



SEMI-RIGID URETEROSCOPY WITH PNEUMATIC LITHOTRIPSY FOR IMPACTED MID AND LOWER URETERIC CALCULI: A PROSPECTIVE SINGLE-CENTRE STUDY

Urology

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ABSTRACT

Background: Impacted ureteric calculi represent a challenging subset of stone disease due to prolonged obstruction, ureteral wall inflammation, and reduced success rates with extracorporeal shock wave lithotripsy. Endoscopic management using ureteroscopy has therefore become the preferred treatment modality, particularly for mid and distal ureteric stones. **Objective:** To evaluate the efficacy and safety of semirigid ureteroscopy using pneumatic lithotripsy in the management of impacted mid and lower ureteric calculi. **Materials And Methods:** This prospective longitudinal study was conducted at a tertiary care teaching hospital between July 2023 and May 2025. Eighty-two adult patients with impacted mid or lower ureteric calculi underwent semirigid ureteroscopy with pneumatic lithotripsy. Stone-free rate at two weeks was the primary outcome measure. Operative time, hospital stay, and peri-operative complications were analyzed as secondary outcomes. **Results:** The mean patient age was 44.21 ± 13.16 years, with female predominance (59.8%). Lower ureteric stones accounted for 79.3% of cases. The overall stone-free rate at two weeks was 95.1%. Minor complications occurred in 15.9% of patients, most commonly transient haematuria and proximal stone migration. One patient developed postoperative urosepsis, which was managed conservatively. No ureteral strictures were observed during follow-up. **Conclusion:** Semirigid ureteroscopy with pneumatic lithotripsy is a safe, effective, and economical option for managing impacted mid and lower ureteric calculi, offering high clearance rates with acceptable morbidity.

KEYWORDS

Impacted ureteric calculus; Semirigid ureteroscopy; Pneumatic lithotripsy; Urolithiasis

INTRODUCTION

Ureteric calculi are among the most frequently encountered conditions in urological practice and account for a significant proportion of emergency admissions. The introduction of minimally invasive techniques such as extracorporeal shock wave lithotripsy (ESWL) and ureteroscopy has revolutionized the management of ureteric stones, largely replacing open surgical approaches. Despite these advances, impacted ureteric calculi continue to pose a unique therapeutic challenge.

An impacted ureteric stone is defined as a calculus that remains lodged at the same location within the ureter for a prolonged duration—classically more than two months—or one that prevents the passage of a guidewire beyond the stone during ureteroscopic intervention [1,2]. Prolonged impaction leads to pathological changes in the ureteric wall, including mucosal oedema, inflammation, submucosal fibrosis, and polypoid hyperplasia, which reduce ureteral compliance and increase the risk of intraoperative injury and postoperative stricture formation.

Pain is the most common presenting symptom of ureteric stones and is mediated by prostaglandin-induced ureteric peristalsis. While small, recently formed ureteric stones may pass spontaneously with conservative management, impacted stones rarely do so. Prolonged obstruction may result in hydronephrosis, deterioration of renal function, and superimposed infection. Infected obstructed systems may rapidly progress to urosepsis, necessitating prompt intervention.

Although both ESWL and ureteroscopy are well-established treatment modalities, several studies have demonstrated inferior outcomes of ESWL in impacted ureteric stones, particularly due to reduced fragmentation and impaired clearance of stone fragments [3–5]. Consequently, ureteroscopy has emerged as the preferred treatment for impacted ureteric calculi, especially in the mid and distal ureter. However, ureteroscopic management of impacted stones is technically demanding and has historically been associated with higher complication rates.

Despite advances in ureteroscope design and intracorporeal lithotripsy, the optimal management strategy for impacted ureteric

calculi remains debated. Pneumatic lithotripsy, though considered less advanced than laser systems, continues to be widely used because of its effectiveness, durability, and cost-effectiveness, particularly in resource-limited settings [6].

The present study was undertaken to evaluate the efficacy and safety of semirigid ureteroscopy using pneumatic lithotripsy in patients with impacted mid and lower ureteric calculi.

