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DOI:10.59736/IJP.23.04.1007

ORIGINAL ARTICLE

Outcome of pneumatic lithotripsy versus holmium laser in distal ureteric stones

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ABSTRACT

Background: The prevalence of distal ureteric stones (DUS) is a serious urological disease having a high morbidity. Pneumatic lithotripsy (PL) and holmium laser lithotripsy (HL) are popular modalities of treatment with HL usually reported to have superior results albeit at increased cost. This study aims at comparing the safety and efficacy of HL and PL in the management of DUS.

Methods: This observational comparative study was conducted at Armed Forces Institute of Urology, Rawalpindi, from Feb to September 2025, including 160 patients of DUS (<2 cm) schedule for either procedure was enrolled and divided in HL or PL, each consists of 80 individuals. One-month stone-free status were analyzed through SPSS-27, with $p \leq 0.05$ considered significant.

Results: Groups were compared at baseline regarding age (55.9 ± 11.7 vs. 57.7 ± 10.5 years, p=0.72), gender (p=0.07), BMI (p=0.64), comorbidities, and stone size (p=0.18). Operative time was similar (47.4 ± 2.6 vs. 43.1 ± 4.2 min, p=0.58). HL resulted in significantly lower postoperative pain scores (VAS 3.3 ± 1.2 vs. 6.6 ± 1.5, p<0.001), shorter hospital stays (<24h: 85% vs. 56.3%, p<0.001), and higher stone-free rates at one month (97.3% vs. 79.4%, p<0.001). Intraoperative hemorrhage (p=0.12), ureteral injury (p=0.56), fever (p=0.24), and infection (p=0.14) were infrequent and not significantly different.

Conclusion: HL provides superior efficacy, reduced pain, and shorter hospitalization compared to PL, while maintaining comparable safety. However, PL remains a feasible option in resource-limited settings.

Keywords: Distal Ureteric Stones, Holmium Laser Lithotripsy, Pneumatic Lithotripsy, Ureteroscopy, Stone-free Rate

This article may be cited as: Rasheed R, Haroon Sabir khan, Muhammad Tanveer Sajid, Syed Yazdan Haider, Badar Murtaza, Nubair Sarwar. Outcome of pneumatic lithotripsy versus holmium laser in distal ureteric stones. Int J Pathol 23(4):419-26. https://doi.org/10.59736/IJP.23.04.1007

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Introduction

Ureterolithiasis or ureteric stones, often known as kidney stones, is a common urological illness affects millions of individuals around the globe, developed from the mineral deposits in the urinary tract, causes severe discomfort along with other related symptoms, which is difficult to manage for both patients and medical professionals (1). It is considered to affect about 9 to 12% of individual at any point in

their life in developed countries (2). In Pakistan the prevalence of kidney stone disease is approximately 16% (3). Risk factors for ureterolithiasis include dietary habits such as frequent consumption of rice, carbonated drinks, spinach, potatoes, pulses, and sweets, along with inadequate water intake, sedentary lifestyle, and smoking. Males gender and individual of age 31–45 years are particularly vulnerable. Genetic predisposition, family history, obesity, and metabolic disorders like diabetes further increase the risk (4,5). The distal ureter is the most common site of stone impaction, with its occurrence influenced by these factors (6,7). If left unmanaged, obstruction may cause hydronephrosis, renal damage, and eventually renal failure in extreme cases (8).

The DUS management is determined by the size and the composition of the stone, and also the status of the patient. The majority of cases receive conservative pharmacologic therapy in order to facilitate natural passage by using small stones (9). Extracorporeal Shock Wave Lithotripsy (ESWL) is not an invasive technique and lower effectiveness in distal stones (10). Ureteroscopic laser lithotripsy has great success rates and PL is less used due to increased risks of complications. The hone standard is Ho: YAG laser lithotripsy, which is precise and has few complications (11).

