Comparison of Mini-percutaneous Nephrolithotomy and Retrograde Intrarenal Surgery in Preschool-aged Children

Eyyup Sabri Pelit, Gökhan Atis, Bülent Kati, Yiğit Akin, Halil Çiftçi, Meftun Culpan, Ercan Yeni, and Turhan Caskurlu

OBJECTIVE To compare the outcomes of mini-percutaneous nephrolithotomy (m-PCNL) and retrograde intrarenal surgery (RIRS) in treating renal stones in preschool-aged children.

MATERIALS AND METHODS Forty-five patients treated with m-PCNL and 32 patients treated with RIRS for renal stones were compared retrospectively. The operative and postoperative outcomes of both groups were analyzed retrospectively.

RESULTS The mean age and gender were similar between the groups. The mean stone size was 19.30 ± 4.21 mm for the RIRS group and 21.06 ± 5.61 mm for the PCNL group (P = .720). The mean operative times, fluoroscopy times, and hospitalization times were statistically higher in the PCNL group. The stone-free rates (SFRs) after a single procedure were 84.4% in the PCNL group and 75% in the RIRS group (P = .036). After auxiliary procedures, the overall SFRs reached 91.1% for the PCNL group and 90.6% for the RIRS group (P = .081). No major complications were observed for both groups. Minor complication (Clavien 1-3) rates were 15.5% and 12.5% for the PCNL and RIRC group, respectively (P = .385).

CONCLUSION RIRS has some advantages over PCNL such as shorter hospitalization times, shorter fluoroscopy times, and shorter operative time in treating renal stones. However, PCNL achieves higher SFR after a single session. UROLOGY 101: 21–25, 2017.

Childhood urolithiasis is a common health problem and accounts for a large proportion of pediatric morbidity and hospitalization in developing countries. Pediatric renal calculi are especially seen in endemic countries such as Turkey and Pakistan.[1] Unlike adult patients, underlying metabolic disorders or anatomical malformation or recurrent infections generally cause kidney stone in pediatric age population. For this reason, pediatric patients are at high risk for recurrent stone disease and may require multiple interventions.[2]

In recent years, with the advancement of miniaturization of urological instruments, minimally invasive techniques are used in the treatment of pediatric renal stones. For years, extracorporeal shock wave lithotripsy (ESWL), mini-percutaneous nephrolithotomy (mini-PCNL), micro-percutaneous nephrolithotomy (micro-PCNL), and retrograde intrarenal surgery (RIRS) have been safely and effectively used for the treatment of pediatric renal stones. Mini-PCNL has been performed for larger stones and need less ancillary procedures but have serious complications due to the fragile parenchyma, small caliber collecting system, and mobile kidney in pediatric patients.[3] In comparison, RIRS is a less invasive alternative method that has been performed for smaller stones and may be performed in multiple stages in stones larger than 2 cm.[4]

In current literature, no previous study has examined RIRS and mini-PCNL for patients' below 6 years old. In this study, we aimed to compare RIRS and mini-PCNL by evaluating stone-free rates (SFRs) and complications in preschool-aged children.

MATERIALS AND METHODS

Seventy-seven patients aged ≤6 years old who underwent RIRS (n = 32) or mini-PCNL (n = 45) for renal stones were reviewed retrospectively between May 2013 and January 2016 in 2 tertiary referral centers in Turkey. Patients were classified individually as belonging to either the RIRS or the mini-PCNL group. All surgeons could perform both types of surgery. Both hospitals are high-volume centers and have surgeons with expertise

Financial Disclosure: *The authors declare that they have no relevant financial interests.*

From the Department of Urology, Faculty of Medicine, Harran University, Sanliurfa, Turkey; and the Department of Urology, Faculty of Medicine, Istanbul Medeniyet University, Istanbul, Turkey

Address correspondence to: Eyyup Sabri Pelit, M.D., Department of Urology, Faculty of Medicine, Harran University, Sanliurfa 63300, Turkey. E-mail: dreyyupsabri@hotmail.com

