International Journal of Urology Research

ISSN Print: 2664-6617
ISSN Online: 2664-6625
Impact Factor: RJIF 5.28
IJUR 2023; 5(1): 15-21
www.urologyjournal.in
Received: 18-01-2023
Accepted: 24-02-2023

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Safety and efficacy of PCNL for the management of renal stones in children

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DOI: https://doi.org/10.33545/26646617.2023.v5.i1a.26

Abstract
Background: The formation of stones is affected mainly by metabolic abnormalities, improper fluid intake, infection, some drugs, and urine pH. The purpose of this work was to assess the safety and efficiency of percutaneous nephrolithotomy (PCNL) for management of renal calculi in children.
Methods: This prospective work was performed on 24 children, younger than 18 years, large renal stones larger than 2 cm) in its maximum diameter and lower calyceal stones of more than 1 cm and small renal stones (<2 cm) with failed extracorporeal shock wave lithotripsy (ESWL) or flexible ureteroscopy (F.URS).
Results: The intraoperative complications included mild bleeding (12.5%) and calyceal perforation (16.7%). Low grade fever occurred in 3(12.5%) cases and high-grade fever occurred in one (4.2%) case. Mild hematuria occurred in 2(8.3%) cases and severe hematuria occurred in 1(4.2%). Colonic injury and urine leakage did not occur in any patient. 19(79.2%) patients were discharged after 2 days and only 5(20.8%) children after 3 days. One (4.2%) patient with residual (0.8cm) in renal pelvis, another (4.2%) patient with residual (1.2cm) in the upper calyx and a third (4.2%) patient with lower calyceal residual stone (1.3 cm).
Conclusions: PCNL is a secure and efficient method for treating the large renal stones in youngsters. Tract dilation in children is a tailored technique that depends on stone burden, age of the patient, degree of hydronephrosis and availability of instruments. Miniaturization in children is important but optimization is more important.

Keywords: Efficacy, PCNL, renal stones, children

Introduction

The prevalence of urolithiasis in paediatric patients is around 1%. However, it is important to note that all children diagnosed with this condition are classified as high risk for experiencing recurrence stone formation. Therefore, it is imperative that these children have an appropriate therapeutic intervention aimed at achieving complete elimination of stones. The selection of the therapy technique is personalised, taking into account criteria such as the age of the individual, the size and number of stones, their location, clinical considerations, and the structure of the urinary system. The occurrence of stones in paediatric patients is often intricate and associated with preexisting metabolic or renal structural abnormalities [1].

The strategy to managing renal stones has seen a transformation in recent decades, transitioning from traditional open surgery to a less intrusive method. The contemporary surgical techniques used for the treatment of renal stones include extracorporeal shock wave lithotripsy (ESWL), flexible ureteroscopy (F.URS), and percutaneous nephrolithotomy (PCNL). According to recommendations from both the European Association of Urology (EAU) and the American Urological Association (AUA), PCNL is considered the preferred therapeutic option for kidney stones that exceed a diameter of 2 cm [2].

The technique known as Paediatric PCNL was initially documented in the year 1985. This procedure enables the management of children who present with a greater quantity of kidney stones or those for whom ESWL is not recommended or is improbable to yield positive outcomes. Paediatric PCNL has been conducted use devices designed for both adult and paediatric patients. The justification for use tiny tools, often known as 'miniperc', lies in the objective of minimising morbidity without sacrificing the effectiveness of stone removal rates.

The rates of stone removal and complications exhibit variability contingent upon the employed method and the level of expertise possessed by the surgeon [2].
The objective of this study was to evaluate the safety and effectiveness of PCNL as a treatment modality for paediatric patients with renal calculi.

