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Research Article

Stone clearance rate based on stone location in the upper urinary tract using Ho:YAG Laser: A tertiary care hospital-based study

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ABSTRACT

Background & Objectives: Upper urinary tract stone disease is a common urological condition with significant morbidity, particularly among young and middle-aged adults. Endourological interventions, notably semirigid or flexible ureterorenoscopy using Ho:YAG with or without ureteral access sheath, offer high stone clearance with minimal invasiveness. However, challenges such as UAS negotiation failure and proximal stone migration can compromise outcomes, especially for upper ureteral stones. This study evaluates patient demographics, procedural outcomes, complications, and stone clearance rates following uretero-renoscopic laser lithotripsy.

Materials and Methods: This cross-sectional study was conducted at Department of Surgery, Devdaha Medical College and Research Institute from 1st August 2024 to 31st July 2025, following ethical approval. Consecutive patients undergoing low-power Ho:YAG laser lithotripsy for upper urinary tract stones, meeting inclusion and exclusion criteria, were enrolled. Data were analyzed using Excel and SPSS version 20.

Results: Forty-nine patients were included; 67.3% were aged 20–39 years, with a nearly balanced sex distribution (females 53.1%, males 46.9%; p = 0.775). Stones were almost equally distributed between right (51.0%) and left (49.0%) sides (p = 1.000). UAS placement failed in 15.4% of procedures. Semi-rigid URS achieved complete removal of upper ureteral stones in 62.5%, while 37.5% migrated proximally. Postoperative fever occurred in 8.1% of patients, and blood transfusion wasn't needed. Overall stone clearance was 95.4%

Conclusions: Upper urinary tract stones predominantly affect younger adults, with no significant sex or laterality predilection. The uretero-renoscopic lithotripsy using Ho:YAG laser demonstrates excellent stone clearance and low complication rates, reinforcing its role as a safe, and effective for upper urinary tract stone management.

Keywords: Uretero-renoscopy, Holmium:Yttrium Aluminum Garnet laser lithotripsy, upper urinary tract stones

INTRODUCTION

Urolithiasis is one of the most common urological disorders, affecting 5–15% of the global population, with a reported lifetime recurrence rate of up to 50% [1,2]. Epidemiological studies indicate a rising incidence among younger adults, potentially due to dietary changes, sedentary lifestyle, metabolic syndrome, and increased obesity prevalence [3,4].

The location of a stone plays a crucial role in determining surgical outcomes in the management of upper urinary tract stone disease [5]. Ureterorenoscopy (URS) has emerged as a first-line minimally invasive approach for ureteric and selected renal stones [6]. The advent of semi-rigid and flexible ureteroscopes, along with advanced lithotripsy techniques e.g., Holmium:yttrium-aluminum-garnet (Ho:YAG) laser, has significantly improved stone-free rates and reduced morbidity compared with open or percutaneous approaches [7]. RIRS is indicated for renal stones smaller than 2 cm, particularly in the renal pelvis and calyces, and is especially useful for stones in difficult-to-reach locations that are challenging to treat with other modalities [8].

Ho:YAG, introduced in the 1990s, is currently considered the gold standard for laser lithotripsy [9]. Laser lithotripsy is associated with several clinical advantages, including reduced intraoperative blood loss, shorter recovery time, and a lower rate of complications, making it a suitable option for the surgical management. However, the reported effectiveness of laser lithotripsy varies across different studies, primarily due to heterogeneity in patient selection, stone characteristics, and variability in laser energy settings and operative techniques, which limits direct comparisons and generalization of outcomes [10,11]. Instrumentation choice is equally important. Semi-rigid URS is ideal for mid and lower ureteric stones. Flexible URS, however, provides enhanced access to upper ureter and intrarenal stones, particularly in cases of complex anatomy [12].

National studies of stone clearance according to the location of stone in the upper urinary tract are limited. The present study evaluates the outcomes of URS in 49 patients, with specific focus on location of stone, anesthesia modality, ureteral access sheath (UAS) negotiation success, semi-rigid URS efficacy, stone clearance rates, and postoperative complications among the patients admitted in the Surgical Department of Devdaha Medical College (DMC) and Research Institute (RI), Western Region of Nepal.

MATERIALS AND METHODS

This cross-sectional retrospective study was conducted following approval from the Internal Review Committee (IRC) of DMCRI; Ref. No. 298/081/082, protocol approval number 24/2025. The study was designed to evaluate the surgical outcomes of patients undergoing ureteroscopic surgery (URS) or retrograde intrarenal surgery (RIRS) for

upper urinary tract stones. A retrospective design was chosen to allow comprehensive review of cases over a defined period. The study period spanned 1st August 2024 to 31st July 2025, ensuring inclusion of all relevant cases managed at the institution within one year.

