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Comparative Evaluation of Thulium Fibre Laser Versus Pneumatic Lithotripsy for Ureteroscopic Management of Ureteric Calculi: A Retrospective Comparative Study.

Dr. Dhirajkumar s Hedda[1*], Dr. Amol Kendre[2]

[1]*Assistant Professor, Department of Urology, Vilasrao Deshmukh Government Medical College and Superspeciality Hospital, Latur, Maharashtra, INDIA.*

[2]*Senior Resident, Department of Urology, Vilasrao Deshmukh Government Medical College and Superspeciality Hospital, Latur, Maharashtra, INDIA.*

Correspondence:
Dr. Dhirajkumar s Hedda.
Assistant Professor, Department of Urology, Vilasrao Deshmukh Government Medical College and Superspeciality Hospital, Latur, Maharashtra, INDIA.

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Abstract

Background: Thulium fibre laser and pneumatic lithotripsy are used during ureteroscopic treatment of ureteric calculi. Comparative assessment should distinguish early clearance from eventual clearance and include delayed ureteric complications. Aim: To compare efficacy, perioperative outcomes and safety of TFL and pneumatic ureteroscopic lithotripsy. ***Materials and Methods***: This modelled a hospital-based retrospective comparative cohort of 250 adults, with 125 patients per technique, undergoing treatment between January 2024 and December 2025. Four-week stone-free status without auxiliary treatment was the primary endpoint. Perioperative outcomes and complications through 12 months were specified. Complete observation of the entire cohort would require records through December 2026. Unadjusted comparisons used Welch's t, Pearson's chi-square or Fisher's exact tests with 95% confidence intervals. ***Results***: Four-week stone-free rates were 95.2% with TFL and 84.0% with pneumatic lithotripsy (absolute difference 11.2 (3.7 to 19.1) percentage points; p=0.004). Retropulsion occurred in 4.0% versus 16.8%, and auxiliary treatment in 4.8% versus 14.4%. Mean operative time was 36.84 versus 42.76 minutes, while active lithotripsy time was 11.82 versus 6.74 minutes. Three-month clearance was 98.4% versus 96.0% (p=0.446). Any listed complication occurred in 12.8% versus 24.0%; frequencies were 1.6% versus 2.4%, without a significant difference. ***Conclusion***: The example demonstrates how early efficacy and resource outcomes could favour TFL while final clearance and rare complications remain uncertain. These values are not patient findings and require replacement with verified data before clinical or academic use.

Keywords: Thulium fibre laser; Pneumatic lithotripsy; Ureteric calculi.

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INTRODUCTION

Ureteric calculi are an important cause of renal colic, urinary obstruction and recurrent healthcare attendance. Ureteroscopy permits direct stone visualization and intracorporeal fragmentation, but successful treatment requires more than immediate disintegration: stone clearance, procedural burden and delayed ureteric morbidity must also be considered. Somani et al. (2017)[1], in the multinational CROES ureteroscopy study, documented an overall complication rate of 7.4%, emphasizing the value of systematic assessment of both intraoperative and postoperative events. Pneumatic lithotripsy remains an established fragmentation technique. Its mechanical action can efficiently break calculi, although proximal displacement and the need to retrieve larger fragments may influence completion of treatment. Li et al. (2015)[2] reported advantages in early clearance with holmium laser compared with pneumatic lithotripsy, while the difference at three months was not significant, demonstrating that the timing of outcome assessment matters. Thulium fibre laser (TFL) has subsequently emerged as another intracorporeal energy source. Andreeva et al. (2020)[3] demonstrated higher ablation rates and less retropulsion than holmium:YAG laser under controlled laboratory conditions. These findings provided a mechanistic basis for clinical investigation but did not establish superiority over pneumatic lithotripsy in patients. Martov et al. (2021)[4] reported favourable operative efficiency and clearance with super-pulsed TFL compared with high-power holmium laser in ureteric stones. Nevertheless, results from comparisons between two lasers cannot be directly extrapolated to a laser-versus-pneumatic comparison. In a direct prospective comparison involving 100 patients, Mahajan et al. (2025)[5] found less retropulsion and better visualization with TFL than pneumatic lithotripsy, but longer lithotripsy time and comparable stone-free rates and complications. Thus, a clinically relevant trade-off may exist between fragmentation time, migration and overall treatment completion. Retrospective assessment of routine hospital practice can complement these studies by evaluating patients treated under everyday conditions and by examining delayed outcomes. Such comparisons must account for stone size, location, impaction, surgeon experience, treatment selection and follow-up completeness. The present study

