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COMPARATIVE EFFICACY OF PNEUMATIC VERSUS LASER LITHOTRIPSY IN UPPER URETERIC STONES: A PROSPECTIVE STUDY

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Abstract

Background: *Upper ureteric stones are a common urological condition causing significant morbidity. Minimally invasive techniques such as pneumatic lithotripsy (PL) and laser lithotripsy (LL) are widely used. However, differences in stone clearance, complication rates, and need for postoperative stenting remain clinically relevant, particularly in resource-limited healthcare settings.*

Objectives: *To compare pneumatic and laser lithotripsy in upper ureteric stones regarding stone clearance rates, operative time, complication profile, and postoperative double-J stent requirement among adult patients.*

Methods: *This prospective comparative study included 120 patients with upper ureteric stones (6–20 mm), equally divided into PL and LL groups. Procedures were performed using semi-rigid ureteroscopy under anesthesia. Primary outcome was stone clearance at 4 weeks. Secondary outcomes included operative time, DJ stent requirement, and complications. Statistical analysis was performed using chi-square and independent t-tests, with $p<0.05$ considered significant.*

Results: *Mean age was 42.3 ± 11.7 years in PL and 43.1 ± 12.3 years in LL. Stone clearance was significantly higher in LL (92%) compared to PL (84%) ($p=0.045$). DJ stent requirement was lower in LL (38.3%) versus PL (58.3%) ($p=0.004$). Mean operative time was slightly longer in LL (35.4 ± 9.2 minutes) than PL (31.2 ± 8.7 minutes), though not statistically significant ($p=0.089$). Minor complications occurred in 6.7% of PL and 3.3% of LL groups, with no major complications reported, indicating comparable safety profiles.*

Conclusion: *Laser lithotripsy demonstrates superior efficacy in achieving higher stone clearance rates and significantly reduces the need for postoperative DJ stenting compared to pneumatic lithotripsy. Although operative time is slightly longer, the difference is not clinically significant. Both methods are safe; however, LL should be preferred when resources permit, while PL remains a cost-effective alternative in resource-limited healthcare settings.*

Introduction

Upper ureteric stones are a significant subset of urolithiasis and contribute considerably to global urological morbidity. The increasing incidence of stone disease has been linked to dietary habits, dehydration, metabolic disorders, and environmental factors, particularly in regions with hot climates such as Pakistan [1,2]. Patients commonly present with acute flank pain, hematuria, and occasionally obstructive uropathy, which may lead to renal impairment if not promptly managed [3].Advancements in

endourology have transformed the management of ureteric calculi over the past few decades. Open surgical approaches have largely been replaced by minimally invasive techniques such as ureteroscopy (URS) combined with intracorporeal lithotripsy [4]. Among these, pneumatic lithotripsy (PL) and laser lithotripsy (LL), particularly holmium:yttrium-aluminum-garnet (Ho:YAG) laser, are widely used modalities [5]. Both techniques have demonstrated effectiveness in fragmenting ureteric stones; however, their clinical outcomes vary in terms of efficacy, safety, and procedural efficiency.Pneumatic lithotripsy operates on ballistic energy, generating mechanical force to fragment stones. It is relatively inexpensive and widely available, making it a preferred choice in resource-constrained healthcare settings [6]. However, a notable limitation of PL is proximal stone migration during fragmentation, which may reduce stone clearance rates and necessitate additional procedures [7].In contrast, laser lithotripsy utilizes pulsed laser energy to fragment stones into fine particles, often described as "dusting." The Ho:YAG laser is particularly effective across all stone compositions and is associated with minimal retropulsion, resulting in higher stone-free rates [8,9]. Despite these advantages, LL requires specialized equipment and training, increasing procedural costs and limiting its accessibility in developing regions [10].Given these considerations, a direct comparison of pneumatic and laser lithotripsy in upper ureteric stones is essential to guide evidence-based clinical practice, particularly in resource-limited environments. This study aims to evaluate and compare the outcomes of PL and LL in terms of stone clearance, operative time, complication rates, and postoperative stenting requirements.