Submitted: August 24, 2016, accepted (with revisions): October 27, 2016

http://dx.doi.org/10.1016/j.urology.2016.10.039
0090-4295

especially in pediatric renal stones. Patients were preoperatively evaluated for complete blood count, serum biochemistry, and urine culture, and had coagulation tests. Urinary tract infection was treated according to the antibiogram results. Urinary ultrasound, noncontrast tomography (NCCT), and/or intravenous pyelography were performed in all patients as an imaging method. Stone size was accepted as the longest axis measured on NCCT and in case of multiple stones, sizes were defined as the sum of the longest diameter of each stone.

Patients' age, stone size, fluoroscopy and operation time, SFRs, stone composition, complication of each procedure, and hospitalization time were retrospectively analyzed.

Mini-PCNL Technique

All procedures were performed in standard prone position under general anesthesia. A 4 Fr ureteric catheter was inserted via pediatric cystoscopy or semi-rigid ureteroscopy with fluoroscopy guidance. Percutaneous renal puncture was achieved with an 18 Ga needle after displaying renal collecting system with contrast material. According to the stone size and age of children, tract dilation was performed up to 20 Fr or 22 Fr with Amplatz renal dilator set. A 17 Fr rigid nephroscope and a pneumatic lithotripsy as an only energy source were used for surgery. Fluoroscopic imaging control to detect the residual fragment was performed at the end of the surgery. Nephrostomy catheter was inserted routinely in all patients and antegrade pyelography was performed to check the location of nephrostomy tube and extravasation. Ureteral catheter and nephrostomy tube were removed on postoperative day 1, 2, or 3 if there are no complications.

RIRS Technique

The procedures were performed under general anesthesia in frog leg or lithotomy position in all patients. Firstly, semi-rigid ureteroscopy was performed to insert the guidewire and to create the ureteral dilation before placing the 9.5 Fr ureteral access sheath (UAS). Ureteral orifice was passively dilated with double-J (DJ) stent for 2-4 weeks if necessary. UAS was inserted over the guidewire with fluoroscopy control. A 7.5 Fr flexible ureteroscope (f-URS, Karl Storz, Tuttlingen, Germany) was passed through the UAS. If the UAS does not pass over the guidewire, we tried to move the f-URS over the guidewire without access sheath. A DJ stent was placed and the procedure was postponed for 2-4 weeks in case of unsuccessful access to the renal collecting system with or without UAS. In all cases, Holmium:YAG laser was used for the stone fragmentation. Stones were fragmented into small pieces less than 3 mm and left for spontaneous passage. Sometimes, nitinol baskets were used to extract residual fragment only for stone analysis. Stone repositioning was performed for lower pole stones, with nitinol basket in some patients. A double-J stent (3 Fr-4 Fr) was placed at the end of the procedure. Ureteral catheter was inserted in selected cases with low stone burden <1 cm and in the absence of residual fragmentation at the end of the surgery. DJ stents were removed 2-4 weeks after the operation and ureteral catheter was removed a day after the surgery.

All patients were evaluated with kidney-ureter-bladder for residual fragmentations and stent localization on the first postoperative day. Patients were reevaluated with ultrasound and kidney-ureter-bladder or NCCT if ancillary treatment modality is necessary at 3 months postoperatively. Procedures were accepted as stone free when there are no residual fragmentations on radiological imaging method at 3-month follow-up. Metabolic assessment was performed in all patients at 1 month postoperatively.

Statistical Analysis

All statistical analyses were performed using SPSS 11.5 (IBM, Armonk, NY). Demographic data, stone characteristic, operative technique, radiation time, complications, SFR, and hospital stay were compared between the 2 groups. Categorical and continuous variables were compared with the chi-square test and Mann-Whitney *U* test, respectively. Statistical significance was defined as $P < .05$.