Patients and Methods

This prospective work was performed on 24 children, younger than 18 years, large renal stones more than 2 cm) in its maximum diameter and lower calyceal stones of more than 1 cm and small renal stones (< 2 cm) with failed ESWL or F.URS. The research was conducted subsequent to obtaining clearance from the Ethics Committee of Tanta University Hospitals, with the assigned approval code of (34937/9/21). The researchers received an informed written agreement from either the patient or the patient's family. The investigation was conducted from August 2021 until February 2023.
Exclusion criteria were untreated urinary tract infection, uncontrolled bleeding disorders and associated renal anomalies.
All participants were subjected to: taking of history, clinical assessment, laboratory tests [full blood count (CBC), bleeding time, clotting time, renal function test, the examination of urine samples and the subsequent culture and sensitivity testing if indicated] and radiology [plain x ray of the urinary tract (PUT), ultrasonography on abdomen and pelvis and non-contrast CT urography (NCCT) performed preoperatively]

Technique

General anesthesia was applied in all cases. The participant was typically positioned in the lithotomy position and external genitalia were prepared and draped before performing visualizing urethro-cystoscopy. Visualizing urethro-cystoscopy was performed to examine the urethra and to identify the ureteric orifice. Insertion of a sensor guide wire 0.035 inch (Boston scientific) under fluoroscopic guidance into the renal pelvis was done. Using fluoroscopy, open tip ureteric catheter (5 Fr) was advanced over the guide wire to the renal pelvis and fixed with Foley catheter. Participants were turned to prone position with proper padding of pressure points. The desired calyx was punctured by 18-gauge Chiba needle (Boston Scientific) in biplanar access technique (0, 30 degree toward the head). Proper calyceal puncture was confirmed with free flow of urine through the needle and a sensor guidewire 0.035 inch (Boston scientific) was placed into pelvicalyceal system. Skin and subcutaneous incision was performed according to size of nephroscope and Amplatz sheath. In cases which (MIP M) system was used: we put safety wire and working wire? This was achieved via introducing reversed central rod with the smallest Alken dilator over the working wire then central rod was removed and another wire was introduced through the dilator. Tract dilatation was achieved by Amplatz dilators or single step dilatation or metal telescoping dilators (Alken). Method of dilatation depends on operator preference and availability of instruments. The size of the tract was determined by the used nephroscope. We used different sizes of the nephroscope according to the age of the patient, stone burden, degree of hydronephrosis, and availability of instruments. We used 9.5 Fr short semi rigid ureteroscope (Karl-Storz, Germany), 20 Fr pediatric nephroscope (Karl-Storz, Germany) and 12 Fr MIP M system (Karl-Storz,Germany).We used different methods of lithotripsy according to stone size, size of the nephroscope and availability of the instruments. The fragmentation was performed by Holmium: YAG Laser or pneumatic Lithoclast OME or Karl Storz Calcuson ultrasonic lithotripter with Endomat Suction Pump. We used Lumenis™ VersaPulse™ Lasers Holmium Laser. A 550-µm holmium laser fiber was used; it is most effective if the fiber tip was very close to the stone surface, where the energy was transmitted directly to the stone surface. Open tip ureteral catheter or antegrade double J stent (DJ) was introduced in all participants. Nephrostogram was done and nephrostomy tube was anchored to the skin and clamped.

Postoperative care

Hemodynamics and urine were monitored. Pain control was achieved with I.V. NSAID drugs and 3rd generation cephalosporin was administered. The postoperative consequence were reported via The Clavien-Dindo Classification of Surgical Complications into 5 grades. Plain X-ray abdomen and pelvis was done, and the urethral catheter was removed following 24h.

Follow up

In uncomplicated cases the nephrostomy tube was eliminated on the 2nd or 3rd postoperative day, in complicated cases (perforation) it remained for 5 days at least until complete healing and the nephrostomy was not removed in cases with residuals.
After one week, all participants were seen for clinical evaluation of nephrostomy tract, urine leak, pain and fever. DJ removal was decided to be performed after 4 weeks if the patient was stone free or with insignificant residuals (≤ 4mm) by kidney, ureter, and bladder (KUB) or by ultrasonography (US) in patients with radiolucent stones, but low dose non-contrast computerized tomography (NCCTU) was done only if there were significant residuals or hydronephrosis in patients with radiolucent stones. Cases with large residuals (more than 4 mm) were scheduled for ESWL, second look PCNL or F.URS were according to the criteria of the residual stones. When the children were stone free, it was planned to undergo complete metabolic evaluation. However, the results of these data are beyond the scope of this study.

