

Outcomes of retrograde intrarenal surgery in renal calculi of varying size

Vigneswara Srinivasan Sockkalingam Venkatachalapathy*, Datson George Palathullil, Dempsey Mohan Sam, Abhishek Prasad, George Palathullil Abraham

Department of Urology, VPS Lakeshore Hospital, Kochi, Kerala, India

*E-mail: viwasri@gmail.com

ABSTRACT

Introduction: Technological advancements have made it possible to attempt retrograde intrarenal surgery (RIRS) in patients with large renal calculi. The objective of this study was to compare the intraoperative adverse events, postoperative complications and stone free rates (SFR) of RIRS in patients with renal calculi of varying sizes.

Methods: Patients who underwent RIRS for renal calculi between January 2016 and June 2020 were categorized into six size groups according to the longest dimension or cumulative measurement of the longest dimension of calculi as follows: Group 1 (1–9 mm), Group 2 (10–19 mm), Group 3 (20–29 mm), Group 4 (30–39 mm), Group 5 (40–49 mm) and Group 6 (≥ 50 mm). All the patients were followed up for a period of 6 months post treatment completion and the outcomes of interest were computed and compared.

Results: Two hundred and ten patients were included in the analysis. Intraoperative adverse events were noted in 9.5%, 8%, 16.9%, 9.1%, 6.7% and 28.6% of the patients in groups 1–6, respectively ($P = 0.453$). The postoperative complications were noted in 4.8%, 5.3%, 6.8%, 15.2%, 26.7% and 42.9% of patients in groups 1–6, respectively ($P = 0.024$). The final SFRs were 95.2%, 100%, 96.6%, 90.9%, 86.7% and 71.4% in groups 1–6, respectively ($P = 0.012$).

Conclusions: RIRS is an effective treatment option for the management of renal stones, including those larger than 20 mm in size. We noted a size dependent increase in the postoperative complications and a reduction in the SFRs. The majority of the postoperative complications were low grade and no stone related events occurred in the patients who were managed conservatively for residual stones after surgery, on the short term follow up.

INTRODUCTION

The incidence of urolithiasis is on a rising trend worldwide.^[1] Miniaturization of the ureterorenoscope, advancements in the laser and the refinements in the surgical techniques has further advanced the ureterorenoscopic management of renal calculi.^[2] The current guidelines recommend retrograde intrarenal surgery (RIRS) as a second-line treatment option for renal stones >20 mm in size.^[3] However, RIRS is evolving from a procedure being reserved for specialized centers to a ubiquitous procedure taking the center stage for the management of renal calculi.^[4] This in turn has lead to broader applications of RIRS,

with RIRS being increasingly attempted in the patients with large and complex renal calculi.

The outcomes of RIRS, for the management of renal calculi in patients with stones >40 mm in size, are seldom reported in the literature. Further, literature reporting the outcomes of RIRS for renal calculi of varying sizes from the Indian subcontinent is lacking. We designed this study to address these issues with an objective to compare the intraoperative adverse events, postoperative complications and stone free rate (SFR) of RIRS in patients with renal calculi of varying sizes.

This is an open access journal, and articles are distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.


For reprints contact: WKHLRPMedknow_reprints@wolterskluwer.com

Received: 15.08.2021, **Revised:** 16.11.2021,

Accepted: 05.02.2022, **Published:** 01.04.2022

Financial support and sponsorship: Nil.

Conflicts of interest: There are no conflicts of interest.

Access this article online	
Quick Response Code:	Website: www.indianjurol.com
	DOI: 10.4103/iju.iju_343_21

METHODS

We retrospectively analyzed the data of the patients who underwent RIRS at our institution between January 2016 and June 2020. The study protocol was approved by the hospital ethical committee prior to initiation of the study (LHRC/EC-2021-01/03, dated -15-04-2021). The methods adopted in the study adhered to the ethical guidelines of the Declaration of Helsinki and its amendments. Informed consent permitting the use of clinical details for academic purposes, was obtained from the patients prior to the procedure. The authors confirm the availability of and access to all the original data reported in this study.