framework was designed to compare stone-free rates, perioperative outcomes and complications after TFL and pneumatic ureteroscopic lithotripsy, including surveillance for hydronephrosis and ureteric stricture for 12 months.

AIM

To retrospectively compare the efficacy and safety of thulium fibre laser lithotripsy and pneumatic lithotripsy in patients who underwent ureteroscopic treatment for ureteric calculi.

OBJECTIVES

1. To compare the stone-free rate following ureteroscopic thulium fibre laser lithotripsy and pneumatic lithotripsy.
2. To compare operative time, stone migration or retropulsion, double-J stenting, auxiliary or repeat procedures, duration of hospitalization and time to complete stone clearance between the two techniques.
3. To compare intraoperative and postoperative complications, including ureteric mucosal injury, perforation, bleeding, urinary tract infection, hydronephrosis and ureteric stricture during 12 months of follow-up.

MATERIALS AND METHODS

Source of data

Data were abstracted from the hospital medical-record department, electronic inpatient and outpatient records, operating-theatre registers, anaesthesia charts, operative notes, discharge summaries, microbiology reports and the radiology archive. The theatre register was used to identify the source population independently of follow-up attendance. Each record was linked using the hospital identifier and then assigned an anonymized study code. A screening log recorded every potentially eligible patient, eligibility decisions and reasons for exclusion.

Study design and location

The study was framed as a hospital-based retrospective comparative observational cohort study conducted in the Department of Urology, [institution name, city, state]. Group A comprised patients treated with thulium fibre laser lithotripsy; Group B comprised patients treated with pneumatic lithotripsy. Treatment allocation reflected documented clinical practice and was not randomized by the investigators. One index treatment episode per patient was included; subsequent procedures for the same stone were classified as outcomes.

Study duration and follow-up

The index-procedure period extended from January 2024 to December 2025. In the completed-cohort template, records were reviewed for 12 months after each index procedure, with the final follow-up window ending in December 2026 and data extraction completed in [January 2027 or later]. Available postoperative encounters around 1–2 weeks, 4 weeks, 3 months, 6 months and 12 months were reviewed; visits were not assumed to have occurred simply because they were scheduled. The actual date, modality and result of every assessment were recorded. If extraction occurred earlier, follow-up was censored at the extraction date or last known contact, whichever occurred first.

Sample size and sampling technique

All eligible records from the defined period were considered using consecutive, census-based sampling. Approximately 250 records were targeted, subject to actual availability

Inclusion criteria

Adults aged 18 years or older with imaging-confirmed unilateral ureteric calculus or calculi were included if they underwent an index ureteroscopic procedure using TFL or pneumatic lithotripsy during the study period. Proximal, middle and distal ureteric stones were eligible. The initial lithotripsy modality, operative details and baseline stone information had to be identifiable. Follow-up availability was documented for each endpoint; incomplete late follow-up did not automatically exclude otherwise eligible patients from baseline and early-outcome analyses.

Exclusion criteria

Patients were excluded for bilateral simultaneous ureteroscopy, simultaneous treatment of renal stones, planned primary flexible intrarenal stone surgery, pre-existing ipsilateral ureteric stricture, major urinary-tract reconstruction or congenital anatomy that materially altered ureteroscopic access, pregnancy, or inability to establish the index modality. Procedures using another energy source as the intended primary treatment were excluded. Rescue conversion from an initially eligible technique was retained in the initial-modality analysis and described separately. Duplicate episodes were removed. Missing outcome data were recorded as missing rather than coded as absence of complications.

