser Technology

2.1.1. Physical Properties and Mechanism of Holmium Laser

The holmium: yttrium-aluminum-garnet (Ho:YAG) laser operates at a wavelength of approximately 2100 nm, which corresponds to a high absorption coefficient in water and biological soft tissues. This wavelength is particularly suitable for precise soft tissue cutting and ablation, as water molecules strongly absorb the laser energy, leading to rapid vaporization of the tissue water content and subsequent tissue dissection. The laser energy is transmitted via flexible optical fibers, allowing for precise delivery to the target tissue with minimal invasiveness. The interaction mechanism primarily involves photothermal effects, where the absorbed energy converts to heat, causing localized tissue vaporization and coagulation. Importantly, the holmium laser induces a limited thermal damage zone, typically confined within a narrow margin around the ablation site, thereby preserving surrounding healthy tissues and reducing collateral damage. This precise energy delivery and limited thermal spread make the holmium laser highly advantageous in urological surgeries such as prostate enucleation and lithotripsy [17][18].

2.1.2. Innovations of Moses Technology

Moses technology represents a significant advancement in holmium laser pulse modulation. It utilizes a dual-pulse emission mode within a single laser firing cycle. The first pulse is designed to separate the water layer between the laser fiber tip and the target tissue or stone, creating a vapor bubble that transiently displaces the water. The second pulse then travels through this vapor channel with minimal energy loss, directly impacting the target tissue or stone. This innovative approach substantially reduces laser energy scattering and absorption in the water medium, enhancing energy delivery efficiency. Consequently, Moses technology improves stone fragmentation efficiency and tissue cutting by increasing the effective laser energy reaching the target. Laboratory and clinical studies have demonstrated that this pulse modulation reduces stone retropulsion during lithotripsy and enhances cutting efficiency during prostate enucleation, leading to shorter operative times and reduced intraoperative bleeding. The improved energy utilization and cutting dynamics translate into higher procedural efficacy and safety [19][16][17].

2.1.3. Impact of Technical Advantages on Surgical Procedures

The technical enhancements provided by Moses technology positively influence surgical operations in several ways. Firstly, the improved precision in laser energy delivery allows for more accurate control over cutting depth and tissue dissection, which is critical in delicate procedures such as holmium laser enucleation of the prostate (HoLEP). Secondly, the reduction in energy loss and retropulsion results in clearer intraoperative visualization, minimizing surgical field obscuration from tissue debris or bleeding, thereby enhancing operative safety. Thirdly, clinical evidence indicates that Moses technology reduces enucleation and hemostasis times, lowers laser energy consumption, and decreases intraoperative blood loss compared to conventional holmium laser modes. These improvements contribute to reduced surgical trauma, diminished postoperative inflammation, and accelerated patient recovery. Moreover, the decreased fiber degradation with Moses fibers enhances procedural efficiency and reduces interruptions. Collectively, these advantages foster safer, faster, and more effective surgeries with improved postoperative outcomes [20][21][22][23].

2.2. Clinical Application of Moses Holmium Laser in Prostate Enucleation

2.2.1. Surgical Indications and Patient Selection

Moses Ho:YAG laser enucleation of the prostate (HoLEP) is primarily indicated for patients with moderate to severe benign prostatic hyperplasia (BPH), particularly those who present with significant lower urinary tract symptoms (LUTS) refractory to medical therapy. The technique is especially suitable for patients with larger prostate volumes, often exceeding 80 mL, where traditional transurethral resection of the prostate (TURP) may be less effective or carry higher complication risks [24]. Additionally, patients with increased bleeding risk, such as those on anticoagulation therapy or with coagulopathies, benefit from the improved hemostatic control afforded by Moses technology, which reduces intraoperative blood loss [22][25]. Comprehensive preoperative assessment includes evaluation of prostate size via imaging, symptom severity, and overall health status to determine surgical tolerance. Patients with significant comorbidities or advanced age have been successfully treated with Moses HoLEP, demonstrating safety and efficacy even in elderly and high-risk cohorts [26][27]. Careful patient selection also involves urodynamic studies to assess bladder function and obstruction severity, as higher preoperative detrusor pressures correlate with better surgical outcomes [28]. Overall, Moses HoLEP is well suited for patients with moderate to severe BPH symptoms, large prostate volumes, and those at increased bleeding risk, provided their general health permits surgical intervention.

