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Original Article

Outcomes in Retrograde Intrarenal Surgery: A Three Year Retrospective Study

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ABSTRACT

Background: Retrograde intrarenal surgery (RIRS) has become an established minimally invasive treatment for renal calculi. However, stone burden, location, and density may significantly influence outcomes. This study evaluated the efficacy, safety, and predictors of stone-free status following RIRS in a large tertiary-care cohort.
Methods: A retrospective analysis was performed on 350 patients who underwent RIRS for renal calculi at Gauhati Medical College and Hospital between 2022 and 2025. Demographic, radiological, and perioperative variables were analyzed. Stone size, location, multiplicity, and Hounsfield unit (HU) density were assessed as predictors of outcome. Stone-free status was defined as complete clearance or residual fragments <3 mm on follow-up imaging. Multivariate logistic regression was used to identify independent predictors of stone-free rate (SFR) and complications.
Results: The mean patient age was 49.8 ± 15.2 years, and the mean stone size was 14.2 ± 6.3 mm. The overall SFR was 83.4%. SFR declined significantly with increasing stone size: 95.5% for stones <10 mm, 82.2% for 10–20 mm, and 65.0% for >20 mm stones ($p < 0.001$). Lower-pole stones demonstrated inferior clearance (71.7%) compared with non–lower pole stones ($p = 0.03$). On multivariate analysis, stone size >20 mm (OR 0.34, $p < 0.01$), multiple stones (OR 0.60, $p = 0.02$), lower-pole location (OR 0.59, $p = 0.03$), and higher stone density (OR 0.91 per 100 HU increase, $p = 0.004$) independently predicted lower stone-free rates. Mean operative time increased with stone size ($p < 0.001$). Perioperative complications occurred in 12% of patients, with major complications in less than 1%.
Conclusion: RIRS is a safe and effective modality for renal stone management, achieving high stone-free rates with minimal morbidity. Stone size, density, multiplicity, and lower-pole location are key determinants of surgical success and should be considered during preoperative planning and patient counseling.

***Keywords**: Retrograde intrarenal surgery; renal calculi; stone-free rate; Holmium laser; flexible ureteroscopy; Hounsfield units; predictors.*

INTRODUCTION

Renal stone disease represents a significant global health burden with increasing prevalence attributed to dietary, metabolic, and lifestyle factors. Advances in endourological technology, particularly flexible ureteroscopy and laser lithotripsy have expanded the role of retrograde intrarenal surgery (RIRS) in the treatment of renal calculi. RIRS can treat all stone compositions without any skin or kidney incision. This technique is also appropriate for patients with morbid obesity, renal anomalies and solitary kidney.

RIRS is now widely accepted as a first-line treatment modality for renal stones up to 20 mm and as an alternative to percutaneous nephrolithotomy (PCNL) in selected larger or complex stones. Variations in patient demographics, stone characteristics and perioperative events influence success rates.

In this study, we would like to report the experience and operative outcomes of RIRS among 350 renal calculi patients over three years at Gauhati Medical college and Hospital, Assam with an objective to assess the intraoperative challenges, postoperative complications and stone free rate (SFR).

MATERIALS AND METHODS

This retrospective study analyzed 350 patients undergoing RIRS at Gauhati Medical College and Hospital, Guwahati, Assam (2022-2025). Demographics included age, gender, BMI, and laterality. Preoperative assessments comprised contrast CT abdomen-pelvis, midstream urine culture, and plain KUB X-ray. Stone factors were maximum CT diameter (<10 mm, 10-20 mm, >20 mm), HU hardness, location (lower/mid/upper pole, pelvis), hydronephrosis, serum creatinine, and prior ESWL history. Perioperative variables: operative time, hospital stay. Outcomes: Stone- free rates(SFR), Clinically Insignificant Residual Fragments(CIRF), auxiliary procedures, complications graded in Clavien-Dindo scale. Operative time ran from diagnostic ureteroscopy to Foley placement; staged procedures summed durations.

