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Endoscopic combined intrarenal surgery versus percutaneuos nephrolithotomy for complex pediatric stone disease: A comparative analysis of efficacy and safety

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Summary

Introduction
Decision-making for complex pediatric urinary system stone disease is still a challenge for pediatric urologists. The interest in supine percutaneous nephrolithotomy (PCNL) is increasing among centers to achieve high surgical success rates with less morbidity. Despite advanced retrograde intrarenal surgery armamentarium, percutaneous approaches remain the first-line surgical treatment modality for >2 cm and complex renal stones. There are no comparative studies yet in the literature for pediatric endoscopic combined intrarenal surgery (ECIRS)

Objective
In this study, we aimed to contribute to the literature by evaluating the safety and efficacy of ECIRS by comparing it with PCNL.

Study design
Patients under 18 years of age who underwent PCNL and ECIRS for urinary tract stone disease at our Pediatric Urology department between 2012 and 2024 were included. Preoperative (demographic characteristics, stone characteristics, biochemical parameters), perioperative (duration of surgery, number of accesses, lasing and fluoroscopy times, endoscopic and fluoroscopic stone-free rates) and postoperative (hospital stay, urinary tract infection, complication and radiological stone-free rates) parameters were retrospectively evaluated.

Results
A total of 68 children [28 (41%) girls and 40 (59%) boys] aged 5 (0–17) years were included in the study. ECIRS was performed in 19 (28%), supine in 28 (41%) and prone PCNL in 21 (30%) patients. Age ($p = 0.029$), Guy's stone score ($p < 0.001$), S.T.O.N.E. ($p < 0.001$), and Seoul National University Renal Stone Complexity (S-ReSC) scores ($p = 0.001$) for preoperative parameters were found to be higher in ECIRS group over both PCNL methods (Summary Table). However, Clinical Research Office of the Endourological Society (CROES) score was seen lower for ECIRS group patients compared to other groups ($p = 0.028$).

Surgery time (in favor of supine over prone PCNL), fluoroscopy time (in favor of ECIRS and Supine PCNL over Prone PCNL), preferred laser type (prone PCNL group was mostly performed with holmium laser, whereas other groups were balanced between Holmium and Thulium Fiber Laser) and exit strategy (the preferred exit strategy was DJ Stent in most of the ECIRS patients, whereas nephrostomy tube was used in some of the PCNL group) showed significant difference among the groups as perioperative parameters ($p = 0.042$, <0.001, <0.001, <0.001, respectively). Surgery time was lower for supine PCNL compared to prone PCNL. For postoperative parameters, stone-free rates, complication rates and urinary tract infections were similar between the 3 groups, while a difference was detected in terms of length of hospital stay in favor of ECIRS over both supine and prone PCNL ($p = 0.006$).

Discussion
The current trial suggests that stone-free and complication rates of ECIRS and supine PCNL were similar in the pediatric complex stone patients. Although, the stones in the ECIRS group we found to be more complex. Also, ECIRS was superior to PCNL in terms of fluoroscopy exposure and hospital stay.

Conclusion
With the widespread use of new generation ureteral access sheaths and flexible ureterorenoscopes, ECIRS may have an important role in treatment of complex pediatric kidney stones.

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Summary table Summary of preoperative, perioperative and postoperative parameters

Variable		ECIRS (n = 19)	Supine PCNL (n = 28)	Prone PCNL (n = 21)	*p* value
Age (years)		5 (1–13)	7 (1–17)	3 (0–10)	**0.029**
Nephrolithometry score	S-ReSC	4 (2–10)	3 (1–5)	3 (1–6)	**0.001**
	CROES	55 (20–215)	140 (20–215)	112 (20–250)	**0.028**
	S.T.O.N.E.	11 (7–13)	8 (6–11)	8 (5–12)	**<0.001**
	GUYS	3 (3–4)	3 (1–4)	2 (1–4)	**<0.001**
Duration of surgery (minutes)		100 (60–200)	90 (40–150)	110 (90–200)	**0.042***
Fluoroscopy time (seconds)		63 (14–122)	60 (9–130)	110 (51–354)	**<0.001**
Hospitalization (days)		1 (1–9)	2 (1–9)	3 (2–14)	**0.006***
Stone free rate (%)	CT scan	2 (33%)	3 (50%)	2 (50%)	1
	USG	11 (78%)	11 (57%)	12 (70%)	0.442
Complication Clavien-Dindo (n, %)	None or <Grade 2	13 (69%)	21 (75%)	14 (67%)	0.794
	≥ Grade 2	6 (31%)	7 (25%)	7 (33%)	
DJ stent as exit strategy		19 (100%)	25 (89%)	16 (76%)	**<0.001**

