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Efficacy of holmium laser versus pneumatic lithotripsy for mid and distal ureteric stones above 10 mm size

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ABSTRACT

Background: Over the past decade, ureteral stone treatment has evolved significantly. Pneumatic lithotripsy is common but prone to stone migration. Holmium laser use has increased due to fewer complications and lower stone migration rates. **Aims and Objectives:** The purpose of the study was to compare Lithoclast with holmium: YAG laser lithotripsy for mid and lower ureteral stone and evaluate the complication rate of both for the endoscopic management of ureteric stone. **Materials and Methods:** This 2-year comparative study at R.G. Kar Medical College and Hospital involved 200 patients with ureteric stones $\geq$10 mm. Patients were randomized to groups and recorded metrics included duration, complications, and post-procedural ureteroscopic evaluations. Data were analyzed using Microsoft Excel, SPSS (v27.0), and GraphPad Prism (v5), employing two-sample and paired t-tests (significance at $P \leq 0.05$). **Results:** Most participants were aged 21–50 years; the association between Hematuria in immediate post-operative period was significantly more common with Lithoclast (91%) than Laser treatment (69%) ($P = 0.0001$). Submucosal hematoma occurred significantly more with Lithoclast (18%) than Laser treatment (2%) ($P = 0.0001$). Ureteric perforation was significantly more common with Lithoclast than with Laser treatment ($P = 0.007$). At 14 days postoperatively, 8% of the Lithoclast group had residual stones, while the Laser group had a 100% stone-free rate ($P = 0.0038$). **Conclusions:** This study highlights the comparative efficacy of laser and pneumatic lithotripsy for ureteric stones showing similar outcomes in demographics, stone characteristics, and operative duration. However, the laser group had a higher stone-free rate, fewer complications such as hematuria and ureteric perforation, and fewer residual stones, supporting its growing preference.

Key words: Holmium laser; Pneumatic lithotripsy; Mid and distal ureteric stones; Stone fragmentation; Stone-free rate; Hematuria; Ureteric perforation residual stones

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INTRODUCTION

The treatment of ureteral stones has undergone a remarkable evolution in the last 15 years.[1] Management issues today depend on the size, location, and composition of the stone; a patient's particular social and employment situation; the equipment available at a given institution; and the relative expertise of the treating urologist.[1] The indications for open stone surgery have been narrowed significantly, and for the most part, open surgery has become a second- or third-line treatment option.[2] Dramatic advances in ureteroscopic design have occurred

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within the last decade. Smaller caliber flexible steerable ureteroscopes permit the endourologist to maneuver into previously inaccessible recesses of the collecting system.[3] Ureteroscopic intracorporeal lithotripsy has now become the first-line therapy for chronically impacted stones.[4] The most widely used method for stone fragmentation is pneumatic lithotripsy;, however, it has a high possibility of stone migration. Recently, there has been an increase in the use of the holmium laser for stone fragmentation due to its fever complications and lower incidence of stone upmigration.[5] Laser technologies are established standard modalities for application on lithotripsy.[6] Interestingly, ureteroscopy (URS) yields better stone-free rates for distal stones independent of the size (94.5%5 vs. 74%, respectively).[6]

This investigation examines the comparative effectiveness of Ho: YAG laser lithotripsy and pneumatic lithotripsy for ureteral calculi exceeding 10 mm in the mid and distal regions. By contributing to the existing literature on optimal treatment strategies for larger ureteral stones, this study aims to provide a comprehensive analysis. While prior research has explored the individual merits of these modalities, a targeted evaluation of stone-free rates and associated complications will offer crucial insights to urologists, enabling them to make evidence-based, patient-oriented treatment decisions.

Aims and objectives

The purpose of the present study is to compare Lithoclast with holmium: YAG laser lithotripsy for mid and lower ureteral stone clearance rate, operative time, evaluate the complication rate, and assess the safety of Ho: YAG laser and pneumatic intracorporeal lithotripsy for the endoscopic management of ureteric stone.