RESULTS

A total of 77 patients were included in this study: 45 patients in the mini-PCNL group and 32 patients in the RIRS group. Male to female ratios in the mini-PCNL and RIRS groups were 24:21 and 17:15, respectively. The mean age in the mini-PCNL group and the RIRS group was 3.71 ± 1.89 (1.7 months-5.4 years) and 3.65 ± 1.95 (1.1-6 years), respectively ($P = .835$). The mean stone size was 21.06 ± 5.61 mm in the mini-PCNL group and 19.30 ± 4.21 mm in the RIRS group ($P = .720$). The mean hospitalization, operation, and fluoroscopy times were 3.46 ± 1.77 days, 85.22 ± 12.87 minutes, and 60.88 ± 23.38 seconds in the mini-PCNL group, and 1.2 ± 0.52 days, 46.25 ± 9.30 minutes, and 4.15 ± 1.98 seconds in the RIRS group, respectively ($P < .001$). Initial SFRs in the mini-PCNL group and the RIRS group were 84.4% and 75%, respectively ($P = .036$). A total of 5 patients required additional intervention (2 ESWL, 2 RIRS, and 1 URS + DJ stent placement) in the mini-PCNL group. Three out of these 5 patients were completely stone free and these additional procedures increased the overall success rate from 84.4% to 91.1%. In the mini-PCNL group, 4 patients were followed up via ultrasonography for insignificant fragments. In the RIRS group, SFR increased to 90.6% after the second intervention (3 re-RIRS, 1 ESWL, and 1 URS + DJ stent placement) and 3 patients had asymptomatic residual fragments <4 mm in the kidney.

In the RIRS group, 12 (37.5%) patients required passive dilatation of the orifice with DJ stent. No active dilatation was performed. UAS was placed in 14 patients (43.7%). A DJ stent was placed in all patients at the end of the procedure.

No major (Clavien IV-V) complication was observed in both groups. Overall, minor (I-III) complication rates in the mini-PCNL group were higher but the differences were not statistically significant ($P = .385$). Three (6.6%) patients required blood transfusion due to hemorrhage; bowel perforation was seen in 1 patient, although there were no retrorenal colon images in abdominal computed tomography and perforated area of descending colon was primarily repaired on postoperative day 2; and 1 patient had hydrothorax due to retroperitoneal saline extravasation and spontaneous resolution was observed after DJ stent insertion. Urinary tract infection was observed in 2 patients in the mini-PCNL group. In the RIRS group, 3 patients had urinary tract infection and required 14-day parenteral antibiotics; ureteral mucosal injury was observed in 1 patient and a DJ stent was inserted, and the procedure was postponed for 4 weeks. During the follow-up, we did not observe

Table 1. Comparison of operative and postoperative data—patient's demographic data

	Mini-PCNL	RIRS	*P* Value*
No. of patients (%)	45 (58.4)	32 (41.6)	
Gender (male/female)	24/21	17/15	.674
Mean age ± SD (years)	3.71 ± 1.89	3.65 ± 1.95	.835
Mean stone size ± SD (mm)	21.06 ± 5.61	19.30 ± 4.21	.720
Mean hospitalization time ±SD (day)	3.46 ± 1.77	1.2 ± 0.52	.001
Mean operative time ± SD (minutes)	85.22 ± 12.87	46.25 ± 9.30	.001
Mean fluoroscopy time ± SD (seconds)	60.88 ± 23.38	4.15 ± 1.98	.001
Initial stone-free rate (%)	38 (84.4)	24 (75)	.036
Stone free rate after additional therapy (%)	41 (91.1)	29(90.6)	.745
Minor (Clavien I-III) complications (%)	7 (15.5)	4 (12.5)	.385
Major (Clavien IV-V) complications	—	—	

PCNL, percutaneous nephrolithotomy; RIRS, retrograde intrarenal surgery.
Chi-square and Mann-Whitney *U* test were used.
* Significant at .05 level.