Adjusted p values of posthoc analysis per parameter.
A *p* value of <0.05 was considered as statistically significant.
DJ stent as exit strategy: ECIRS vs Prone PCNL: 0.034.
Hospitalization: ECIRS vs Prone PCNL: 0.018.
Fluoroscopy time: ECIRS vs Prone PCNL: 0.031, Supine vs Prone PCNL: 0.028.
Duration of surgery: Supine vs Prone PCNL: 0.027.
All nephrolithometry scores were $p < 0.05$ between ECIRS vs both PCNL methods.
Age: Prone PCNL vs Supine PCNL: 0.018.

Introduction

The European Association of Urology (EAU) 2023 Guidelines recommend percutaneous nephrolithotomy (PCNL) as the primary surgical approach for >2 cm pediatric stone disease. However, there is an ongoing debate for the appropriate surgical strategy for patients with complex stones. Currently, it is considered rational to reach a mutual decision by taking into account patient-specific characteristics, expectations, and the surgeon's level of expertise [1]. Advancements in technology and state-of-the-art methods have brought about significant alterations in the surgical treatment of pediatric urolithiasis. Miniaturized technologies and minimally invasive approaches are being utilized more frequently in the treatment of urinary stones in children in an effort to reduce surgical complications and enhance patient outcomes; furthermore, the interest on supine percutaneous surgery is evolving day by day [2,3]. It is known that various patient positions exist for percutaneous surgery, but as one size does not fit all, it is mandatory to assess the patient's anatomy, stone characteristics before choosing the appropriate position for every surgery [4].

In order to guide treatment strategy for complex stones several measures have been described. For the time being, there are more than fifty tools to predict outcomes after PCNL for adult patients [5]. Predictors of the stone-free rate (SFR) following (PCNL) include the Guys Stone Score (GSS), the nephrolithometric nomogram developed by the Clinical Research Office of the Endourological Society (CROES), and the renal stone complexity (S-ReSC) instrument established by Seoul National University [6–8]. The utilization of these scores in pediatric population is lacking in literature to compare alternative treatment options.

Endoscopic combined intrarenal surgery (ECIRS) was first introduced in 2008 and the technique involves a combination of antegrade and retrograde approaches and aims to directly visualize and puncture the collecting system, as well as facilitate the transfer of the fragmented stone during lithotripsy. Therefore, it is designed to expedite the lithotripsy procedure and enhance the efficacy of stone fragmentation [9]. In a recent meta-analysis including 33 studies on adult ECIRS patients, the mean SFR was >80% (ranging from 52% to 98.3%) and the complication rate ranged from 5.8% to 70.6%, indeed most of the complications were classified as Clavien–Dindo grade 1 or 2. The reported mean operative time was in a range of 42–140 min and the mean hospital stay ranged from shorter than 2 days to longer than 10 days among the included studies (10). In another meta-analysis including 14 studies, Cracco et al. reported an SFR of >80% which ranges from 61% to 97%, and complications with a range of 5.8%–44%, regardless of the tract size or puncture guidance which are mostly reported as Clavien-Dindo grade 1 or 2 [10].

Despite the ongoing tendency in terms of gaining popularity of ECIRS for adults, the data regarding the efficacy of ECIRS for pediatric population is limited. Consequently, the precise efficacy and safety of ECIRS in pediatric urology remain unclear, as the existing body of literature lacks sufficient experience [11]. To the best of our knowledge, there are no comparative studies involving retrograde intrarenal surgery or percutaneous nephrolithotomy in children yet. Therefore, we aimed to contribute to the literature by evaluating the outcomes and safety of ECIRS in comparison with PCNL to provide evidence-based guidance for pediatric endourologists in clinical decision-making and surgical planning for complex pediatric stone disease.