MATERIALS AND METHODS

This 2-year comparative study at R.G. Kar Medical College and Hospital involved 200 patients with ureteric stones ≥10 mm. Patients aged >12 years with single/multiple stones and no prior stone surgery were included. Exclusions were unwilling/unfit for surgery, ureteric stricture, previous ureteric surgery, chronic kidney disease, active sepsis, coagulopathy, pregnancy, stones <10 mm, and duplex ureter.

Methodology

Patients were randomized to pneumatic or laser lithotripter groups. Recorded metrics included procedure duration, complication rates, and post-procedural ureteroscopic evaluations. Equipment used: 8.5F single channel ureterorenoscope, lithoclast pneumatic lithotripter, and 100W Quanta Holmium laser with 365-micron fiber. Laser settings: 1-1.5 J/pulse, 5–12 Hz; pneumatic: 5 bar, 10 Hz. Post-procedure, a 5F ureteral stent was inserted. Data were analyzed using Microsoft Excel, SPSS (v27.0), and GraphPad Prism (v5), employing two-sample and paired t-tests (significance at P≤0.05).

Ethical approval

The procedures followed in accordance with the ethical standards of the responsible committee of the institution with the addition of the approved study design in the title.

RESULTS AND ANALYSIS

Most participants were aged 21–50 years; no significant correlation was found between age and treatment group (P=0.6763). The Laser and Lithoclast groups had similar mean ages (38.21 vs. 39.83 years); no significant difference (P=0.4241). Sex distribution was similar between groups (Laser: 29% female, 71% male; Lithoclast: 26% female, 74% male; P=0.6347).

Table 1 shows that the Laser and Lithoclast groups showed no significant difference in mean stone size (13.31 mm vs. 13.74 mm, P=0.1987).

Figure 1 shows stone location analysis with no significant difference noted between Laser and Lithoclast groups (P=0.665); 38-42% had stones below the sacroiliac joint, and 58–62% over the sacral ala.

Table 2 shows the Laser and Lithoclast procedures had similar operative durations (41.58±12.99 vs. 38.49±16.81 min; P=0.1473).

Table 3 shows Hematuria was significantly more common with Lithoclast (91%) than Laser treatment (69%) (P=0.0001). S.M. Hematoma occurred significantly more with Lithoclast (18%) than with Laser treatment (2%) (P=0.0001). Ureteric perforation was significantly more common with Lithoclast (7%) than with Laser treatment (0%) (P=0.0070). The study evenly divided subjects between Laser and Lithoclast (50% each), with all participants classified as negative for avulsion. Fever occurred in 2% of the Laser group and 7% of the Lithoclast group, with no significant difference (P=0.0881). 98% of the Laser group and 94% of the Lithoclast group were discharged on POD2, with no significant difference (P=0.1489). At 14 days postoperatively, 8% of the Lithoclast group had residual stones, whereas the Laser group had a 100% stone-free rate (P=0.0038). The Laser group had a 99% DJ stent removal rate at 14 days, compared to 90% in the Lithoclast group (P=0.0052).

Table 1: Distribution of mean stone size: group

Type of surgery	Number	Mean	SD	Minimum	Maximum	Median	P-value
Stone size							
Laser	100	13.3100	1.9524	10.0000	19.0000	13.0000	0.1987
Lithoclast	100	13.7400	2.7029	10.0000	23.0000	13.0000	

Table 2: Distribution of mean OT TIMING group

Type of surgery	Number	Mean	SD	Minimum	Maximum	Median	P-value
OT timing							
Laser	100	41.5800	12.9896	24.0000	95.0000	40.0000	0.1473
Lithoclast	100	38.4900	16.8058	20.0000	98.0000	31.0000	