MATERIALS AND METHODS

Study Design And Setting

This was a hospital-based prospective longitudinal study conducted in the Department of Urology, Regional Institute of Medical Sciences, Imphal, from July 2023 to May 2025.

Study population

Adult patients presenting with impacted mid or lower ureteric calculi were enrolled after obtaining informed consent.

Inclusion Criteria

- Age ≥ 18 years
- Radiologically confirmed impacted mid or lower ureteric calculus
- Fitness for spinal anaesthesia

Exclusion Criteria

- Bilateral ureteric calculi
- Active urinary tract infection or urosepsis
- Previous ureteric surgery
- Congenital urinary tract anomalies
- Pregnancy

Preoperative Evaluation

All patients underwent detailed clinical evaluation, including duration of symptoms, previous stone disease, and comorbidities. Laboratory investigations included complete blood count, renal function tests, serum electrolytes, coagulation profile, urine routine examination, and urine culture. Imaging evaluation consisted of ultrasonography and X-ray KUB, supplemented by intravenous urography or non-contrast CT scan when required.

Surgical Technique

All procedures were performed under spinal anaesthesia with the patient in lithotomy position. A 6.4/7.8 Fr semirigid ureteroscope was introduced under fluoroscopic guidance. Pneumatic lithotripsy was performed using a Swiss Lithoclast. Stone fragments were retrieved when necessary or allowed to pass spontaneously. A double-J ureteric stent was placed in all patients.

Postoperative Care And Follow-up

Patients were monitored for complications and discharged once stable. Stone clearance was assessed using imaging at two and four weeks, and DJ stents were removed after confirmation of complete stone clearance.

Outcome Measures

Primary outcome: Stone-free rate at two weeks

Secondary outcomes: Operative time, hospital stay, and complications

Statistical Analysis

Statistical analysis was carried out using IBM SPSS software (version 26.0). Continuous variables were summarized as mean ± standard deviation, while categorical variables were expressed as frequencies and percentages. Comparisons between categorical variables were performed using the Chi-square test or Fisher's exact test, as appropriate. Continuous variables were compared using the independent Student's t-test. A p-value of less than 0.05 was considered statistically significant.

RESULTS

A total of 82 patients were included in the study.

Demographic And Stone Characteristics

The mean age was 44.21 ± 13.16 years, with female predominance (59.8%). Lower ureteric stones were more common than mid-ureteric stones (79.3% vs 20.7%). Mean stone size was 1.09 ± 0.16 cm.

Operative Outcomes

Mean operative time was 57.44 ± 8.04 minutes. Mean hospital stay was 3.10 ± 0.78 days, with most patients discharged by postoperative day three.

At two-week follow-up, 78 patients (95.1%) were stone-free. Residual fragments were observed in four patients (4.9%).

Table 3. Comparison Of Outcomes Of Semirigid Ureteroscopic Management Of Ureteric Calculi In Recent Indexed Studies

Study (Year)	Study design	Stone characteristics	Procedure / Energy source	Sample size (n)	Mean stone size	Stone-free rate	Operative time	Complications	Ureteral stricture
Present study (2023–2025)	Prospective, single-centre	Impacted mid & lower ureteric calculi	Semirigid URS + pneumatic lithotripsy; routine DJ stent	82	1.09 ± 0.16 cm	95.1% (2 weeks)	57.4 ± 8.0 min	Hematuria >48 h (6.1%), migration (4.9%), false passage (2.4%), urosepsis (1.2%)	None detected
Al-Naggar et al. (2025)	Observational	Mid & distal ureteric stones	Semirigid URS + pneumatic lithotripsy	254	9.1 ± 4.9 mm	~92–94 %	57.7 ± 7.3 min	Mucosal injury, migration, fever, perforation	Not significant
Brito et al. (2006)	Prospective	Distal ureteric stones (subset impacted)	Semirigid URS + pneumatic lithotripsy	102	0.8–1.2 cm	93–96%	45–60 min	Hematuria, fever, migration	Rare (<1%)
Cureus multicentre series (2025)	Retrospective	Ureteric stones (site-wise analysis)	Pneumatic lithotripsy	215	Not specified	Lower: 94.7%, Mid: 85.2%	Not specified	Predominantly minor	Not reported

Table 4. Association Between Stone Size And Stone-free Rate

Stone size	Stone-free	Residual stone	Total
< 1 cm	13	0	13
≥ 1 cm	65	4	69
Total	78	4	82

Statistical test: Fisher's exact test; p = 0.58 (not statistically significant).