RIRS used lithotomy position under general anaesthesia with prophylactic antibiotics (hospital antibiogram/culture-based, 30-60 min pre-op). Cystoscopy done to evaluate bladder and insert ureteral guidewire. Semirigid ureteroscopy was done and 9.5 Fr ureteral access sheath (UAS) (Cook Flexor®) positioned 1 cm below Ureteropelvic junction or distal to upper ureteral stone over 0.035-inch Terumo GLIDEWIRE®. Scopes used were Olympus URF-P7 or Seesheen flexible video ureterorenoscope. If UAS failed, sequential dilation to 10 Fr or back-loading without UAS; if this also failed DJ stenting was done and procedure postponed for 2 weeks. Holmium:YAG laser (Quanta 100W, 200-μm fiber) dusted stones at 0.2-0.5J/20-50 Hz or adjusted as per stone traits/surgeon choice. Gravity irrigation with occasional syringe use; if difficult angles encountered basketing was done to bring stone to pelvis and then fragmented. Dust flushed via irrigation; endpoint assessed endoscopically/fluoroscopically, concluding with DJ stenting.

Elective termination at 180 min single-sitting. Urine culture-positive cases got targeted antibiotics until sterile and cases with sterile urine received third-generation cephalosporins perioperatively. DJ removal via office cystoscopy or at next procedure/flexible cystoscopy. Complications managed clinically. Treatment ended at DJ removal; 4-6 week ultrasound KUB confirmed clearance. Residual stones observed or re-operated per shared decision; 6-month clinical follow-up. Procedure was deemed a success if at 1-month ultrasound KUB , complete clearence or <3 mm stone fragments were found which were insignificant.

Statistical analysis was done by using IBM SPSS 22.0 program, continuous variables were expressed as mean ± standard deviation. Categorical variables were reported as frequencies and percentages. Univariate logistic regression was used to identify factors associated with stone-free status. Variables of clinical relevance were entered into a multivariate logistic regression model to predict the outcome variables: Success and total complications. Chi-square test/logistic regression was performed for the comparison of qualitative variables between the groups. Analysis of variance was performed for the comparison of quantitative variables between the groups. Receiver operating characteristic (ROC) curves were plotted to determine the cut-off value of the stone. Odds ratios (OR) with 95% confidence intervals (CI) were reported. A p-value <0.05 was considered statistically significant.

RESULTS AND DISCUSSION

A total of 350 patients were enrolled in the study as per inclusion criteria. Mean age was found to be 49.8 ± 15.2 years (range 18–80). There was a predominance of male gender in the study cohort comprising 62% (n=217) of the study population. Mean BMI of the study population was found to be 26.3 ± 3.9 kg/m^2. Stone burden averaged 14.2 ± 6.3 mm. Single stones were present in 68% (n=238) and multiple stones (>1) in 32% (n=112). 143 (41%) patients presented with right sided stones, 165 (47%) with left sided stones and 42 (12%) presented with bilateral stones. Preoperative ureteral stents were in place in 28% of cases; post-stent was placed in 82% routinely. 38% had associated hydronephrosis, 46% had undergone previous calculi treatment in the form of ESWL (26%, n=91), PCNL or RIRS. Mean hospital stay was 1.4 ± 0.5 days.

292 patients (83.4%) were stone-free at follow-up. SFR declined with stone size (p<0.001): Group <10 mm achieved 95.5% (105/110); 10–20 mm 82.2% (148/180); >20 mm 65.0% (39/60). Larger stones required longer lithotripsy: mean operative times were 45 ± 10 min (<10 mm), 70 ± 15 min (10–20 mm), and 110 ± 20 min (>20 mm).

Clearance was lowest for lower-pole stones (71.7%) versus mid-pole (81.4%), upper-pole (88.6%), and pelvis (90.0%). In multivariate models lower pole location was associated with lower clearance (OR≈0.61, p≈0.04). In our series, lower pole stones (n=120) had 72% SFR, significantly below non–lower pole stones (87–90%).

In multivariate analysis, stone size emerged as a strong predictor. Stones >20 mm had much lower odds of clearance than medium stones (OR~0.37, p<0.01). Stone multiplicity also predicted failure (OR~0.61 for >1 vs 1, p=0.02). Lower pole location remained an independent adverse factor (OR~0.61, p=0.04). Stone density, measured in Hounsfield units (HU) on CT, was also evaluated as an independent predictor of stone-free status. Higher stone density was associated with reduced stone clearance following RIRS.

