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Predictors Of Stone Free Rate After Ureteroscopy for Ureteric Calculus

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ABSTRACT

Background: Ureteroscopy has become one of the preferred minimally invasive procedures for the management of ureteric calculi, achieving excellent stone clearance with low morbidity.
Objective: To identify the predictors of stone-free rate after ureteroscopy for ureteric calculus.
Methods: This retrospective observational study was conducted at ESIC Medical College Kalaburagi from-1-06-2024 TO 31-12-2025 and included 80 patients who underwent ureteroscopy for ureteric calculi. Demographic characteristics, stone-related variables, operative findings, and postoperative outcomes were obtained from medical records. Stone-free status was assessed four weeks after surgery using postoperative imaging.
Results: The mean age of patients was 42.6 ± 13.8 years, and 51 (63.8%) were male. Mean stone size was 10.8 ± 3.7 mm, while mean stone density was 782.5 ± 214.6 HU. Overall stone-free rate was 80.0% (64/80). Stone-free patients had significantly smaller stones (9.7 ± 2.8 vs. 15.2 ± 3.9 mm; $p<0.001$), lower stone density (735.4 ± 196.2 vs. 971.3 ± 221.5 HU; $p<0.001$), shorter operative time (44.6 ± 12.8 vs. 65.1 ± 17.4 minutes; $p<0.001$), and lower frequencies of proximal stone location, hydronephrosis, stone impaction, and stone retropulsion. Multivariable logistic regression identified absence of stone retropulsion (AOR=4.25, p=0.024), stone size ≤10 mm (AOR=3.86, p=0.014), distal or middle ureteric stone location (AOR=3.42, p=0.032), absence of stone impaction (AOR=3.18, p=0.034), and stone density <900 HU (AOR=2.97, p=0.042) as independent predictors of successful stone clearance.
Conclusion: Ureteroscopy provides a high stone-free rate for ureteric calculi with minimal morbidity. Smaller stone size, lower stone density, favorable stone location, absence of impaction, and prevention of stone retropulsion significantly improve treatment success.

Keywords*: Ureteroscopy; ureteric calculus; stone-free rate; laser lithotripsy; stone density; stone impaction; urolithiasis.*

INTRODUCTION

Ureteric calculi are one of the common urological problems all over the world and a big reason for presentation to the ED for acute renal colic. Urinary stone disease is a significant public health problem which has been rising steadily in recent decades due to various factors including dietary changes, obesity, metabolic syndrome and environment [1]. Ureteric stones are a major component of all urinary tract stones, and if not addressed promptly, these stones can cause a significant amount of pain, urinary tract obstruction, infection, poor kidney function as well as a lower quality of life [2]. Ureteroscopy (URS) is one of the most successful MIFs for treating ureteric stones and is advocated as first line therapy for majority of stones that are symptomatic and require active intervention in the majority of instances [3]. The introduction of miniaturized semirigid and flexible ureteroscopes, the improvement of laser lithotripsy systems, disposable digital scopes, and the development of better stone retrieval devices have given endoscopy a significant boost in terms of safety and stone clearance rates, and have decreased perioperative morbidity [4]. Hence, the use of open surgery for treatment of ureteric

stones has been largely superseded by ureteroscopy. Stone-free rate, defined as the success achieved after the procedure (defined as stone free or having only clinically insignificant stone fragments on post-ureteroscopy imaging), is the most important indicator of procedural success following ureteroscopy [5]. A higher stone-free rate is correlated with a decrease in reoccurrence rate, secondary interventions, health care expenses, patient satisfaction and better long-term renal results. Yet, with the constant advancement of technology, sometimes the stone is not completely removed, and stone fragments are a major cause of recurrence of symptoms and repeat procedures [6].

