

Current status of retrograde intrarenal surgery for management of nephrolithiasis in children

Yaser El-Hout, Aziza Elnaeema, Walid A. Farhat

Division of Urology, The Hospital for Sick Children, Toronto, Canada

ABSTRACT

Purpose: To review the current status of retrograde intrarenal surgery (RIRS) for renal stones in children focusing on its indications, outcomes and success in the management of nephrolithiasis.

Materials and Methods: Between 1988 and 2009, a comprehensive PubMed/MEDLINE literature review on RIRS was conducted.

Results: The available literature is limited and heterogeneous, skewed by favorable results on ureteral stone outcomes. However, recent case series report outcomes comparable to time-honored modalities: percutaneous nephrolithotomy and shock wave lithotripsy. Concerns about urinary tract damage are not substantiated by the yet available intermediate-term follow-up.

Conclusions: RIRS seems to be an effective modality in pediatric nephrolithiasis management. However, long-term outcomes and comparative prospective randomized studies are awaited.

Key words: Endoscopy, kidney, pediatrics, stones

INTRODUCTION

With improving sensitivity of radiologic imaging and changing referral patterns, there is an increasing trend in the diagnosis of urologic stone disease in children.^[1] Although pediatric stone disease is still less common than in adults, with a prevalence of 4.7 per 100,000 versus 62 per 100,000 inpatients,^[2] stones in children pose unique concerns in their management, owing to the distinct pediatric urologic anatomy and stone pathophysiology as well as profound healthcare concerns, owing to the high recurrence rate. With the rapid advances in technology, the historic open surgery for stones has been replaced by less-invasive modalities,

particularly extracorporeal shockwave lithotripsy (ESWL) and percutaneous nephrolithotomy (PCNL) being advocated as primary treatment, each alone or in combination.^[3,4] For adult nephrolithiasis, retrograde intrarenal surgery (RIRS) is a known option to treat upper tract calculi with excellent success.^[5] In children, RIRS emerged over the last couple of decades and is now an established and accepted modality for kidney stone management. The European (EUA) and American Urological Associations guidelines for pediatric renal stones still advocate ESWL as the first-choice treatment modality, followed by PCNL for larger or complex calculi.^[6,7] Nonetheless, the miniaturization of endoscopes, fiber-optics technology, availability of holmium:YAG laser and other ancillary instruments have rendered RIRS an attractive modality for pediatric patients. With ongoing accumulation of experience in pediatric RIRS, we sought to address its current status focusing on its indications, outcomes and success in the management of nephrolithiasis in children.

For correspondence: Dr. Walid A. Farhat, Associate Professor, Pediatric Urologist, Division of Urology, The Hospital for Sick Children, 555 University Avenue, Toronto, M5G 1X8, Ontario, Canada. E-mail: walid.farhat@sickkids.com

MATERIALS AND METHODS

We conducted a comprehensive PubMed/MEDLINE search of the available literature on RIRS between the years 1988 and 2009. We included articles on the pediatric population written in English. Almost all articles were case series. Articles describing technical aspects that would facilitate RIRS were also reviewed. Prior to 1988, pediatric ureteroscopy was not

Access this article online

Quick Response Code: 	Website: www.indianjurol.com
	DOI: 10.4103/0970-1591.74463

described and articles prior to this period were excluded. We focused on patient populations, stone characteristics, including size and location, and outcomes, including stone burden clearance and complications, in contemporary case series addressing pediatric patients with renal stones.

RESULTS

Over the last half decade, less than a dozen case series are published reporting on their experience in utilizing RIRS for the management of renal stones in children [Table 1]. Many of those case series^[8-11] had small study populations and included the outcome of ureteral calculi, being the major stone location managed, to the overall analysis. Reporting on a heterogeneous stone location skewed and increased the success rates to a misleading higher rate ranging from 88 to 100%. Smaldone *et al.*^[12] had one of the largest case series of 100 patients, one-third of who had renal stones. A success rate of 91% is reported, noting that the average size of the stones was only 8 mm. The outcome for renal stones was not reported separately and more than 20 patients underwent ureteroscopy as a staged or a secondary procedure, making it difficult to interpret the outcome of RIRS as a single modality. Lower success rates were generally noted in studies that exclusively reported on renal stones. The location of stones seems to impact the success rate as well. Cannon *et al.*^[13] noted a 76% success rate in a series of 21 patients, all having lower pole stones averaging 1.2 cm in size. Similar success was noted in a study from our institution,^[14] where Dave *et al.* reported a 75% success for pelvic stones. Polar calculi had a 100% success, but results should be cautiously interpreted as only four patients were treated (two upper pole and two lower pole), all requiring multiple sessions (2–3 times). Of note, seven patients had staghorn calculi, with a discouraging success rate of 14%. The Children's Hospital of Philadelphia recently reported the largest case series utilizing flexible pediatric ureteroscopy^[15] with RIRS used to manage 101 renal stones (87 lower polar). The overall average stone size was 6 mm. For an arbitrary cut-off of 10 mm, this study