Inclusion and exclusion criteria

All patients who underwent unilateral RIRS for renal calculus/calculi were included in the study. Patients under the age of 18 years, or those who underwent bilateral RIRS or percutaneous nephrolithotomy (PCNL) or other surgeries along with RIRS or those who underwent RIRS for ureteral or impacted pelviureteric junction calculi were excluded from this study. Patients who had not undergone recommended imaging evaluation or underwent scheduled staged procedures were also excluded. Patients who lost to follow up were also not considered in the evaluation.

Retrograde intrarenal surgery procedure

A noncontrast computed tomography (CT) of the abdomen and pelvis or CT urogram was obtained within 2 weeks prior to the procedure. All the patients were explained about the possibility of a staged procedure, possible complications and reported SFR of the procedure. Informed consent for surgery was obtained. All the surgical procedures were performed by a single endourologist, with a prior experience of performing 200 RIRS procedures. The procedures began with diagnostic semirigid ureteroscopy. A double-J (DJ) stent was placed in non-accommodative ureters and a staged procedure was scheduled after two to 4 weeks. In all other cases, the ureter was sequentially dilated upto 12 Fr or 10 Fr and a 9.5/11.5 Fr ureteral access sheath (UAS) was placed. Olympus URF-P6 or URF-P7 (Olympus, Japan) or Storz Flex X² or Flex X^{2s} (Karl Storz, Germany) flexible ureterorenoscopes were used, according to the availability, without preferring one over the other. Disposable scopes were not used. A 100W high-power Holmium/YAG system (VersaPulse PowerSuite, Lumenis, Israel) and a reusable 200- μ m laser fiber were used in all the cases.

The laser was set on 0.2–0.5J energy and 20–50 Hz frequency. Gravity irrigation was used with occasional use of gentle manual syringe irrigation, when required. Calculi were dusted, rather than fragmenting them into bigger pieces.^[5] If the angulation was difficult, the calculi were basketed out of the lower calyx prior to dusting. If they were dusted in the lower calyx, the dust particles were flushed out of the lower

calyx by directing the irrigation towards the stone dust at the end of the procedure. Endoscopic visual and fluoroscopic assessments were made at the end of the procedure and based on the findings, a decision to “stage it or not” was made at the surgeon’s discretion. The procedures were concluded with the placement of a DJ stent.

The procedures were terminated electively if the operative duration in a single sitting exceeded 180 min. In those cases, a DJ stent was placed and a staged procedure was scheduled after two to 4 weeks. Staged procedures were also planned for patients with high stone bulk or unfavorable pelvicalyceal anatomy^[6] at the discretion of the operating surgeon. Urine culture positive patients were treated with culture directed antibiotics and the procedures were performed after confirming a sterile culture. In patients with sterile urine culture, third generation cephalosporins were used in the perioperative period.

The DJ stent was removed by office based flexible cystoscopy, if subsequent staged procedures were not scheduled. In cases where a staged procedure was scheduled, the DJ stent was removed either at the subsequent staged procedure under anesthesia or the replaced DJ stent was removed by flexible cystoscopy at a later date. In the event of postoperative complications, evaluation and management was performed according to the clinical presentation. The removal of the DJ stent was considered as the completion of the treatment. A follow up ultrasonography, to confirm the stone clearance, was performed at four to 6 weeks after the completion of the treatment. The patients with residual stones were either observed or were re-operated according to the shared doctor patient decision. All the patients were clinically followed up for 6 months after the completion of the treatment.

Patient categorization and variables considered in the analysis

The patients were categorized into six size groups according to the longest dimension/cumulative measurement of the longest dimension of calculi as follows: Group 1 (1–9 mm), Group 2 (10–19 mm), Group 3 (20–29 mm), Group 4 (30–39 mm), Group 5 (40–49 mm), Group 6 (\geq 50 mm).

In each group, the following variables were recorded and analyzed: demographic details of the patients, side and location of the calculi, number of primary RIRS, number of procedures performed under anesthesia and the total operative duration. The duration of the procedure was calculated from the beginning of the diagnostic ureteroscopy to the placement of foleys catheter. If the patient underwent more than one procedure, the total operative duration was calculated by summing up the duration of all the procedures that the patient underwent under anesthesia. The number of the day care procedures, not requiring overnight hospitalization, were also recorded.