Table 2. Stone composition in the mini-PCNL and RIRS groups

Stone Composition	Mini-PCNL (%)	RIRS (%)
Ca Oxalate/phosphate	22 (48.8)	13 (40.6)
Struvite	4 (8.8)	4 (12.5)
Uric acid	3 (6.6)	3 (9.3)
Cystine	6 (13.3)	6 (18.7)
Unknown	10 (22.2)	6 (18.7)

Abbreviations as in Table 1.

any hydronephrosis or recurrent urinary infections in any of the patients, which may reflect ureteral stricture. Demographic data, operative findings of patients, and stone composition are summarized in Tables 1 and 2.

DISCUSSION

The incidence of renal stones in pediatric age population ranges between 1% and 5%.[5] Although kidney stones in pediatric patients are an uncommon health problem, these patients may require multiple interventions due to the repetitive nature of pediatric renal stones. Because of this, minimal invasive treatment modalities like ESWL, mini-PCNL, micro-PCNL, and RIRS have important roles in pediatric stone treatment.[6] All these modalities were compared with each other in adult patients. However, in pediatric patients there is not enough literature about the comparison of these modalities. We compare the RIRS with the mini-PCNL specifically in preschool-aged children in the literature.

The first pediatric PCNL series were performed using adult equipment in 1985. In these series, success rate was similar but the complication and transfusion rates were higher.[7,8] To prevent the higher complication rates, Jackman et al published the first mini-PCNL series in 1998. Eleven procedures were performed with the 11 Fr sheath and the 7 Fr rigid cystoscope without any complication.[9] In recent literature, SFRs of the mini-PCNL ranged from 75% to 100%.[7-11] Bodakci et al achieved a complete stone-free state in 81.2% of infant patients at the end of the postoperative first week in 48 mini-PCNL procedures.[12] In a prospective study of Kareem Daw et al, SFR after primary mini-PCNL was 76.9% in 26 preschool-aged patients and infants. SFR improved from 76.9% to 92.3% after ESWL.[11] Guven et al reported an SFR of 94.7% in 17 infants and all patients were stone free after additional procedures.[13] In our study, SFR was 84.4% and increased to 91.1% after additional procedures. In parallel to the literature on PCNL in children, success rates in our study are similar in preschool-aged patients.

Complications of the PCNL in pediatric age population are related to the caliber of the sheath and the number of the tract. In the first mini-PCNL series, an 11 Fr caliber sheath was used without any complication.[9] Desai et al showed that transfusion rate dramatically increased above the 22 Fr dilatation so they recommended that the dilatation of the tract should be below 24 Fr.[10] Celik et al compared the pediatric PCNL with different-sized instruments. SFR was 78% with a 9.5 Fr nephroscope, 75.8% with an 18 Fr nephroscope, and 71.4% with an 24 Fr nephroscope. They showed that there was no significant complication rate between the groups except transfusion rates. Transfusion rates were significantly lower in the ultra–mini-PCNL group.[14] We dilate the renal tract up to 20 Fr or 22 Fr with Amplatz renal dilator set according to the stone size and age of children. In our opinion, the 22 Fr sheath should be used in stones larger than 2 cm to improve the SFR if the patient's age and physical development are appropriate.

Despite the high success rate of mini-PCNL, serious complications and higher transfusion rates have been reported to be associated with stone size, sheath caliber, and tract number operative time.[13,15] The transfusion rate ranged from 4% to 23.9% in pediatric PCNL literature. Colon perforation and renal pelvis perforation have been reported in some publications.[11,12] In our study, there was no Clavien 4-5 complication and transfusion rate was lower than in pediatric PCNL literature.[16-18] This is because our experience has increased in pediatric patients due to the hospital localization in endemic stone region.

