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ORIGINAL PAPER

Retrograde Intrarenal Surgery (RIRS) for upper urinary tract stones in children below 12 years of age: A single centre experience

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Summary *Objective: Retrograde Intra Renal Surgery (RIRS) is a minimally invasive surgical modality for the treatment of renal stones. We evaluated the efficacy of RIRS in children below aged 12 years of age in the form of stone-free rate (SFR), complications and the feasibility of the procedure.*

Materials & methods: This retrospective study included all children ≤ 12 years of age, with upper urinary tract stones single or multiple ≤ 15 mm in size who underwent RIRS between February 2019 to November 2021. RIRS was performed with 7.5 Fr flexible ureterorenoscope over the guidewire, the stones were dusted with Laser and the ureteral stent was left after RIRS. All patients had the post-procedure stent removed within 3 weeks after checking for residual stones with X-ray and ultrasonography of Kidney-Ureter-Bladder (USG-KUB). Follow-up USG KUB was done at 4 months.

Results: 15 patients included in our study met the inclusion criteria. The mean age was 8.7 ± 2.8 years, the mean stone size was 11.26 ± 2.14 mm and 26.6 % had multiple stones. Retrograde access failure was noted in 36.3 % in non stented patients. The mean operative time was 72.6 ± 20 minutes, fluoroscopy time was 4.4 ± 0.9 minutes and the mean LASER time was 26 ± 3.9 minutes. The mean hospital stay was 2.8 ± 0.9 days. Ureteral access sheath (UAS) was used in one patient. Conversion to mini PCNL was done in one pre stented patient due to access failure and one patient had a second look RIRS for residual stone. No major complications were noted except onr patient who had sepsis. The stone-free rates were 93.3% after primary RIRS and 100% after second look RIRS.

Conclusions: RIRS is a feasible, safe procedure for pediatric upper urinary stones with excellent stone-free rates and a low rate of complications.

KEY WORDS: *RIRS; Laser lithotripsy; Flexible ureterorenoscopy; Pediatric upper urinary stones.*

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INTRODUCTION

There is a global increase in the prevalence of urolithiasis in children attributed to lifestyle changes, dietary habits, climate changes, childhood obesity and the wider availability of ultrasonography (1). Underlying causes such as metabolic disorders, anatomical anomalies and infection should be investigated in pediatric stone disease and failure to evaluate these causes will lead to higher stone recurrence after treatment (2).

The European guidelines on the management of pediatric stones recommend *Extracorporeal Shockwave Lithotripsy* (ESWL) or *Percutaneous Nephrolithotomy* (PCNL) for the treatment of renal and upper ureteric calculi in the pediatric age group based on stone location, volume and density but with increasing evidence on the outcome of *Flexible ureterorenoscopy* (FURS), it has been added to the armamentarium to treat upper urinary tract stones in children (3). With the miniaturization of endourological instruments, *retrograde intrarenal surgery* (RIRS) has advantages over ESWL and PCNL due to its high *stone-free rate* (SFR) which is usually achieved in a single sitting with acceptable efficacy and low morbidity in pediatric patients. There are very few studies done to evaluate the efficacy of this method in pediatric patients. Hence in our study, we evaluated the efficacy of RIRS among children up to 12 years of age.

The primary objective of our study is to evaluate the SFR with RIRS for upper urinary tract stones in pediatric patients. The secondary objectives were the evaluation of post-procedure complications, radiation time, pain score, and duration of hospital stay.

MATERIALS AND METHODS

This is an observational retrospective study done at a tertiary care centre. The study was conducted from February 2019 to November 2021 and the data was collected from the hospital records. All pediatric patients aged 12 years and below with renal and upper ureteric stones of size less than 1.5 cm treated with RIRS were included.

Children with genetic disorders, medical renal disease and previous stone treatment on the same side were excluded.

Fifteen children met the inclusion criteria and demographic data and laboratory investigations were collected from hospital records. All patients had *Xray of Kidney-Ureter-Bladder* (Xray-KUB) and *Ultrasongraphy of Kidney-Ureter-Bladder* (USG-KUB) and those with normal serum