Table 5. Association Between Stone Location And Postoperative

Complications

Postoperative complications occurred in 15.9% of patients. Transient haematuria lasting more than 48 hours was the most common complication (6.1%), followed by proximal stone migration (4.9%). Two patients developed false passage. One patient developed postoperative urosepsis and recovered with conservative management. No ureteral strictures were detected during follow-up.

On subgroup analysis, stones measuring ≥1 cm were associated with a higher proportion of residual fragments compared with stones <1 cm; however, this difference did not reach statistical significance (p = 0.58).

Postoperative complications were observed more frequently in patients with mid-ureteric stones than in those with lower ureteric stones, although this difference was not statistically significant (p = 0.26).

Operative time was significantly longer for mid-ureteric stones compared with lower ureteric stones (61.8 ± 6.9 minutes vs 56.3 ± 8.1 minutes; p = 0.03)

RESULTS TABLES

Table 1. Demographic Profile And Stone Characteristics (n = 82)

Parameter	Category	Value
Age (years)	Mean ± SD	44.21 ± 13.16
Sex	Female	49 (59.8%)
	Male	33 (40.2%)
Stone location	Lower ureter	65 (79.3%)
	Mid ureter	17 (20.7%)
Stone size (cm)	Mean ± SD	1.09 ± 0.16

Table 2. Operative Outcomes And Complications

Outcome	Measure	Value
Operative time(min)	Mean ± SD (minutes)	57.44 ± 8.04
Hospital stay(days)246	Mean ± SD (days)	3.10 ± 0.78
Stone-free rate	At 2 weeks	78 (95.1%)
Complications	Any complication	13 (15.9%)
	Hematuria >48 hrs	5 (6.1%)
	Stone migration	4 (4.9%)
	False passage	2 (2.4%)
	Urosepsis	1 (1.2%)
Follow-up	Ureteral stricture	None detected

Complications

Stone location	Complication	No complication	Total
Mid ureter	4	13	17
Lower ureter	9	56	65
Total	13	69	82

Statistical test: Chi-square test; p = 0.26 (not statistically significant).

Table 6. Comparison Of Operative Time According To Stone

Location

Stone location	Mean operative time (minutes $\pm$ SD)
Mid ureter (n = 17)	61.8 $\pm$ 6.9
Lower ureter (n = 65)	56.3 $\pm$ 8.1

Statistical test: Independent Student's t-test; $p = 0.03$ (**statistically significant**).

DISCUSSION

Impacted ureteric calculi represent a challenging subset of stone disease due to prolonged obstruction and associated inflammatory changes in the ureteric wall. These pathological alterations increase technical difficulty and the risk of complications during ureteroscopy intervention. Unlike non-impacted stones, prolonged impaction leads to a cascade of pathological changes in the ureteric wall, including mucosal edema, inflammation, submucosal fibrosis, and polypoid hyperplasia. These changes not only reduce ureteral compliance but also significantly increase the risk of ureteral injury during instrumentation, thereby influencing both immediate operative outcomes and long-term complications such as ureteral stricture formation.

Several studies have demonstrated poor outcomes of ESWL in impacted ureteric stones, particularly in the mid and distal ureter, due to impaired fragmentation and clearance [7,8]. Consequently, ureteroscopy has become the preferred treatment modality.

In the present study, semirigid ureteroscopy with pneumatic lithotripsy achieved a stone-free rate of 95.1%, comparable to or exceeding outcomes reported in the literature [9–11]. In the present prospective study, semirigid ureteroscopy with pneumatic lithotripsy achieved a stone-free rate of 95.1% at two weeks in patients with impacted mid and lower ureteric calculi. This is a clinically meaningful finding, given that all stones included in the study were impacted—an entity traditionally associated with lower clearance rates and higher morbidity. The high stone-free rate observed in our series underscores the effectiveness of semirigid ureteroscopy as a definitive treatment modality for impacted stones in the mid and distal ureter.