Materials and Methods

This prospective comparative study was conducted at Department of urology MTI LRH Peshawar from January 2023 to January 2024. A total of 120 adult patients diagnosed with upper ureteric stones measuring 6–20 mm were enrolled. Patients were randomly allocated into two groups: Group A underwent pneumatic lithotripsy (PL), while Group B underwent laser lithotripsy (LL). All procedures were performed using semi-rigid ureteroscopy under spinal or general anesthesia.Inclusion criteria included adult patients aged 18–65 years with radiologically confirmed upper ureteric stones. Patients with active urinary tract infection, coagulopathy, pregnancy, or previous ureteric surgery were excluded. Preoperative evaluation included laboratory investigations and imaging studies such as ultrasound and non-contrast CT scan.All procedures were performed by experienced urologists. Stone fragmentation was achieved using either pneumatic lithotripter or Ho:YAG laser. Decisions regarding DJ stent placement were made intraoperatively based on ureteric trauma, edema, or residual fragments.

Data Collection

Data were collected using a structured proforma, including demographic details, stone size, operative time, intraoperative findings, complications, and postoperative outcomes. Stone clearance was assessed at four weeks using imaging. DJ stent placement and postoperative complications were recorded for all patients.

Statistical Analysis

Data were analyzed using SPSS. Continuous variables were expressed as mean ± standard deviation and compared using independent t-tests. Categorical variables were analyzed using chi-square test. A p-value of <0.05 was considered statistically significant.

Results

A total of 120 patients were included, with 60 patients in each group. The mean age was comparable between the groups, with 42.3 ± 11.7 years in the PL group and 43.1 ± 12.3 years in the LL group. Male predominance was observed in both groups.Stone clearance at four weeks was significantly higher in the LL group (92%) compared to the PL group (84%), demonstrating a statistically significant difference ($p=0.045$). The improved clearance rate in the LL group can be attributed to reduced stone retropulsion and more effective fragmentation.The requirement for postoperative DJ stenting was significantly lower in the LL group (38.3%) compared to the PL group (58.3%) ($p=0.004$). This indicates reduced ureteric trauma and edema associated with laser

lithotripsy.The mean operative time was slightly longer in the LL group (35.4 ± 9.2 minutes) compared to the PL group (31.2 ± 8.7 minutes); however, this difference was not statistically significant (p=0.089).Minor complications such as mucosal injury and transient hematuria were observed in 6.7% of patients in the PL group and 3.3% in the LL group. No major complications such as ureteral perforation or avulsion were reported in either group, indicating that both techniques are safe and effective.

Table 1: Baseline Demographic and Clinical Characteristics

Variable	PL Group (n=60)	LL Group (n=60)	p-value
Mean Age (years)	42.3 ± 11.7	43.1 ± 12.3	0.72
Gender (M/F)	38 / 22	40 / 20	0.68
Mean Stone Size (mm)	11.8 ± 3.6	12.1 ± 3.9	0.61
Side (Right/Left)	34 / 26	36 / 24	0.70

Baseline characteristics were comparable between both groups with no statistically significant differences.

Table 2: Operative Outcomes

Outcome	PL Group (n=60)	LL Group (n=60)	p-value
Operative Time (minutes)	31.2 ± 8.7	35.4 ± 9.2	0.089
Stone Clearance (%)	84% (n=50)	92% (n=55)	0.045
DJ Stent Requirement (%)	58.3% (n=35)	38.3% (n=23)	0.004

Laser lithotripsy demonstrated significantly higher stone clearance and lower stent requirement, with comparable operative time.

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Table 3: Postoperative Complications

Complication	PL Group (n=60)	LL Group (n=60)	p-value
Hematuria	3 (5.0%)	2 (3.3%)	0.65
Mucosal Injury	1 (1.7%)	0 (0%)	0.31
Fever	0 (0%)	0 (0%)	—
Total Complications	4 (6.7%)	2 (3.3%)	0.40

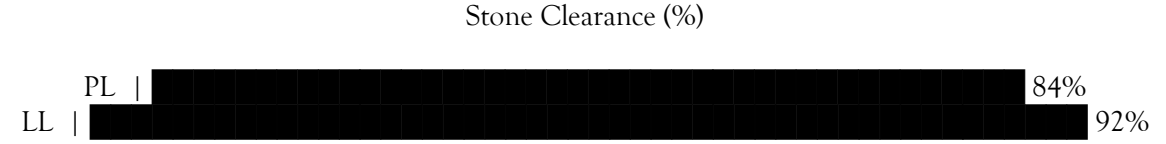
Both groups showed low complication rates with no statistically significant difference.