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creatine underwent *Computed Tomography* (CT) urography. Those patients who already had non-contrast CT KUB underwent DTPA Renogram to assess the renal functional status.
All procedures were performed under general anaesthesia after confirming a sterile urine culture. Patients have been given prophylactic antibiotic ceftriaxone 100 mg/kg IV at the time of induction of anaesthesia. Patients were positioned in lithotomy position and cystourethroscopy was performed using a 6.5 Fr Storz semirigid ureteroscope and a 0.032-inch guidewire was inserted into the ureter. Balloon dilatation of the ureteric orifice was done over the guidewire followed by semirigid ureteroscopy to assess the distensibility of the ureter. After this, under fluoroscopic and visual supervision, a 7.5 Fr FURS (*Storz FLEX X2*) was placed into the ureter over the guidewire without the use of an access sheath.
If the FURS could not be negotiated, the ureteral stent was inserted for passive dilatation and RIRS was performed later in 2 weeks. The complete pelvicalyceal system was examined with the FURS. Stone dusting was done using 272 microns Holmium laser fibre with a power of 0.2-0.6 J and 10-20 Hz frequency. This ensured that the stone was dusted and not fragmented. Visual inspection of the pelvicalyceal system and fluoroscopy was done to look for any residual stone fragments after surgery and the ureter was evaluated while removal of FURS to detect any potential ureteral trauma. A 5 Fr ureteral stent was routinely placed at the end of the RIRS and was left in place between 1 to 3 weeks. Per urethral Foleys catheter was removed on the first post-operative day.
We used the Visual Analog Scale for postoperative pain assessment. The children went home with prophylactic antibiotics for 5 days and oxybutynin till the stent removal. Xray and USG KUB were done before the stent removal between 1 to 3 weeks after RIRS to assess any residual calculi. The presence of any calculi ≥ 3 mm was considered treatment failure in calculating SFR. After confirming the absence of residual calculi, the ureteral stent was removed under general anesthesia. Follow-up USG KUB was performed at 4 months to assess the stone recurrence. The statistical investigation was performed using *Microsoft Excel*. The collected data was evaluated and presented as a range, mean, standard deviation, and percentages.

Results

In our study, 15 children with upper urinary tract stones met the inclusion criteria. Four patients had multiple stones in the kidney.
Demographics shown in Table 1.
Out of 15 patients, four patients had elective ureteral stenting before the RIRS procedure and 11 patients were not pre-stented. Retrograde access failed in 36.3% of non-stented patients requiring a second attempt after a 2 week stenting period. Conversion to mini PCNL was necessary in one of the patients who had elective pre-stenting due to access failure.
Ureteral access sheath (UAS) (9/11 Fr 25 cm) was used only in one patient due to higher stone volume and capacious ureter. All patients were discharged on the second postoperative day, except one patient who had a post-operative fever – grade 2 on the Clavien Dindo scale – and required high dose antibiotics with a longer hospital stay of 6 days. One patient with 14 mm lower pole calculi was found to have residual calculi of 7 mm in the lower pole three weeks after RIRS due to migration of the fragment which was not identified during the initial procedure. Redo RIRS was done for this patient with complete clearance.
The average fluoroscopy time was 4.4 ± 0.9 minutes.
The stone-free rate was 93.3% after primary RIRS and 100% after a second look RIRS.
The operative and post-operative are shown in Table 2.

Table 1.
Demographic details.

Variables	Number of patients (%)	Mean	Range
Age-years			
0-4 years	2	8.73 ± 2.81 years	3-12 years
5-8 years	4		
9-12 years	9		
Sex			
Male	7		
Female	8		
Side			
Right	9		
Left	6		
Stone location			
Upper ureter	2 (13.3 %)		
Renal pelvis	6 (40 %)		
Upper calyx	3 (20 %)		
Mid Calyx	2 (13.3 %)		
Lower Calyx	2 (13.3 %)		
Multiple stones	4 (26.6 %)		
Stone size - mm		11.26 ± 2.15 mm	7 to 14 mm
Hounsfield units (HU)		1132 ± 234.37 HU	720-1432 HU

Table 2.
Operative and post operative details.

Variables	Number of patients (%)	Mean	Range
Elective ureteral stent	4 /15 (26.6%)		
Ureteral access sheath used	1 (6.6%)		
Access failure during first RIRS in non stented patients	4 /11 (36.3%)		
Total number of access failure (with & without ureteral stent)	1 / 15 (6.6%)		
Operative time (minutes)		72.6 ± 20	50 to 120
Laser time (minutes)		26.07 ± 3.9	15 to 30
Radiation time (minutes)		4.4 ± 0.9	3 to 6
Hospital stay (days)		2.8 ± 0.9	2 to 6
Conversion to mini PCNL	1 (6.6%)		
Residual stone	1 (6.6%)		
Redo RIRS for residual stone	1 (6.6%)		
Post-operative complications Clavien Didno - grade 2	1 (6.6%)		
Pain score (Visual analog scale)		1.2 ± 0.9	0 to 2
Stone free rate After primary RIRS Final		 93.3% 100%	

Discussion

Management of urolithiasis in children poses a challenge because of smaller size kidneys with a small collecting system, and a small-caliber ureter. *Ferretti et al.* (4) in their study noted that an high proportion of children with stones was associated with co- morbidities like urologic malformations (42.8%), urinary infections (25%), metabolic disorders (17.8%) and non-urologic diseases (25%). This study demonstrates the need for thorough investigations in pediatric stone patients to reduce the chances of recurrent stone formation and to reduce the complications of the surgical treatment.