Apart from the intra-operative complications, we also documented irreversible damage/breakage of the flexible ureterorenoscope or stone basket and included them in the intra-operative adverse events. The intra-operative adverse events and postoperative complications were also recorded. Acute pyelonephritis and sepsis were diagnosed as per the accepted criteria.^[7,8] The postoperative complications were classified as per the Clavien–Dindo grading and in patients with more than one postoperative complications, the highest Clavien score was recorded.^[9,10] A stone size of >2 mm on the follow up ultrasonography was considered as a residual fragment and the SFR was defined as 2U.^[11] The anatomical challenges encountered while accessing the calculi were also noted. The outcomes for different flexible ureterorenoscopes used in the study, were not assessed separately. Emergency operation was defined as any procedure performed for the postoperative complications. Reoperation was defined as the elective procedure performed for residual stones. The stone related events in the follow up period were also noted.^[12]

Statistical analysis

IBM SPSS version 20 (IBM Corp., Armonk, NY, USA) was used for statistical analysis. Qualitative (categorical) variables were represented by frequency and percentage. Quantitative (continuous/score) variables were represented by mean and standard deviation. 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 size, for the prediction of relevant and statistically significant outcomes of the study. Sensitivity and 1-specificity were used to arrive at the cut-off value. A $P < 0.05$ was considered statistically significant.

RESULTS

Two hundred and ten patients were eligible for the final analysis. The smallest size of the calculus was 3 mm and the largest was 60 mm. The mean size of the calculi was 22.8 ± 11.8 mm. The patient's demographic details, side of the stone, size and location of the stone in the various groups are shown in Table 1. One hundred and eighty-three patients (87.1%) underwent primary RIRS, without the need of prior DJ stent placement. Eighty-three patients (39.5%) underwent a single staged procedure. One hundred and twenty patients (57.1%) underwent a two staged procedure. Seven patients (3.3%) required a three staged procedure. Two hundred and ten patients underwent a total of 344 procedures under anesthesia. The mean number of procedures per patient was 1.64 ± 0.55 . Of the 344 procedures, 136 (39.5%) were day care procedures. Of the 210 procedures, which were either single staged or were the first stage of multistaged procedures (only sitting or first sitting), 58 (27.6%) were day care procedures. Of the 134

procedures which were subsequent stages of a multistaged procedure (second and third sitting), 78 (58.2%) were day care procedures.

The mean total duration of the procedures per patient was 117.1 ± 70.5 min. Intraoperative adverse events were noted in 24 patients (11.4%). In each group, the number of the patients who underwent primary RIRS, number of procedures, total operative duration and intraoperative adverse events are shown in Table 2. Postoperative complications were noted in 21 patients (10.0%). Emergency operation (pigtail nephrostomy tube insertion) was required in one patient. The final SFR was 95.2% (200 patients). The postoperative complications and the final SFR in various groups are shown in Table 3.

The smallest size of the residual calculus was 3 mm and the largest size was 8 mm (calyceal diverticulum calculus). The mean size of the residual calculi was 4.60 ± 1.58 mm. Nine out of the 10 patients with residual calculi (90.0%) opted for observation and refused re-surgery. One patient (10.0%) underwent repeat RIRS for clearance of the residual stone and was rendered stone free. Among the patients who chose observation of the residual calculi, none had a stone related adverse event, during the follow-up period.

A cut-off stone size of 30 mm (area under the curve [AUC] [95% confidence interval (CI)]: 0.720 [0.661–0.779], sensitivity: 57.1%, specificity: 81.0%) predicted postoperative complications [Figure 1a] and a cut-off stone size of 31 mm (AUC [95% CI]: 0.767 [0.677–0.857], sensitivity: 70.0%, specificity: 81.5%) predicted residual stones on the ROC curve analysis [Figure 1b]. Surgical outcomes, namely, stone size, intraoperative adverse events, postoperative complications, and residual stone rates in patients with access related anatomical challenges are shown in Table 4.

