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Research Article

Comparison Of Pneumatic And Laser Lithotripsy In The Endoscopic Treatment Of Proximal Ureteric Calculus

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ABSTRACT

Background: Proximal ureteric calculi pose significant challenges in endoscopic management due to higher rates of stone retropulsion and complications. Pneumatic and laser lithotripsy are widely used intracorporeal techniques, but limited comparative data exist specifically for proximal ureteric stones.

Objective: To compare the efficacy, safety, and clinical outcomes of pneumatic lithotripsy (PL) versus holmium:YAG laser lithotripsy (LL) in the treatment of proximal ureteric calculi.

Materials and Methods: This was a hospital-based, comparative study conducted over two years in the Department of Urology at the Government General Hospital, Kurnool. Fifty patients with single proximal ureteric calculi (<2 cm) were randomized into two groups: PL (n=25) and LL (n=25). Preoperative, intraoperative, and postoperative parameters—including stone size, operative time, stone-free rate (SFR), hospital stay, and complications—were recorded. Statistical analysis was performed using SPSS version 29.0.2.0, with p < 0.05 considered statistically significant.

Results: Both groups were comparable in age, gender, and stone size. Mean operative time was significantly longer in the LL group (40.16 ± 7.64 min) compared to PL (33.12 ± 6.13 min, *p*<0.001). Stone retropulsion was higher in the PL group (28% vs. 12%), though not statistically significant (*p*=0.157). The LL group had a significantly higher SFR at one month (96%) compared to PL (76%, *p*=0.042). Rates of postoperative fever, hematuria, pain, and UTI were lower in the LL group, but differences were not statistically significant. The mean hospital stay was comparable between groups.

Conclusion: Both pneumatic and laser lithotripsy are effective for proximal ureteric calculi. However, laser lithotripsy provides superior stone clearance with fewer complications and should be the preferred modality where resources permit. Pneumatic lithotripsy remains a viable and cost-effective alternative in resource-limited settings.

***Keywords**: Ureteric calculus, pneumatic lithotripsy, holmium:YAG laser, ureteroscopy, stone-free rate, endourology.*

INTRODUCTION

Urolithiasis, or urinary tract stone disease, remains a common and recurrent problem worldwide, contributing significantly to patient morbidity and healthcare burden. Globally, the lifetime risk of developing urolithiasis is estimated to be between 1% and 15%, with variations based on geography, climate, dietary habits, fluid intake, and genetic predisposition [1,2]. Ureteric stones represent about 20% of all urinary tract calculi, and among these, proximal ureteric calculi pose a unique clinical challenge due to their anatomical location and lower rates of spontaneous passage compared to distal ureteric stones [3].

The management of proximal ureteric calculi has evolved significantly over the past few decades. Earlier, open surgeries and extracorporeal shock wave lithotripsy (ESWL) were commonly employed. However, with the advancement of endourological techniques, ureteroscopic lithotripsy (URSL) has emerged as a highly effective and minimally invasive modality for the treatment of ureteral stones [4]. The evolution of endoscopic technology, availability of high-resolution optics, smaller-caliber ureteroscopes, and efficient intracorporeal lithotripters have revolutionized the management of ureteric calculi and reduced morbidity associated with surgical intervention [5].

Among the available intracorporeal lithotripsy devices, pneumatic lithotripsy (PL) and holmium:YAG laser lithotripsy (LL) are the two most commonly used techniques in clinical practice. Pneumatic lithotripsy employs mechanical energy to fragment stones via a ballistic probe mechanism. It is cost-effective, easy to use, and particularly effective in fragmenting hard stones such as calcium oxalate monohydrate. However, it has a higher rate of stone retropulsion, especially in the proximal ureter, which may necessitate secondary procedures and prolong treatment duration [6,7].

On the other hand, holmium:YAG laser lithotripsy, introduced in the 1990s, has become the gold standard for intracorporeal lithotripsy. It works by delivering high-energy laser pulses that generate a photothermal and photomechanical effect, leading to stone disintegration. It can fragment stones of all compositions and sizes and allows precise control with minimal stone migration [8]. Moreover, the laser fiber can be manipulated with high flexibility, making it ideal for proximal ureteric and renal stones. Despite its higher cost, laser lithotripsy is associated with superior stone-free rates, reduced need for auxiliary procedures, and fewer complications such as ureteral trauma and perforation [9,10].

Although several studies have evaluated the efficacy of both techniques, the literature comparing pneumatic versus laser lithotripsy specifically for proximal ureteric calculi remains limited. Proximal ureteric stones are technically more challenging due to the limited working space, tendency for retropulsion into the kidney, and higher risk of mucosal injury. Therefore, selecting the appropriate modality is crucial for achieving optimal outcomes while minimizing complications.