Procedure and methodology

Preoperative assessment was reconstructed from existing records. Age, sex, body mass index, comorbidities, renal function, urine culture, previous ipsilateral interventions and pre-stenting were recorded. Imaging was reviewed for stone number,

maximum diameter, location, density in Hounsfield units when CT was available, and hydronephrosis. Stone impaction was classified from documented inability to pass a guidewire beyond the stone or an explicit operative description; undocumented impaction was not inferred from stone size alone.

Anaesthetic technique, ureteroscope type and calibre, guidewire use, dilation, irrigation method and surgeon were extracted from the operative and anaesthesia records. In Group A, the TFL model, fibre diameter, pulse energy, frequency, total power, fragmentation/dusting technique and laser-on time were recorded when available. In Group B, device model, probe size, pressure or pulse settings and active fragmentation time were extracted. Historical settings were not replaced with a uniform regimen that had not actually been used. Fragment extraction, anti-retropulsion devices, rescue flexible ureteroscopy, conversion of modality and double-J stent insertion were recorded in both groups. Indications for stenting, intended removal date and actual removal date were distinguished.

Total operative time was defined as ureteroscope insertion to completion of the final endoscopic step, including stent insertion where performed. Active lithotripsy time was kept separate from total operative time. Postoperative stay was calculated from procedure completion to discharge. When only calendar dates were available, the lower timing precision was documented. Auxiliary procedures included repeat ureteroscopy, shock-wave lithotripsy or another intervention specifically required to clear residual index-stone material; routine stent removal was not counted as an auxiliary stone-clearance procedure.

Outcome definitions and postoperative assessment

The primary endpoint was imaging-documented stone-free status at approximately four weeks (prespecified window: 21–42 days) after the index procedure without an auxiliary stone-clearance intervention before that assessment. Stone-free status meant no detectable residual index-stone fragment; a threshold such as "≤2 mm residual fragment" was not combined with this definition. The modality used—ultrasonography, plain radiography or noncontrast CT—was retained. Where routine follow-up relied on ultrasound with or without radiography, the result was described as imaging-based clearance rather than CT-confirmed clearance. Sensitivity analysis restricted to patients assessed with the same modality was specified.

Three-month clearance incorporated any auxiliary procedures and was reported separately from single-session success. Clinically significant retropulsion meant proximal displacement that prevented planned semirigid completion or required rescue flexible ureteroscopy or a subsequent procedure. Time to clearance was measured from the index procedure to the first imaging assessment documenting clearance. This represented time to documented, not necessarily biological, clearance. Patients without documented clearance were censored; they were not assigned the date of their last visit as a clearance date.

Mucosal injury and perforation were identified from operative documentation. Bleeding was counted when it impaired endoscopic visualization or required a clinical intervention, rather than for transient expected haematuria alone. Postoperative UTI required compatible symptoms and a positive culture within 30 days; suspected or culture-unconfirmed infections were recorded separately. Persistent or new hydronephrosis was assessed relative to baseline and after stent removal. Ureteric stricture required a documented fixed narrowing supported by appropriate imaging or endoscopy, with obstruction assessed where relevant; hydronephrosis alone was not equated with stricture. For persistent pain or hydronephrosis, available CT urography, retrograde imaging or functional assessment was reviewed. No additional investigation was claimed to have been performed solely for the retrospective study.

Sample processing

No new biological specimens were collected for this record-based study. Existing urine microscopy and culture results, serum creatinine and other relevant laboratory reports were abstracted with their collection dates. Stone-composition reports were recorded only when analysis had actually been performed. Missing culture or stone-composition reports were designated unavailable. Laboratory processing methods were described from institutional records only if verified.

Data collection and quality control

A structured extraction sheet captured eligibility, demographics, comorbidities, stone characteristics, treatment dates, procedure details, outcomes and follow-up completeness. Source documents were cross-checked for conflicting dates and outcome classifications. An audit subset was independently reviewed, with disagreements resolved against the original record. A separate linkage file was kept securely, and the analysis file contained study codes only. The numbers screened, excluded, included and assessed at each follow-up point were summarized in a flow diagram for the final report.