HL compares to PL in the treatment of DUS as it is more effective and safer. The total rate of stone clearance was much greater in comparison with PL, 86%-64%. (12). The operation time was shorter, with a mean of 35.7 ±3.2 minutes as compared to PL at 50.2 ±5.3 minutes. Patients also enjoy shorter hospital stays with the laser treatment, as 74% of them are discharged within 24 hours as opposed to only 36% in the pneumatic group. The complication rate with HL was 10%, while with PL, 36% of cases developed light hematuria (12). However, PL can be practical in settings where cost and availability of equipment remain concerns (13).

Even though HL has been proven to be more successful, less time, and less complications in most regions of the world, high cost and equipment requirements are quite critical in restricting the availability to resource-poor regions. Therefore, considering the high prevalence of nephrolithiasis in Pakistan and regional dietary and lifestyle influence, this study was conducted with region-specific evidence to guide the selection of treatment modalities that are safe, effective, and cost-effective.

Methods

This observational comparative study was conducted in the Department of Armed Forces Institute of Urology (AFIU), Rawalpindi, by including patient's data from Feb to September 2025. The sample size was 160 patients, determine through OpenEpi software at 95% confidence interval, 90% power, and a 10% dropout rate. Patients were equally divided into two groups: Group A (HL) and Group B (PL). Each group was consisting of 80 patients, taking the anticipated frequency of successfully stone removal in HL 86% and in PL 64% (12). The inclusion criteria were patients of either gender, age ≥18 years with DUS less than 2 cm, confirmed by ultrasound or CT KUB, and recommended for endoscopic treatment. Pregnant or lactating women, patients with severe comorbidities such as renal failure, uncontrolled diabetes, or bleeding disorders, stones >2 cm, and a previous history of major ureteric surgery or other conditions affecting the distal ureter was excluded.

DUS were defined as calculi located in the distal one-third of the ureter, from the pelvic-ureteric junction to the uretero-vesical junction, with a maximum size of 2 cm confirmed on imaging. PL was defined as stone fragmentation using a pneumatic device (Swiss LithoClast), while Holmium (Ho: YAG) laser lithotripsy involved laser-based fragmentation with controlled energy delivery. The effectiveness of each modality was evaluated by stone-free rate and operative time. Outcome measures were stone free status, length of surgery, complications, post-surgery pain and stay at the hospital.

Stone-free status was considered as the absence of the residual fragments > 2 mm on the imaging done one month after the procedure using ultrasound or CT KUB and classified as stone-free, *partial clearance* as residual fragments ≤2 mm, and *not stone-free* as fragments >2 mm. Operative time was estimated by the time the scope was inserted to the removal of the stone. The complications were categorized as intra and postoperative (within 30 days) and covered hemorrhage, infection, fever, ureteral injury and stone migration. Postop pain was measured using (VAS, 010) in 24 hours, and hospital stay was determined between admission and discharge and was categorized into less than 24 hours and more than 24 hours.

Ethical permission of the study was received under ref No. Uro-Trg-1/IRB/2025/08 dated:18/02/2025. Patient's data on the demographic and clinical was taken away on patients. Each surgery was carried out by professional urologists. The information about the operations, complications, and the results after the operations were recorded. One month after the operation, the status of stone-free was evaluated using ultrasound or CT KUB.

The analysis was perform SPSS-27. Mean ± standard deviation was calculated for age, BMI, operative time, VAS score, and hospital stay. Frequencies and percentages were calculated for gender, stone-free status, and complications. Man-Whitney U test was utilized to compared means of continuous variables whereas fisher exact utilized to compare between the two groups in terms of categorical variables. P-value below 0.05 was regarded to be significant.

Result

This study consists of 160 patients, 80 in each group. The mean age was 55.9 ± 11.7 years in the HL group and 57.7 ± 10.5 years in the PL group, with no statistically significant difference (p=0.72). Gender distribution also showed no significant variation, with 66.3% males in the HL group and 56.3% in the PL group (p=0.07). Similarly, BMI (29.4 ± 3.8 vs. 28.8 ± 3.6, p=0.64), hypertension (23.8% vs. 26.3%, p=0.72), diabetes (33.8% vs. 31.3%, p=0.84), and mean stone size (1.68 ± 0.43 cm vs. 1.75 ± 0.38 cm, p=0.18) did not differ significantly at baseline (table -1).