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Materials and methods

Patient groups

Patients under 18 years of age who underwent PCNL and ECIRS for urinary tract stone disease at our Pediatric Urology clinic between 2012 and 2024 were included. Ethical approval was obtained from the local ethics committee (Ref: 09.2024.63). We affirm that all study procedures comply with the Declaration of Helsinki principles. While drafting this manuscript, the PROCESS guidelines were followed [12]. Patients with missing data and those who underwent bilateral simultaneous surgery were excluded from the study. The first group consisted of PCNL patients; the second group underwent ECIRS. The efficacy and complication of these two groups were retrospectively analyzed.

Surgical procedures

All surgeries were performed under Galdakao-modified supine Valdivia position [9]. In certain old cases prone approach was used before 2016 when supine was preferred as the primary approach for PCNL. All cases were performed by a single FEBU-certified endourologist. Retrograde pyelography was performed in all patients to identify the collecting system. Ultrasonographic and fluoroscopic Bull's Eye technique were used for puncture, with the support of direct vision with a reusable fiber optic 7.5 French (Fr) flexible ureterorenoscopes (FURS) without access sheath. Every patient was dilated until 20 Fr with metal percutaneous dilators, afterwards 24 Fr dilatator was used in case of a difficult dilatation. Age, stone burden, BMI, previous surgeries, preferred calices of puncture were the main factors for the decision of dilatation. After dilatation, a 3 mm laparoscopic trocar which has a 14 French outer diameter or a 12/16 Fr amplatz sheat was inserted into the collecting system. Lithotripsy was performed with a 6.5 Fr semirigid ultrathin ureteroscope (4.5/6.5 Fr semirigid ultrathin ureterorenoscope, Richard Wolf®, Germany) or with an 11 Fr mini-nephroscope (Olympus®, Japan) with 272-micron Thulium Fibre or Holmium Laser. All patients were evaluated for stone-free rate by retrograde pyelography and endoscopic visualization at the end of surgery. A 4.8 Fr double J stent was used as the exit strategy in almost all patients.

Parameters

Preoperative (demographic characteristics, stone characteristics, biochemical parameters), perioperative (duration of surgery, number of accesses, lasing and fluoroscopy times, endoscopic and fluoroscopic stone-free rates) were all noted. For preoperative stone characteristics several well-known tolls [Guy's stone score, S.T.O.N.E. score, Clinical Research Office of the Endourological Society (CROES) score, and Seoul National University Renal Stone Complexity (S-ReSC) score], hydronephrosis status, number of stones and preoperative urinary diversion ratio were used.

Postoperative comparison involved hospital stay, urinary tract infection rate, complication rate according to the Clavien-Dindo classification [13] and radiological stone-free rates parameters.

In both groups, residual stones were evaluated by USG and X-rays and occasionally by CT for follow-up, after removal of the double J stent. Fragments larger than 4 mm in the greatest dimension are considered residual stones. From the available reported data in the literature, the majority of the studies used a <4 mm size as a cut-off for the residual fragments based on postoperative imaging for which there was no standardization in imaging modality or time for evaluation [14,15].

Statistical analyses

Data entry and analyses were done using Statistical Package for Social Sciences (SPSS) version 25.0 (IBM Corporation, Armonk, New York). The normality of the distribution of the variables was evaluated using the Shapiro–Wilk test. As the distribution of continuous variables did not show a normal distribution, continuous data were presented with median, minimum, and maximum. Qualitative analyses were made with the Chi-square test, quantitative parameters were analyzed with the Kruskal–Wallis test, and a p-value less than 0.05 was considered statistically significant.

Results

A total of consecutive 68 children [28 (41%) girls and 40 (59%) boys] aged 5 (0–17) years were included in the study. ECIRS was performed in 19 (28%), supine in 28 (41%) and prone PCNL in 21 (30%) patients.

Comorbidities that may cause a high stone volume for the patients were;

Neurological and musculoskeletal disorders were seen in 3 patients for ECIRS group, 1 patient in supine PCNL group, and in 2 patients for prone PCNL group.

After the surgery, stone analysis and metabolic work-up revealed 4 cystinuria patients in ECIRS group, whereas only 1 patient were diagnosed with cystinuria in supine PCNL group and no patient in prone PCNL group.

Other patients' stone compositions were mostly calcium oxalate (9 patients in ECIRS group, 9 patients in supine PCNL group and 6 patients in prone PCNL group).