Statistical methods

The intended analysis platform was IBM SPSS Statistics version 26; the actual software and version used were to be documented in the completed report. Continuous variables were summarized as mean (SD) when approximately symmetric and median (interquartile range) when skewed. Categorical variables were expressed as n (%) with explicit denominators. Welch's independent-samples t test was used for appropriate continuous comparisons; Mann–Whitney testing was specified for markedly skewed data. Pearson's chi-square test was used for categorical comparisons, with two-sided

Fisher's exact testing for sparse cells. Between-group mean differences and absolute risk differences were reported with 95% confidence intervals. Two-sided $p<0.05$ was the threshold for the primary endpoint; secondary outcomes were interpreted as exploratory, without asserting multiplicity-adjusted significance.

For the actual patient-level analysis, baseline standardized differences and treatment-selection patterns were examined. A parsimonious adjusted model for four-week clearance included initial modality and prespecified confounders such as stone size, proximal location, impaction, pre-stenting and surgeon/calendar period, subject to event counts and overlap. Penalized regression was considered if sparse failures prevented stable conventional logistic regression. Post-treatment variables such as stenting or retropulsion were not automatically adjusted for as baseline confounders. Adjusted estimates were not invented from aggregate tables. Time to documented clearance was assessed with censoring, with the interval between imaging visits acknowledged. Missing endpoints, reasons for missingness and group-specific follow-up were reported; sensitivity analyses examined alternative assumptions about missing clearance outcomes.

Ethical considerations

For the final past-tense report, the appropriate wording was: "The study was approved by [Institutional Ethics Committee; approval number and date]. A waiver of consent for retrospective record review was granted where applicable, and confidentiality was maintained." This statement was retained as a placeholder pending actual approval documentation; no approval or waiver is asserted here.

RESULTS

Table 1: Baseline demographic and stone characteristics

Characteristic / outcome	Group A n (%) or mean (SD)	Group B n (%) or mean (SD)	A − B difference (95% CI)	Test statistic	p value
Age, years	42.68 (12.41)	43.92 (11.86)	-1.24 (-4.26 to 1.78)	t=-0.808	0.420
Male sex	83 (66.4)	79 (63.2)	3.2 (-8.6 to 14.8)	χ^2=0.281	0.596
Body mass index, kg/m²	25.36 (3.72)	25.81 (3.94)	-0.45 (-1.40 to 0.50)	t=-0.928	0.354
Largest stone diameter, mm	11.24 (3.18)	11.58 (3.42)	-0.34 (-1.16 to 0.48)	t=-0.814	0.416
Stone density, HU	986.40 (241.60)	1012.80 (256.30)	-26.40 (-88.45 to 35.65)	t=-0.838	0.403
Proximal ureteric location	36 (28.8)	39 (31.2)	-2.4 (-13.6 to 8.9)	χ^2=0.171	0.679
Impacted calculus	29 (23.2)	32 (25.6)	-2.4 (-13.0 to 8.2)	χ^2=0.195	0.659
Moderate/severe preoperative hydronephrosis	42 (33.6)	46 (36.8)	-3.2 (-14.8 to 8.6)	χ^2=0.281	0.596
Preoperative double-J stent	24 (19.2)	27 (21.6)	-2.4 (-12.4 to 7.6)	χ^2=0.222	0.638
Diabetes mellitus	22 (17.6)	25 (20.0)	-2.4 (-12.1 to 7.3)	χ^2=0.236	0.627

Differences are percentage points for categorical variables and original measurement units for continuous variables; positive values indicate higher values in Group A. Continuous comparisons: Welch's t test. Categorical comparisons: Pearson χ^2 without continuity correction, or two-sided Fisher's exact test for sparse cells. Fisher's test has no separate χ^2 statistic. Risk-difference CIs use the Newcombe–Wilson method; mean-difference CIs use Welch's method. Tests and CIs use different inferential constructions and may not align exactly near p=0.05.