ESWL has been one of the standard treatment methods for renal stones up to 2 cm however it has its own disadvantages. The stone-free rates depend upon the stone volume, density, location, caliceal anatomy, and renal function. The overall stone-free rates of 79.9%, clinically insignificant residual fragments in 13.2% at 3 months, retreatment rate of 53.9%, and complication rate of 9.69% were observed in a large retrospective study by *Muslumangolu et al.* (5) The need for general anesthesia, multiple sessions, pre ESWL stenting for larger stones, post-procedure steinstrasse, technical difficulties in stone localization and unknown long term effects on renal parenchyma are the drawbacks of ESWL.

PCNL is a more invasive method reserved for larger and complex renal stones. *Unsal et al.* (6) in their study of PCNL in children below 18 years divided into 3 groups based on their age and reported overall average stone-free rates of 82.3% after the primary procedure and 93.1% after the adjunctive procedure.

They noted more bleeding and a drop in hemoglobin in children between 8 to 16 years which also depended upon the size of the instruments. The most frequently reported complication is bleeding requiring blood transfusion in less than 10% and others are postoperative infection, pain, and fever. The average hospital stay was between 3 to 4 days for PCNL.

With the miniaturization of FURS and the availability of efficient energy sources, RIRS for upper urinary tract stones has become a safe option. A systematic review of studies between 1990 to 2014 by *Ishii et al.* (7) on the safety and efficacy of *flexible ureterorenoscopy and lasertripsy* (FURSL) in children with a mean age of 7.3 years reported mean stone-free rates of 85.5% and complication rate of 12.4% for the size of the stone varied from 1 to 30 mm. *Kim et al.* (8) reported in their study of 170 FURS procedures in children with a mean age of 5.2 years, stone-free rates of 100% for stones burden < 10 mm and 97% for stones > 10 mm after a single RIRS procedure.

A study by *Unsal et al.* (9) reported a series of RIRS in 16 children below 7 years of age with a stone-free rate of 100% for stones below 10 mm and 81.8% for stones > 10 mm in size with one complication of ureteral perforation occurring after balloon dilatation of ureteric orifice.

Ferretti S et al. (4) reported in their study of 28 children with a mean age of 8 years with urinary tract stones achieved stone free rate of 76.6% after first procedure and 93.3% after redo surgery with no major complications. In their study the stone size ranged from 5 to 24 mm with a mean stone area of 1.15 cm^2 and they used rigid URS, RIRS and combination of both procedures to treat the stone. In our study the stone-free rate observed was 93.3%, with no major complications for the mean stone size of 11.2 ± 2.15 mm after a single RIRS procedure.

As RIRS procedure is done through a natural orifice (urethra) without any need for a puncture in the kidney which causes minimal post-procedure pain, low requirement of analgesics, faster recovery, and shorter hospital stay. Complications like bleeding, clot retention, and need for blood transfusion are rare with this procedure (9) We used balloon dilatation of the ureteric orifice in all cases but *Kim et al.* (8) did not use active ureteric dilatation with good stone-free rates and other studies mention hydrodistension is equally effective (3).

We did not routinely perform pre-procedure ureteral stenting and our retrograde access failure rate was 36.3% for primary RIRS in non stented patients. *Chandramohan et al.* (10) in their study of RIRS of 67 preschool children aged < 5 years for pediatric renal stones reported routine pre-procedure stenting in all their patients and reported only a 5.98 % retrograde access failure rate. *Corcoran et al.* (11) mention that routine placement of a pre-procedure ureteral stent for passive ureteral dilatation is not required for successful ureteroscopic access to the renal pelvis in prepubertal age group children. If the initial attempt of ureteroscopy is unsuccessful then placement of a ureteral stent decreases the number of procedures while maintaining a low complication rate.