The first series of pediatric RIRS was published in 2007 by Cannon et al. The SFR was found to be 76% in this study, but it is noteworthy that the majority of patients were postpubertal.[19] Kim et al reported SFR as 99% in 167 pediatric kidney stones. However, access sheath could not be inserted in 57% of patients during the operation. In these patients, passive dilatation with DJ stents was the preferred method of choice.[20] In 2014, Erkurt et al published one of the largest series of RIRS in preschool-aged pediatric population. SFRs after a single and second procedure were 83.07% and 92.3%, respectively. UAS was able to be inserted in 61.5% of patients.[21] In pediatric patients' literature, complication rates of RIRS ranged between 0% and 27.7%. The most frequently observed complications were urinary system infection, postoperative hematuria, fever, ureteral mucosal injury and more severely ureteral stricture, and ureteral perforation.[22,23] In this study, SFR was 75% and 90.6% after the first and second procedures, respectively, which is similar to current literature. UAS placement in the first session was lower compared to literature because of the younger age of the patients.

Despite the high SFR of PCNL in a single session, it has more serious complications than the RIRS procedure. Saad et al compared the outcomes of PCNL and RIRS in large pediatric kidney stones. They found that the SFRs of RIRS and PCNL were 71% and 95.5%, respectively. This study reveals lower SFR with RIRS vs PCNL for treatment of large complex pediatric stones.[24] Another comparative study showed that SFRs for stones <20 mm and >20 mm in the RIRS group were 87.3% and 50%, respectively; on the other hand, SFRs for stones <20 mm and >20 mm in the PCNL group were 100% and 83.9%, respectively. Resorlu et al showed that the success rate of RIRS has increased in inverse proportion to the stone size.[4] In our study, SFR was higher compared to these studies due to the smaller stone size of patients.

Mean hospitalization time, operative time, and fluoroscopy time were found to be shorter in the RIRS group. Hospital stay was longer in the PCNL group. It is caused by the drainage nephrostomy tube and ongoing postoperative pain. High radiation exposure, longer hospitalization time, severe complications (Clavien 4-5), and postoperative pain can be significantly improved with a RIRS procedure with almost the same SFR.

The main limitation of the present study was it being a retrospective study besides significant differences between the stone sizes in both groups.

CONCLUSION

Although PCNL procedures have higher rates of severe complications (Clavien 4-5) than RIRS for the treatment of preschool-aged kidney stones, initial SFRs in PCNL were better than the RIRS procedure. On the other hand, decreased radiation exposure, shorter hospital stay, and fewer complication rates make RIRS a safe and effective alternative to mini-PCNL in preschool-aged patients.