Statistical analysis

The data was inputted into the computer and afterwards analysed utilising IBM SPSS software package version 20.0. (IBM Corp, Armonk, NY). The qualitative data were represented utilising numerical values and percentages. The Shapiro-Wilk test was employed to assess the adherence of the distribution to the assumption of normality. The quantitative data were characterised by employing several statistical measures, including the range (comprising the minimum and maximum values), the mean, the standard deviation, the median, and the interquartile range (IQR). Significance of the obtained results was judged at the 5% level.

Results

The patients' age with mean of 11.67±3.32. 17 (70.8%) patients were males while 7 (29.2%) were females**.** Table 1

Table 1: Patient demographic data (n = 24)

		No. (%)
Age (years)		11.67±3.32
	Preschool age (3 – 6)	2 (8.3%)
	School age (6 – 12)	9 (37.5%)
	Adolescent (12 – 18)	13 (54.2%)
Sex	Male	17 (70.8%)
	Female	7 (29.2%)

Data are presented as mean ± SD or frequency (%).

Regarding the history of urological procedures to our patients, there were Five (22.8%) patients had urological procedures, three (12.5%) underwent PCNL for renal stone, two (8.3%) had PCNL for the same stones in another hospital and there were residuals that needed 2nd stage PCNL. The last one (4.2%) had PCNL for another renal pelvic stone 2 years ago and was stone free at that time. We also had one (4.2%) patient with failed ESWL (hard stone) and another (4.2%) patient with failed F.URS (inaccessible). Figure 1.

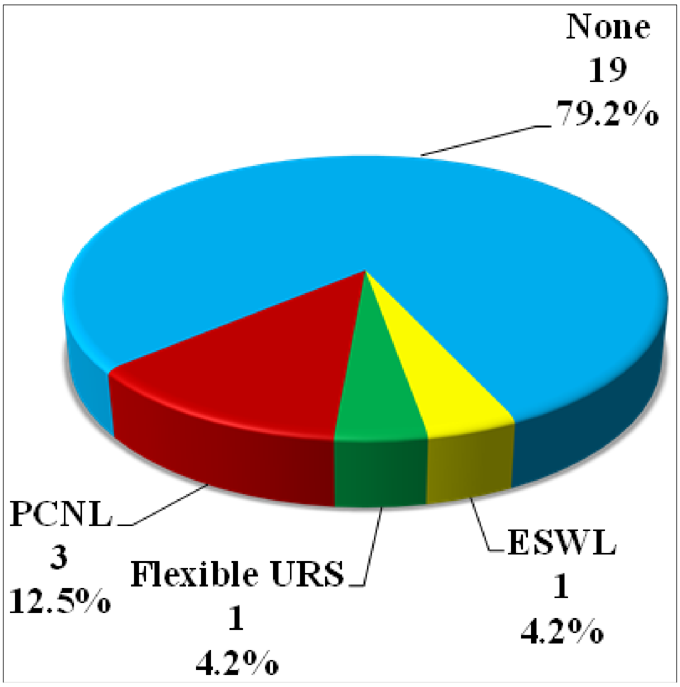

Fig 1: Distribution of the studied cases according to previous procedures (n = 24)

Non-contrast CTU was the main tool for the assessment of stone characteristics. Figure 2