shows a success rate of 100% for sub-centimetric calculi, yet an impressive 97% success for calculi larger than 1 cm. However, it is noteworthy that access was not possible in the first surgery for 59% of the patients, raising concerns for additional anesthesia for more than half of their patients. In another recent publication, Tanaka *et al.*^[16] reported their 5-year experience on pediatric RIRS, noting a 50% stone-free rate on initial post-operative follow-up and 58% on extended follow-up. Peculiar to this study is its assessment of the influence of pre-operative factors on initial stone-free status and the need for extra procedures. Interestingly, initial stone-free status depended on pre-operative stone size ($P = 0.005$) but not on stone location. The younger patient age ($P = 0.04$) and larger pre-operative stone size ($P = 0.002$) influenced the need for extra procedures that were required in more than half of the stones ≥ 6 mm but in no stone < 6 mm.

Technical aspects associated with RIRS include the need of dilatation and stenting. Intuitively, dilatation of the ureter would be needed when larger rigid ureteroscopes are used. In fact, Bassiri *et al.*^[17] performed 66 rigid ureteroscopies using 11.5, 9, 8.5 or 8 Fr ureteroscopes on 26, 14, 5 and 21 patients (mean age 9 years, range 2–15 years), respectively; ureteral dilatation was necessary in 23, 0, 0 and 2 cases, respectively. Herndon *et al.* did not require dilatation using Wolfe 4.5 Fr or 6.5 Fr tapered semi-rigid ureteroscope alongside a guide wire to access the upper tracts for stones.^[18] With the advent of flexible ureteroscopes, rendered as fine as 4.5 Fr, coupled with ureteral access sheaths, dilatation of the ureter becomes virtually pointless. Indeed, in the Philadelphia flexible ureteroscopy case series, no ureter was actively dilated.^[15] The need for post-operative stenting seems inconsistent and controversial in literature. Some investigators prophylactically stented all their patients based on perceived complexity or difficulty of case, with no clear indicators; dangler strings, to obviate the need of further general anesthesia, were again used based on unclear surgeon discretion.^[14,15] Hendron *et al.* stented six of 29 children (21%); two had infection associated with either autonomic dysreflexia or stone impaction, two for

Table 1: Contemporary results of RIRS for pediatric renal calculi

Series	Patients (n)	Ureteral stones	Renal stones	Average size (mm)	Outcome
Tan <i>et al.</i> ^[8]	23	25 stones	2 stones	9	95% success
Minevich <i>et al.</i> ^[9]	58	58 stones	7 patients	Not available	98% success
Thomas <i>et al.</i> ^[10]	29	28 patients	1 patient	6	88% success
Sofer <i>et al.</i> ^[11]	21	12 patients	9	11	100% success
Smaldone <i>et al.</i> ^[12]	100	67	33	8.3	91% success
Cannon <i>et al.</i> ^[13]	21	0	All lower pole	12	76% success
Dave <i>et al.</i> ^[14]	19	0	23 stones	17	Pelvic 75% success Polar 100% success Staghorn 14% success
Kim <i>et al.</i> ^[15]	167	66 stones	101 stones (87 lower pole)	6	100% success (<10 mm) 97% success (>10 mm)
Tanaka <i>et al.</i> ^[16]	50	0	52	8	58% success

Table 2: Raza *et al.*: Comparative outcomes for different treatment modalities

	ESWL	PCNL	RIRS (+ Ho laser)
	122	37	35
No. of renal units	140	43	35
Mean age (years)	7.7	6.4	5.9
No. of treatments	209	46	53
Mean stone size (mm)	17	40	12
Need for ancillary procedures	45%	34%	26%
Complication rate	26%	6%	0%
Overall stone-free rate	84%	79%	100%
	(for <20 mm)		
	54%		
	(for >20 mm)		

extravasation or perforation, one for edema and one for subsequent ESWL.^[18]

