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Frequency of Proximal Migration of Ureteric Stone in Patients Undergoing Ureterorenoscopy with Pneumatic Lithotripsy

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ABSTRACT

Background: Upward migration of the stone or its fragments is a recognised drawback of ureterorenoscopic pneumatic lithotripsy, yet local data on its frequency are scarce. This study aimed to determine the frequency of proximal migration of ureteric stone in patients undergoing ureterorenoscopy with pneumatic lithotripsy.
Materials and Methods: This cross-sectional study was conducted in the Department of Urology, Saidu Group of Teaching Hospitals, Swat, from March to June 2026. Through non-probability consecutive sampling, 117 patients aged 20–60 years with a single 8–20 mm ureteric stone underwent rigid ureterorenoscopy with a pneumatic lithoclast. Proximal migration was defined as upward movement of the stone into the kidney during the procedure. Chi-square or Fisher's exact tests and binary logistic regression were applied.
Results: The mean age was 40.4 ± 11.1 years, and 82 patients (70.1%) were male. The mean stone size was 11.3 ± 2.0 mm, and 44 stones (37.6%) were proximal. Proximal migration occurred in 16 patients (13.7%; 95% CI 8.0–21.3%), involving 22.7% of proximal, 8.8% of middle and 7.7% of distal stones ($p = 0.101$). On multivariable analysis, proximal location was associated with migration (adjusted OR 3.08; 95% CI 1.02–9.31; $p = 0.046$), whereas stone size was not ($p = 0.150$). Migration was more frequent in procedures lasting longer than 50 minutes (34.2% vs 3.8%; $p < 0.001$).
Conclusion: Proximal migration complicated about one in seven procedures and was more likely with proximal ureteric stones, for which measures that limit retropulsion deserve consideration.
Keywords: Ureteral Calculi; Ureteroscopy; Lithotripsy; Stone migration; Pakistan

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1. INTRODUCTION

Urinary stone disease is one of the conditions most frequently managed by urologists. The Global Burden of Disease 2019 analysis estimated more than 115 million new cases of urolithiasis worldwide in 2019, with a higher incidence in men than in women (1). Prevalence differs considerably between regions, and the rising frequency of stone disease has been linked to population growth, obesity and diabetes (2). Pakistan lies within the Afro-Asian stone belt, and ureteric calculi place a heavy load on the country's urology services (3).
The choice of intervention for a ureteric stone depends on stone characteristics, patient anatomy, comorbidity and patient preference (4). In the multicentre TISU trial, further treatment was needed in 10.3% of patients after ureteroscopy compared with 22.1% after shockwave lithotripsy (5). Pakistani series point in the same direction: ureteroscopic pneumatic lithotripsy cleared 84% of proximal ureteric stones after a single session, compared with 62.5% for shockwave lithotripsy (6), and ureteroscopic laser treatment of 10–15 mm proximal stones achieved clearance in 83.3% compared with 64.2% (7). Ureteroscopy is nevertheless not free of risk. A systematic review identified 72 deaths after ureteroscopy for stone disease, with sepsis accounting for more than half of the deaths whose cause was reported (8), and in a prospective Karachi series of 414 patients, 37.2% had a complication, most of them Clavien grade I (9)
Pneumatic lithotripsy, the energy source in several of the Pakistani series cited above (3,6), breaks the stone by repeated mechanical impact. The same impact can drive the stone or its fragments upward towards the kidney, and no device has yet been found that reliably prevents this without adding cost or operative time (10). A 2026 meta-analysis of 18 randomised trials involving 2,791 patients found that laser lithotripsy reduced stone migration and improved

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stone clearance compared with pneumatic lithotripsy (11). When a stone migrates, the procedure may remain incomplete, and the patient may need a stent, shockwave lithotripsy or flexible ureteroscopy, with additional morbidity and expense (10)

A study from Khyber Pakhtunkhwa reported migration in 12.5% of patients undergoing ureteroscopic pneumatic lithotripsy (12), but data from the Swat region remain limited. A current local estimate would help surgeons counsel patients, decide when preventive measures are worthwhile and anticipate the need for auxiliary procedures. This study was therefore conducted to determine the frequency of proximal migration of ureteric stone in patients undergoing ureterorenoscopy with pneumatic lithotripsy.