In our experience, we did not routinely use UAS except in one patient due to larger stone volume and a capacious ureter. We did not use the basket for stone retrieval as the stone was dusted with laser energy and it was not necessary for the repeated passage of FURS to retrieve the stone fragments which increases the chance of ureteral trauma. In a study (10) of RIRS for renal stones in preschool children only in 63.5 % of the cases, UAS could be safely used even though all of the patients had undergone pre-RIRS stenting and in the study are reported 2 ureteral injuries of grade 1 and grade 2 according to the Traxer and Thomas classification (12) which were managed by post-procedure stenting for 4 weeks with no long term complications like ureteral stricture. They have also noted lower success rate of placing UAS in children less than 4 years old in spite of pre-RIRS ureteral stent insertion for passive ureteral dilatation. *Anbarasan et al.* (13) reported the results of RIRS using 9.5 Fr UAS in 21 pediatric patients with a mean age of 11.8 years with a mean follow-up of 26 months with no long-term complications. In their study, only 8 patients had pre-procedure stenting. *Berrettini et al.* (14) performed RIRS for stones in 13 preschool children with body weight < 20 kg, and all of them had pre-procedure stenting. They concluded that the use of UAS is safe and effective with no long term complications. *Mosquera et al.* (15) reported from the data collected from 48 patients with a mean age of 10.7 years mention that use of UAS was safe with excellent outcomes, especially for large and multiple stones. They noticed grade 1 ureteric injury in one patient and suggest to use the smallest size UAS. All our patients had post-procedure stenting and most of the studies advocate post-procedure stenting or ureteral catheter drainage with variable duration.

Chen Y et al. (16) did a systematic review on the safety and

efficacy of PCNL versus RIRS for pediatric upper urinary stones and noted significantly shorter hospital stay and fluoroscopy time for RIRS than PCNL. The overall minor and major complication rates were higher in PCNL but not statistically significant. RIRS benefits from the significantly lesser requirement of blood transfusion. They also found no significant differences in the stone-free rates and operative times. *Bas O et al.* (17) reported that for stones between 10-20 mm, RIRS has similar success and complication rates with shorter hospital stay and low radiation exposure when compared to micro-PCNL. For stones larger than 2 cm, *Saad KS et al.* (18) reported that RIRS monotherapy has lower stone-free rates than mini-PCNL but with the advantages of decreased radiation exposure, fewer complications, and shorter hospital stay. *Mokhless et al.* (19) in their prospective study compared ESWL versus RIRS for 10 to 20 mm stones and found that stone free rate after a single session was 70% and 86.6% and overall stone-free rate at 3 months was 93.3% and 96% with no major complications in both the groups. *Ergin et al.* (20) did a retrospective study that reported similar stone-free rates for ESWL and RIRS for pediatric renal stones between 10 to 20 mm with no complications seen in either modality. ESWL had longer fluoroscopy time and shorter hospital stay but RIRS had a higher cost per patient. The mean fluoroscopy time in our study was 4.4 ± 0.9 minutes and the lower radiation is beneficial for pediatric patients when additional procedures are required for stone clearance.

He Qing et al. (21) in their systematic review of three modalities of treatment – ESWL, PCNL and RIRS – for pediatric upper urinary tract stones concluded that ESWL provides shorter hospital stay and operative time, lower SFR, higher auxiliary procedure rate with relatively lower *effectiveness quotient* (EQ). PCNL is associated with higher SFR than ESWL, but has longer fluoroscopy time, operative time, and highest EQ when compared to RIRS and ESWL. RIRS offers higher SFR after a single session, a lower retreatment rate than ESWL, a shorter hospital stay than PCNL, and lower EQ. Complication rates were comparable among the three modalities however higher complication rates were found in subgroups of PCNL. There was no major post-operative complication in our study, only one patient had sepsis requiring high dose antibiotics and a longer hospital stay. *Mosquera et al.* (22) reviewed the data of 57 children who underwent FURSL for lower pole stones from two large European tertiary endourology centers and reported initial and final stone-free rates of 82.4% and 98.2% respectively; 1.19 procedures per patient were required to be stone free.

Despite the advantages of RIRS, there are certain drawbacks associated with this procedure. Pre-procedure ureteral stent under general anesthesia for passive ureteral dilatation may be required especially in children below 5 years of age. It has lower stone-free rates for stones sizes more than 2 cm and may require additional procedures. There are chances of ureteral injury during placement of UAS and sometimes the UAS could not be safely used in spite of pre-procedure stenting. Most of the patients require ureteral stent insertion after RIRS which requires another procedure under general anesthesia for stent removal. These additional procedures could influence the EQ of RIRS. With increasing expertise, RIRS has become a good option over ESWL for upper urinary stones of 10 to 20 mm size in children as it has higher stone-free rates which are usually achieved in a single sitting, and also over PCNL as it has lower morbidity and low post-operative complications with faster recovery. Our study suggests that RIRS is a feasible and safe alternative to PCNL for pediatric patients with upper urinary stones in selected cases with lower complication rates and a faster recovery period.

Conclusions

Pediatric RIRS requires expertise and to be carried out in tertiary centers.

Routine pre-procedure ureteral stenting and use of ureteral access sheath are not required; however, a randomized prospective study with multivariate analysis would be helpful. RIRS is a safe endourological procedure with high stone-free rates, low complication rate for the treatment of pediatric upper urinary tract stones less than 2 cm in size.

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