DISCUSSION

Our study showed a stone size dependent increase in the number of procedures, total operative duration, postoperative complications and the residual stone rates. Instead of clubbing all the stones greater than 20 mm in a single group, we further sub-categorized our study cohort based on the size of the stone with an aim to assess whether an incremental change in the size of the stone affects the peri-operative outcomes and if yes, to approximately calculate the stone size at which such a significant change is noted.

Pre-procedural stent placement was performed only in 27 patients (12.9%) which is lower than that reported in the contemporary studies.^[4,13] We attribute the high rates of primary RIRS to the routine sequential ureteral dilatation upto 12 Fr (upto 10 Fr in a few cases, if dilation

Table 1: Patient demographics and stone characteristics

Variable	Group 1 (n=21), n (%)	Group 2 (n=75), n (%)	Group 3 (n=59), n (%)	Group 4 (n=33), n (%)	Group 5 (n=15), n (%)	Group 6 (n=7), n (%)
Gender						
Male	16 (76.2)	57 (76.0)	38 (64.4)	22 (66.7)	11 (73.3)	6 (85.7)
Female	5 (23.8)	18 (24.0)	21 (35.6)	11 (33.3)	4 (26.7)	1 (14.3)
Age (years)	42.7±13.4	49±13.7	50.1±12.0	48.6±11.4	48.5±10.9	49.6±12.9
Stone side						
Left	13 (61.9)	41 (54.7)	28 (47.5)	23 (69.7)	7 (46.7)	4 (57.1)
Right	8 (38.1)	34 (45.3)	31 (52.5)	10 (30.3)	8 (53.3)	3 (42.9)
Stone size (mm)	7.43±1.78	14.6±2.45	23.6±3.01	33.3±2.78	44.6±3.29	54±3.32
Stone location						
Pelvis	4 (19.0)	28 (37.3)	15 (25.4)	1 (3.0)	0	0
Upper calyx	0	6 (8.0)	3 (5.1)	0	0	0
Middle calyx	4 (19.0)	3 (4.0)	1 (1.7)	0	0	0
Lower calyx	10 (47.6)	25 (33.3)	6 (10.2)	1 (3.0)	0	0
Pelvis and single calyx	0	9 (12.0)	27 (45.8)	20 (60.6)	2 (13.3)	0
Pelvis and multiple calyces	0	0	3 (5.1)	9 (27.3)	10 (66.7)	7 (100.0)
Multiple calyces	1 (4.8)	2 (2.7)	2 (3.4)	0	2 (13.3)	0
Upper moiety	1 (4.8)	0	0	1 (3.0)	0	0
Lower moiety	0	1 (1.3)	0	0	0	0
Both moieties	0	0	0	1 (3.0)	1 (6.7)	0
Calyceal diverticulum	1 (4.8)	1 (1.3)	2 (3.4)	0	0	0

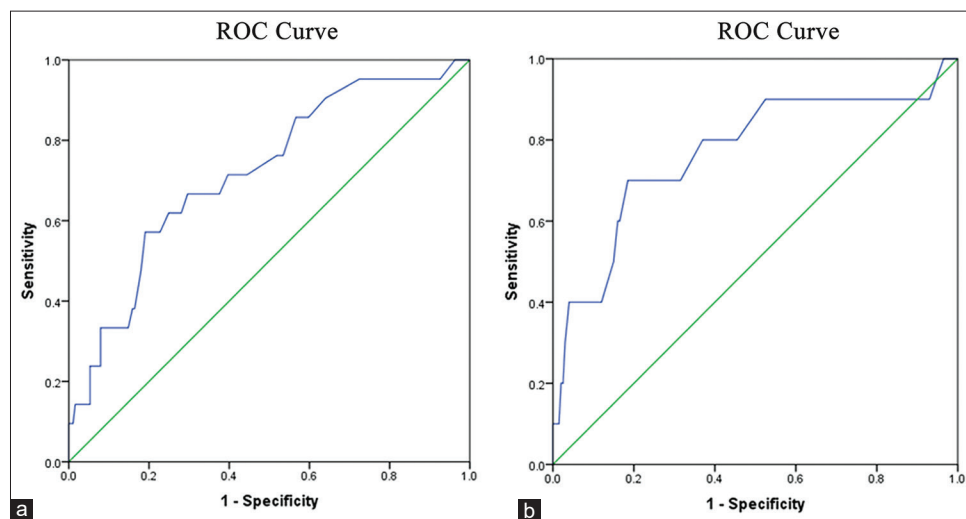


Figure 1: Receiver operating characteristic curves to find the cut off value for stone size to predict postoperative complications and residual stones. (a) Area under the curve is 0.720 (0.661–0.779). The cut off for stone size was 30 mm with 57.1% sensitivity and 81.0% specificity to predict the postoperative complications. (b). Area under the curve is 0.767 (0.677–0.857). The cut off for stone size was 31 mm with 70.0% sensitivity and 81.5% specificity to predict the residual stones