In the cohort, mean age was 42.68 (12.41) years in Group A and 43.92 (11.86) years in Group B. Men comprised 66.4% and 63.2%, respectively. Mean stone diameter was 11.24 (3.18) versus 11.58 (3.42) mm. Proximal stones occurred in 28.8% versus 31.2%, and impacted calculi in 23.2% versus 25.6%. None of the listed baseline comparisons reached $p<0.05$. This did not demonstrate exchangeability or exclude clinically important confounding in a retrospective study.

Table 2: Stone clearance and additional treatment

Characteristic / outcome	Group A n (%) or mean (SD)	Group B n (%) or mean (SD)	A − B difference (95% CI)	Test statistic	p value
Stone-free at 4 weeks without auxiliary procedure (primary)	119 (95.2)	105 (84.0)	11.2 (3.7 to 19.1)	χ^2=8.413	0.004
Stone-free at 3 months, including auxiliary procedures	123 (98.4)	120 (96.0)	2.4 (-2.2 to 7.6)	Fisher exact	0.446
Clinically significant retropulsion/migration	5 (4.0)	21 (16.8)	-12.8 (-20.7 to -5.3)	χ^2=10.989	<0.001
Any auxiliary stone-clearance procedure by 3 months	6 (4.8)	18 (14.4)	-9.6 (-17.3 to -2.3)	χ^2=6.637	0.010
Repeat ureteroscopy by 3 months	4 (3.2)	12 (9.6)	-6.4 (-13.1 to -0.2)	χ^2=4.274	0.039

Differences are percentage points for categorical variables and original measurement units for continuous variables; positive values indicate higher values in Group A. Continuous comparisons: Welch's t test. Categorical comparisons: Pearson χ^2 without continuity correction, or two-sided Fisher's exact test for sparse cells. Fisher's test has no separate χ^2 statistic. Risk-difference CIs use the Newcombe–Wilson method; mean-difference CIs use Welch's method. Tests and CIs use different inferential constructions and may not align exactly near p=0.05.

Four-week stone-free status without an auxiliary procedure was achieved in 119/125 patients (95.2%) in Group A and 105/125 (84.0%) in Group B, an absolute difference of 11.2 (3.7 to 19.1) percentage points (p=0.004). By three months, clearance including auxiliary treatment was 98.4% versus 96.0% (p=0.446), without a statistically demonstrable difference. Clinically significant retropulsion occurred in 4.0% versus 16.8% (p<0.001), while auxiliary procedures were recorded in 4.8% versus 14.4% (p=0.010). Repeat ureteroscopy was a subset of auxiliary procedures and occurred in 3.2% versus 9.6%. The three-month result therefore represented the combined treatment pathway, rather than the effect of the index procedure alone.

Table 3: Operative and postoperative resource outcomes

Characteristic / outcome	Group A n (%) or mean (SD)	Group B n (%) or mean (SD)	A − B difference (95% CI)	Test statistic	p value
Total operative time, min	36.84 (11.62)	42.76 (13.54)	-5.92 (-9.06 to -2.78)	t=-3.710	<0.001
Active lithotripsy time, min	11.82 (4.16)	6.74 (2.83)	5.08 (4.19 to 5.97)	t=11.288	<0.001
Postoperative double-J stent insertion	94 (75.2)	108 (86.4)	-11.2 (-20.8 to -1.4)	χ^2=5.054	0.025
Postoperative hospital stay, days	1.42 (0.63)	1.86 (0.91)	-0.44 (-0.64 to -0.24)	t=-4.445	<0.001
Time to first documented clearance, days*	14.62 (6.38)	20.84 (9.16)	-6.22 (-8.22 to -4.22)	t=-6.128	<0.001

Differences are percentage points for categorical variables and original measurement units for continuous variables; positive values indicate higher values in Group A. Continuous comparisons: Welch's t test. Categorical comparisons: Pearson χ^2 without continuity correction, or two-sided Fisher's exact test for sparse cells. Fisher's test has no separate χ^2 statistic. Risk-difference CIs use the Newcombe–Wilson method; mean-difference CIs use Welch's method. Tests and CIs use different inferential constructions and may not align exactly near p=0.05.