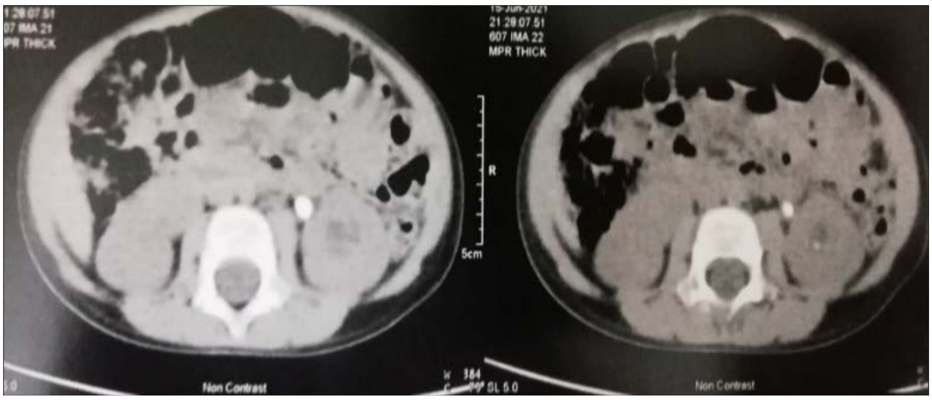

Fig 2: Axial cuts of non-contrast CTU showing renal pelvic stone in 6years girl.

Regarding stone multiplicity in our patients, there were 16 (66.7%) with single stone and 8 (33.3%) had multiple stones. Regarding cases with multiple stones, three (12.5%) had stones in renal pelvis and lower calyx, two (8.3%) with stones in upper and middle calyces, two (8.3%) with stones in middle and lower calyces, one (4.2%) case with two stones in middle calyx. The cases with single stone showed the following distribution: 8(33.3%) in renal pelvis, 3(12.5%) in upper calyx, 2(8.3%) in middle calyx while 3(12.5%) in lower calyx. Seventeen (70.8%) children had radiopaque stone while 7(29.2%) had radiolucent stones. Stone size with a mean size 2.33±0.4cm while median hounsfield units (HU) of the stones was 840. Table 2

Table 2: Distribution of the studied cases according to stone characteristics (n = 24)

		No. (%)
Stone side	Right	20(83.3%)
	Left	4(16.7%)
Multiplicity	Single	16(66.7%)
	Multiple	8(33.3%)
Stone site	Pelvis	8(33.3%)
	Upper calyx	3(12.5%)
	Middle calyx	3(12.5%)
	Lower calyx	3(12.5%)
	Pelvis + Lower calyx	3(12.5%)
	Upper + Middle calyx	2(8.3%)
	Middle + Lower calyx	2(8.3%)
Opacity	Radiopaque	17(70.8%)
	Radiolucent	7(29.2%)
Stone size (cm)		2.33±0.40
HU		840.0 (552.5 – 1112.5)

Data are presented as frequency (%), mean ± SD or median HU: Hounsfield units

The operative time ranged from 55.0 – 110.0 min. regarding the size of the used nephoscope, 14 (58.3%) cases was performed by 20Fr pediatric nephoscope, 8(33.3%) by 9.5 Fr short semi-rigid URS and 2(8.4%) by 12 Fr MIP STORZ M system. Regarding the site and number of the tracts used in our patients, there were 19(79.2%) with single tract,5(20.8%) with multiple tracts (2 tracts), 13(54.2%) with single tract in lower calyx, 6(25%) with single tract in middle calyx,3(12%) with 2 tracts in lower and middle calyces while 2 (8.3%) with 2 tracts in upper and lower calyces, 8(33.3%) with multiple stones (two stones) and we used two tracts only in 5(20.8%) patients to reach the stone. We used in our study single tract to manage patients with two stones in 3(12.5%) cases, 2(8.3%) cases with renal pelvic and lower calyceal stones were removed through lower calyceal tract, 1(4.2%) with two stones in middle calyx was managed by single tract through the middle calyx. Amplatz dilators were used in 14(58.3%) cases and single step dilatation in 7(16.7%) cases while telescoping metal dilators were used in 3(12.5%) cases. Holmium laser was used in 10(41.7%) cases, ultrasonic lithotripsy in 6(25%) cases while pneumatic lithotripsy in 8(33.3%) cases. Postoperative DJ stent was inserted in 15(62.5%) patients while open tip ureteral catheter was inserted in the remaining 9 (37.5%) patients. Our primary Stone free rate after 1 month was 87.5% as 21 children were stone free following the initial session of PCNL. On the other hand, we had 3(12.5%) patients with significant residuals that needed auxiliary procedures. One(4.2%) patient with residual (0.8cm) in renal pelvis that needed ESWL, another (4.2%) with residual(1.2cm) in the upper calyx that needed F.URS and a third(4.2%) with lower calyceal residual stone (1.3cm) that needed 2nd look PCNL. Table 3