Table 3: Distribution of complications and postop events

Postop complications	Laser		Lithoclast	
	Yes	No	Yes	No
Hematuria	69	31	91	9
S.M hematoma	2	98	18	82
Perforation	0	100	7	93
Avulsion	0	100	0	100
Retained stone	0	100	8	92
POD2 fever	2	98	7	93
Discharge POD2	98	2	94	6
Dj stent removal at POD 14	99	1	90	10

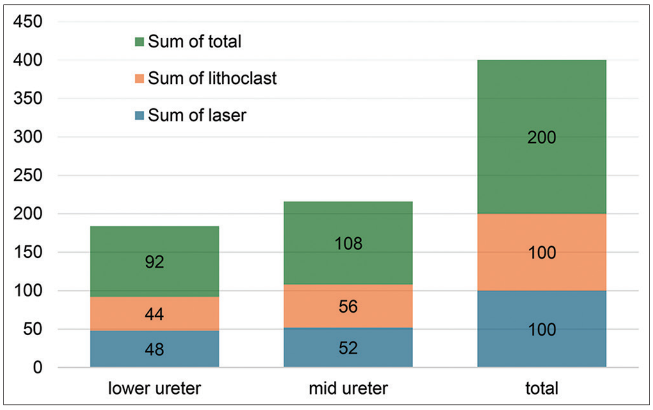

Figure 1: Association between stone location group

DISCUSSION

The demographic analysis showed, the Laser group had a mean age of 38.21 years, whereas the Lithoclast group had a mean age of 39.83 years. Most participants in both groups were aged 21–50, with 78% in the laser group and 72% in the lithoclast group. Gender distribution was 29% female and 71% male in the laser group, and 26% female and 74% male in the lithoclast group. Binbay et al., in his study, found mean patient age (39.6±5.6 years vs. 40.2±6.4 years), male: female ratio (26:14 vs. 23:17) (65% male, 35% female for group 1 and 57.5% male, 42.5% female), and stone size (118.8±58.3 mm^2 vs. 110.7±54.4 mm^2) were all similar between the pneumatic and laser groups.[4] Akdeniz et al., in his investigation, found median age was 43.93±15.94 years in group pneumatic lithotripsy and 46.15±14.54 years in group laser lithotripsy.[5] Comparable findings were reported by Ercil et al., in a separate investigation. Their study comprised two groups: Group 1 consisted of 75 patients (48 males, 27 females) with a mean age of 41.23 (±11.87) years, whereas Group 2 included 66 patients (42 males, 24 females) with a mean age of 40.17 (±12.4) years.[7]

Our analysis showed no significant difference in mean stone sizes between the Laser (13.31 mm) and Lithoclast (13.74 mm) groups (P=0.1987). Stone location also had no significant correlation with treatment type (Laser: 38% below sacroiliac joint, 62% above sacral ala; Lithoclast: 42% below, 58% above; P=0.665). Mean operative durations were similar (Laser: 41.58±12.9896 min, Lithoclast: 38.49±16.8058 min; P=0.1473). Razzaghi et al., in their study, found that the mean±standard deviation duration of lithotripsy was 13.7±12.6 min laser group and 7.9±4.2 min in the pneumatic group (P=0.29). The immediate stone-free rate was 100% in the laser group and 82.1% in the pneumatic group (P=0.001). Stone pushing back occurred only in 10 (17.9%) patients in the pneumatic group.[8] Khoder et al., in their study, found, mean operative time was 81.3±4.5 min (25–140 min) in the 1^{st} group and 65.7±3.8 min (25–120 min) in the 2^{nd} group. Complete fragmentation during a single procedure was achieved in all patients of the 1^{st} group (100%). In the 2^{nd} group, only 42 patients (82.4%) were rendered stone free by a single laser lithotripsy procedure. The overall stone-free rate for both groups was 95.8%.[6] Li et al., in their study concluded, in our trial, we did not have any major complications such as ureteral avulsion or laceration and urosepsis. The average post-operative stay was also comparable (1.7±2.4 days for pneumatic and 1.5±3.1 days for laser, P=0.62).[9]

Hematuria was observed in 69% of laser-treated patients and 91% of those receiving lithoclast therapy, showing a significant correlation with treatment type (P=0.0001). In the Laser group, 2% developed S.M. Hematoma, whereas 18% in the Lithoclast group did (P=0.0001).