to 12 Fr was not possible) and routine use of small sized 9.5/11.5 Fr UAS. Combining pop-dusting to conventional stone dusting has been described to achieve higher SFR.^[5] At the authors institution, the procedures began at dusting settings ([0.2–0.5J] and [20–50 Hz]) and contact lithotripsy. Towards the completion of the procedure, even though the laser settings were not altered, the technique was changed to non-contact lithotripsy. The authors followed the technique of working uniformly around the stone, so that only fine stone dust without large fragments, was created.^[14]

Encouraging evidence is available which supports undertaking ureteroscopy as a day care procedure.^[15] A

significant proportion of the patients in our study also underwent RIRS as a day care procedure and it is being increasingly adopted at our department. In our study, the proportion of procedures performed as a day care in the single staged procedures or in the first stage of multistaged procedures were lower than the proportion of the day care procedures in the subsequent stages of the multistaged procedures. We presume this results from the comparatively higher stone bulk and longer operative duration associated with a single staged procedures and the first stage of multistaged procedures. The departmental policy of posting the patients, planned for subsequent stages of a multistaged procedure, earlier in the day in operative list might have also played a role.

Table 2: Operative data and intraoperative adverse events

Variable	Group 1 (n=21), n (%)	Group 2 (n=75), n (%)	Group 3 (n=59), n (%)	Group 4 (n=33), n (%)	Group 5 (n=15), n (%)	Group 6 (n=7), n (%)	P
Primary RIRS without the need for prior DJ stent	18 (85.7)	63 (84.0)	50 (84.7)	30 (90.9)	15 (100.0)	7 (100.0)	0.189
Number of procedures	1.19±0.4	1.37±0.49	1.73±0.49	2.03±0.3	2.07±0.46	2.29±0.49	0.000
1	17 (81.0)	47 (62.7)	17 (28.8)	1 (3.0)	1 (6.7)	0	
2	4 (19.0)	28 (37.3)	41 (69.5)	30 (90.9)	12 (80.0)	5 (71.4)	
3	0	0	1 (1.7)	2 (6.1)	2 (13.3)	2 (28.6)	
Total operative duration (min)	45.0±14.1	71.2±30.4	118.9±47.8	185±44.3	222±37.4	267.1±47.9	0.000
Intraoperative adverse events	2 (9.5)	6 (8)	10 (16.9)	3 (9.1)	1 (6.7)	2 (28.6)	0.453
Ureteral access sheath related ureteral wall injury - Grade 1	1 (50.0)	2 (33.3)	3 (30.0)	0	0	0	
Inability to reach a part of calculus and left alone	0	0	2 (20.0)	1 (33.3)	0	0	
Inability to access the calculus completely and left alone	1 (50.0)	0	0	0	0	0	
Infundibular/calyceal tear	0	3 (50.0)	1 (10.0)	2 (66.7)	0	1 (50.0)	
Pelvic tear	0	1 (16.7)	2 (20.0)	0	0	0	
Damage requiring replacement of the flexible ureterorenoscope	0	0	1 (10.0)	0	1 (100.0)	1 (50.0)	
Broken and entrapped basket	0	0	1 (10.0)	0	0	0 (0.0)	

RIRS = Retrograde intrarenal surgery, DJ = Double-J

Table 3: Postoperative complications with claviendo grading and final stone free rates