Table 3: Descriptive analysis of the studied cases according to operative data and residuals

		No.(%)
Operative time (min.)		81.04±15.18
Type of PCNL	20 Fr nephroscope	14 (58.3%)
	9.5 Fr semi-rigid URS	8 (33.3%)
	12 Fr MIP M system	2 (8.4%)
Tract number	Single	19 (79.2%)
	Multiple	5 (20.8%)
Tract site	Lower calyx	13 (54.2%)
	Middle calyx	6 (25%)
	Lower and Middle calyx	3 (12.%)
	Lower and Upper calyx	2 (8.3%)
Dilatation	Amplatz dilators	14 (58.3%)
	Single step dilatation	7 (29.2%)
	Telescoping metal dilators	3 (12.5%)
Lithotripsy	Holmium:YAG Laser	10 (41.7%)
	Pneumatic	8 (33.3%)
	Ultrasonic	6 (25%)
Stents	Open tip ureteral catheter plus nephrostomy	9 (37.5%)
	DJ plus nephrostomy	13 (54.2%)
	DJ without nephrostomy	2 (8.3%)
Residuals		
Patients with no residuals		21(87.5%)
Patients with residuals		3(12.5%)
	Pelvic stone 0.8 cm	1(4.2%)
	Upper calyx stone 1.2 cm	1(4.2%)
	Lower calyceal stone 1.3 cm	1(4.2%)

Data are presented as mean ± SD or frequency (%). PCNL: Percutaneous nephrolithotomy

The intra operative complications that were reported include mild bleeding (12.5%), calyceal perforation (16.7%). The postoperative consequences were graded based on Clavien-dindo grade system. Low grade fever (grade 1 complication) occurred in 3(12.5%) cases and high-grade fever (grade 2 complication) occurred in one (4.2%) case. These patients were treated with antipyretic and antibiotics. Mild hematuria (grade1 complication) occurred in 2(8.3%) cases and improved with good hydration, severe hematuria in 1(4.2%) (Grade 2 complication) improved with good hydration and blood transfusion. Colonic injury and urine leakage did not occur in any patient. 19(79.2%) patients were discharged after 2 days and only 5(20.8%) were discharged after 3 days. Table 4

Table 4: Intra and postoperative complication and hospital stay.

		No. (%)
Intraoperative complications	Bleeding	3(12.5%)
	Calyceal Perforation	4(16.7%)
Post -operative complications		
Hematuria	No	21(87.5%)
	Yes	3(12.5%)
	Mild	2(8.3%)
	Severe	1(4.2%)
Fever	No	20(83.3%)
	Low grade (37.5 – 38.5)	3(12.5%)
	High grade (above 38.5)	1(4.2%)
Need for blood transfusions	No	23(95.8%)
	Yes	1(4.2%)
Colon injury	No	24 (100%)
	Yes	0
Urine leakage	No	24 (100%)
	Yes	0
Hb drop		0.97±0.54
Hospital stay		
2		19(79.2%)
3		5(20.8%)

Data are presented as mean ± SD or frequency (%). Hb: Hemoglobin.

