

# Review Article about the Latest Medical Devices Used to Break Up Kidney Stones

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**Annotation:** The management of kidney stones has undergone significant advancements in recent years, with a focus on improving surgical techniques and device efficacy. The literature reveals a progression of methodologies and technologies aimed at enhancing stone fragmentation and retrieval, which are critical for effective treatment outcomes.

## 1. Introduction

In 2010, explored the comparative effectiveness of percutaneous nephrolithotomy (PCNL) using pneumatic lithotripsy versus ultrasonic lithotripsy, emphasizing the importance of optimal access tracts and the various lithotripsy techniques available for stone fragmentation. This foundational work set the stage for subsequent innovations in lithotripsy, particularly the emergence of the holmium laser as a standard treatment modality.

By 2017, [1] highlighted the increasing prevalence of kidney stones and the shift towards ureteroscopy (URS) as the primary surgical approach for upper urinary tract stones, facilitated by advancements in holmium laser technology. This shift reflects a broader trend towards minimally invasive techniques, which continued to evolve in the following years.

In 2018, [2] examined the efficacy of "dusting" techniques using high-powered lasers for larger

stones, noting a reduction in operative time and complications associated with traditional basketing methods. This study underscored the ongoing refinement of laser lithotripsy methods, further enhancing the arsenal of tools available to urologists.

[3] contributed to this discourse by addressing the complications associated with lithotripsy, such as inflammatory infections and the risk of residual stones. Their research introduced a controlled fragmentation method using a continuous-wave diode laser, which not only aimed for effective stone fragmentation but also sought to mitigate postoperative infections.

The evolution of flexible ureterorenoscopy (fURS) was discussed by [4], who emphasized the role of advanced laser technologies in improving clinical outcomes for stone management. This narrative of innovation continued with [5], who evaluated the EMS Swiss LithoClast® Trilogy's efficacy for PCNL, highlighting its unique combination of ultrasonic and electromagnetic energy for enhanced stone clearance.

A systematic review by [6] compared dusting versus traditional stone fragmentation and extraction techniques in retrograde intrarenal surgery, revealing ongoing debates regarding the optimal management of stone fragments post-laser lithotripsy. This illustrates the complexity and variability in treatment approaches that practitioners must navigate.

[7] further contextualized the role of PCNL in contemporary urolithiasis treatment, acknowledging the advancements in flexible ureteroscopy while reaffirming PCNL's significance for larger stones. This tension between traditional and emerging techniques highlights the dynamic nature of kidney stone management.

Finally, [8] examined the impact of new laser systems on flexible ureteroscopic treatment, emphasizing the potential of thulium fiber lasers and innovative technologies to redefine treatment paradigms. This ongoing evolution reflects a commitment to enhancing patient safety and treatment efficacy in the face of rising kidney stone prevalence.

Overall, the literature illustrates a clear trajectory of innovation in the field of kidney stone management, characterized by the integration of advanced technologies and techniques aimed at improving patient outcomes. Each article contributes to a nuanced understanding of the current landscape, paving the way for future research and clinical practice.

## 2. Literature review

The article titled "Comparison of Percutaneous Nephrolithotomy Using Pneumatic Lithotripsy (Lithoclast®) Alone or in Combination with Ultrasonic Lithotripsy" by provides a comprehensive examination of the techniques and technologies involved in the management of large or multiple kidney stones, particularly focusing on percutaneous nephrolithotomy (PCNL). The authors effectively delineate the procedural steps involved in PCNL, which include percutaneous access, tract dilation, and stone fragmentation, thereby offering a structured overview of the procedure's complexities.

One of the significant contributions of this article is its critical evaluation of various lithotripsy techniques employed during PCNL. The authors highlight electrohydraulic lithotripsy (EHL) as a cost-effective option; however, they caution that it is the least safe among the lithotripsy devices discussed. This acknowledgment of the trade-offs between cost and safety is crucial for practitioners when selecting the appropriate technology for their patients. Furthermore, the authors present the holmium:yttrium-aluminum-garnet (Ho:YAG) laser as a highly effective tool for fragmenting renal stones, noting its ability to handle various types of calculi and compatibility with flexible endoscopes. However, they also point out a significant drawback: the need for manual extraction of the resultant stone fragments, which can complicate the procedure and potentially increase the duration of surgery.

The article also addresses the use of the Lithoclast® lithotripter, emphasizing its pneumatic mechanism that allows for stone fragmentation without generating thermal effects, thus

minimizing the risk of thermal injury to surrounding tissues. This detail is particularly relevant in the context of patient safety and post-operative recovery, as thermal injuries can lead to complications that may prolong hospitalization or necessitate further interventions.