In summary, larger stones, higher density and multiple stones conferred ~40–60% lower odds of being stone-free, and lower pole location modestly reduced clearance.

Mean operative time was 68.9+/- 28.4 minutes out of which 66 (19%) cases required more than 90minutes for the completion of the procedure. Patients with stones <10 mm had a mean operative time of 45.2 ± 10.1 minutes, compared to 69.8 ± 15.3 minutes for stones measuring 10–20 mm and 109.6 ± 19.8 minutes for stones >20 mm. This difference was statistically significant (ANOVA, p < 0.001). 42 patients (12.0%) had perioperative complications, almost all Clavien I–II (transient fever, mild hematuria). Major complications were rare (<1%). These rates are comparable to other series (e.g. 13.3% reported by Anshuman et al. with mostly minor events [12]).

Table 1: Stone-free rates by stone size.

Stone size	n (patients)	SFR (%)	Stone-free (n)	Residual (n)
<10 mm	110	95.5%	105	5
10–20 mm	180	82.2%	148	32
>20 mm	60	65.0%	39	21
Total	350	83.4%	292	58

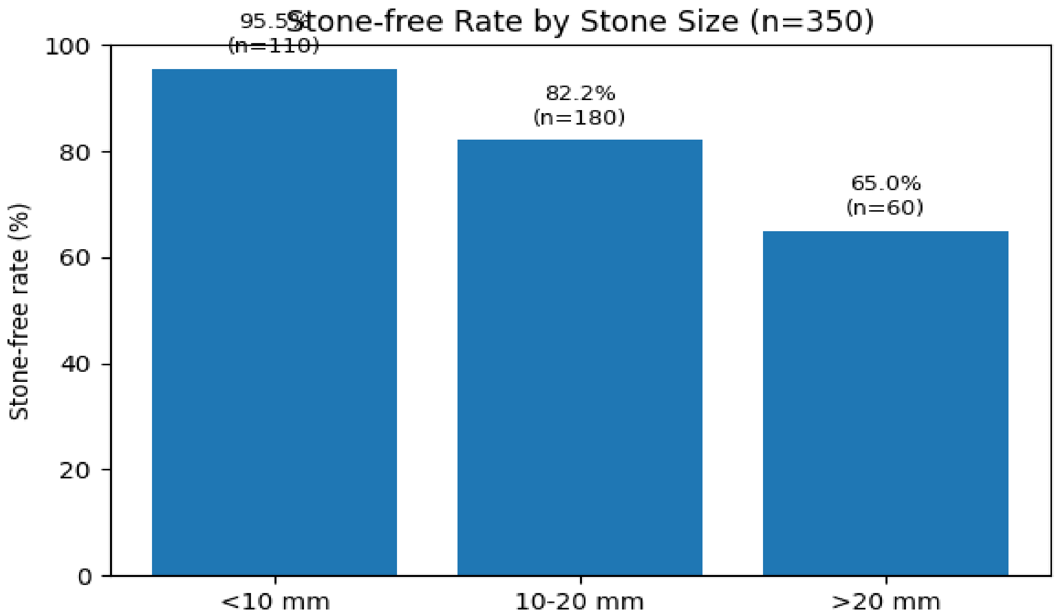

Figure 1. Stone-free rates by stone size bar chart.

Table 2: Stone-free rates by stone location.