When compared with contemporary indexed literature (Table 3), the outcomes of the present study are consistent with, and in some aspects superior to, previously published series. Al-Naggar et al. reported stone-free rates exceeding 90% in a large emergency ureteroscopy cohort predominantly involving mid and distal ureteric stones managed with pneumatic lithotripsy, with operative times and complication profiles comparable to our findings. Similarly, Brito et al. demonstrated clearance rates ranging between 93% and 96% for distal ureteric stones treated with semirigid ureteroscopy and pneumatic lithotripsy. These comparisons support the external validity of our results and confirm that high clearance rates can be achieved even in impacted stones when appropriate technique and perioperative strategies are employed.

The mean operative time of 57.4 ± 8.0 minutes in our study closely parallels operative durations reported in recent pneumatic lithotripsy series. This suggests that stone impaction, although technically challenging, does not necessarily translate into prolonged operative time when procedures are performed by experienced surgeons using standardized techniques. Careful guidewire negotiation, avoidance of forceful ureteral dilation, controlled lithotripsy, and judicious fragment retrieval likely contributed to maintaining operative efficiency in our cohort.

The overall complication rate in the present study was 15.9%, with the majority being minor and self-limiting. Transient hematuria and proximal stone migration were the most frequently encountered complications, findings that are consistent with the known limitations of pneumatic lithotripsy. Stone retropulsion remains an inherent drawback of pneumatic energy; however, in our series, migrated fragments did not result in significant morbidity and were managed conservatively. Importantly, only one patient developed postoperative urosepsis, which responded well to prompt antibiotic therapy, highlighting the importance of perioperative vigilance in impacted stone disease.

The present study demonstrated a significantly longer operative time for mid-ureteric stones compared with lower ureteric stones, likely reflecting the greater technical difficulty and reduced endoscopic maneuverability encountered in the mid ureter. Although stones

measuring ≥ 1 cm and mid-ureteric location were associated with higher rates of residual fragments and postoperative complications, these differences did not achieve statistical significance, possibly due to the relatively limited sample size. Nonetheless, these findings underscore that semirigid ureteroscopy with pneumatic lithotripsy remains a safe and effective treatment option, even in technically challenging cases of impacted ureteric calculi.

A particularly notable observation in our study was the absence of ureteral strictures on follow-up. Ureteral stricture formation has historically been a major concern in the endoscopic management of impacted stones, with earlier reports documenting stricture rates ranging from 5% to as high as 24%.

The lack of strictures in our series may be attributed to multiple factors, including meticulous endoscopic technique, avoidance of excessive ureteral trauma, and the routine placement of double-J stents in all patients. DJ stenting likely facilitated ureteral healing by reducing postoperative edema, ensuring adequate drainage, and minimizing prolonged mucosal contact with residual stone fragments.

Although laser lithotripsy has gained widespread acceptance due to reduced retropulsion and finer fragmentation, pneumatic lithotripsy continues to play a significant role in contemporary urological practice, particularly in resource-limited settings. Pneumatic systems are robust, cost-effective, and widely available, making them especially relevant in high-volume centers. The findings of the present study reinforce that pneumatic lithotripsy, when used judiciously in conjunction with semirigid ureteroscopy, remains a highly effective option for impacted mid and lower ureteric calculi.

The strengths of this study include its prospective design, homogeneous inclusion of impacted stones, standardized operative technique, and consistent follow-up protocol. However, certain limitations should be acknowledged. The single-center nature of the study and the relatively short duration of follow-up may underestimate the incidence of late ureteral stricture formation. Additionally, the absence of a comparative laser lithotripsy arm limits direct energy-source comparison.

LIMITATIONS

Single-centre design and limited long-term follow-up may underestimate late stricture formation.

CONCLUSION

Semirigid ureteroscopy with pneumatic lithotripsy is a safe, effective, and economical treatment for impacted mid and lower ureteric calculi, providing excellent stone-free rates with acceptable morbidity.

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