DISCUSSION

The ultimate objective of stone therapy is to render the patient stone free. This is particularly crucial in the pediatric population that is by default considered high risk for complications and for recurrence. The importance of post-treatment stone-free status in children was demonstrated by Afshar *et al.*, who showed that 69% of the children with residual fragments ≤ 5 mm up to 48 months after ESWL had symptomatic episodes or increase in stone size.^[19] This feature of pediatric stone disease should be factored in the choice of treatment modality. Indeed, ureteroscopy in children lagged behind its use in adults owing to the initial unavailability of small instruments, coupled by the plethora in ESWL in the 1980s. However, ESWL was not the panacea in renal stone management, despite a cumulative success rate of 60–99%. The results of ESWL are worse in stone burden of ≥ 2 cm, lower pole or impacted ureteropelvic junction stones and in dense stones composed of calcium oxalate monohydrate or cystine.^[20] The main drawback of ESWL is, depending on stone burden, that up to 75% of the patients would require multiple sessions.^[21,22] In children, that would translate into additional general anesthesia sessions and further radiation exposure, which opposes the concept of minimizing interventions and fluoroscopy in children to as low as reasonably achievable.^[23] Recent concern arises on the possible long-term risks of hypertension and diabetes with ESWL.^[24] The susceptibility of pediatric kidneys in this regard is still unexplored. It remains to say that ESWL is still not Food and Drug Administration approved in children.^[6] On the other hand, PCNL has a role in larger stone burden/staghorn calculi, acute obstruction or infection and after failed ESWL. Despite a success rate of 85–98% and “mini-perc” modification, PCNL remains relatively invasive, which is restrictive in infants and younger children as well as when further procedures for

recurrent stones are required.^[25-27]

With the realization of the limitations of ESWL and PCNL and the progressive technology in miniaturization of semi-rigid ureteroscopes, Ritchey *et al.* adopted retrograde endoscopy for pediatric distal ureteral stones in 1988, with high success approaching 100%.^[28] Further refinement of flexible scopes, as fine as 4.5 Fr, with durability and improved optics, has expanded the use of retrograde endoscopic surgery to target more proximal stones as first-line modality. Holmium:YAG laser offered an efficient energy source for now possible single-session treatments and 270° deflecting tips offered access to lower calyceal stones.

As RIRS was getting established in clinical practice, concerns were raised regarding its safety and efficacy as well as its potential complications. In theory, manipulation of the delicate ureteral orifices and ureters in children could lead to ischemic insult as well as dilation and decompensation of the ureterovesical junction, leading to vesicoureteral reflux, ureteral strictures, perforation or avulsion. However, Schuster *et al.* reviewed 221 ureteroscopies in children and found only two patients developing strictures and eight having low-grade vesicoureteral reflux.^[29] This low complication rate was not correlated with the size of the scope used, duration of the procedure or the length of follow-up. Further studies demonstrated the safety of RIRS.^[30] Furthermore, RIRS was shown to have comparable or better efficacy to established modalities. De Dominicis *et al.* randomly compared ureteroscopy and ESWL in 31 children. After single treatment, 16 of 17 (94%) patients were stone free after ureteroscopy versus 6 of 14 (43%) patients being stone free after ESWL.^[31] Pearle *et al.* compared RIRS to ESWL in a prospective randomized trial in their efficacy on lower pole stones up to 1 cm. On follow-up imaging, 35% of ESWL treated versus 50% of RIRS treated were stone free (*P*-value not significant).^[32]

Given that this was an adult study, cautious extrapolation into children is warranted. Raza *et al.* retrospectively compared a 15-year experience (1988–2003) with different stone management modalities. They concluded that for renal stones <20 mm, ESWL was the most effective primary treatment modality. For renal stones ≥ 20 mm or staghorn stones, PCNL was the preferred primary treatment with lower rates of ancillary procedure and re-treatments. Holmium laser ureteroscopy and RIRS had high stone-free rates and low complication rates, but superiority was demonstrated for ureteral stones only.^[33] [Table 2].

Finally, it was shown that ureteroscopy is more cost-effective than ESWL. Parker *et al.*^[34] retrospectively compared the cumulative cost of treatment for proximal stones of 111 patients undergoing ESWL (73 with stones <1 cm) versus 109 patients undergoing ureteroscopy (81 with stones <1 cm) over 1997–2001. In the ureteroscopy group, 91% were

successfully treated with one intervention versus 55% of the ESWL group ($P < 0.0001$). With ureteroscopy failure, all but one was treated successfully with a second ureteroscopy. With ESWL failure, 52% were treated successfully by subsequent URS. The remaining ESWL failures were treated with repeat ESWL with a 62% success rate. The ureteroscopy group required fewer days to be stone free (8 versus 25.5 days, $P < 0.0001$). Ureteroscopy had significantly lower charges for the initial procedure (\$ 7,575 versus \$ 9,507, $P < 0.0001$) and lower total charges (\$ 9,378 versus \$ 15,583, $P < 0.0001$). Although this applies for ureteral stones, no similar studies were conducted for renal stones.