Previous reconstruction for the upper urinary tract or those with a diagnosis of anatomical urinary tract obstruction during the surgery rates were similar among the groups; 3 patients had UPJ obstruction during the ECIRS sessions, 2 patients had previous pyeloplasty and 2 patient had UPJ obstruction in Supine PCNL group, and 1 patient had previously treated with endopyelotomy for UPJ obstruction and 3 patients were treated with pyeloplasty previously in prone PCNL group.

For the preoperative parameters as shown in Table 1; multiple demographic variables did not show statistically significant differences, while patients in ECIRS group were younger than the supine PCNL group whereas older than the prone PCNL group. [5 (1–13) years for ECIRS, 7 (1–17) for the supine PCNL and 3 (0–10) for the prone PCNL ($p = 0.029$)]. The median diameters and number of stones

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Table 1 Preoperative parameters.

Variable		ECIRS (n = 19)	Supine PCNL (n = 28)	Prone PCNL (n = 21)	*p* value
Age (years)		5 (1–13)	7 (1–17)	3 (0–10)	**0.029**
Side (n, %)	Right	14 (73%)	14 (50%)	10 (48%)	0.187
	Left	5 (27%)	14 (50%)	11 (52%)	
Largest stone diameter in mm (Median, min–max)		14 (6–19)	13 (4–18)	11 (6–30)	0.428
Number of Stones (Median, min–max)		3 (1–9)	1 (1–5)	1 (1–9)	**0.031**
Nephrolithometry score	S-ReSC	4 (2–10)	3 (1–5)	3 (1–6)	**0.001**
	CROES	55 (20–215)	140 (20–215)	112 (20–250)	**0.028**
	S.T.O.N.E.	11 (7–13)	8 (6–11)	8 (5–12)	**<0.001**
	GUYS	3 (3–4)	3 (1–4)	2 (1–4)	**<0.001**
Radiopacity of stone (n,%)		19 (94%)	23 (82%)	16 (76%)	0.288
Preoperative Urinary Diversion (n, %)	No diversion	6 (31%)	18 (64%)	17 (81%)	**0.006***
	DJ stent	13 (68%)	9 (32%)	4 (19%)	
	Nephrostomy	0	1 (3%)	0	
Preoperative hydronephrosis (HN)	No HN	3 (15%)	4 (14%)	5 (23%)	0.204
	Grade 1	1 (5%)	6 (21%)	8 (38%)	
	Grade 2	8 (42%)	10 (35%)	6 (28%)	
	Grade 3	6 (31%)	5 (17%)	2 (9%)	
	Grade 4	1 (5%)	3 (10%)	0	
Preoperative sterile urine culture		14 (73%)	22 (78%)	18 (90%)	0.424
Localization	Ureter (%)	1 (5%)	2 (7%)	0	0.715
	Renal pelvis (%)	5 (26%)	9 (32%)	8	
	Upper pole (%)	0	1 (3%)	0	
	Middle zone (%)	0	2 (7%)	2	
	Lower pole (%)	0	2 (7%)	1	
	Multiple cal (not lower pole)	2 (10%)	1 (3%)	3	
	Multiple cal (Lower Pole)	11 (57%)	11 (39%)	7	
Maximum Hounsfield Unit (Median, min–max)		1207 (686–2024)	1391 (326–2260)	1167 (450–1990)	0.406
Average Hounsfield Unit (Median, min–max)		1082 (646–1475)	1157 (284–2095)	919 (323–1852)	0.382
Total stone volume (Median, min–max)		1757 (248–6009)	800 (280–7249)	847 (309–2944)	0.805
Total stone surface area (Median, min–max)		1292 (218–3701)	652 (246–5251)	928 (276–2392)	0.980

A p value of <0.05 was considered as statistically significant.

were similar among the groups. Preoperative hydronephrosis status was also not different among the groups. The stone burden was calculated with both stone surface area and total stone volumes; the median stone surface area was 1292 (218–3701) mm^2 in the ECIRS group, 652 (246–5251) in the supine PCNL group and 928 (276–2392) in the prone PCNL group ($p = 0.980$). The median stone volume was 1757 (248–6009) mm^3 in the ECIRS group, 800 (280–7249) in the supine PCNL group and 847 (309–2944) in the prone PCNL group ($p = 0.805$). Average Hounsfield Units among the groups were also similar; 1082 (646–1475) for the ECIRS group, 1157 (284–2095) for the supine PCNL group and 919 (323–1852) for the prone PCNL group ($p = 0.382$). The stone configuration and complexity were assessed with 4 validated nomograms and showed significant differences between groups. The most advantegous group in terms of complexity was the prone PCNL group, whereas the patients in the ECIRS group were assessed as the most complex stones by nephrolitometry scores.