2.2.2. Surgical Procedure and Technical Considerations

The surgical workflow of Moses HoLEP begins with thorough preoperative preparation, including imaging studies such as transrectal ultrasound or MRI to assess prostate anatomy and size, and urodynamic evaluation to confirm bladder outlet obstruction [22]. During the procedure, the laser fiber is introduced transurethrally, and the enucleation is performed by carefully dissecting the adenomatous prostatic tissue from the surgical capsule. The Moses technology employs pulse modulation to optimize energy delivery, enhancing tissue ablation efficiency and hemostasis [16][21]. Key technical steps include precise localization of the surgical plane, meticulous enucleation of the median and lateral lobes, and effective hemostasis to minimize bleeding. The laser's pulse modulation reduces fiber degradation and carbonization, improving visibility and control during tissue separation [23]. Surgeons must exercise caution to protect the urethra and adjacent neurovascular structures to prevent complications such as urinary incontinence and erectile dysfunction [20]. Morcellation follows enucleation to remove the excised tissue fragments. Recent advancements, including the second-generation Moses 2.0 system, have further shortened enucleation and hemostasis times while reducing energy usage [20][29]. Standardized surgical protocols and surgeon experience are critical to optimize outcomes and minimize perioperative risks.

2.2.3. Clinical Efficacy and Safety Evaluation

Clinical studies consistently demonstrate that Moses HoLEP offers significant improvements in surgical efficiency and patient outcomes compared to traditional HoLEP. Prospective randomized controlled trials reveal that Moses technology reduces total operative time, enucleation time, and hemostasis duration, with mean operative times shortened by approximately 20-25% [22][21]. Blood loss is significantly decreased, as evidenced by smaller postoperative hematocrit drops, contributing to enhanced safety profiles [22][25]. Functional outcomes postoperatively include marked improvements in maximum urinary flow rates (Qmax), reduced post-void residual volumes (PVR), and alleviation of LUTS, leading to better quality of life [18][30]. The incidence of complications such as urinary incontinence, urethral strictures, and need for catheter reinsertion is

low and comparable to or better than standard HoLEP [31][32]. Meta-analyses confirm the superiority of Moses HoLEP in terms of shorter hospital stays and faster catheter removal, facilitating same-day discharge protocols [23][30]. Although some studies report no significant difference in long-term functional outcomes, the enhanced intraoperative efficiency and reduced morbidity render Moses HoLEP a safe and effective surgical modality for BPH management. Further large-scale, multicenter trials with longer follow-up are warranted to consolidate these findings [33][18].

2.3. The Future Development and Challenges of Moses Holmium Laser Technology

2.3.1. Review of Recent Clinical Research Findings

Recent clinical research has increasingly validated the superiority of Moses technology in holmium laser enucleation of the prostate (HoLEP) compared to traditional holmium laser techniques. Multicenter randomized controlled trials (RCTs) have demonstrated that Moses technology significantly reduces intraoperative laser retropulsion, which translates into enhanced surgical precision and efficiency. This reduction in retropulsion facilitates more controlled tissue ablation and shorter operative times, which are critical for patient safety and improved outcomes [17]. Furthermore, optimization of intraoperative laser parameters, such as pulse modulation and energy settings, has been a focal point in recent studies aiming to enhance both surgical efficacy and safety. Adjusting these parameters has been shown to improve enucleation speed and hemostasis without increasing complication rates, thereby improving overall procedural efficiency [17]. Long-term follow-up data from these clinical trials reveal sustained symptomatic relief and low recurrence rates, underscoring the durability of the therapeutic effect provided by Moses technology. Patients undergoing HoLEP with Moses laser report improved urinary flow rates and quality of life measures that persist over extended periods, confirming the long-term benefits of this advanced laser modality [34]. Despite these promising results, the heterogeneity in study designs and patient populations calls for further large-scale, well-designed RCTs to consolidate these findings and establish standardized protocols. Nonetheless, current evidence strongly supports the clinical advantages of Moses technology in improving surgical outcomes for benign prostatic hyperplasia (BPH) treatment, marking a significant advancement over conventional holmium laser methods [17][34].

2.3.2. Trends in Technological Improvements and Equipment Upgrades

Technological advancements in Moses holmium laser systems are focused on increasing laser power output and innovating optical fiber materials to enhance laser delivery stability and efficiency. Recent developments have seen the integration of higher wattage lasers, which enable faster tissue ablation and improved hemostatic control during prostate enucleation procedures. Innovations in fiber design, including more durable and flexible fibers with optimized core diameters, have contributed to more consistent energy transmission and reduced fiber degradation, thereby enhancing procedural reliability [35]. Another significant trend is the integration of intelligent navigation systems within laser platforms. These systems employ real-time imaging and feedback mechanisms to assist surgeons in precise localization and delineation of prostatic tissue planes, facilitating more accurate and complete enucleation while minimizing collateral tissue damage. Such smart navigation technologies represent a leap forward in surgical precision and safety, especially in anatomically complex cases [35]. Additionally, the combination of Moses laser technology with robotic-assisted surgical platforms is emerging as a promising approach to further enhance operative accuracy and ergonomics. Robotic assistance offers improved dexterity and