The operative time was not differing in both groups significantly. Intraoperative hemorrhage occurred in 1.3% of patients undergoing HL and 3.8% in the PL group, but this difference was not statistically significant (p=0.12). Similarly, ureteral injury was infrequent in both groups (p=0.56) (table -2).

Within 24 hours postoperatively, patients treated with HL reported significantly lower pain scores (VAS 3.3 ± 1.2) compared to those undergoing PL (VAS 5.4 ± 1.5, p<0.001). Most patients in HL group were discharged within 24 hours (p<0.001).

Postoperative fever and infection were infrequent in both groups, with insignificant differences (table -3).

At one-month follow-up, stone clearance was significantly higher with HL than PL (97.5% vs. 78.8%, $p < 0.001$). The frequency of partial clearance (≤2 mm residual fragments) was significantly lower in the HL group (2.5% vs. 13.7%, $p = 0.01$), while **no patient in the HL group had clinically significant residual fragments (>2 mm)** compared with 7.5% in the PL group ($p = 0.02$). Stone migration and ureteral stricture were rare in both groups, with no statistically significant differences.

Table 1: Baseline Characteristics of Patients

Variable	HL (n=80)	PL (n=80)	p-value
Age (years), mean ± SD	55.9 ± 11.7	57.7 ± 10.5	0.72
Male, n (%)	53 (66.3%)	45 (56.3%)	0.07
BMI (kg/m²), mean ± SD	29.4 ± 3.8	28.8 ± 3.6	0.64
Hypertension, n (%)	19 (23.8)	21 (26.3)	0.72
Diabetes, n (%)	27 (33.8%)	25 (31.3)	0.84
Stone size (cm), mean ± SD	1.68 ± 0.43	1.75 ± 0.38	0.18

Table 2: Operative Outcomes

Variable	HL (n=80)	PL (n=80)	p-value
Operative time (min), mean ± SD	47.4 ± 2.6	43.1 ± 4.2	0.58
Intraoperative hemorrhage, n(%)	1 (1.3%)	3 (3.8%)	0.12
Ureteral injury, n (%)	1 (1.3%)	2 (2.5%)	0.56

Table 3: Postoperative (Within 24 Hours) Outcomes

Variable	HL (n=80)	PL (n=80)	p-value
VAS pain score, mean ± SD	3.3 ± 1.2	6.6 ± 1.5	**<0.001**
Hospital stay <24h, n (%)	68 (85%)	45 (56.3%)	**<0.001**
Postoperative fever, n (%)	2 (2.5%)	5 (6.3%)	0.24
Postoperative infection, n (%)	2 (2.5%)	3 (3.8%)	0.14

Table 4: One-month Postoperative Outcomes

Variable	HL (n=80)	PL (n=80)	p-value
Complete clearance (Stone-free), n (%)	78 (97.5)	63 (78.8)	<0.001
Partial clearance (≤2 mm fragments), n (%)	2 (2.5)	11 (13.7)	0.01
Not stone-free (>2 mm fragments), n (%)	0 (0)	6 (7.5)	0.02
Stone migration, n (%)	0 (0)	3 (3.8)	0.08
Ureteral stricture, n (%)	0 (0)	1 (1.3)	0.31

Discussion

The results of HL and PL were compared in the management of DUS in this study. We find that HL provides better clinical outcome, though in terms of postoperative pain outcome, hospital stay, and stone-free rate, whereas both modalities had similar outcomes in terms of operative time and intraoperative complications.

However, in our study, there was no statistically significant difference in the operative time between HL and PL: 47.4 ± 2.6 minutes versus 43.1 ± 4.2 minutes, respectively. This finding agrees with that of Arvind et al. (2025), who similarly found no significant difference in the duration of surgery between the two modalities: 41.58 minutes for HL versus 38.49 minutes for PL (14). Other studies, however, have also demonstrated conflicting findings by reporting significantly longer operative times when using HL (46.78 minutes) compared to PL (42.10 minutes); this is most likely because of the more precise fragmentation technique of the laser, which requires more meticulous handling (15).