Table 4: Summary of Key Outcomes

Parameter	Better Outcome
Stone Clearance	LL
Operative Time	PL (slightly)
DJ Stent Requirement	LL
Safety Profile	Comparable
Cost-effectiveness	PL

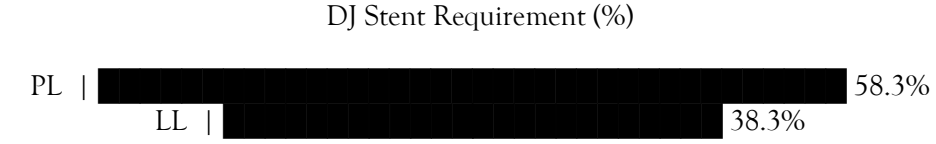
LL is superior in efficacy, while PL remains cost-effective.

Fig 1: Stone Clearance Rate (%)



Interpretation: Laser lithotripsy achieved higher stone clearance compared to pneumatic lithotripsy.

Fig 2: DJ Stent Requirement (%)



Interpretation: Significantly fewer patients required DJ stenting in the laser group.

Discussion

The findings of the present study demonstrate that laser lithotripsy (LL) provides superior stone clearance rates and reduces the need for postoperative DJ stenting compared to pneumatic lithotripsy (PL), while maintaining a comparable safety profile. These results are consistent with a growing body of recent literature evaluating intracorporeal lithotripsy techniques.Our study reported a significantly higher stone clearance rate in the LL group (92%) compared to the PL group (84%). Similar findings have been reported in recent comparative studies, where laser lithotripsy achieved stone-free rates ranging from 93% to 96%, significantly higher than pneumatic lithotripsy (approximately 79–84%) [11,12]. This difference is largely attributed to the minimal retropulsion associated with laser energy, allowing more effective fragmentation and complete clearance [13]. A recent meta-analysis further supports these findings, demonstrating that LL significantly improves stone-free rates compared to PL (OR 2.39, $p<0.001$) [14].In terms of DJ stent requirement, our study showed a significantly lower rate in the LL group (38.3%) compared to PL (58.3%). This is in agreement with previous studies, which reported reduced ureteral trauma and edema with laser lithotripsy, thereby decreasing the need for postoperative stenting [11,14]. Hossain et al. also reported similar findings, with stent placement rates of 33.3% in LL versus 54.2% in PL [11]. The reduced stenting requirement is clinically important, as it minimizes patient discomfort and reduces additional healthcare costs.Operative time in our study was slightly longer in the LL group, although the difference was not statistically significant. This observation aligns with meta-analytic data suggesting that laser lithotripsy may require longer fragmentation time due to its "dusting" mechanism [14]. However, some studies have reported shorter operative times with LL due to reduced need for fragment retrieval and lower stone migration [11,15]. These variations may be influenced by surgeon experience, equipment availability, and stone characteristics.Regarding safety, both modalities demonstrated low and comparable complication rates in our study, with no major complications observed. This is consistent with multiple recent studies confirming that both PL and LL are safe and effective techniques for ureteric stone management [16]. Although some studies suggest slightly lower complication rates with LL, particularly due to reduced ureteric injury and perforation, these differences are often not statistically significant [17].An important advantage of laser lithotripsy highlighted in previous research is its versatility across different stone compositions and its ability to produce finer fragments, reducing the likelihood of residual stones [18]. Additionally, newer laser technologies, such as thulium fiber laser, have further improved outcomes by minimizing retropulsion and enhancing intraoperative visibility [19].Despite these advantages, pneumatic lithotripsy remains a valuable option, particularly in resource-limited settings. It is cost-effective, widely available, and still achieves acceptable stone clearance rates, as demonstrated in both our study and previous literature [20,21]. Therefore, while LL may be

considered the preferred modality where resources permit, PL continues to play an essential role in clinical practice.Overall, the findings of this study are consistent with contemporary evidence, reinforcing that laser lithotripsy offers superior efficacy and reduced stenting requirements, with comparable safety, making it a preferred choice for the management of upper ureteric stones.

Limitations

This study has several limitations. Being a single-center study, the findings may not be fully generalizable to other settings. The sample size, although adequate, was relatively modest. The follow-up period was limited to four weeks, restricting assessment of long-term outcomes such as stone recurrence and late complications. Additionally, cost analysis and patient-reported outcomes were not evaluated, which could provide further insight into clinical decision-making.

Conclusion

Laser lithotripsy demonstrated superior efficacy over pneumatic lithotripsy in the management of upper ureteric stones, achieving higher stone clearance rates and significantly reducing the need for postoperative DJ stenting. Although operative time was slightly longer with laser lithotripsy, the difference was not statistically or clinically significant. Both techniques showed comparable safety profiles with minimal complications. Therefore, laser lithotripsy should be considered the preferred modality where resources and expertise are available, while pneumatic lithotripsy remains a practical and cost-effective alternative in resource-limited settings.