This comparative study was undertaken to evaluate and compare the clinical outcomes, intraoperative and postoperative complications, stone-free rates, and hospital stay duration between pneumatic and laser lithotripsy in the treatment of proximal ureteric calculi. By analyzing these parameters, the study aims to provide evidence to guide urologists in selecting the most effective and safe lithotripsy modality tailored to the clinical scenario.

MATERIALS AND METHODS

Study Design and Setting

This was a hospital-based, comparative study conducted over two years in the Department of Urology at the Government General Hospital, Kurnool. The study aimed to compare the outcomes of laser lithotripsy and pneumatic lithotripsy in the management of proximal ureteric calculi.

Study Population and Sampling

All patients undergoing ureteroscopic lithotripsy at the study center who fulfilled the inclusion criteria were considered for inclusion. A total of 50 patients were enrolled using a random sampling method and were divided equally into two groups: Group A (laser lithotripsy) and Group B (pneumatic lithotripsy), with 25 patients in each group.

Inclusion Criteria

- Age between 18 and 65 years
- Presence of a single proximal ureteric calculus located above the transverse process of the L4 vertebra on non-contrast computed tomography (NCCT) KUB
- Stone size up to 2 cm

Exclusion Criteria

- Stone size >2 cm
- Multiple calculi
- Bleeding diathesis
- Sepsis
- Renal failure
- Pregnancy

- Technical difficulty in passing the ureteroscope

Preoperative Evaluation
All patients were evaluated based on a detailed medical history including symptoms such as loin pain, nausea, vomiting, hematuria, and lithuria. A general physical examination and per abdominal examination were conducted.

Investigations
All patients underwent the following investigations preoperatively:

- Complete hemogram
- Blood urea and serum creatinine
- Urine routine examination, culture and sensitivity
- Ultrasonography (USG) of the abdomen
- NCCT KUB
- Postoperative plain X-ray KUB and USG abdomen (for residual stone evaluation)

Ethical Considerations
The study protocol was approved by the Institutional Research and Ethics Committee of the Government General Hospital, Kurnool. Informed written consent was obtained from all participants prior to inclusion in the study.

Surgical Procedure
All procedures were performed under spinal anesthesia. A preoperative prophylactic antibiotic dose of 1 g ceftriaxone was administered to all patients in accordance with institutional protocol and local microbial sensitivity patterns.

- **Laser Lithotripsy Group (Group A):**Holmium:YAG laser lithotripsy was performed using a 365-micron fiber with frequency settings between 5–10 Hz and energy levels of 0.5–1.4 J.
- **Pneumatic Lithotripsy Group (Group B):** Pneumatic lithotripsy was performed using a lithoclast with a 3 Fr probe, delivering compressed air bursts at 4 kg/cm² with a frequency up to 12 Hz.

A semi-rigid ureteroscope of 6/7.5 or 8/9.5 Fr was used in both groups. Post-procedure, a 5 Fr double J (DJ) stent was inserted and Foley catheterization was done.

Postoperative Care and Follow-Up
A plain X-ray KUB was performed on the first postoperative day to assess residual calculi. The Foley catheter was removed on postoperative day 2, and patients were typically discharged the same day following uneventful recovery. The DJ stent was removed four weeks postoperatively. All patients were followed up on day 31 with repeat X-ray KUB and USG to assess stone clearance.

Outcome Measures and Data Collection
Parameters recorded included:

- Stone size and location
- Duration of surgery
- Length of hospital stay
- Stone clearance status
- Intraoperative complications: mucosal injury, ureteric perforation, hematuria
- Postoperative complications: pain, fever, urinary tract infection (UTI)
- Reasons for procedural failure: retrograde stone migration, retained fragments, or need for alternative procedures such as retrograde intrarenal surgery (RIRS), percutaneous nephrolithotomy (PCNL), or extracorporeal shock wave lithotripsy (ESWL)

Complications were assessed daily during the hospital stay and at follow-up.

Statistical Analysis
Data were entered in Microsoft Excel and analyzed using IBM SPSS Statistics Version 29.0.2.0. Descriptive statistics were reported as mean ± standard deviation for continuous variables and frequencies with percentages for categorical variables. Comparative analyses were performed using an independent samples t-test, Mann-Whitney U test, and Chi-square test as appropriate. A p-value <0.05 was considered statistically significant.