Ureteric perforation occurred in 7% of Lithoclast patients, compared to none in the Laser group (P=0.0070). Both groups had equal distribution (50%) with no avulsion present. Fever on the second postoperative day occurred in 2% of Laser patients and 7% of Lithoclast patients, with no significant correlation (P=0.0881). Discharge on the second postoperative day was 98% for the Laser group and 94% for the Lithoclast group (P=0.1489). A significant association was found between treatment and residual stones (P=0.0038); 8% of Lithoclast patients had residual stones at 14 days, whereas the Laser group had a 100% stone-free rate. DJ stent removal at 14 days was 99% in the Laser group, with one early removal at 8 days, and 90% in the Lithoclast group, with 8 delayed removals at 21 days post-operation and two early removals at 9 days due to severe symptoms (P=0.0052).

Chen et al., in their study, found that, for all stone sizes, the rate of double J insertion was lower in the laser than in the pneumatic group (72.1% vs. 91.9%, P<0.001). The stone-free rate was higher in the laser group (53.4% vs. 40.1%, P=0.041).[10] The study concluded that ureteroscopic lithotripsy was safe and effective, with minor complications including minor pain, gross hematuria, or stent-related discomforts.[10] Chen et al., in their study, showed that there was a significant difference between the 2 groups, the mean operative time of LL was much shorter than that of PL group (weighted mean difference=11.52, 95% CI −17.06–−5.99, P<0.0001).[11] The results showed LL improved an early stone-free rate than PL (OR 2.69, 95% CI 1.91–3.78, P=0.00001). In terms of stone migration rate, no significance was detected among the 2 groups (OR 0.64, 95% CI 0.41–1.00, P=0.05).[11] Shah and Shrestha in their study showed that Stone free rate in this study in pneumatic group was 86.15% and in laser group it was 96.92%.[12] On further evaluating the data by dividing into mid and distal ureteric calculus, Ho: YAG laser was superior to the pneumatic group in terms of stone-free rate in mid-ureteric calculus. This study showed complete stone clearance of 76.67% in the pneumatic group and 93.33% in the laser group for mid-ureteric stone (P<0.05). Failure of procedure was 23.33% in the pneumatic group and 6.67% in the laser group.[12]

Limitations of the study

1. Single centre study
2. Requires bigger study sample data.

CONCLUSION

This study provides valuable insights into the comparative efficacy of laser and pneumatic lithotripsy for ureteric stone management. Both techniques demonstrated comparable outcomes in terms of patient demographics, stone characteristics, and operative duration. However, the laser group showed superior results in several key areas, including a higher stone-free rate, lower incidence of complications such as hematuria and ureteric perforation, and fewer cases of residual stones. The findings align with previous studies, supporting the growing preference for laser lithotripsy in urological practice. While both methods remain viable options, the laser technique appears to offer distinct advantages in terms of safety and efficacy. Future research should focus on long-term outcomes and cost-effectiveness to further guide clinical decision-making in the management of ureteric stones.

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Authors' Contributions:
Ar- Definition of intellectual content, literature survey, prepared first draft of manuscript, implementation of study protocol, data collection, data analysis, manuscript preparation and submission of article; **SMD-** Concept, design, clinical protocol, manuscript preparation, submission of article, editing, and manuscript revision; coordination and manuscript revision; **SKS-** Design of study, statistical analysis and interpretation, review manuscript; **SKT-** Review manuscript; **PPM-** Review manuscript; **AS-** Literature survey and preparation of figures; **AA-** Literature survey and preparation of figures, **RKD-** Coordination and manuscript revision.

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