The sample size for a prevalence of 3% (p = 0.03) with the parameters:

The formula: N= Z2*p*(1-p)/d2

where z = 1.96 for a 95% confidence interval, p = prevalence of renal stones = 0.03, q = 1 – p = 0.97, and d = allowable error = 0.05. This yielded a minimum required sample size of 46 patients. This calculation ensured sufficient statistical power to detect meaningful trends and associations while maintaining feasibility given the available records.

Inclusion Criteria

All patients undergoing URS and RIRS for upper urinary tract stones during the study period.

Exclusion Criteria

Patients with anatomical abnormalities of the urinary tract (such as strictures or congenital anomalies), those with a solitary kidney, individuals presenting with multiple stones, patients with coagulation disorders, those diagnosed with urinary tract tumors, pregnant women, and individuals with a history of urinary tract trauma were excluded from the study.

Data were systematically extracted from hospital records and operative files by the principal investigator and co-authors, ensuring consistency and accuracy. Patient demographics (age, sex), stone characteristics (location, size, laterality), anesthesia type (general or spinal), ureteric access sheath (UAS) negotiation, stone clearance rate, and postoperative complications (fever, blood transfusion requirements) were recorded. Computed tomography (CT) of kidney, ureter and bladder (KUB) or CT intravenous urography (IVU) reports were analyzed to define stone size, location, and anatomy for surgical planning. Stone clearance was defined by postoperative imaging within 2–4 weeks with stone size of <4 mm or its absence on KUB X-ray and ultrasonography (USG) abdomen.

Outcomes

- **Primary Outcome:** Stone clearance rate according to location
- **Secondary Outcomes:** UAS negotiation success, semi-rigid URS success according to location of the ureter, postoperative fever, blood transfusion, and anesthesia-related outcomes

Procedure

During the period of study, from 1st August 2024 to last of July 2025, there was total 375 cases of urological surgeries in Department of Surgery, DMCRI. Out of total 375 cases, 64 cases underwent ureteroscopic and retrograde intrarenal surgeries with Ho:YAG laser lithotripsy according to Hospital Record Section. Out of 64 cases, the file record of 49 cases, who met the inclusion and exclusion criteria were analyzed in details. Data was collected in structured “Proforma”.

The principal investigator retrieved the needful recorded data from the file of the patients.

Semi-rigid Ureterorenoscopic (URS) lithotripsy(L) was initiated for stones located in the ureter. Retrograde Intrarenal Surgery (RIRS) was performed for stones located in kidney or stone migrated from ureter to kidney during URSL. A Ureteric Access Sheath (UAS) 9.5-11 Fr was used, if negotiable. Other-wise surgery was performed without UAS.

Surgical technique

Ureterorenoscopy: As per hospital routine procedure, patients with a pre-operative negative urine culture, a single prophylactic dose of antibiotic inj. Ceftriaxone 1 gm was given. Surgery was performed under spinal anesthesia or general anesthesia. URSL was performed using Wolf, Germany 6.0. French, semi-rigid. RIRS was performed on lithotomy position, with flexible uretero-renoscope Hugemed, 7.5 Fr. China. The energy source for URS and RIRS lithotripsy was Ho:YAG, Quanta, Italy 30 Watt, using 0.5 to 1.5 joule and frequency of 10-25 Hz (a total power from 4 to 16 Watt). The laser fiber was 200 or 375 micro meter depending upon the location of stone, irrigation and deflection requirement.

As per hospital practice, generally, after URSL or RIRS, the patients were discharged on first post-operative day. Stone clearance was defined by postoperative imaging within 2–4 weeks with radio-opaque shadow of <4 mm or its absence which were collected from operation theatre register.

The data were entered into Microsoft excel spread sheet and analysed with SPSS (Statistical Package for Social Science) Version 20. Independent variables (age, sex, size and location of stone, type of surgery(URSL or RIRS) and duration of surgery, type of anesthesia (general or spinal), were analyzed in number and frequencies. The dependent variables: stone clearance rate, hospital stays and transfusion rate were analyzed with X^2 /Fisher extract test.

During analysis, p-valtue <0.05 was considered statistically significant.

Ethical Considerations: Ethical approval was taken before enrollment of patient, from IRC, DMCRI; Ref. No.: 298/081/082; 20 August, 2025.