The median Guy's stone score, S.T.O.N.E. score, S-ReSC score was higher in the ECIRS group ($p < 0.001$, $p < 0.001$, $p = 0.001$) whereas CROES score was lower in the ECIRS group ($p = 0.028$) which means the stone complexity is higher in terms of all nephrolithometry scores.

13 patients (%68) were pre-stented in the ECIRS group, whereas 9 patients (%32) were pre-stented in the supine PCNL group and only 4 patients (%19) were pre-stented in the prone PCNL group at the time of surgery ($p = 0.006$).

The perioperative parameters are listed in Table 2; duration of surgery was 100 (60–200) minutes in the ECIRS group, 90 (40–150) in the supine PCNL (%54) and 110 (90–200) in the prone PCNL group ($p = 0.042$). Posthoc analysis showed that only statisticly significant difference was observed in favor of supine PCNL over prone PCNL. The preferred laser type was Thulium Fiber in the ECIRS group (%58), Holmium in the supine PCNL (%54) and prone PCNL (%100) groups ($p < 0.001$).

Lasing time was not statistically different between groups ($p = 0.264$), whereas the mean fluoroscopy time was 63 (14–122) seconds for the ECIRS group, 60 (9–130) for the supine PCNL group and 110 (51–354) for the prone PCNL group ($p = <0.001$). At the end of the surgery, the endoscopic and fluoroscopic stone-free rates were also similar among the groups; %89 for ECIRS, %96 for supine PCNL and %100 for prone PCNL ($p = 0.358$). The exit strategy was DJ stent in all patients after ECIRS, no patient required an insertion of a nephrostomy tube. For supine PCNL, %89 of patients had DJ stent and %11 nephrostomy after the surgery and %76 DJ stent and %24 nephrostomy were used as exit strategies after prone PCNL ($p = <0.001$).

Significant differences in postoperative complication and stone-free rates were not detected between the three

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Table 2 Perioperative parameters.

Variable		ECIRS (n = 19)	Supine PCNL (n = 28)	Prone PCNL (n = 21)	*p* value
Duration of surgery (minutes)		100 (60–200)	90 (40–150)	110 (90–200)	**0.042***
Extra percutaneous accesses (Median, min–max)		1 (6%)	0	3 (14%)	0.123
Percutaneous tract diameter (French) (Median, min–max)		12 (9–16)	12 (11–16)	13 (9–16)	0.093
Lasing time (seconds) (Median, min–max)		14 (7–43)	17 (2–81)	58 (6–124)	0.264
Fluoroscopy time (seconds)		63 (14–122)	60 (9–130)	110 (51–354)	**<0.001**
Type of Laser	Holmium (n, %)	8 (42%)	15 (54%)	21 (100%)	**<0.001**
	Thulium Fiber (n, %)	11 (58%)	11 (46%)	0	
Endoscopic and fluoroscopic stone free rate (%)		17 (89%)	21 (96%)	27 (100%)	0.358
DJ stent as exit strategy		19 (100%)	25 (89%)	16 (76%)	**<0.001**

A p value of <0.05 was considered as statistically significant.

groups as can be seen in Table 3; stone-free rates were %78 in the ECIRS group, %57 in the supine PNCL group and %70 in the prone PCNL group (p = 0.442). Clavien-Dindo grade 2 and higher complications were detected in 6 patients (%31) in the ECIRS group, 7 patients (%25) in the supine PCNL group and 7 patients (%33) in the prone PCNL group (p = 0.794). Although none of the patients required blood transfusion, angioembolization or nephrectomy after surgery and no organ damage was reported following surgery. Median discharge day was postoperative 1st day for the ECIRS group, 2nd day for the supine PCNL group and 3rd day for the prone PCNL group respectively (p = 0.006) (Table 3).

In posthoc analysis, a statistically significant difference was detected in favor of ECIRS over both supine and prone PCNL.