stable instrument control, which when coupled with the refined laser capabilities of Moses technology, may reduce surgeon fatigue and improve outcomes in minimally invasive prostate surgery. This synergy between laser and robotic technologies is expected to drive the next generation of urological surgical innovations [35]. Collectively, these technological improvements and equipment upgrades underscore a trend toward more efficient, precise, and user-friendly laser systems that can elevate the standard of care in prostate surgery.

2.3.3. Future Applications and Challenges

Looking forward, the application of Moses holmium laser technology is anticipated to expand beyond benign prostatic hyperplasia to include adjunctive roles in prostate cancer treatment and other urological disorders. The precision and reduced collateral damage afforded by Moses technology make it a compelling candidate for focal laser ablation therapies targeting localized prostate cancer, potentially offering a minimally invasive alternative with fewer side effects compared to conventional treatments [35]. Moreover, the technology's versatility could be leveraged in managing other urological conditions such as bladder tumors and ureteral strictures, broadening its clinical utility. However, several challenges must be addressed to facilitate widespread adoption. High equipment costs and limited availability currently restrict access to Moses laser systems, particularly in resource-constrained settings. Strategies to reduce manufacturing costs and enhance device affordability are critical to promoting broader dissemination and equitable patient access [34]. Additionally, despite encouraging short- and medium-term outcomes, there remains a need for extensive large-sample, multicenter studies to rigorously evaluate the long-term safety, efficacy, and cost-effectiveness of Moses technology in diverse patient populations. Such data are essential to inform clinical guidelines and justify reimbursement policies. Furthermore, gaps in laser technology education among urologists, as highlighted by recent surveys, must be addressed through standardized and updated training curricula to ensure optimal and safe utilization of this advanced technology [36]. In summary, while Moses holmium laser technology holds great promise for revolutionizing urological surgery, overcoming economic, educational, and evidentiary barriers will be pivotal to realizing its full potential in clinical practice.

3. Conclusions

In conclusion, the advent of Moses Holmium laser technology marks a significant milestone in the evolution of minimally invasive urological surgery, particularly in the management of prostate diseases. From an expert perspective, this technology exemplifies how innovative modifications in laser energy delivery can profoundly enhance surgical outcomes. By optimizing the interaction between laser energy and tissue, Moses technology has demonstrably improved the efficiency and safety of prostate enucleation procedures. Clinical evidence consistently underscores its advantages, notably in reducing intraoperative bleeding, shortening operative times, and facilitating faster postoperative recovery. These benefits not only improve patient safety and comfort but also have the potential to reduce healthcare resource utilization, a critical consideration in modern surgical practice.

Balancing the diverse research perspectives, it is clear that while the initial clinical outcomes are promising, ongoing studies continue to refine the technical parameters and explore broader applications within urology. The continuous evolution of the technology, including hardware upgrades and procedural innovations, reflects a dynamic field responsive to both clinical needs and technological possibilities. This iterative development process is essential to address the nuances of different patient populations and disease severities, ensuring that the technology's application is

both effective and personalized.

However, it is equally important to acknowledge the challenges that accompany the adoption of Moses Holmium laser technology. Cost considerations and the need for specialized training represent significant barriers to widespread implementation, particularly in resource-limited settings. Moreover, long-term comparative studies are necessary to fully establish its superiority over conventional laser techniques and other minimally invasive modalities. Such research will help delineate patient selection criteria and optimize procedural protocols, thereby maximizing clinical benefits while minimizing risks.

Looking ahead, the potential of Moses Holmium laser technology to become a cornerstone in the minimally invasive treatment of prostate diseases is substantial. Its capacity to enhance surgical precision and patient outcomes aligns well with the broader trend toward personalized and less invasive therapeutic strategies in urology. As the technology matures and becomes more accessible, it is anticipated that its integration into clinical practice will expand, supported by accumulating evidence and refined expertise.

In summary, Moses Holmium laser technology represents a transformative advancement in prostate surgery, combining innovative laser physics with practical clinical benefits. The ongoing dialogue between technological innovation and clinical application exemplifies the balanced approach necessary for the successful integration of new surgical tools. With continued research, training, and cost management, this technology holds the promise of significantly improving the standard of care for patients with prostate conditions, ultimately shaping the future landscape of urological surgery.

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