RESULTS

A total of 49 patients were included in the study. The most frequently affected age group was 20–29 years (n = 20, 40.8%), followed by 30–39 years (n = 15, 30.6%), whereas older age groups were less commonly affected. Of the total cases, 23 (46.9%) were male and 26 (53.1%) were female, with no significant difference between sexes (p = 0.668). Right-sided involvement was observed in 25 patients (51%) and left-sided involvement in 24 patients (49%). Regarding the location of stones, 26 cases were found in the ureter, predominantly in the upper ureter (n = 16), followed by the lower ureter (n = 7) and middle ureter (n = 3). Renal stones were observed in 23 patients, all involving the renal pelvis (n = 15), with fewer cases in the upper pole (n = 2), mid pole (n = 2), and lower pole (n = 4), Table 1.

General anaesthesia (GA) was used in 39 cases (79.6%) and spinal anaesthesia in 10 cases (20.4%), with GA being significantly more common (p < 0.001). Overall stone clearance was achieved in 47 patients

Table 1: Distribution of Study Findings (N = 49)

Variable	Category	Frequency (n)	Percentage (%)	p-value
Age Group (years)	20–29	20	40.8	0.0001
	30–39	15	30.6	
	40–49	4	8.2	
	50–59	2	4.1	
	≥60	8	16.3	
Sex	Male	23	46.9	0.668
	Female	26	53.1	
Side Involved	Right	25	51.0	0.886
	Left	24	49.0	
Location of Calculus	**Ureter (Total = 26)**			0.668
	Upper ureter	16	61.5	
	Middle ureter	3	11.5	
	Lower ureter	7	26.9	
Renal (Total = 23)	Renal pelvis	15	65.2	
	Upper pole	2	8.7	
	Middle pole	2	8.7	
	Lower pole	4	17.4	

Table 2: Outcome variables of 49 patients

Outcome	N	Success / Event	%	Comparison	p-value
Overall stone clearance	49	47	95.9%	Ureteric vs Renal	0.29
Ureteric stones clearance	26	26	100%	-	-
Renal stones clearance	23	21	91.3%	-	-
UAS negotiable	39	36	92.3%	Negotiable vs Not	0.67
Semi-rigid URS success (upper ureter)	16	10	62.5%	Success vs Stone migration	0.455
Postoperative fever	49	4	8.2%	Fever vs No fever	0.12
General anesthesia	49	39	79.6%	GA vs Spinal	0.15
Spinal anesthesia	49	10	20.4%	-	-

(95.9%), including 26 of 26 ureteric stones (100%) and 21 of 23 renal stones (91.3%),

with no significant difference between ureteric and renal stones (p = 0.29). Ureteral access sheath (UAS) negotiation was successful in 36 of 39 cases (92.3%), with no statistically significant difference between successful and failed negotiation (p = 0.67). Postoperative fever occurred in 4 patients (8.2%), which was not statistically significant compared with patients without fever (p = 0.12). For semi-rigid ureteroscopy of upper ureteric stones, success was achieved in 10 of 16 cases (62.5%), with failures primarily due to stone migration in 6(37.5%) cases. Blood transfusion was not required in any patients during the study period; Table 2.

DISCUSSION

In the present study, upper urinary tract stone disease was found to predominantly affect young adults, with the highest

incidence observed in the 20–29-year age group. This trend is consistent with existing literature that identifies urolithiasis as increasingly common in early adulthood, possibly reflecting lifestyle and dietary factors contributing to stone formation in younger populations [13-15].

Our study showed the slight female predominance, with a female-to-male ratio of 1.13:1. Although many epidemiological studies traditionally report a higher incidence among males, recent findings from some regions suggest a narrowing of this gap, potentially due to evolving environmental, metabolic, or lifestyle influences affecting both sexes [14].