*Time-to-clearance means include only patients with documented clearance by three months: Group A n=123; Group B n=120. These conditional means exclude two and five uncleared patients, respectively, and are descriptive/exploratory; a full analysis should use censoring-aware methods. Other rows use n=125 per group.

Mean total operative time was 36.84 (11.62) minutes with TFL and 42.76 (13.54) minutes with pneumatic lithotripsy, a difference of -5.92 (-9.06 to -2.78) minutes (p<0.001). In contrast, active lithotripsy lasted longer in the TFL group: 11.82 (4.16) versus 6.74 (2.83) minutes.

Table 4: Intraoperative and postoperative complications

Characteristic / outcome	Group A n (%) or mean (SD)	Group B n (%) or mean (SD)	A − B difference (95% CI)	Test statistic	p value
Ureteric mucosal injury (intraoperative)	5 (4.0)	12 (9.6)	-5.6 (-12.4 to 0.8)	χ^2=3.093	0.079
Ureteric perforation (intraoperative)	1 (0.8)	3 (2.4)	-1.6 (-6.1 to 2.3)	Fisher exact	0.622
Bleeding impairing vision or requiring treatment	3 (2.4)	7 (5.6)	-3.2 (-8.9 to 2.1)	χ^2=1.667	0.197
Symptomatic culture-confirmed UTI within 30 days	6 (4.8)	11 (8.8)	-4.0 (-10.8 to 2.5)	χ^2=1.578	0.209
Persistent/new hydronephrosis at 12 months	4 (3.2)	8 (6.4)	-3.2 (-9.2 to 2.5)	χ^2=1.401	0.237
Confirmed ureteric stricture within 12 months	2 (1.6)	3 (2.4)	-0.8 (-5.4 to 3.5)	Fisher exact	1.000
Any listed complication per patient	16 (12.8)	30 (24.0)	-11.2 (-20.7 to -1.6)	χ^2=5.222	0.022

Differences are percentage points for categorical variables and original measurement units for continuous variables; positive values indicate higher values in Group A. Continuous comparisons: Welch's t test. Categorical comparisons: Pearson χ^2 without continuity correction, or two-sided Fisher's exact test for sparse cells. Fisher's test has no separate χ^2

statistic. Risk-difference CIs use the Newcombe–Wilson method; mean-difference CIs use Welch's method. Tests and CIs use different inferential constructions and may not align exactly near p=0.05.

Mucosal injury was recorded in 4.0% versus 9.6%, perforation in 0.8% versus 2.4%, and clinically relevant bleeding in 2.4% versus 5.6% in Groups A and B, respectively. Postoperative culture-confirmed UTI occurred in 4.8% versus 8.8%. Persistent or new hydronephrosis at 12 months was present in 3.2% versus 6.4%, while confirmed ureteric stricture occurred in 1.6% versus 2.4%. None of these individual comparisons reached p<0.05. At least one listed complication occurred in 12.8% versus 24.0% (difference -11.2 (-20.7 to -1.6) percentage points; p=0.022). The exploratory composite difference did not establish a reduction in any specific rare complication or prove equivalent stricture risk.

DISCUSSION

The discussion below compares a constructed numerical scenario with published evidence. It is a model for interpretation, not a claim that a local clinical study reproduced the findings. The main pattern was better four-week single-session clearance, less retropulsion and fewer auxiliary procedures with TFL, accompanied by longer active lithotripsy but shorter total operative time. Three-month clearance was high in both groups. Individual complications, especially ureteric stricture, remained too infrequent for firm comparative conclusions.

Baseline profile and interpretation of clearance

Table 1 showed broadly similar measured demographic and stone variables. However, retrospective allocation could still reflect equipment availability, surgeon preference, stone complexity and calendar period. Somani et al. (2017)[1] demonstrated the value of large-scale ureteroscopy outcome surveillance, but its multinational mix of renal and ureteric cases prevents a direct numerical benchmark for this narrowly defined cohort. The present example would require adjustment and transparent eligibility reporting before an observed treatment association could be interpreted confidently.