RESULTS AND OBSERVATIONS

Table 1: Age and Gender Distribution of Patients in PL and LL Groups

Parameter	PL Group (n = 25)	LL Group (n = 25)

Age (years)		
Minimum	21	25
Maximum	64	64
Mean ± SD	41.88 ± 14.06	42.16 ± 10.77
Gender		
Male, n (%)	18 (72%)	17 (68%)
Female, n (%)	7 (28%)	8 (32%)

Table 2: Ureteric Calculus Side and Size Distribution in PL and LL Groups

Parameter	PL Group (n = 25)	LL Group (n = 25)	p-value
Side of Ureteric Calculus			
Right, n (%)	12 (48%)	14 (56%)	—
Left, n (%)	13 (52%)	11 (44%)	—
Average Stone Size (mm)	9.56 ± 1.89	9.60 ± 1.93	0.941

Table 3: Operative Time Comparison

	Range of Operative time	Mean operating Time	p-value
Group PL	22 – 45 min	33.12±6.13 min	<0.001
Group LL	24 – 56 min	40.16±7.64 min	

Table 4: Comparison of Stone Retropulsion and Hematuria in PL and LL Groups

Parameter	PL Group (n = 25)	LL Group (n = 25)	p-value
Stone Retropulsion			
Number of patients with retropulsion	7 (28%)	3 (12%)	0.157
Postoperative Hematuria			
Incidence of hematuria (%)	2 (8%)	3 (12%)	0.637

Table 5: Comparison of the incidence of mucosal injury

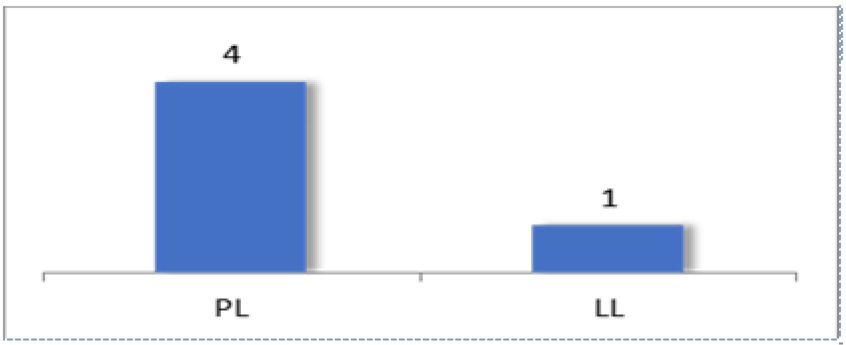
	PL	LL	p-value
No. of pt with mucosal injury	1	2	0.552

Table 6: Comparison of Post-operative Fever and Pain in PL and LL Groups

Parameter	PL Group (n = 25)	LL Group (n = 25)	p-value
Post-operative Fever	3 (12%)	1 (4%)	0.297
Post-operative Pain	3 (12%)	1 (4%)	0.297

Table 7: Comparison of UTI

	PL	LL	p-value
Incidence of UTI	4	1	0.157



Graph 1: Comparison of UTI

Table 8: Comparison of Average Hospital Stay and Stone-Free Rate (SFR) at One Month

Parameter	PL Group (n = 25)	LL Group (n = 25)	p-value
Mean Hospital Stay (days)	2.72 ± 1.308	2.40 ± 1.118	0.201

Stone-Free Rate (SFR) at 1 Month	76% (19/25)	96% (24/25)	0.042*

*Statistically significant at p < 0.05

DISCUSSION

The present study was undertaken to compare the efficacy, safety, and clinical outcomes of pneumatic lithotripsy (PL) and holmium:YAG laser lithotripsy (LL) in the management of proximal ureteric calculi. Proximal ureteric stones, owing to their anatomical location, present unique challenges such as retropulsion, difficulty in accessibility, and increased complication risk. Hence, the choice of an optimal lithotripsy modality is critical for successful outcomes.

In our study, both groups were comparable in terms of demographic characteristics such as age and gender distribution. The mean age in the PL group was 41.88 ± 14.06 years and in the LL group was 42.16 ± 10.77 years, with no significant difference. Gender distribution was also similar, showing male predominance in both groups, consistent with global trends indicating a higher prevalence of urolithiasis among males [1,2].

The mean stone size was also similar between the groups (PL: 9.56 ± 1.89 mm vs. LL: 9.60 ± 1.93 mm), ruling out size bias in outcome comparison. The stone laterality (right vs. left) was almost equally distributed, further balancing the study groups.

One of the key findings of our study was the **significant difference in operative time**, with the LL group having a longer average duration (40.16 ± 7.64 min) compared to the PL group (33.12 ± 6.13 min, p<0.001). This is in line with other studies that have shown laser lithotripsy to take longer due to the dusting technique used and the need for finer fragmentation [3,4].

Stone retropulsion was more commonly observed in the PL group (28%) compared to the LL group (12%), although the difference was not statistically significant (p=0.157). This observation aligns with previous reports that note a higher incidence of retropulsion with pneumatic lithotripsy due to the mechanical force transmitted to the stone [5]. Laser lithotripsy offers a better control of fragmentation with less retropulsion, especially in the proximal ureter where gravity and irrigation pressure play a lesser role in preventing stone migration [6].