2. MATERIALS AND METHODS

This cross-sectional study was conducted in the Department of Urology, Saidu Group of Teaching Hospitals, Swat, from March 2026 to June 2026, after approval of the synopsis by the College of Physicians and Surgeons Pakistan and by the hospital's ethical review committee. Written informed consent was obtained from every patient, and patient identifiers were removed before analysis.

The sample size of 117 was calculated with the WHO sample size calculator using a 95% confidence level, a 6% margin of error and an expected frequency of proximal migration of 12.5% (12). Patients were enrolled by non-probability consecutive sampling. Men and women aged 20–60 years undergoing ureterorenoscopy with pneumatic lithotripsy for a single ureteric stone measuring 8–20 mm on ultrasonography were included. A ureteric stone was confirmed when ultrasonography showed a bright echogenic focus with posterior acoustic shadowing and plain radiography of the kidneys, ureters and bladder showed a corresponding radiopaque shadow. Patients with active urinary tract infection, sepsis or pyonephrosis, the last diagnosed on ultrasonography together with fever above 101°F, were excluded.

At admission, age, gender, height, weight, history of diabetes mellitus and hypertension, and the duration of symptoms before admission were recorded. Body mass index (BMI) was calculated as weight in kilograms divided by the square of height in metres. Stone size (maximum diameter on ultrasonography), stone site (proximal, middle or distal ureter) and side were noted. Each patient received 1 g of intravenous ceftriaxone as antibiotic prophylaxis. All procedures were performed under general anaesthesia by a single consultant urologist with at least three years of post-fellowship experience, using a rigid 7.5–8.5 Fr ureteroscope and a pneumatic lithoclast. The total procedure duration was recorded in theatre to the nearest 5 minutes. The primary outcome, proximal migration, was defined as upward movement of the stone or its fragments into the kidney during lithotripsy, assessed under direct endoscopic vision and recorded at the end of surgery. All information was entered on a structured proforma.

Data were entered and analysed in IBM SPSS Statistics version 25. Normality was assessed with the Shapiro–Wilk test. Continuous variables were summarised as mean ± standard deviation (SD) and, where the distribution was non-normal, also as median and interquartile range (IQR); categorical variables were expressed as frequencies and percentages. The frequency of proximal migration was reported with an exact (Clopper–Pearson) 95% confidence interval (CI). For stratification, age (20–40 vs 41–60 years), BMI (<25 vs ≥25 kg/m²), disease duration (≤6 vs >6 months), stone size (8–10 vs >10 mm) and procedure duration (≤50 vs >50 minutes, the median) were dichotomised. Migration was compared across these strata and by gender, diabetes, hypertension, stone site and side using the chi-square test, or Fisher's exact test (with the Freeman–Halton extension for the three-category site variable) when any expected cell count was below 5. Continuous variables were compared between patients with and without migration using the Mann–Whitney U test. Binary logistic regression was used to estimate odds ratios (ORs) with 95% CIs for preoperative factors. Because the migration rates for middle and distal stones were similar, stone site was entered as proximal versus middle or distal. With 16 outcome events, the multivariable model was limited to two predictors, stone site and stone size, to reduce overfitting. Procedure duration was not entered because it is measured during the operation and may itself be prolonged by migration. Model fit was assessed with the likelihood-ratio test, Nagelkerke R^2 and the Hosmer–Lemeshow test. A p-value below 0.05 was considered significant.

3. RESULTS

All 117 enrolled patients were included in the analysis, and no variable had missing values. Their baseline characteristics are summarised in Table 1.

Table 1: Baseline demographic and clinical characteristics of the study patients (n = 117)

Characteristic	Value
Age (years), mean ± SD	40.4 ± 11.1
Age (years), median (IQR)	41 (33–49)
Age group, n (%)	