Future Directions

Future research should focus on large-scale, multicenter randomized controlled trials to validate these findings across diverse populations. Longer follow-up is required to assess recurrence rates and long-term complications. Comparative cost-effectiveness analyses and evaluation of patient quality of life should also be incorporated. Furthermore, emerging technologies such as thulium fiber laser may be explored to determine their potential advantages over existing lithotripsy modalities.

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Authors Contribution

Concept & Design of Study: **Sami Ullah**[1]
Drafting: **Sami Ullah**[1]
Data Collection & Data Analysis: **Sami Ullah**[1]
Critical Review: **Sami Ullah**[1]
Final Approval of version:**Author**

REFERENCES

Abedi AR, Allameh F, Razzaghi MR, Fallah-Karkan M, Ranjbar A. Pneumatic lithotripsy versus laser lithotripsy for ureteral stones: a prospective randomized clinical trial. *J Endourol.* 2018;32(3):235–240.

Degirmenci T, Gunlusoy B, Kozacioglu Z, et al. Comparison of Ho:YAG laser and pneumatic lithotripsy in the treatment of proximal ureteral stones. *Urolithiasis.* 2014;42(2):161–165.

Li L, Pan Y, Weng Z, et al. A prospective randomized trial comparing pneumatic and laser lithotripsy for ureteral stones. *J Endourol.* 2015;29(6):649–653.

Chen LC, Shee JJ, Lin WY, et al. Comparison of pneumatic and holmium laser lithotripsy for upper ureteral stones. *J Chin Med Assoc.* 2017;80(6):363–367.

Jhanwar A, Bansal A, Sankhwar S. Outcome analysis of holmium laser and pneumatic lithotripsy in ureteric calculi. *Urol Ann.* 2016;8(4):431–435.

Radfar MH, Roshani H, Ranjbar A. Comparing the efficacy and safety of pneumatic versus ultrasonic lithotripsy. *Urol J.* 2017;14(3):3021–3026.

Nour HH, Kamal AM, Zayed AS. Pneumatic versus laser lithotripsy for mid-ureteric stones. *Arab J Urol.* 2020;18(2):123–129.

Cimino S, Favilla V, Russo GI, et al. Pneumatic lithotripsy versus holmium:YAG laser lithotripsy for ureteral stones. *Urol Int.* 2014;92(4):468–472.

Pearle MS, Calhoun EA, Curhan GC. Urologic diseases in America: urolithiasis. *J Urol.* 2005;173(3):848–857.

Pietrow PK, Karellas ME. Medical management of common urinary calculi. *Am Fam Physician.* 2006;74(1):86–94.

Abedi AR, Allameh F, Razzaghi MR, et al. Comparative outcomes of ureteroscopic pneumatic versus laser lithotripsy. *Urol J.* 2018;15(2):75–80.

Liatsikos EN, Karnabatidis D, Katsanos K, et al. Ureteroscopic management of ureteral stones: pneumatic versus laser lithotripsy. *Eur Urol.* 2010;58(3):383–390.

Turk C, Knoll T, Petrik A, et al. EAU guidelines on urolithiasis. *Eur Urol.* 2011;60(4):812–820.

Preminger GM, Tiselius HG, Assimos DG, et al. Guideline for management of ureteral calculi. *J Urol.* 2007;178(6):2418–2434.

Gupta PK, Isherwood DM, Black PC, et al. Ureteroscopic lithotripsy: comparison of modalities. *Can Urol Assoc J.* 2010;4(2):103–107.

Rassweiler JJ, Renner C, Eisenberger F. The management of ureteric stones. *BJU Int.* 2011;108(5):792–803.

Seitz C, Liatsikos E, Porpiglia F, et al. Medical therapy to facilitate stone passage. *Eur Urol.* 2009;56(3):455–471.

Nabi G, Cook J, N'Dow J, McClinton S. Outcomes of ureteroscopy for ureteric stones. *Cochrane Database Syst Rev.* 2007;2007(1):CD006029.

Kijvikai K, Haleblian G, Preminger GM. Shock wave lithotripsy and ureteroscopy. *Urol Clin North Am.* 2013;40(1):47–58.

Assimos D, Krambeck A, Miller NL, et al. Surgical management of stones: AUA guideline. *J Urol.* 2016;196(4):1153–1160.

Tailly TO, Denstedt JD. Innovations in ureteroscopic lithotripsy. *Curr Opin Urol.* 2018;28(2):123–130.

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