Variable	Group 1 (n=21), n (%)	Group 2 (n=75), n (%)	Group 3 (n=59), n (%)	Group 4 (n=33), n (%)	Group 5 (n=15), n (%)	Group 6 (n=7), n (%)	P
Postoperative complications (Clavien grade)	1 (4.8)	4 (5.3)	4 (6.8)	5 (15.2)	4 (26.7)	3 (42.9)	0.024
Hematuria with clots (1)	1 (100.0)	2 (50.0)	2 (50.0)	3 (60.0)	2 (50.0)	2 (66.7)	
Hematuria with clots and pyelonephritis (2)	0	1 (25.0)	0	0	0	0	
Pyelonephritis (2)	0	1 (25.0)	1 (25.0)	1 (20.0)	0	1 (33.3)	
Sepsis (4a)	0	0	0	1 (20.0)	0	0	
Subcapsular hematoma (2)	0	0	1 (25.0)	0	0	0	
Steinstrasse managed by medical management (2)	0	0	0	0	1 (25.0)	0	
Steinstrasse which needed surgical intervention (3a)	0	0	0	0	1 (25.0)	0	
Final stone free rates	20 (95.2)	75 (100.0)	57 (96.6)	30 (90.9)	13 (86.7)	5 (71.4)	0.012

Table 4: Anatomical challenges regarding access during retrograde intrarenal surgery and the outcomes

Anatomical challenges	Number of patients	Stone size (mm)	Intraoperative adverse events, n (%)	Postoperative complications, n (%)	Residual stones, n (%)
Infundibular stenosis, post PCNL	6	21.7±9.14	1 (16.7)	3 (50.0)	2 (33.3)
Partial pelviureteric junction obstruction, postpyeloplasty	3	18.0±5.57	1 (33.3)	0	0
Calyceal diverticulum	4	14.8±6.70	1 (25.0)	0	1 (25.0)
Duplicated collecting system	5	25.8±16.9	1 (20.0)	1 (20.0)	0
Impacted infundibular calculus	3	28.7±12.2	2 (66.7)	1 (33.3)	0
Ectopic pelvic kidney	1	39.0±0.00	0	0	0

PCNL = Percutaneous nephrolithotomy

A stone size dependent rise in the intraoperative adverse events was not seen in our study. UAS associated ureteral wall injury (Grade 1) was noted in six patients (2.86%).^[16] Again, the sequential ureteral dilatation and the use of smaller UAS might have influenced the low recorded rates of nonserious ureteral wall injuries in our study, which are lower than that reported by the other studies.^[16] The renal pelvic tear and infundibular/calyceal tear recorded in our study resulted either from high irrigation pressures or because of direct injury with the laser. In three patients, irreversible damage necessitated replacement of the flexible ureterorenoscope. In 2 patients, the deflection mechanism was damaged due to excessive strain on the scope and in one patient, inadvertent firing of the laser fiber inside the ureterorenoscope resulted in the irreversible damage.

Hematuria with clots requiring prolonged catheterization and hospitalization was the most common postoperative complication in our series, which resolved spontaneously in all the cases. Hematuria was a frequent postoperative complication in a few of the other studies as well.^[17] Two patients presented with steinstrasse postoperatively and both had a DJ stent *in situ*. One of them underwent emergency operation, while the other improved with medical management alone. Postoperative complications higher than Clavien grade 2 were recorded in 2 patients. These comparatively lower rates of infective complications, as noted in our series can be attributed to the routine use of UAS in all the patients, avoiding excessive irrigation pressures, setting up an upper limit for the duration of the procedure and taking up the patient only after confirming a sterile urine culture.^[18]

Five patients with stone size ≤6 mm and high-risk profession underwent RIRS and all were rendered stone free.^[3] The SFR of our series is encouraging, considering the significant number of patients with stone size greater than 20 mm. In cases of large renal calculi (particularly greater than 30 mm), we followed the practice of thoroughly dusting about 70%–80% of the stone bulk in the initial stage and dealt with the remaining calculi electively in the subsequent stages. This helps in completing the procedure within 180 min, thereby effectively limiting the morbidity and also helps in avoiding the troublesome steinstrasse, postoperatively or during the next sitting. The management protocol for residual stones after RIRS is not well established and hence

a shared decision making process was undertaken in all the patients after discussing all the available options.