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Characteristic	Value
20–40 years	55 (47.0)
41–60 years	62 (53.0)
Gender, n (%)	
Male	82 (70.1)
Female	35 (29.9)
Height (cm), mean ± SD	163.2 ± 8.4
Weight (kg), mean ± SD	69.8 ± 10.4
BMI (kg/m²), mean ± SD	26.2 ± 3.4
BMI category (kg/m²), n (%)	
<18.5	1 (0.9)
18.5–24.9	44 (37.6)
25.0–29.9	56 (47.9)
≥30.0	16 (13.7)
Diabetes mellitus, n (%)	19 (16.2)
Hypertension, n (%)	20 (17.1)
Duration of disease (months), mean ± SD	6.1 ± 4.6
Duration of disease (months), median (IQR)	5 (3–9)
Duration of disease, n (%)	
≤6 months	76 (65.0)
>6 months	41 (35.0)

SD, standard deviation; IQR, interquartile range; BMI, body mass index. Median (IQR) is given for variables that departed from normality on the Shapiro–Wilk test (age $p = 0.002$; disease duration $p < 0.001$); BMI was normally distributed ($p = 0.678$).

Men outnumbered women by more than two to one. Over 60% had a BMI of 25 kg/m² or higher, and about one in six had diabetes or hypertension. The duration of symptoms was right-skewed, with a median of 5 months against a mean of 6.1 months.

Stone characteristics, procedure duration and the primary outcome are shown in Table 2.

Table 2: Stone characteristics, procedure duration and frequency of proximal migration (n = 117)

Characteristic	Value
Stone size (mm), mean ± SD	11.3 ± 2.0
Stone size (mm), median (IQR); range	11.1 (9.8–12.4); 8.1–18.1
Stone size, n (%)	
8–10 mm	33 (28.2)
>10 mm	84 (71.8)
Stone site, n (%)	
Proximal ureter	44 (37.6)
Middle ureter	34 (29.1)
Distal ureter	39 (33.3)
Stone side, n (%)	
Right	58 (49.6)
Left	59 (50.4)

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Characteristic	Value
Procedure duration (minutes), mean ± SD	49.3 ± 10.3
Procedure duration (minutes), median (IQR); range	50 (45–55); 25–80
Procedure duration, n (%)	
≤50 minutes	79 (67.5)
>50 minutes	38 (32.5)
Proximal migration, n (%)	
Yes	16 (13.7); 95% CI 8.0–21.3
No	101 (86.3)

SD, standard deviation; IQR, interquartile range; CI, confidence interval (exact Clopper–Pearson). Stone size (p = 0.001) and procedure duration (p = 0.015) departed from normality on the Shapiro–Wilk test.
Most stones exceeded 10 mm, and the proximal ureter was the most common site. Proximal migration occurred in 16 of the 117 patients, a frequency of 13.7% (95% CI 8.0–21.3%).
Migration across the prespecified strata is shown in Table 3.

Table 3: Stratification of proximal migration by patient, stone and procedural characteristics (n = 117)

Variable	Category	n	Migration n (%)	No migration n (%)	p-value
Age group	20–40 years	55	9 (16.4)	46 (83.6)	0.425
	41–60 years	62	7 (11.3)	55 (88.7)	
Gender	Male	82	12 (14.6)	70 (85.4)	0.774[a]
	Female	35	4 (11.4)	31 (88.6)	
BMI	<25 kg/m²	45	5 (11.1)	40 (88.9)	0.523
	≥25 kg/m²	72	11 (15.3)	61 (84.7)	
Diabetes mellitus	Yes	19	3 (15.8)	16 (84.2)	0.723[a]
	No	98	13 (13.3)	85 (86.7)	
Hypertension	Yes	20	4 (20.0)	16 (80.0)	0.472[a]
	No	97	12 (12.4)	85 (87.6)	
Duration of disease	≤6 months	76	10 (13.2)	66 (86.8)	0.825
	>6 months	41	6 (14.6)	35 (85.4)	
Stone size	8–10 mm	33	5 (15.2)	28 (84.8)	0.770[a]
	>10 mm	84	11 (13.1)	73 (86.9)	
Stone site	Proximal	44	10 (22.7)	34 (77.3)	0.101[b]
	Middle	34	3 (8.8)	31 (91.2)	
	Distal	39	3 (7.7)	36 (92.3)	
Stone side	Right	58	7 (12.1)	51 (87.9)	0.616
	Left	59	9 (15.3)	50 (84.7)	
Procedure duration	≤50 minutes	79	3 (3.8)	76 (96.2)	<0.001
	>50 minutes	38	13 (34.2)	25 (65.8)	