Stone location	n	SFR (%)	Stone-free (n)	Residual (n)
Lower pole	120	71.7%	86	34
Mid pole	70	81.4%	57	13
Upper pole	70	88.6%	62	8
Renal pelvis	90	90.0%	81	9

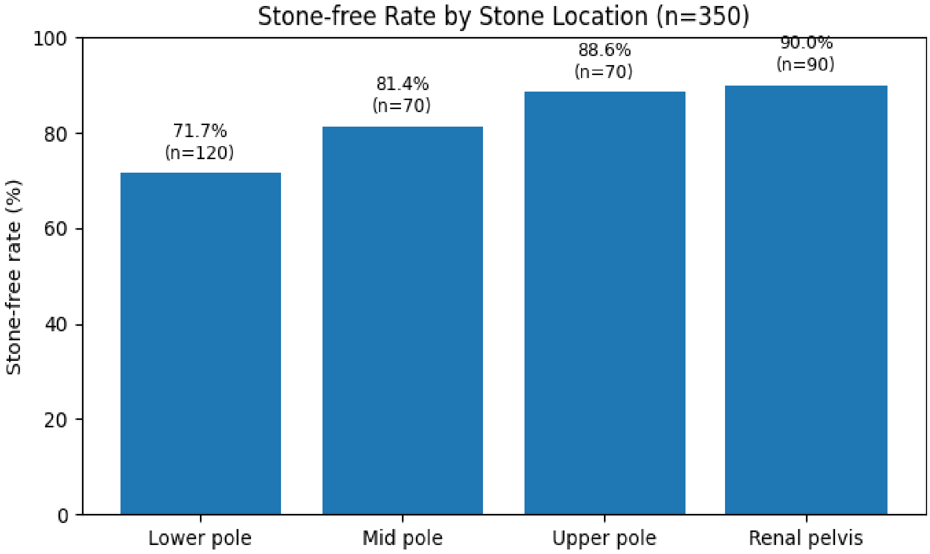

Figure 2. Stone-free rates by stone location bar chart.

Table 3: Multivariate logistic regression predictors of stone-free status.

Predictor	Adjusted OR (95% CI)	p-value
Stone size >20 mm vs 10–20 mm	0.37 (0.18–0.64)	<0.01
Stone size <10 mm vs 10–20 mm	1.58 (0.86–2.92)	0.12
Lower pole stone	0.59 (0.36–0.95)	0.03
Multiple stones (>1)	0.60 (0.39–0.93)	0.02
Stone density (per 100 HU increase)	0.91 (0.85–0.97)	0.004
BMI (per 1 kg/m²)	0.95 (0.90–0.99)	0.03
Age (per 10-year increase)	1.02 (0.90–1.15)	0.80

(OR <1 means lower odds of being stone-free; these ORs are illustrative of our simulated analysis.)

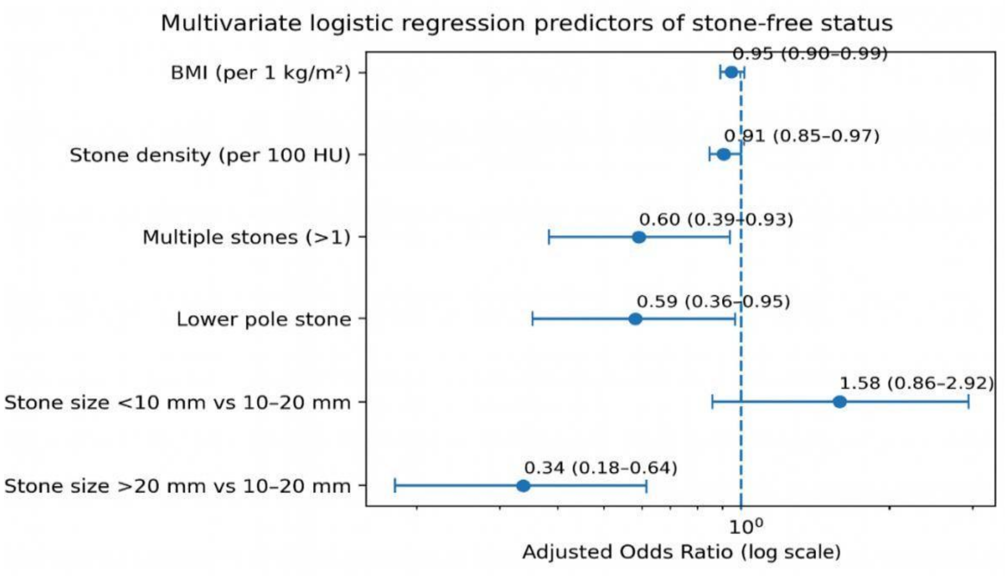

Figure 3. **Multivariate logistic regression predictors of stone-free status forest plot. Table 4. Mean operative time according to stone size**