Postoperative complications, including hematuria, pain, and fever, were slightly more frequent in the PL group but without statistically significant differences. Hematuria was observed in 8% of PL patients and 12% in LL, and pain and fever occurred in 12% and 4% respectively in the LL group. These findings are consistent with previous trials where complication rates were comparable, although slightly higher in mechanical lithotripsy techniques due to greater mucosal trauma [7,8].

The **incidence of postoperative UTI** was higher in the PL group (16%) than in the LL group (4%), again not statistically significant (p=0.157). The presence of residual fragments and prolonged instrumentation might have contributed to infection risk.

The **mean hospital stay** was slightly longer in the PL group (2.72 ± 1.308 days) compared to the LL group (2.40 ± 1.118 days), which again is consistent with studies indicating that more efficient stone clearance in LL may contribute to shorter hospital stays [9].

The most important clinical endpoint—**stone-free rate (SFR) at one month**—was significantly higher in the LL group (96%) compared to the PL group (76%), with a p-value of 0.042. This statistically significant difference confirms findings from multiple studies and meta-analyses, establishing the superiority of laser lithotripsy in achieving complete clearance of ureteric stones, especially in the proximal segment [10,11].

Although cost is a consideration in choosing between PL and LL, the higher stone clearance rate and reduced need for auxiliary procedures in LL may offset the initial expense in the long run [12].

CONCLUSION

This study demonstrates that both pneumatic lithotripsy (PL) and holmium:YAG laser lithotripsy (LL) are effective and safe for the endoscopic management of proximal ureteric calculi. However, LL was associated with a **significantly higher stone-free rate** at one month (p = 0.042) and a **lower incidence of stone retropulsion and postoperative complications** such as fever, hematuria, and urinary tract infection, although these differences were not statistically significant.

While LL required a **longer operative time**, the overall hospital stay was comparable between the two groups. These findings suggest that **laser lithotripsy offers superior stone clearance with fewer intra- and postoperative issues**, making it the **preferred modality** for treating proximal ureteric stones, particularly when optimal resources and expertise are available.

Pneumatic lithotripsy remains a **cost-effective and practical alternative**, especially in resource-limited settings, but may be associated with a **higher rate of auxiliary procedures** due to stone migration and the presence of residual fragments.

REFERENCES

1. Romero V, Akpinar H, Assimos DG. Kidney Stones: A Global Picture of Prevalence, Incidence, and Associated Risk Factors. *Rev Urol*. 2010;12(2-3):e86–e96.
2. Scales CD Jr, Smith AC, Hanley JM, Saigal CS. Prevalence of kidney stones in the United States. *Eur Urol*. 2012;62(1):160–165.
3. Gupta PK, Mishra A, Nayyar R, et al. Evaluation of pneumatic lithotripsy and holmium:YAG laser lithotripsy in management of ureteral calculi. *Indian J Urol*. 2008;24(2):208–210.
4. Alkan E, Yanaral F, Ozkanli MU, et al. Comparison of the outcomes of holmium laser and pneumatic lithotripsy for ureteral stones: A randomized clinical trial. *Urolithiasis*. 2017;45(6):573–577.
5. Michel MS, Trojan L, Rassweiler JJ. Complications in percutaneous nephrolithotomy. *Eur Urol*. 2007;51(4):899–906.
6. Teichman JM, Vassar GJ, Bishoff JT, Bellman GC. Holmium:YAG lithotripsy in the ureter: The effect of pulse energy and pulse repetition rate on fragmentation efficiency. *J Urol*. 1998;160(2):471–476.
7. Lee H, Kang DH, Chung DY, et al. Comparison of the surgical outcomes of holmium:YAG laser and pneumatic lithotripsy in ureteroscopic treatment of ureteral calculi. *Korean J Urol*. 2011;52(10):713–717.
8. Wang H, Man L, Li G, et al. Laser lithotripsy versus pneumatic lithotripsy in the endoscopic management of ureteral stones: A systematic review and meta-analysis. *J Endourol*. 2010;24(3):339–346.
9. El-Nahas AR, Ibrahim HM, Youssef RF, et al. Semi-rigid ureteroscopy for ureteral stones: impact of stone size on the outcome. *Urology*. 2009;73(1):48–52.
10. Grasso M, Conlin M, Bagley D. Retrograde ureteroscopic approach to the upper urinary tract. *Urol Clin North Am*. 1998;25(4):619–631.
11. Chan KF, Vassar GJ, Pfefer TJ, Teichman JM. Holmium:YAG laser lithotripsy: A dominant photothermal ablative mechanism with chemical decomposition of urinary calculi. *J Urol*. 2001;166(2):682–688.
12. Kuo RL, Aslan P, Preminger GM. Laser lithotripsy: A review of recent advancements. *Curr Opin Urol*. 2002;12(4):299–303.