We noted a significant increase in the complexity of the renal stones in Group 4 patients as compared to Group 3, which is evident from the comparatively higher percentage of renal stones involving multiple calyces, pelvis with single calyx and pelvis with multiple calyces in Group 4 (54.2% in Group 3 vs. 87.9% in Group 4). The authors presume that the higher stone complexity resulted in a significant increase in the postoperative complications and residual stones as noted in Group 4 when compared to Group 3. A similar trend of worsening of these outcomes was also noted in the subsequent larger stone size groups as well. To predict the postoperative complications and residual stones, we calculated the cut-off stone sizes by the ROC curve analysis. These cut-offs can never be 100% sensitive and 100% specific. Nevertheless, they are a simple means of predicting specific outcomes of interest with reasonable certainty and might help in preoperative decision making and patient counselling.

All the patients with post PCNL infundibular stenosis required laser incision and had higher postoperative complication and residual stone rates.^[19,20] In patients with calculi in the calyceal diverticulum, widening of the diverticular neck with holmium laser had to be performed to access the stones.^[21] The diverticular opening could not be identified in one patient and thus the calculi could not be cleared. In our series, patients with duplex collecting system had varying levels of incomplete duplication and the UAS was placed in the common ureter after sequential dilatation. The moiety of interest was dilated as per the requirement. Even though, the patients with access related anatomical challenges comprised only 10.5% (22 patients) of the studied cohort, these patients contributed 25% (6 of the 24 patients) to the intraoperative adverse events, 23.8% (5 of the 21 patients) to the postoperative complications and 30% (3 of the 10 patients) to the residual stones.

Our study was a single center retrospective study and prospective multicentric studies are required to establish the reproducibility of these outcomes in larger population. We have not considered parameters such as stone volume and Hounsfield unit of the stones similar to a few previous studies,^[22] due to the unavailability of information in the

majority of the patients. Also, separate documentation of anesthesia time, flexible ureteroscopy time and laser time would have further added to our study. Again, the data was not uniformly available in all the patients and can be considered a limitation of our study. Analysis of cost effectiveness and quality of life related to the disease and treatment modality are vital while reporting the outcomes.^[23,24] But these parameters were not evaluated in our study and is among the limitations of the study. Postoperative ultrasonography was preferred over the more accurate CT to assess SFR, primarily because of the financial constraints of the studied population. Besides, our follow up period was short and serial ultrasonography reports were not available in patients with residual stones after RIRS. Extended period of follow up with serial ultrasonography would have provided a better understanding of the natural history of the residual stones after RIRS.

CONCLUSIONS

RIRS is an effective treatment option for the management of renal stones, including those greater than 20 mm in size. We observed a size dependent increase in the postoperative complications and a reduction in the SFRs. The majority of the postoperative complications were low grade. There were no stone related events in the patients who were managed conservatively for residual stones after surgery, on short term follow up.