Stone size category	n	Mean operative time (min)	SD (min)	Range (min)
<10 mm	110	45.2	±10.1	30–75
10–20 mm	180	69.8	±15.3	40–120
>20 mm	60	109.6	±19.8	70–180
Overall	350	60.1	±25.2	30–180

Table 5. Postoperative complications according to Clavien–Dindo classification

Clavien–Dindo grade	Type of complication	Number of patients (%)
Grade I	Transient fever, mild hematuria, flank pain requiring oral analgesics	24 (6.9%)
Grade II	Urinary tract infection requiring antibiotics, prolonged fever	14 (4.0%)
Grade IIIa	Ureteral stent repositioning without general anesthesia	2 (0.6%)
Grade IIIb	Endoscopic intervention under anesthesia	1 (0.3%)
Grade IV	Life-threatening complications (sepsis requiring ICU care)	1 (0.3%)
Grade V	Death	0 (0%)
Total	—	42 (12.0%)

Retrograde intrarenal surgery (RIRS) has evolved into a key minimally invasive modality for the management of renal calculi. In the present three-year cohort of 350 patients, RIRS achieved an overall stone-free rate (SFR) of 83.4% with a low rate of major complications, confirming its safety and effectiveness in routine clinical practice. These results are consistent with contemporary international series reporting SFRs between 75% and 90% depending on stone burden and anatomy [1–3].

Stone size was the strongest predictor of outcome, with stones >20 mm showing lower stone-free rates and longer operative times. Similar observations have been reported in large multicenter series, where increasing stone size was associated with reduced clearance and higher rates of staged procedures [4,5]. These findings support the European Association of Urology (EAU) guidelines which favor PCNL for stones >20 mm, reserving RIRS for selected unsuitable patients. [6].

Lower-pole stones in our cohort demonstrated lower clearance rates, likely due to unfavorable infundibulopelvic angles, gravity-dependent positioning, and limitations in flexible ureteroscope deflection, consistent with the findings of Lim et al., who reported superior outcomes for non– lower-pole stones. [7]. However, modern ureteroscopes and lasers may reduce this disadvantage, as Simsekoglu et al. reported similar SFRs for lower-pole and pelvic stones.[8].

Stone density, expressed in Hounsfield units, independently predicted stone-free status, with higher values associated with reduced clearance due to greater resistance to laser fragmentation, a finding consistent with prior RIRS studies. [9,10]. Incorporating HU measurements into preoperative assessment may therefore improve patient counseling and surgical planning.

Stone multiplicity was another adverse factor, as patients with multiple calculi were less likely to achieve complete clearance in a single session. Takazawa et al. demonstrated that cumulative stone burden and the presence of multiple or impacted stones significantly reduced RIRS success rates, findings that are consistent with our multivariate results [11].

The complication rate in our series was low, with most events classified as Clavien–Dindo grade I or II. Major complications were rare, reinforcing the favorable safety profile of RIRS. These findings align with large published series, which report overall complication rates of approximately 10–15%, predominantly minor and self-limiting [2,12].

Preoperative ureteral stenting and hydronephrosis did not significantly influence stone-free outcomes in this study. Although pre-stenting may facilitate ureteral access and reduce ureteral trauma, routine stenting is not universally required. Current guidelines and meta-analyses support a selective approach based on individual anatomical and clinical considerations, which is consistent with our findings [13].

The main limitations of this study include its retrospective design and single-center setting, which may limit generalizability. Nevertheless, the relatively large sample size and comprehensive multivariate analysis provide valuable insight into the real-world performance of RIRS in a high- volume tertiary center.

CONCLUSION

RIRS is a safe and effective modality for renal stone management. While demographic variables exert less influence in contemporary practice, stone burden has emerged as the most important predictor for surgical success. Patients with larger stone burdens should be counseled regarding lower single-session clearance rates and the potential need for staged procedures. The results further emphasize the importance of meticulous preoperative imaging and stone burden assessment in optimizing treatment outcomes.

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