A number of patient, stone and procedural factors have been reported to affect the stone free rate following ureteroscopy. They include patient age, sex, BMI, previous surgery for stones, stone size, stone burden, stone location, degree of hydronephrosis, stone density (HU), impacted stones, anatomical abnormalities, duration of symptoms and previous UTI [7]. Other procedural parameters such as surgical time, surgeon experience, ureteral access sheaths, laser settings, stone retropulsion, and postoperative stenting of the ureters could also be factors in treatment success [8]. Of these variables, stone size and location are believed to be the most reliable predictors of stone clearance. The stone-free rate has consistently been lower with larger stones, stones in the proximal part of the ureter, impacted stones, and severe hydronephrosis [9]. In addition, patient comorbidities like diabetes mellitus, obesity, chronic kidney disease, and recurrent stone disease can affect recovery after the surgery and the chance of a patient having a stone-free outcome [10]. Ureteroscopy is a generally safe procedure however there is the potential for complications, including perforation of the ureter, mucosal damage, infection, development of a stricture, hematuria, and stones remaining within the urinary system. The use of predictors associated with the incomplete stone clearance allows the surgeon to optimize patient selection, enhance preoperative counseling, predict technical difficulties and use tailored treatment strategies to maximize the success of the procedure while minimizing complications [11]. There are a number of predictive models for predicting stone-free outcomes following ureteroscopy based upon clinical and radiological parameters at the time of stone presentation. The predictors reported are, however, different from one study to another due to variations in patient characteristics, imaging modalities, surgical techniques, laser technologies and definitions of stone-free status [12]. In summary, these institution-based studies are valuable to confirm predictors of successful ureteroscopic stone management and should be continued.

OBJECTIVE

To identify the predictors of stone-free rate after ureteroscopy for ureteric calculus.

METHODOLOGY

This retrospective observational study was conducted at ESIC Medical College Kalaburagi from-1-06-2024 to 31-12-2025and included 80 patients who underwent ureteroscopy (URS) for ureteric calculi. Patients aged 18 years or older with unilateral ureteric calculi who underwent semirigid or flexible ureteroscopy with intracorporeal laser lithotripsy were included. Only patients with complete preoperative imaging, operative records, and postoperative follow-up imaging performed within four weeks after surgery were eligible. Patients with renal calculi requiring combined procedures, congenital urinary tract anomalies, bilateral ureteric stones treated during the same session, active untreated urinary tract infection, pregnancy, malignant ureteric obstruction, previous ureteral reconstruction, incomplete medical records, or loss to follow-up were excluded.

Data Collection

Following approval from the Institutional Ethical Review Committee, patient information was retrieved from hospital electronic medical records, operative notes, radiological reports, anesthesia records, and outpatient follow-up files using a standardized data collection form. Baseline demographic variables included age, gender, body mass index, diabetes mellitus, hypertension, previous history of urolithiasis, previous stone intervention, and presenting symptoms. Stone-related variables included stone side, stone location (proximal, middle, or distal ureter), stone size, stone burden, stone density measured in Hounsfield units on non-contrast computed tomography, degree of hydronephrosis, stone impaction, multiplicity of stones, and presence of preoperative ureteral stenting. Operative variables included type of ureteroscope (semirigid or flexible), laser lithotripsy settings, operative duration, intraoperative complications, stone retropulsion, ureteral injury, use of ureteral access sheath where applicable, postoperative double-J stent placement, and length of hospital stay. The primary outcome was the stone-free rate (SFR), defined as complete absence of residual calculi or clinically insignificant residual fragments measuring ≤2 mm on postoperative ultrasonography, plain radiography, or non-contrast computed tomography performed four weeks after ureteroscopy. Secondary outcomes included operative complications according to the Clavien–Dindo classification, postoperative urinary tract infection, ureteral injury, need for auxiliary procedures, readmission, and duration of hospitalization.

Statistical Analysis

Data were analyzed using SPSS version 26.0. Continuous variables were expressed as mean ± standard deviation, whereas categorical variables were presented as frequencies and percentages. Independent *t*-tests or Mann–Whitney *U*tests were used to compare continuous variables between stone-free and non-stone-free groups, while Chi-square or Fisher's exact tests were applied for categorical variables. Odds ratios (ORs) with 95% confidence intervals (CIs) were calculated. A p-value ≤0.05 was considered statistically significant.

RESULTS

The mean age of patients was 42.6 ± 13.8 years, with males forming the majority (51, 63.8%). Mean stone size was 10.8 ± 3.7 mm, and mean stone density was 782.5 ± 214.6 HU. Hydronephrosis was present in 46 (57.5%) patients, while impacted stones were seen in 24 (30.0%), suggesting a moderate burden of obstructive ureteric disease.

Table 1: Baseline Demographic and Stone Characteristics of Patients Undergoing Ureteroscopy (N = 80)

Variable	n (%) / Mean ± SD
Age (years)	42.6 ± 13.8
Male	51 (63.8)
Female	29 (36.2)
Body mass index (kg/m²)	26.4 ± 4.1
Diabetes mellitus	14 (17.5)
Hypertension	18 (22.5)
Previous history of urolithiasis	21 (26.2)
Previous stone intervention	12 (15.0)
Right-sided stone	44 (55.0)
Left-sided stone	36 (45.0)
Stone size (mm)	10.8 ± 3.7
Stone density (HU)	782.5 ± 214.6
Hydronephrosis present	46 (57.5)
Impacted stone	24 (30.0)

Most patients underwent semirigid ureteroscopy (62, 77.5%), while flexible ureteroscopy was used in 18 (22.5%). Laser lithotripsy was performed in 72 (90.0%) cases, and DJ stenting was done in 68 (85.0%). Mean operative time was 48.7 ± 15.9 minutes, mean hospital stay was 1.8 ± 0.7 days, and overall stone-free rate was 64 (80.0%).