The early clearance difference in Table 2 was 11.2 percentage points, whereas final clearance differed by only 2.4 percentage points. Li et al. (2015)[2] similarly distinguished an early advantage of laser treatment from convergence at three months, although that trial evaluated holmium rather than TFL. Andreeva et al. (2020)[3] provided laboratory evidence of lower retropulsion and greater ablation efficiency with TFL versus holmium; this supports biological plausibility but is not direct clinical confirmation against pneumatic treatment. Martov et al. (2021)[4] reported no residual stones in the TFL arm at 30 days compared with five residual cases after holmium treatment. Different comparators, stone populations and assessment definitions limit quantitative pooling of these findings with the present example.

The most directly applicable evidence was Mahajan et al. (2025)[5]. In their 50-patient-per-group comparison, retropulsion occurred in 2 TFL patients and 10 pneumatic patients. Stone-free rates and complication rates were comparable. Thus, the reduction in migration agrees in direction with direct evidence, but its significant primary clearance difference should not be presented as an established consequence of TFL. Their longer TFL lithotripsy time also shows why a claim of universally faster fragmentation would be misleading.

Ulvik et al. (2022)[6] reported overall single-session clearance of 92% with TFL versus 67% with holmium, but ureteral-stone clearance was 100% in both arms; the overall difference was driven by renal stones. Citing that aggregate result as proof of superiority for ureteric stones would therefore be inappropriate. Haas et al. (2023)[7] found no significant difference in ureteroscope time, stone-free rate or complications between TFL and pulse-modulated holmium. These trials show that apparent benefit depends on comparator technology and stone location.

Chandramohan et al. (2023)[8] reported shorter operating and lasering times with TFL but similar clearance and complications in patients with middle and distal ureteric stones. Enikeev et al. (2021)[9], in a prospective single-arm series of 149 patients, demonstrated feasible ureteric TFL treatment and an association between pulse energy and retropulsion. Gupta et al. (2024)[10], studying 40 patients per arm, did not demonstrate statistically significant differences in several operative efficiency measures against holmium. Together, these reports support documenting actual settings and anatomy rather than treating the energy-source label as the only determinant of success.

Operative time, migration and additional treatment

Table 3, longer active fragmentation phase with TFL despite shorter total operative duration. Such a pattern could arise if less migration and fewer larger-fragment retrieval manoeuvres offset the additional fragmentation time. This is a plausible explanation, not a demonstrated mechanism without step-specific operative timing. Lithotripsy time, laser-on time, ureteroscope time and skin-to-skin time should not be used interchangeably when comparing publications.

Nour et al. (2020)[11] found longer operative time with pneumatic treatment in large mid-ureteric stones, but similar stone-free outcomes and complications, with lower treatment costs for pneumatic lithotripsy. Conversely, Rabani et al. (2019)[12] reported shorter operating duration in the pneumatic group, with similar clearance and complications. Abedi et al. (2018)[13], in a retrospective comparison of 250 patients, described advantages in clearance and migration with holmium laser but an operative-time advantage with pneumatic treatment. All three studies involved holmium rather than TFL. Their varying time results underline the effects of surgeon experience, fragment extraction and outcome definitions.

Bagbanci et al. (2017)[14] compared upper-ureter treatment with anti-retropulsion protection in both groups and still found an early success advantage for holmium laser over pneumatic lithotripsy. This makes anti-retropulsion-device use an

important procedural covariate in any retrospective comparison. Ercil et al. (2016)[15] found better first-day clearance with holmium in multiple distal ureteric stones, while one-month success was similar. Such convergence is consistent with the distinction between initial success and eventual clearance after additional treatment or passage of fragments.

The stenting and hospital-stay differences should be interpreted cautiously. Stenting may reflect mucosal injury, impaction, access difficulty or local routine, and is not an uncomplicated surrogate for treatment harm. Hospital stay also depends on anaesthesia, infection monitoring, distance from hospital and discharge policy. Similarly, the mean interval to documented clearance among patients already known to have cleared is subject to selection and visit-timing bias. An actual time-to-event analysis should retain uncleared patients and address irregular imaging intervals. Cost-effectiveness cannot be inferred from operative time or admission duration alone without device, consumable, maintenance and repeat-treatment costs.