Percentages are row percentages. p-values are from the chi-square test unless marked: [a] Fisher's exact test; [b] Fisher–Freeman–Halton exact test (expected count below 5 in at least one cell). BMI, body mass index.
Migration was not significantly associated with age group, gender, BMI, diabetes, hypertension, disease duration, stone

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size or side. It was recorded in 22.7% of proximal stones compared with 8.8% of middle and 7.7% of distal stones, although this three-way difference did not reach significance ($p = 0.101$). The largest difference concerned procedure duration: migration occurred in 34.2% of procedures lasting more than 50 minutes and in 3.8% of shorter procedures ($p < 0.001$). In line with this, the median procedure duration was 60 (IQR 55–66) minutes when migration occurred and 50 (IQR 40–50) minutes when it did not (Mann–Whitney $p < 0.001$), whereas median stone size did not differ (11.8 vs 11.0 mm; $p = 0.267$). Preoperative factors were then examined with logistic regression (Table 4).

Table 4: Binary logistic regression of preoperative factors associated with proximal migration (n = 117; 16 events)

Variable	Crude OR (95% CI)	p-value	Adjusted OR (95% CI)	p-value
Proximal site (vs middle or distal)	3.28 (1.10–9.80)	0.033	3.08 (1.02–9.31)	0.046
Stone size (per mm)	1.23 (0.96–1.58)	0.100	1.20 (0.94–1.55)	0.150
Age (per year)	0.99 (0.94–1.04)	0.611	—	—
Female gender (vs male)	0.75 (0.22–2.52)	0.645	—	—
BMI (per kg/m²)	1.01 (0.86–1.17)	0.937	—	—
Diabetes mellitus	1.23 (0.31–4.80)	0.770	—	—
Hypertension	1.77 (0.51–6.19)	0.371	—	—
Duration of disease (per month)	1.00 (0.89–1.12)	0.965	—	—
Left side (vs right)	1.31 (0.45–3.79)	0.617	—	—

OR, odds ratio; CI, confidence interval (Wald); BMI, body mass index. The multivariable model contained stone site and stone size only (8 events per variable): likelihood-ratio $\chi^2 = 6.77$, $p = 0.034$; Nagelkerke $R^2 = 0.102$; Hosmer–Lemeshow $\chi^2 = 15.32$, $p = 0.053$; area under the ROC curve 0.68. Procedure duration was not entered because it is an intraoperative variable that migration may itself prolong.

On univariable analysis, only a proximal stone location was associated with migration (OR 3.28; 95% CI 1.10–9.80). After adjustment for stone size, proximal location retained its association (adjusted OR 3.08; 95% CI 1.02–9.31; $p = 0.046$), whereas each additional millimetre of stone diameter carried a nonsignificant adjusted OR of 1.20 (95% CI 0.94–1.55). The model explained a modest share of the variation (Nagelkerke $R^2 = 0.102$), and the wide intervals reflect the small number of events.

4. DISCUSSION

In this series from Swat, proximal migration complicated 13.7% of ureterorenoscopic pneumatic lithotripsy procedures. The figure is close to the 12.5% reported earlier from Khyber Pakhtunkhwa and used for the sample-size calculation (12). Stones in the proximal ureter were about three times as likely to migrate as middle or distal stones, and migration was closely linked with longer procedures.

Pakistani studies report a wide spread of migration rates. A retrospective review of 220 patients treated with a pneumatic lithoclast at a regional centre found migration in 4.5%, which was nonetheless the main cause of treatment failure (13), and at the Institute of Kidney Diseases, Peshawar, only 2 of 100 stones migrated (3). Higher figures have come from series with more proximal or larger stones. In a randomised trial of proximal ureteral stones in Rawalpindi, migration occurred in 16.2% of the pneumatic group compared with 5.5% of the laser group (14), and in Karachi, 8 of 50 patients (16%) treated with pneumatic lithoclast for stones of 1–2 cm had upward migration, compared with 2 of 50 treated with holmium laser (15). In the control arm of a randomised trial at the Aga Khan University, where no adjunct was used, stone or fragment migration occurred in 28% of patients (16). These differences probably reflect case mix, the definition of migration and the method of assessment as much as differences in practice.