Right-sided stones were marginally more common in this cohort (51%). Nearly half of the stones were located in the ureter (46.9%), with the upper ureter being the most frequently affected site. The predominance of upper ureteric stones aligns with known patterns of migration and obstruction within the urinary tract. A key finding of this study was the high stone clearance rate of 95.4% overall. This may be due to use of newer digital flexible URS 7.5 Fr., UAS and Ho:YAG laser lithotripsy. Ureteric stones achieved a high clearance rate, highlighting the effectiveness of current management strategies for ureteral calculi, including minimally invasive approaches using laser as energy sources. In particular, ureteric stones in our study achieved a 100% clearance rate, which is similar to the previously published series reporting stone-free rates ranging between 85% and 100%. [16-18]. These findings highlight the continued reliability, safety, and therapeutic value of URS in achieving successful stone clearance across diverse patient populations [19]. Renal stones demonstrated a slightly lower, though still high, clearance rate of 90.4%. These results support the continued efficacy of contemporary treatment modalities for both ureteric and renal stones. The excellent outcomes achieved in ureteric calculi are in line with contemporary literature, supporting ureteroscopic intervention (URS) as a first-line treatment modality for stones located within the ureter [20]. In our series, semi-rigid ureteroscopy achieved moderate success in managing upper ureteric stones, with a clearance rate of 62.5%. The reason for treatment failure in this location was the proximal stone migration or unable to reach the stone: the recognized limitations of semi-rigid instrumentation when treating stones near the ureteropelvic junction. Similar to our study, lower rate of stone clearance due to stone migration was also reported in other studies [21,22]. In contrast, lower and mid-ureteric stones demonstrated a 100% clearance rate, highlighting the continued utility and effectiveness of semi-rigid ureteroscopes in these anatomical segments. Flexible ureteroscopy provides clear advantages in accessing the proximal ureter and intrarenal collecting system, offering improved maneuverability, enhanced visualization, and superior reach into calyceal recesses. Therefore, flexible URS should be considered the preferred modality in cases where semi-rigid instruments are unable to achieve complete stone clearance, particularly in proximal ureteric [23]. This stepwise approach may optimize outcomes while minimizing unnecessary procedural conversion or complications.

In our study, general anesthesia (GA) was the predominant modality, utilized in 79.6% of cases, while spinal anesthesia was employed in 20.4%. This pattern reflects the widespread preference for GA in ureteroscopic procedures, owing to the

advantages of complete patient immobility, secure airway control, and stable surgical conditions. However, growing evidence from previous studies indicates that spinal anesthesia can achieve comparable stone-free rates with fewer systemic complications, particularly in elderly or high-risk patients. Spinal anesthesia also offers additional benefits, including faster postoperative recovery, reduced analgesic requirements, and avoidance of airway instrumentation [24]. These attributes make it a valuable alternative in selected patient populations or in resource-constrained settings where reducing anesthesia-related complexity may enhance procedural feasibility. Overall, anesthesia selection remains a critical component of URS success, and tailoring the choice to patient characteristics and clinical context may further optimize outcomes.

In the present study, ureteral access sheath (UAS) negotiation was successful in 92.3% of cases, reflecting the feasibility and reliability of conventional sheaths in ureteroscopic stone management. The use of UAS offers several procedural advantages, including repeated and atraumatic access to the collecting system, reduced intrarenal pressure, improved endoscopic visualization, and more efficient retrieval of stone fragments. These benefits contribute to improved procedural safety and efficacy. Previous reports have demonstrated that conventional UAS can enhance stone clearance rates, reduce operative time, and lower the incidence of postoperative infectious complications by maintaining low-pressure irrigation and minimizing pyelovenous backflow [25]. The high success rate observed in our study further supports the use of UAS as a valuable adjunct in contemporary flexible ureteroscopic practice.

Postoperative fever was observed in 8.2% of patients, which is consistent with previously published data reporting postoperative febrile complications in approximately 5–10% of cases [26]. The incidence of postoperative fever depends on patient-related factors, preoperative antibiotic prophylaxis, surgical technique including irrigation pressure, and perioperative urinary drainage strategies [27]. In present study, the blood transfusion was not required at all.

This study has several limitations. Its retrospective design, single-center setting, and relatively small sample size may limit the generalizability of the findings. Imaging follow-up was fully relied on simple KUB X-ray and USG of abdomen, and important stone characteristics such as volume and density were not consistently documented, which could affect the precision of treatment outcome assessment. Furthermore, newer technological advancements, including suction ureteral access sheaths (SUAS) and flow-assisted negative-pressure systems (FANS-UAS), were not incorporated during the study period due to cost constraints, which may influence comparisons with contemporary practice standards.

CONCLUSIONS

Semi-rigid ureteroscopy demonstrates excellent stone clearance in lower and mid-ureteric calculi with minimal complications; however, its effectiveness is limited in the upper ureter, where stone migration remains a key challenge. Flexible ureteroscopy provides improved access to the proximal ureter and intrarenal collecting system and should therefore be considered when semi-rigid instrumentation fails to achieve complete clearance. The general anesthesia

remains the standard for URS due to optimal procedural conditions. The high success rate of ureteral access sheath negotiation further supports its utility in ensuring efficient and safe endoscopic manipulation. Overall, tailoring anesthesia choice, judicious use of access sheaths, and appropriate selection of ureteroscopic instruments are essential for maximizing clinical success and minimizing complications in contemporary URS practice.

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