Our study reported a low incidence of intraoperative hemorrhage and ureteral injury in both groups, with no statistically significant difference. Similarly, Ejaz et al. (2023) and Arvind et al. (2025) have also documented low rates of hemorrhagic complications when using HL compared to PL (14,16). Controlled energy delivery might account for less mucosal trauma with HL. The mechanical injury associated with PL increases the risk of hematuria and mucosal trauma. Jadhav et al. (2024) also mentioned higher frequencies of ureteral perforation and stone migration in PL, favoring the safety of HL (15).

In our series, the postoperative pain scores within 24 hrs. were significantly lower in the HL group with a VAS of 3.3 ± 1.2 compared to PL, which had a VAS of 6.6 ± 1.5, with $p<0.001$. These findings are in line with the results from Ansari et al. 2024 and Hassan et al. 2024 who demonstrated decreased postoperative pain and analgesic requirements following HL (17,18). There was a low rate of fever and infection in both groups of our cohort, with no statistical difference observed. However, several prior studies have noted a higher incidence of postoperative fever and acute pyelonephritis in PL compared to HL (19,20). In our study, a significantly larger percentage of HL patients were discharged within 24 hours compared to PL (85% vs. 56.3%, $p<0.001$). Such findings agree with literature showing that the mean hospital stays for HL are shorter at 2.40 days than for PL, which is 2.69 days (15).

One of the most significant findings of this study was the markedly higher stone-free rate with HL (97.3%) compared to PL (79.4%), as reported in the literature globally. Arvind et al. 2025 (14) reported stone-free rates of 100% for HL and 92% for PL. Giyasov et al. 2024 emphasized better efficacy of endoscopic HL compared to ESWL, demonstrating stone-free rates of 99.02 and 76.2%, respectively (21). Superior clearance with HL is demonstrated in the current series due to the high degree of accuracy of fragmentation by HL with minimal chance of residual fragments.

In our cohort, the incidence of stone migration and ureteral strictures with either modality was low and did not differ significantly between groups. However, previous literature has always reported higher stone migration with PL compared to HL: 18.96% versus 3.44%, respectively (15). As for stricture formation, though this was a rare event in our series, the literature reports that it may be facilitated by longer operative times and larger stones, even with HL. However, HL is usually much safer when compared to other laser modalities (22,23).

Limitations & future direction

The limitations included a single center and small sample size, which limit the generalizability of the findings. Follow-up was limited to one month, and long-term results, regarding the formation of recurrent stones or late complications, were not evaluated. Moreover, a cost-effectiveness analysis was not carried out, which could explain better the practicality of HL versus PL in settings with scarce resources. Notwithstanding this, the study yielded strong evidence for HL. Still, PL is considered a good alternative in centers where the cost and availability of laser technology are significant issues. The findings highlight the need for resource-appropriate treatment planning, balancing clinical outcomes with feasibility in different healthcare environments.

Conclusion

This study demonstrate that HL is better than PL in the management of DUS. In spite of the fact that PL can still be applied in the resource-limited conditions as it is less expensive and easier to organize, HL can be viewed as the modality of choice in the environments where it is allowed by the facilities because it is more effective and most importantly patient-centered.

Conflict of Interest: None
Funding Disclosure: The study is self-funded

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HISTORY	
Date received:	08-10-2025
Date sent for review:	09-12-2025
Date received reviewers' comments:	14-12-2025
Date received revised manuscript:	18-12-2025
Date accepted:	24-12-2025

CONTRIBUTION OF AUTHORS	
AUTHOR	**CONTRIBUTION**
Conception/Design	RR, HSK
Data acquisition, analysis and interpretation	HSK, MTS, SYH
Manuscript writing and approval	RR, HSK, MTS, SYH, NS
All the authors agree to take responsibility for every facet of the work, making sure that any concerns about its integrity or veracity are thoroughly examined and addressed.	