Discussion

Complex renal stones are treated with different methods among centers, even legal requirements and national policies can influence how pediatric stones are treated. Minimally invasive procedures like URS and mini PCNL appear to be gaining popularity, according to findings of a worldwide survey among pediatric endourology caregivers [16]. Although, The EAU 2023 Guidelines currently recommend PCNL as the primary surgical approach for large pediatric stone cases as a guideline suggestion, there is obvious a need for further studies to document newer less invasive modalities in children.

The current trial provides the first comparison of ECIRS against supine PCNL in pediatric complex stones. In this study, despite the high stone complexity and higher number of stones; stone-free and Clavien-Dindo complication rates of ECIRS were found to be non-inferior to PCNL, also ECIRS was found to be superior in terms of fluoroscopy exposure and hospital stay. The less radiation exposure during ECIRS may be meaningful in the pediatric age group in terms of avoiding long-term possible toxicity of radiation exposure.

The choice of operative method for children was decided according to the stone burden and complexity which could be assessed by any means of nephrolithometry scores. Since we preferred to use mini PCNL, our other aim was to decrease intrarenal pressures. Thus, for patients who were prone to infective complications, such as spina bifida, we aimed to shorten the operation time and lower the number of accesses, we preferred ECIRS. Previously it has been shown by an international study, that retrograde intrarenal surgery can safely be performed with or without an access sheet with similar SFR and re-intervention rates in the pediatric population [17]. Overall the main idea in pediatric stone surgery is to have the least number of percutaneous access and to decrease the intrarenal pressure to have better outcomes. In our study, for an optimal assessment, the collecting system anatomy was carefully assessed by either with a retrograde pyelography in every patient for possible other access sites or retrograde intervention.

In a recent meta-analysis with 669 pediatric kidney stone patients, the shock wave lithotripsy group presented a range of stone-free rates between 21% and 90% while the flexible ureteroscopy group presented a range of stone-free rates between 37% and 97% and demonstrated significantly

Table 3 Postoperative parameters.

Variable		ECIRS (n = 19)	Supine PCNL (n = 28)	Prone PCNL (n = 21)	*p* value
Hospitalization (days)		1 (1–9)	2 (1–9)	3 (2–14)	**0.006***
Postoperative febrile UTI (n, %)		1 (5%)	2 (7%)	1 (5%)	1
Complication Clavien-Dindo (n, %)	None or <Grade 2	13 (69%)	21 (75%)	14 (67%)	0.794
	≥ Grade 2	6 (31%)	7 (25%)	7 (33%)	
Stone free rate (%)*	CT scan	**2/6 (33%)**	**3/6 (50%)**	**2/4 (50%)**	1
	USG	**11/19 (78%)**	**11/20 (57%)**	**12/17 (70%)**	0.442

• Stone free status were assessed by USG or CT per group are indicated in parentheses.
A *p* value of <0.05 was considered as statistically significant.

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higher stone-free rate and hospital stay in flexible ureteroscopy vs shock wave lithotripsy (SWL) but no difference for complications between the groups [18]. Also, the long-term impacts of the shock waves on the developing kidney remain unknown [19,20]. Therefore, SWL is losing its popularity among pediatric endourologists. One previous study has shown a high success rate (%95.9) with SWL in >2 cm renal stones, but there is not a comparison among groups with stone complexity scores and localization of stones. Also, the average Hounsfield Units were lower (572 ± 169.08) in those patients compared to our study [21]. These studies suggest that even in the pediatric age group, certain invasive procedures are required for the management of complex stones.