CONCLUSIONS

No doubt, there is an increasing trend in the adoption of RIRS as both a first line and a single modality in the management of renal stones in children. This has been facilitated by both the rapidly evolving technology and the particular drawbacks that are intrinsically associated with ESWL and PCNL. However, particular clinical scenarios, for example, anatomic anomalies, concomitant renal and ureteral stones, and decreased fragment clearance after ESWL, stone burden in size and multiplicity or dense stones (cystine) not favorable for ESWL, need to be factored into the decision-making process to which treatment modality/combination is preferable. The initial concerns of increased risks and complications associated with ureteroscopic manipulation of the delicate ureteral orifices and ureters of children do not seem to be substantiated in the literature. There remains, however, a limited and a non-uniform reporting in the literature of the outcome of RIRS in children, making the surgeon's experience of principal importance in counseling and offering treatment to children with renal stones. In addition, access to technology and resources in different parts of the world is inconsistent. Until prospective randomized trials comparing different treatment options are available, the ideal management of pediatric renal stones remains individualized rather than standardized.

REFERENCES

1. Tanaka ST, Pope JC 4th: Pediatric stone disease. *Curr Urol Rep* 2009;10:138-43.
2. Pearle MS, Calhoun E, Curhan GC: Urolithiasis. In *Urologic Diseases in America*. In: Litwin MS, Saigal CS, editors. Washington, DC: US Department of Health and Human Services, National Institutes of Health, National Institute of Diabetes and Digestive and Kidney Diseases. US Government Printing Office, NIH Publication No. 07-5512; 2007. p.283-319.
3. Muslumanoglu AY, Tefekli A, Sarilar O, Binbay M, Altunrende F, Ozkuvanci U. Extracorporeal shockwave lithotripsy as first line treatment alternative for urinary tract stones in children: A large scale retrospective analysis. *J Urol* 2003;170:2405-8.
4. Dawaba MS, Shokeir AA, Hafez AT, Shoma AM, El-Sherbiny MT, Mokhtar A, *et al.* Percutaneous nephrolithotomy in children: Early and late anatomical and functional results. *J Urol* 2004;172:1078-81.
5. Grasso M. Ureteropyeloscopic treatment of ureteral and intrarenal calculi. *Urol Clin North Am* 2000;27:623-31.
6. Straub M, Gschwend J, Zorn C. Pediatric urolithiasis: The current surgical management. *Pediatr Nephrol* 2010;25:1239-44.
7. Preminger GM, Assimos DG, Lingeman JE, Nakada SY, Pearle MS, Wolf JS Jr; AUA Nephrolithiasis Guideline Panel). Chapter 1: AUA guideline on management of staghorn calculi: Diagnosis and treatment recommendations. *J Urol* 2005;173:1991-2000.
8. Tan AH, Denstedt JD, Razvi H. Ureteroscopy for pediatric urolithiasis: An evolving first-line therapy. *Pediatric Urol* 2004;65:153-6.
9. Minevich E, Defoor W, Reddy P, Nishinaka K, Wacksman J, Sheldon C, *et al.* Ureteroscopy is safe and effective in prepubertal children. *J Urol* 2005;174:276-9.
10. Thomas JC, DeMarco RT, Donohoe JM, Adams MC, Brock JW 3rd, Pope JC 4th. Pediatric ureteroscopic stone management. *J Urol* 2005;174:1072-4.
11. Sofer M, Binyamini J, Ekstein PM, Bar-Yosef Y, Chen J, Matzkin H, *et al.* Holmium laser ureteroscopic treatment of various pathologic features in pediatrics. *Urology* 2007;69:566-9.
12. Smaldone MC, Cannon GM Jr, Wu HY, Bassett J, Polsky EG, Bellinger MF, *et al.* Is ureteroscopy first line treatment for pediatric stone disease? *J Urol* 2007;178:2128-31.
13. Cannon GM, Smaldone MC, Wu HY, Bassett JC, Bellinger MF, Docimo SG, *et al.* Ureteroscopic management of lower pole stones in a pediatric population. *J Endourol* 2007;21:1179-82.
14. Dave S, Khoury AE, Braga L, Farhat WA: Single-institutional study on role of ureteroscopy and retrograde intrarenal surgery in treatment of pediatric renal calculi. *Urology* 2008;72:1018-21.
15. Kim SS, Kolon TF, Canter D, White M, Casale P. Pediatric flexible ureteroscopic lithotripsy: The children's hospital of Philadelphia experience. *J Urol* 2008;180:2616-9.
16. Tanaka ST, Makari JH, Pope JC 4th, Adams MC, Brock JW 3rd, Thomas JC. Pediatric ureteroscopic management of intrarenal calculi. *J Urol* 2008;180:2150-3.
17. Bassiri A, Ahmadnia H, Darabi MR, Yonessi M. Transureteral Lithotripsy in Pediatric Practice. *J Endourol* 2002;16:257-60.
18. Herndon CD, Viamonte L, Joseph DB. Ureteroscopy in children: Is there a need for ureteral dilation and postoperative stenting? *J Pediatr Urol* 2006;2:290-3.
19. Afshar K, McLorie G, Papanikolaou F, Malek R, Harvey E, Pippi-Salle JL, *et al.* Outcome of small residual stone fragments following shock wave lithotripsy in children. *J Urol* 2004;172:1600-3.
20. Jayanthi VR, Arnold PM, Koff SA. Strategies for managing upper tract calculi in young children. *J Urol* 1999;162:1234-7.
21. Muslumanoglu AY, Tefekli A, Sarilar O, Binbay M, Altunrende F, Ozkuvanci U. Extracorporeal shock wave lithotripsy as first line treatment alternative for urinary tract stones in children: A large scale retrospective analysis. *J Urol* 2003;170:2405-8.
22. Aksoy Y, Ozbey I, Atmaca AF, Polat O. Extracorporeal shock wave lithotripsy in children: Experience using a MPL-9000 lithotriptor. *World J Urol* 2004;22:115-9.
23. Strauss KJ, Kaste SC. The ALARA (as low as reasonably achievable) concept in pediatric interventional and fluoroscopic imaging: Striving to keep radiation doses as low as possible during fluoroscopy of pediatric patients—A white paper executive summary. *Radiology* 2006;240:621-2.
24. Krambeck AE, Gettman MT, Rohlinger AL, Lohse CM, Patterson DE, Segura JW. Diabetes mellitus and hypertension associated with shock wave lithotripsy of renal and proximal ureteral stones at 19 years of follow up. *J Urol* 2006;175:1742-7.
25. Desai MR, Kukreja RA, Patel SH, Bapat SD. Percutaneous nephrolithotomy for complex pediatric renal calculus disease. *J Endourol* 2004;18:23-7.
26. Desai M. Endoscopic management of stones in children. *Curr Opin Urol* 2005;15:107-12.
27. Jackman SV, Hedican SP, Peters CA, Docimo SG. Percutaneous nephrolithotomy in infants and preschool age children: Experience with a new technique. *Urology* 1998;52:697-701.