REFERENCES

1. Raheem OA, Khandwala YS, Sur RL, Ghani KR, Denstedt JD. Burden of urolithiasis: Trends in prevalence, treatments, and costs. *Eur Urol Focus* 2017;3:18-26.
2. Alenezi H, Denstedt JD. Flexible ureteroscopy: Technological advancements, current indications and outcomes in the treatment of urolithiasis. *Asian J Urol* 2015;2:133-41.
3. Türk C, Petřík A, Sarica K, Seitz C, Skolarikos A, Straub M, *et al.* EAU guidelines on interventional treatment for urolithiasis. *Eur Urol* 2016;69:475-82.
4. Giusti G, Proietti S, Villa L, Cloutier J, Rosso M, Gadda GM, *et al.* Current standard technique for modern flexible ureteroscopy: Tips and tricks. *Eur Urol* 2016;70:188-94.
5. Pietropaolo A, Jones P, Whitehurst L, Somani BK. Role of 'dusting and pop-dusting' using a high-powered (100 W) laser machine in the treatment of large stones (≥ 15 mm): Prospective outcomes over 16 months. *Urolithiasis* 2019;47:391-4.
6. Karim SS, Hanna L, Geraghty R, Somani BK. Role of pelvicalyceal anatomy in the outcomes of retrograde intrarenal surgery (RIRS) for lower pole stones: Outcomes with a systematic review of literature. *Urolithiasis* 2020;48:263-70.
7. Johnson JR, Russo TA. Acute pyelonephritis in adults. *N Engl J Med* 2018;378:48-59.
8. Singer M, Deutschman CS, Seymour CW, Shankar-Hari M, Annane D, Bauer M, *et al.* The third international consensus definitions for sepsis and septic shock (sepsis-3). *JAMA* 2016;315:801-10.
9. Dindo D, Demartines N, Clavien PA. Classification of surgical complications: A new proposal with evaluation in a cohort of 6336 patients and results of a survey. *Ann Surg* 2004;240:205-13.
10. Akilov FA, Giyasov SI, Mukhtarov ST, Nasirov FR, Alidjanov JF. Applicability of the Clavien-Dindo grading system for assessing the postoperative complications of endoscopic surgery for nephrolithiasis: A critical review. *Turk J Urol* 2013;39:153-60.
11. Somani BK, Desai M, Traxer O, Lahme S. Stone-free rate (SFR): A new proposal for defining levels of SFR. *Urolithiasis* 2014;42:95.
12. Kang HW, Lee SK, Kim WT, Kim YJ, Yun SJ, Lee SC, *et al.* Natural history of asymptomatic renal stones and prediction of stone related events. *J Urol* 2013;189:1740-6.
13. Goldberg H, Golomb D, Shtabholtz Y, Tapiero S, Creiderman G, Shariv A, *et al.* The "old" 15 mm renal stone size limit for RIRS remains a clinically significant threshold size. *World J Urol* 2017;35:1947-54.
14. Kronenberg P, Somani B. advances in lasers for the treatment of stones-a systematic review. *Curr Urol Rep* 2018;19:45.
15. Ghosh A, Oliver R, Way C, White L, Somani BK. Results of day-case ureterorenoscopy (DC-URS) for stone disease: Prospective outcomes over 4.5 years. *World J Urol* 2017;35:1757-64.
16. Traxer O, Thomas A. Prospective evaluation and classification of ureteral wall injuries resulting from insertion of a ureteral access sheath during retrograde intrarenal surgery. *J Urol* 2013;189:580-4.
17. Xu Y, Min Z, Wan SP, Nie H, Duan G. Complications of retrograde intrarenal surgery classified by the modified Clavien grading system. *Urolithiasis* 2018;46:197-202.
18. Berardinelli F, De Francesco P, Marchioni M, Cera N, Proietti S, Hennessey D, *et al.* Infective complications after retrograde intrarenal surgery: A new standardized classification system. *Int Urol Nephrol* 2016;48:1757-62.
19. Kim HL, Gerber GS. Use of ureteroscopy and holmium: Yttrium-aluminum-garnet laser in the treatment of an infundibular stenosis. *Urology* 2000;55:129-31.
20. Taylor E, Miller J, Chi T, Stoller ML. Complications associated with percutaneous nephrolithotomy. *Transl Androl Urol* 2012;1:223-8.
21. Palmero JL, Miralles J, Garau C, Nuño de la Rosa I, Amoros A, Benedicto A. Retrograde intrarenal surgery (RIRS) in the treatment of calyceal diverticulum with lithiasis. *Arch Esp Urol* 2014;67:331-6.
22. Sorokin I, Cardona-Grau DK, Rehfuss A, Birney A, Stavrakis C, Leinwand G, *et al.* Stone volume is best predictor of operative time required in retrograde intrarenal surgery for renal calculi: Implications for surgical planning and quality improvement. *Urolithiasis* 2016;44:545-50.
23. Geraghty RM, Jones P, Herrmann TR, Aboumarzouk O, Somani BK. Ureteroscopy is more cost effective than shock wave lithotripsy for stone treatment: Systematic review and meta-analysis. *World J Urol* 2018;36:1783-93.
24. New F, Somani BK. A complete world literature review of quality of life (QOL) in patients with kidney stone disease (KSD). *Curr Urol Rep* 2016;17:88.

How to cite this article: Venkatachalapathy VS, Palathullil DG, Sam DM, Prasad A, Abraham GP. Outcomes of retrograde intrarenal surgery in renal calculi of varying size. *Indian J Urol* 2022;38:128-34.