Up to now, PCNL remains the standard procedure for complex stones also for children. Various types of PCNL are described based on the access diameters; standard PCNL (24–30 Fr), mini-PCNL (16–18/20 Fr), ultra-mini PCNL (11–14 Fr), micro-PCNL (<10 Fr). Mahmood et al. evaluated a total of 134 children who underwent PCNL, the overall SFR was 89.5% in the Mini-PCNL group and 94.7% in the Standard PCNL group. The complication rates were similar. In a matched cohort study by Lee et al., 31 pediatric patients were compared with adult patients in terms of stone-free rates and complication status after PCNL that revealed no difference in SFR at time of hospital discharge (86.1% vs. 86.4%) and no significant difference in length of stay, nor complication rates [22]. In a meta-analysis, Yuan et al. demonstrated that PCNL has a higher stone-free rate than RIRS with a shortened operative time. There was no difference in Clavien-Dindo grade 1,2 and 3 complications between PCNL and RIRS [23]. The studies mainly focusing on comparing miniaturized elements' have shown lower morbidity and equivalent stone clearance rates with smaller scopes in the pediatric groups [24]. In light of these findings, it is suggested to miniaturize the armamentarium to achieve safe and efficient outcomes [3,25,26]. Controversially, in a meta-analysis of pediatric standard PCNL, adult-sized instruments were found to have comparable outcomes to pediatric-sized ones in terms of stone-free rates and reported complications [27].

When comparing ECIRS with PCNL, a meta-analysis including 17 studies reported shorter operative time and lower complication rates for ECIRS over PCNL, but the Conventional PCNL showed a higher stone-free rate compared to PCNL [14]. Controversially in 2 other meta-analyses, ECIRS was found to have higher stone-free rates, lower complication rates and shorter hospital stay compared to PCNL [28,29].

In a randomized controlled trial published by Wen et al. 67 patients with similar preoperative parameters and stone characteristics were randomized for ECIRS and mini-PCNL. The mean operative time was 105.33 ± 30.28 min in ECIRS group, which was significantly longer than MPCNL group (83.58 ± 24.37 min). The one-step SFR was significantly higher in the ECIRS group compared to MPCNL (87.88% vs 58.82%). Nevertheless, complication rate was low in both groups and no difference was reported between ECIRS and Mini-PCNL (48% vs 67%). However, regarding the pediatric population no comparison has been available between PCNL and ECIRS. There is only one study in the literature for pediatric ECIRS. Xu et al. retrospectively evaluated 13 patients in terms of preoperative characteristics, perioperative findings and postoperative outcomes. Only 13 patients with renal stones larger than 2 cm were operated in the GMSV position, The average stone size was 2.7 cm (range: 2.1–3.7 cm), mean operative time was 70.5 min (range: 54–93 min), the mean hospital stay was 6.4 days (range: 4–9 days). Complete stone clearance was reported as; 8 kidneys at 48 h postoperatively, 11 kidneys at 2 weeks postoperatively, and 14 kidneys at 1 month postoperatively. They outline the limitations as all children made three hospital visits and received anesthesia three times [11]. The overall reported complications and stone-free rates were higher than in our study. According to our opinion, although the study group was small, and stone sizes were rather smaller; they showed that ECIRS is an option for children with an acceptable complication rate. Moreover, our study involved larger number of patients and more complex stones, and also provided a comparison of ECIRS against PCNL.

On the other hand, he adult literature on ECIRS shows higher stone-free rates and higher complication rates compared to our pediatric ECIRS series. Despite the complex anatomy and narrow collecting system of children, our SFRs are comparable with other series and showed lower morbidity among the studies.

A major limitation of ECIRS, is the need for an extra surgeon in the operating room, compared to PCNL and retrograde ureteroscopy. Also, the failure of ureteral access in non-presented patients is another limiting factor for ECIRS compared to PCNL. Since our institution is a tertiary referral center, lots of admissions are present from whole country regarding particularly pediatric stone cases. Therefore, these limitations can easily be overcomed at our department. Furthermore, our study suggests that particularly complex stone surgery requires an experienced team and referral centers.

Limitations of the study

As this is a retrospective study, patient groups were not similar in terms of stone and patient-related factors.

Conclusions

Centers with high experience of pediatric retrograde intrarenal surgery and PCNL may choose ECIRS as the preferred surgical strategy for complex pediatric renal stones. Our results suggest that despite the higher stone complexity, stone-free and Clavien-Dindo complication rates of ECIRS were found to be non-inferior to PCNL presenting the first report for children. Moreover, ECIRS was found to be superior in terms of fluoroscopy exposure and hospital stay. As increased experience with ECIRS with new generation ureteral access sheaths and thinner flexible ureterorenoscopes, it will possibly result in better stone-free rates and lower morbidity for the pediatric complex stones. Performing a combined surgery seems to have a synergistic effect and overcome their limitations. However, multicenter and prospective studies are needed to improve outcomes and the widespread use of this method for children.

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Declaration of competing interest

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