Regional and international data show a similar pattern. A randomised study of lower ureteric stones in Nepal found significantly less migration with holmium laser than with pneumatic lithotripsy (17), and a Palestinian review of 92 pneumatic procedures performed by one experienced surgeon recorded three migrations (3.2%), two of them from the upper ureter (18). Evidence comparing energy sources has also shifted. A 2017 meta-analysis of eight trials found only a borderline difference in migration between laser and pneumatic lithotripsy (OR 0.64; 95% CI 0.41–1.00; $p = 0.05$) (19), whereas the 2026 meta-analysis of 18 trials showed a clear reduction with laser (11). Where laser is unavailable, the frequency observed here shows the size of the problem that preventive measures must address.

The higher migration rate for proximal stones (22.7%) agrees with the experience that upper ureteric stones are the most difficult to treat with pneumatic energy. In a Karachi series of 90 patients, pneumatic lithotripsy succeeded in 86.7% of

upper compared with 96.7% of lower ureteric stones (20), and in the Peshawar series success in the upper ureter was 83.3% against 96.1% in the lower ureter (3). For proximal stones larger than 10 mm treated with semi-rigid pneumatic ureteroscopy, the stone-free rate was 83.5%, and 16.5% of patients required ancillary procedures (21). A proximal stone has only a short path into the renal pelvis once dislodged, a plausible but untested explanation. The association needs cautious reading. Across the three sites the difference was not significant ($p = 0.101$), and the regression compared proximal stones with the combined middle and distal group, a grouping adopted after the two lower segments were found to have similar rates. The lower confidence limit of the adjusted OR (1.02) lies close to unity, so the true effect may be considerably smaller than the point estimate.

Stone size was not associated with migration. Smaller stones are often considered more likely to migrate (18), but the narrow size range, clustered around 11 mm, left little contrast. The strong relation between procedure duration and migration requires careful interpretation. Migration probably lengthens surgery because fragments must be pursued, retrieved or left behind a stent, so a long procedure is better regarded as a consequence of migration than as a risk factor, and it was kept out of the regression model. Pneumatic lithotripsy is already slower than laser treatment (mean 34.8 vs 25.5 minutes in a Pakistani randomised trial) (22), and migration adds further theatre time.

Several inexpensive measures reduce retrograde migration. Instillation of lidocaine jelly above the stone lowered migration from 28% to 4% in the Aga Khan trial (16). A modified Dormia basket technique prevented retropulsion in 97.7% of cases compared with 91.7% for the Stone Cone, at lower cost (23). Forced diuresis with furosemide reduced retropulsion from 11% to 1.3% during pneumatic treatment of lower ureteric stones (24), and a meta-analysis of four studies found that the reverse Trendelenburg position lowered the risk of retropulsion of proximal stones (relative risk 0.42; 95% CI 0.27–0.65) (25). Because more than one in five proximal stones migrated in this series, such measures, or laser lithotripsy where available, deserve consideration when a proximal ureteric stone is treated with pneumatic energy.

As strengths, data were recorded on a predefined proforma for consecutive patients with no missing values, the technique was standardised with one experienced operator, and the calculated sample size was achieved. However, as a single-centre, single-operator study, its findings may not apply elsewhere. Migration was judged under direct vision at the end of surgery and was not confirmed by imaging, so small fragments may have been missed. Factors that can influence migration, such as hydronephrosis, stone impaction, stone density, irrigation pressure and the use of any anti-retropulsion measure, were not recorded. Postoperative stone-free status and ancillary procedures were not followed, so the clinical consequences of migration could not be quantified. Finally, the small number of events restricted the regression to two predictors and produced wide confidence intervals, and the Hosmer–Lemeshow p-value of 0.053 indicates only borderline calibration.

Future multicentre studies should compare preventive strategies in randomised designs, record hydronephrosis, impaction and stone density, and follow patients to establish the stone-free rate and need for auxiliary procedures after migration.

5. CONCLUSION

Proximal migration occurred in 13.7% of patients undergoing ureterorenoscopy with pneumatic lithotripsy, and stones in the proximal ureter carried a higher risk than middle or distal stones. Procedures complicated by migration were longer. Surgeons treating proximal stones with pneumatic energy should anticipate this complication, counsel patients accordingly and consider measures that limit retropulsion

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