References

1. Dwyer ME, Krambeck AE, Bergstralh EJ, Milliner DS, Lieske JC, Rule AD. Temporal trends in incidence of kidney stones among children: a 25-year population based study. *J Urol*. 2012;188:247-252. doi:10.1016/j.juro.2012.03.021.
2. Bastug F, Gunduz Z, Tulpar S, et al. Urolithiasis in infants: evaluation of risk factors. *World J Urol*. 2013;31:1117-1122.
3. Bilen CY, Gunay M, Ozden E, et al. Tubeless mini percutaneous nephrolithotomy in infants and preschool children: a preliminary report. *J Urol*. 2010;184:2498-2503.
4. Resorlu B, Unsal A, Tepeler A, et al. Comparison of retrograde intrarenal surgery and mini-percutaneous nephrolithotomy in children with moderate-size kidney stones: results of multi-institutional analysis. *Urology*. 2012;80:519-523. doi:10.1016/j.urology.2012.04.018. [Epub Jun 5, 2012].
5. Routh JC, Graham DA, Nelson CP. Epidemiological trends in pediatric urolithiasis at United States freestanding pediatric hospitals. *J Urol*. 2010;184:1100-1104. doi:10.1016/j.juro.2010.05.018. [Epub Jul 21, 2010].
6. Sen H, Seckiner I, Bayrak O, Erturhan S, Demirbağ A. Treatment alternatives for urinary system stone disease in preschool aged children: results of 616 cases. *J Pediatr Urol*. 2015;11:34, e1-e5. doi:10.1016/j.jpurol.2014.11.010. [Epub Feb 3, 2015].
7. Woodside JR, Stevens GF, Stark GL, et al. Percutaneous stone removal in children. *J Urol*. 1985;134:1166-1167.
8. Hulbert JC, Reddy PK, Gonzalez R, et al. Percutaneous nephrostolithotomy: an alternative approach to the management of pediatric calculus disease. *Pediatrics*. 1985;76:610-612.
9. Jackman SV, Docimo SG, Cadeddu JA, et al. The "mini-perc" technique: a less invasive alternative to percutaneous nephrolithotomy. *World J Urol*. 1998;16:371-374.
10. Desai MR, Kukreja RA, Patel SH, et al. Percutaneous nephrolithotomy for complex pediatric renal calculus disease. *J Endourol*. 2004;18:24-27.
11. Daw K, Shouman AM, Elsheemy MS, et al. Outcome of minipercutaneous nephrolithotomy for renal stones in infants and preschool children: a prospective study. *Urology*. 2015;86:1019-1026. doi:10.1016/j.urology.2015.08.019. [Epub Sep 2, 2015].
12. Bodakci MN, Daggülli M, Sancaktutar AA, et al. Minipercutaneous nephrolithotomy in infants: a single-center experience in an endemic region in Turkey. *Urolithiasis*. 2014;42:427-433. doi:10.1007/s00240-014-0677-9. [Epub Jul 9, 2014].
13. Guven S, Istanbulluoglu O, Gul U, et al. Successful percutaneous nephrolithotomy in children: multicenter study on current status of its use, efficacy and complications using Clavien classification. *J Urol*. 2011;185:1419-1424.
14. Celik H, Camtosun A, Dede O, Dagguli M, Altintas R, Tasdemir C. Comparison of the results of pediatric percutaneous nephrolithotomy with different sized instruments. *Urolithiasis*. 2016. doi:10.1007/s00240-016-0887-4. [Epub May 7, 2016].
15. Unsal A, Resorlu B, Kara C, et al. Safety and efficacy of percutaneous nephrolithotomy in infants, preschool age, and older children with different sizes of instruments. *Urology*. 2010;76:247-252.
16. 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;240:205-213.
17. Tefekli A, Ali Karadag M, Tepeler K, et al. Classification of percutaneous nephrolithotomy complications using the modified Clavien grading system: looking for a standard. *Eur Urol*. 2008;53:184-190.
18. Rassweiler JJ, Rassweiler MC, Michel MS. Classification of complications: is the Clavien-Dindo classification the gold standard? *Eur Urol*. 2012;62:256-260.
19. Cannon GM, Smaldone MC, Wu HY, et al. Ureteroscopic management of lower-pole stones in a pediatric population. *J Endourol*. 2007;21:1179-1182.
20. Kim SS, Kolon TF, Canter D, White M, Casale P. Pediatric flexible ureteroscopic lithotripsy: the Children's Hospital of Philadelphia

experience. *J Urol*. 2008;180:2616-2619, discussion 2619. doi:10.1016/j.juro.2008.08.051. [Epub Oct 31, 2008].

21. Erkurt B, Caskurlu T, Atis G, et al. Treatment of renal stones with flexible ureteroscopy in preschool age children. *Urolithiasis*. 2014;42:241-245. doi:10.1007/s00240-013-0636-x. [Epub Dec 28, 2013].
22. Smaldone MC, Cannon GM Jr, Wu HY, et al. Is ureteroscopy first line treatment for pediatric stone disease? *J Urol*. 2007;178:2128-2131, discussion 2131. [Epub Sep 17, 2007].
23. Unsal A, Resorlu B. Retrograde intrarenal surgery in infants and preschool-age children. *J Pediatr Surg*. 2011;46:2195-2199. doi:10.1016/j.jpedsurg.2011.07.013.
24. Saad KS, Youssif ME, Al Islam Nafis Hamdy S, Fahmy A, El Din Hanno AG, El-Nahas AR. Percutaneous nephrolithotomy vs retrograde intrarenal surgery for large renal stones in pediatric patients: a randomized controlled trial. *J Urol*. 2015;194:1716-1720. doi:10.1016/j.juro.2015.06.101. [Epub Jul 10, 2015].