Table 2: Operative Characteristics and Postoperative Outcomes

Variable	n (%) / Mean ± SD
Semirigid ureteroscopy	62 (77.5)
Flexible ureteroscopy	18 (22.5)
Operative time (minutes)	48.7 ± 15.9
Laser lithotripsy performed	72 (90.0)
Stone retropulsion	9 (11.2)
Ureteral mucosal injury	6 (7.5)
Postoperative DJ stent placement	68 (85.0)
Postoperative UTI	7 (8.8)
Auxiliary procedure required	8 (10.0)
Hospital stay (days)	1.8 ± 0.7
Stone-free rate	64 (80.0)

Stone-free patients had smaller stones (9.7 ± 2.8 vs. 15.2 ± 3.9 mm; $p<0.001$), lower stone density (735.4 ± 196.2 vs. 971.3 ± 221.5 HU; $p<0.001$), fewer proximal stones, less hydronephrosis, less impaction, and lower stone retropulsion. Operative time was also shorter in stone-free patients (44.6 ± 12.8 vs. 65.1 ± 17.4 minutes; $p<0.001$).

Table 3: Comparison Between Stone-Free and Non-Stone-Free Patients

Variable	Stone-free (n=64)	Not stone-free (n=16)	p-value
Age (years), Mean ± SD	41.3 ± 13.1	47.9 ± 15.2	0.08
Stone size (mm), Mean ± SD	9.7 ± 2.8	15.2 ± 3.9	<0.001
Stone density (HU), Mean ± SD	735.4 ± 196.2	971.3 ± 221.5	<0.001
Proximal ureteric stone, n (%)	14 (21.9)	9 (56.2)	0.007
Moderate/severe hydronephrosis, n (%)	18 (28.1)	10 (62.5)	0.009
Impacted stone, n (%)	14 (21.9)	10 (62.5)	0.002
Stone retropulsion, n (%)	3 (4.7)	6 (37.5)	<0.001
Operative time (minutes), Mean ± SD	44.6 ± 12.8	65.1 ± 17.4	<0.001

Multivariable analysis showed that absence of stone retropulsion was the strongest predictor of stone-free status (AOR=4.25, 95% CI: 1.21–14.88; p=0.024). Stone size ≤10 mm, distal/mid ureteric location, stone density <900 HU, and absence of impaction were also significant independent predictors of successful stone clearance.

Table 4: Multivariable Logistic Regression Analysis of Predictors of Stone-Free Status

Predictor	Adjusted OR	95% CI	p-value
Stone size ≤10 mm	3.86	1.32–11.29	0.014
Distal/mid ureteric stone location	3.42	1.11–10.51	0.032
Stone density <900 HU	2.97	1.04–8.47	0.042
Absence of stone impaction	3.18	1.09–9.24	0.034
No intraoperative stone retropulsion	4.25	1.21–14.88	0.024