Complications and delayed ureteric safety

The composite complication frequency was lower with TFL, but the individual outcomes were not statistically distinguishable. This does not demonstrate that the techniques have equivalent safety. A composite combining mild mucosal injury, infection and stricture also combines outcomes of unequal clinical importance. Its components must remain visible, and patient overlap must be accounted for.

Ahmad Para et al. (2023)[16] reported ureteric strictures in 11/238 TFL-treated patients (4.62%) and 4/240 holmium-treated patients (1.67%). These observations are relevant as a safety signal, but they are not a comparison with pneumatic lithotripsy. The paper's quoted significance level for these counts appears inconsistent with a conventional unadjusted two-group analysis, so the counts and proportions are more appropriate to cite than repeating that p value uncritically. Villani et al. (2025)[17] reported stricture rates of 11% with higher-power manufacturer presets versus 1% with individualized TFL presets, despite similar clearance. This observational finding reinforces the need to record power, frequency and irrigation conditions, and not to assume that one laser platform has a fixed safety profile.

Darwish et al. (2019)[18] used 12-month ultrasound follow-up with additional investigations for suspected obstruction and reported strictures after 1.5% of procedures. Their work supports evaluating delayed obstruction rather than relying only on early symptoms. Sunaryo et al. (2022)[19], using a large administrative dataset, identified strictures in 2.9% after ureteroscopy and associations with preoperative hydronephrosis and previous stone treatment. Administrative coding and mixed procedures limit direct comparison, but the study demonstrates that uncommon strictures can have substantial clinical consequences.

Taratkin et al. (2020)[20] found similar volume-averaged temperature increases for TFL and holmium at matched settings in an experimental model, with irrigation influencing heating. Peng et al. (2020)[21] also demonstrated that laser power and irrigation rate jointly determine temperature rise. Taratkin et al. (2021)[22] examined laser ablation in different environments and showed that the physical interaction is more complex than a simple ranking of devices. These laboratory findings explain why thermal exposure cannot be inferred solely from the device name, and why settings, duty cycle and irrigation should be extracted whenever records allow.

CONCLUSION

In 250-patient comparison, TFL showed higher four-week stone-free rates and lower retropulsion and auxiliary-procedure frequencies than pneumatic lithotripsy. Total operative time and hospitalization were shorter despite longer active lithotripsy. Three-month clearance was high in both groups, and uncommon individual complications, including ureteric stricture, were not demonstrably different. These constructed findings do not establish clinical superiority or safety. A final conclusion for the institution must be based on verified patient records, appropriate confounding control and complete or correctly censored 12-month follow-up.

LIMITATIONS OF THE STUDY

1. Retrospective, nonrandomized allocation creates selection bias and confounding by stone complexity, surgeon preference, equipment availability and treatment period.
2. A single-centre study may not generalize to hospitals with different equipment, surgeon experience, discharge practices or imaging protocols.
3. Missing or inconsistent documentation can misclassify impaction, retropulsion, operative injury, laser settings and postoperative infection.
4. Ultrasound and plain radiography may miss small residual fragments compared with CT. Differential imaging between groups can bias stone-free estimates.
5. Incomplete follow-up and exclusion of patients without late visits can bias stricture estimates. Absence of a recorded event is not proof that no event occurred.
6. The 2024–2025 procedure cohort cannot have complete 12-month observation before the end of December 2026. An earlier report requires censoring and cannot present complete-cohort 12-month rates.
7. A sample of about 250 is insufficient to exclude clinically meaningful differences in rare events such as perforation and stricture. Nonsignificant p values do not establish equivalence.

8. Secondary-outcome testing is exploratory and subject to multiplicity. Adjusted models may be unstable if outcome events are few or treatment groups have limited overlap.
9. Stent policy, anti-retropulsion devices, rescue flexible ureteroscopy and surgeon learning can influence outcomes independently of the primary energy source.
10. Time to first documented clearance depends on imaging schedules; comparing means only among cleared patients can be biased. Cost, patient-reported stent burden and quality of life may be unavailable.

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