28. Ritchey M, Patterson DE, Kelalis PP, Segura JW. A case of pediatric ureteroscopic lasertripsy. *J Urol* 1988;139:1272-4.
29. Schuster TG, Russell KY, Bloom DA, Koo HP, Faerber GJ. Ureteroscopy for the treatment of urolithiasis in children. *J Urol* 2002;167:1813.
30. Lesani OA, Palmer JS. Retrograde proximal rigid ureteroscopy and pyeloscopy in prepubertal children: Safe and effective. *J Urol* 2006;176:1570-3.
31. De Dominicis M, Matarazzo E, Capozza N, Collura G, Caione P. Retrograde ureteroscopy for distal ureteric stone removal in children. *BJU Int* 2005;95:1049-52.
32. Pearle MS, Lingeman JE, Leveillee R, Kuo R, Preminger GM, Nadler RB, *et al.* Prospective, randomized trial comparing shock wave lithotripsy and ureteroscopy for lower pole caliceal calculi 1 cm or less. *J Urol* 2005;173:2005-9.
33. Raza A, Turna B, Smith G, Moussa S, Tolley DA. Pediatric urolithiasis: 15 years of local experience with minimally invasive endourological management of pediatric calculi. *J Urol* 2005;174:682-5.
34. Parker BD, Frederick RD, Philip Reilly T, Lowry PS, Bird ET. Efficiency and cost of treating proximal ureteral stones: Shock wave lithotripsy versus ureteroscopy plus holmium: Yttrium-aluminum-garnet laser. *Urology* 2004;64:1102-6.

How to cite this article: El-Hout Y, Elnaeema A, Farhat WA. Current status of retrograde intrarenal surgery for management of nephrolithiasis in children. *Indian J Urol* 2010;26:568-72.

Source of Support: Nil, **Conflict of Interest:** None declared.