Moreover, the authors provide insights into the complication rates associated with different approaches to PCNL, particularly noting a 5% complication rate with the supracostal approach. This statistic is essential for clinicians to consider when planning surgical interventions, as it underscores the importance of weighing the benefits of access methods against potential risks.

The article titled "Efficacy and safety of the EMS Swiss LithoClast® Trilogy for PCNL: results of the European multicentre prospective study on behalf of European Section of UroTechnology" by [5] presents a comprehensive evaluation of the Swiss LithoClast® Trilogy, a novel device in the realm of intracorporeal lithotripsy for the treatment of renal stones, particularly those exceeding 20 mm in size. The study is grounded in the context of percutaneous nephrolithotomy (PCNL), which has long been established as the first-line intervention for larger kidney stones.

The authors detail the technological advancements associated with the Swiss LithoClast® Trilogy, highlighting its unique design that integrates both ultrasonic and electromagnetic energy through a single probe. This dual-energy application is significant as it enhances the efficiency of stone fragmentation, a critical factor in the overall success of lithotripsy procedures. Furthermore, the device's suction capability contributes to a trifecta effect, which not only aids in faster stone clearance but also minimizes the risk of potential complications associated with stone migration during the procedure.

A key aspect of the article is its focus on the reported high efficiency of fragmentation, which is quantified through metrics such as stone surface area and three-dimensional stone volumes. This quantitative analysis is crucial as it provides empirical support for the device's efficacy, allowing for a comparative assessment against traditional methods. The findings suggest that the Swiss LithoClast® Trilogy may lead to improved patient outcomes by reducing operative times and enhancing stone clearance rates.

However, while the study presents promising results, it is essential to consider the broader implications of adopting new medical technologies in clinical practice. The authors acknowledge the necessity for ongoing evaluation of the long-term safety and effectiveness of the Swiss LithoClast® Trilogy. As with any new medical device, rigorous post-market surveillance and further studies are vital to ensure that the benefits observed in controlled settings translate into real-world applications.

The article titled "Comparison and outcomes of dusting versus stone fragmentation and extraction in retrograde intrarenal surgery: results of a systematic review and meta-analysis" by [6] provides a comprehensive evaluation of contemporary techniques in the management of kidney stones, specifically focusing on retrograde intrarenal surgery (RIRS). The authors highlight the significant advancements in medical devices, particularly the advent of digital, disposable, and miniaturized ureteroscopes, which have revolutionized the treatment landscape for renal stones, making RIRS the predominant approach for kidney stone disease (KSD).

The systematic review and meta-analysis conducted by the authors meticulously compare two primary techniques employed post-laser lithotripsy: dusting and fragmentation/extraction. The study's primary outcome centers on the assessment of stone-free rates (SFR) and retreatment rates associated with each technique. The results indicate that while both methods are effective, the nuances of their outcomes warrant careful consideration in clinical practice. The article effectively synthesizes data from multiple studies, thereby enhancing the reliability of its conclusions regarding the efficacy of each technique.

Moreover, the authors delve into secondary outcomes, including surgical time, length of hospital stay, and postoperative complications. This multifaceted approach allows for a more comprehensive understanding of the implications of each technique beyond mere stone removal.

For instance, the authors suggest that dusting may lead to shorter surgical times and reduced hospital stays, which are critical factors in improving patient throughput and resource utilization.

However, while the findings are valuable, the article does not fully address the potential variability in patient outcomes based on stone characteristics or individual anatomical differences, which could influence the choice of technique. Additionally, the discussion surrounding the long-term implications of leaving fragments in situ, as seen in the dusting technique, could benefit from further exploration, particularly regarding the risk of future stone formation.

The article titled "Is There Still a Place for Percutaneous Nephrolithotomy in Current Times?" by [7] provides a comprehensive overview of the evolving landscape of surgical treatments for urolithiasis, specifically focusing on the role of percutaneous nephrolithotomy (PCNL) in the management of kidney stones. The authors effectively highlight the advancements in endourology and the recommendations set forth by the European Urology Guidelines, which position PCNL as the first-line treatment for larger stones exceeding 2 cm, while also discussing the roles of retrograde intrarenal surgery (RIRS) and extracorporeal shockwave lithotripsy (ESWL) as alternative options.

One of the key insights from the article is the historical context and technological evolution surrounding PCNL. The authors trace the development of percutaneous techniques from their inception in the mid-20th century to modern refinements such as mini-PERC and ultra-mini-PCNL, which have significantly reduced complications associated with traditional approaches. This historical perspective is crucial as it underscores the ongoing innovation within the field, especially with the introduction of high-power Holmium:YAG lasers, which have enhanced the efficacy of lithotripsy ([7]).