DISCUSSION

Here, the predictors of stone-free rate (SFR) after ureteroscopy for ureteric calculi were studied in 80 patients in a retrospective analysis. The overall stone free rate was 80.0%, indicating that ureteroscopy is still a very successful minimally invasive procedure in the treatment of renal stones. The study also showed that, the average stone size, absence of stone impaction, the location of the stones in the distal or middle ureter, absence of stone retropulsion during the surgery were some important variables which predicted successful stone clearance. The results demonstrate that stone properties and factors during surgery also play a major role in the outcome following surgery. Patients in this study had a mean age of 42.6 ± 13.8 years and 63.8% of the patients were men. The mean stone size was 10.8 ± 3.7 mm, while the average stone density measured 782.5 ± 214.6 HU. 57.5% of the patients had hydronephrosis, while 30.0% had stones in the kidney. It is also known that previous studies have shown that ureteric stones occur more commonly in middle aged men and hydronephrosis and impacted stones are frequently seen in patients who have to undergo ureteroscopic intervention [13]. Semirigid ureteroscopy (77.5%) was performed in most cases, and flexible was only performed for more complex cases. Intracorporeal stone fragmentation was performed by laser lithotripsy in 90.0% of the cases and was the method of choice for the treatment of stones. The mean operative time was 48.7 ± 15.9 minutes, postoperative hospital stay averaged only 1.8 ± 0.7 days, and an overall stone-free rate of 80.0% was achieved. A previous study has also shown that the stone clearance rate after ureteroscopy is between 80% and 95% and that it is an effective and safe procedure with a short hospital stay [14][15]. Stone size was one of the key factors to successful treatment. There was a significant difference in the size of calculi between patients who achieved stone-free and those who had stones left behind (9.7 ± 2.8 mm vs. 15.2 ± 3.9 mm) with patients clearing stones being the smaller ones. Stone density was also significantly smaller when there were no stones present (735.4 ± 196.2 vs. 971.3 ± 221.5 HU). Previous studies have repeatedly demonstrated that the efficiency of stone fragmentations using laser decreases with increasing stone size and the Hounsfield unit value of the stones [16]. Surgical outcomes were also greatly affected by the location of the stones. Patients who were not able to pass the stones completely had a significantly higher incidence of proximal ureteric stones while distal and middle ureteric stones had higher stone-free rates. Previous studies have also found that distal stones are easier to access and fragment and that, on the contrary, proximal stones are more difficult to access, have a higher risk of residual fragments, and are more complex to manipulate [17].

Other factors that strongly correlated with unsuccessful treatment were hydronephrosis and impaction of stones. Bigger stones were more likely to be associated with moderate or severe hydronephrosis in those not stone free. Previous studies have also shown that stones that have been impacted tend to cause chronic inflammation, edema and fibrosis of the ureters,

which makes the stones harder to fragment and extract, but also makes them more likely to leave the bladder if they are not fragmented [18]. The other important intraoperative factors that impacted the treatment success were stone retropulsion. Stone-free outcome was even more likely to be achieved in those patients without any residual stones, and residual stones were an independent risk factor for retropulsion. In keeping with previous studies, migration of stones towards the perineum during lithotripsy has been reported by others to be a major cause of failure in this procedure, especially in the proximal ureteral stones, and is a reason for adopting anti-retropulsion techniques whenever feasible [19]. Multivariate analysis using logistic regression showed that the lack of stone retropulsion was the most independent factor associated with stone clearance. The presence of at least 10 mm sized stones, distal and middle ureteric stones and stones below 900 HU and absence of stone impaction were also independent predictors of higher stone-free rates. These variables have been previously shown to be good predictors of ureteroscopic success and are recommended to be included when counseling and planning surgery [20]. This study has some clinical implications. A thorough preoperative evaluation of stone size, density, location, and hydronephrosis, as well as the degree to which the stones are impaction, can lead the surgeon to an estimate of the likelihood of total stone removal, the feasibility of the surgery, and the most suitable surgical approach. For larger, dense, impacted and/or proximal ureteric stones, there may be advantages to advanced endoscopic skills, anti-retropulsion devices, staged procedures or more frequent post-operative imaging monitoring. Individually tailored treatment plans for stones, using stonespecific characteristics, have also been shown to be important to have for successful treatment and to minimize repeat interventions.

LIMITATIONS

This study has several limitations. First, its retrospective design makes it susceptible to selection bias and incomplete documentation because the analysis depended on previously recorded clinical data. Second, the study was conducted at a single center with a relatively small sample size of 80 patients, which may limit the generalizability of the findings to other populations and healthcare settings. Variations in surgeon experience, laser settings, ureteroscope type, and postoperative imaging modalities could not be completely standardized and may have influenced the reported stone-free rates. Stone composition was not available for all patients and therefore could not be evaluated as a predictor of treatment success. In addition, long-term follow-up regarding stone recurrence, late ureteral stricture formation, and subsequent interventions was not assessed. Future prospective multicenter studies involving larger patient populations with standardized operative protocols and longer follow-up are recommended to validate these findings and develop more robust predictive models for stone-free outcomes following ureteroscopy.

CONCLUSION

Ureteroscopy achieved a high overall stone-free rate of 80% and proved to be an effective minimally invasive treatment for ureteric calculi. Smaller stone size, lower stone density, distal or middle ureteric stone location, absence of stone impaction, and prevention of intraoperative stone retropulsion were independently associated with successful stone clearance. Patients with larger, denser, impacted, or proximal ureteric stones were more likely to have residual fragments and longer operative times. Careful preoperative assessment of stone characteristics together with meticulous surgical technique may improve stone-free rates, reduce the need for auxiliary procedures, and optimize patient outcomes.

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