The article also critically evaluates the limitations of various techniques, particularly RIRS, which faces challenges in fragment retrieval and managing intrarenal pressure during procedures. The authors acknowledge that while flexible ureterorenoscopy has gained traction for larger stones, the complexity of treating such stones often necessitates multiple sessions, thereby complicating patient care ([7]). This nuanced discussion adds depth to the evaluation of treatment modalities, suggesting that the choice of surgical approach should not solely depend on stone size but also consider patient-specific factors.

Moreover, the introduction of disposable instruments to address sterilization and fragility concerns associated with reusable flexible ureterorenoscopes represents a significant advancement in the field. The authors emphasize that while these innovations enhance procedural safety and efficiency, they also introduce new considerations regarding cost and availability, which may impact clinical decision-making ([7]).

The article titled "Flexible ureteroscopic treatment of kidney stones: How do the new laser systems change our concepts?" by [8] provides a thorough examination of the evolving landscape of flexible ureteroscopy (fURS) as a treatment modality for kidney stones, with a particular emphasis on the advancements in laser technologies. The authors articulate the significance of fURS in contemporary urological practice, highlighting its acceptance as an effective intervention for managing urinary stones.

The review begins by acknowledging the long-standing use of the holmium laser, which has established itself as the gold standard for intracavitary laser lithotripsy over the past three decades. Despite its efficacy, the authors point out critical limitations associated with the holmium laser, including its inability to completely pulverize stones and the adverse effects of stone retropulsion and thermal damage to surrounding tissue. These challenges have prompted the exploration of alternative laser technologies that promise improved clinical outcomes and enhanced patient safety.

One of the key advancements discussed is the introduction of thulium fiber lasers and Moses technology. The authors detail how these innovations facilitate a more efficient dusting lithotripsy

effect, which is achieved by manipulating pulse energy and frequency. This technique not only improves the fragmentation of stones but also minimizes the retropulsion effect, thus addressing one of the significant drawbacks of traditional holmium lasers. The review critically evaluates the implications of these advancements, suggesting that they may pave the way for a new gold standard in laser lithotripsy.

Furthermore, the article emphasizes the importance of considering various parameters, such as pulse frequency and laser fiber adaptability, in evaluating the performance of these new systems. The authors highlight that while high-pulse-frequency devices offer promising ablation efficacy, they also present practical challenges related to precise targeting. This nuanced discussion is essential for clinicians to understand the complexities involved in selecting the appropriate laser system for individual patients.

### 3. Conclusion

The literature on the latest medical devices for breaking up kidney stones reveals a significant evolution in techniques and technologies aimed at improving patient outcomes in urolithiasis management. The introduction of various lithotripsy methods has been pivotal in enhancing the effectiveness of stone fragmentation and retrieval processes.

The foundational work by [1] in 2010 established a comparative analysis of pneumatic versus ultrasonic lithotripsy in percutaneous nephrolithotomy (PCNL), highlighting the importance of access techniques and lithotripsy methods. This research laid the groundwork for subsequent innovations, particularly the adoption of the holmium laser, which emerged as a standard due to its effectiveness in fragmenting various stone types.

By 2017, advancements in ureteroscopy (URS) were noted, with [2] emphasizing the shift toward minimally invasive techniques, largely facilitated by improvements in holmium laser technology. This trend toward less invasive procedures continued to gain momentum, as evidenced by [3] in 2018, who explored high-powered laser "dusting" techniques that reduced operative time and complications compared to traditional methods.

The introduction of controlled fragmentation methods using a continuous-wave diode laser by [4] further illustrated the ongoing refinement of lithotripsy techniques, addressing complications such as inflammatory infections and residual stone risks. The evolution of flexible ureterorenoscopy (fURS) was also highlighted, with [5] emphasizing advanced laser technologies' role in improving clinical outcomes.

In examining the efficacy of the EMS Swiss LithoClast® Trilogy, [6] noted its unique combination of ultrasonic and electromagnetic energy, which enhanced stone clearance during PCNL. This dual-energy approach represents a significant advancement in lithotripsy devices, contributing to improved patient outcomes.

A systematic review by [7] compared dusting versus traditional fragmentation techniques, revealing ongoing debates regarding the optimal management of stone fragments post-laser lithotripsy. This complexity in treatment approaches underscores the need for practitioners to navigate varying methodologies based on individual patient circumstances.

The role of PCNL in contemporary treatment was reaffirmed by [8], who acknowledged the advancements in flexible ureteroscopy while emphasizing PCNL's importance for larger stones. Finally, [9] discussed the impact of new laser systems, such as thulium fiber lasers, on redefining treatment paradigms, indicating a commitment to improving patient safety and treatment efficacy.

In conclusion, the literature presents a clear trajectory of innovation in kidney stone management, characterized by the integration of advanced technologies and methodologies. Each article contributes to a comprehensive understanding of the current landscape, highlighting the dynamic nature of treatment options available to clinicians and the potential for future advancements in the field.

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