Discussion

While kidney stones are often considered to be infrequent in the paediatric population, new research has shown their significance as a health concern, particularly in underdeveloped nations. In the context of this age group, the occurrence of stone illness is frequently linked to anatomical and metabolic irregularities, as well as infectious ailments, resulting in a notable propensity for recurrence. These considerations contribute to the increased significance of minimally invasive treatments within this particular demographic [3, 4].

In the current study, the stone burden, age of the patient and availability of instruments were considered during the choice of our equipment. Dilatation up to 24 Fr was needed in patients with large stone burden, older children, but younger children dilatation was done up to 16 Fr to either by 9.5 Fr short semi rigid ureteroscope or 12 Fr MIP-M system according to available instruments. Several studies have shown that the dilatation of the 24 F or 26 F size in children doesn't result in substantial rates of morbidity. Traxer *et al.* [5] have revealed that the use of a tiny access does not provide any advantageous outcomes in relation to renal scarring, as seen in animal models. Based on the findings of some studies, it may be argued that a decline in instruments size hasn't resulted in a significant reduction in complication rates [6]. The study conducted by Bilen *et al.* [7] shown that there weren't no statistically significant differences in complication rates while using devices of varying sizes. On the other hand, other research has shown that the utilisation of nephroscopes with reduced dimensions has the potential to decrease both morbidity and death rates [6]. According to the findings of Zeren *et al.* [8], there exists a correlation between intraoperative bleeding and factors such as stone load, surgical time, and sheath size.

Amplatz dilators were the main instrument of dilation in our study. Amplatz dilators were used in 14 patients, single step dilatation was used in 7 patients and while telescoping metal dilators were used only in 3 patients. Salerno *et al* [9] reported that amplatz dilators was the method of dilatation in all cases of PCNL. El-Nahas *et al* [10] stated that coaxial telescopic dilators had been the method of choice of dilatation in 60 PCNL procedures in 50 children.

In our study, laser lithotripsy was the main method of stone fragmentation. Holmium:YAG laser with 550-µm fiber using an average power 30 W (1.5J× 20 Hz) was used in 10 cases. In addition, ultrasonic lithotripsy had been utilized in 6 instances while pneumatic lithotripsy was utilized in 8 cases. Bujons *et al* [11] reported that lithotripsy was performed employing a 9.5 semirigid ureteroscope manufactured by Karl Storz in Berlin, Germany. The procedure used a high-power Holmium: yttrium-aluminum-garnet (Ho:YAG) laser with a 550-µm fibre, operating at an average power of 70 W. This approach was employed for the management of difficult calculi in paediatric patients. In their study, Jou *et al.* [12] found that modifying the power to 30 W had favourable outcomes in terms of enhanced efficiency. In their study, El-Nahas *et al.* [10] documented the utilisation of ultrasonic, pneumatic, or holmium:YAG laser lithotripsies for the purpose of stone breakup. Mahmood *et al* [13] reported that pneumatic lithotripsy was used in all patients either standard PCNL or mini-PCNL was used.

In our 24 patients, postoperative DJ stent was inserted in 15 patients (62.5) while open tip ureteric catheter was inserted in the remaining 9 children (37.5%). Rashid *et al* [14]

reported that DJ was used in 24 patients (86%).
Mahmood *et al* [15] reported that DJ was inserted routinely in all patients.

In the current study, 3 patients had mild intraoperative bleeding and no one had severe bleeding that needed to abort the procedure.

In a study conducted by Desai *et al*. [16], it was shown that there exists a correlation between bleeding and both the diameter and quantity of tracts. In a recent study conducted by Zeren *et al*. [17], a noteworthy association was seen between intraoperative bleeding and factors such as operational duration, stone load, and sheath size. In a study conducted by Gunes *et al*. [18], it was shown that there was a greater prevalence of problems in children under the age of 7 when adult-sized equipment were used. According to Aron *et al*. [19], the primary factor contributing to bleeding throughout PCNL is the application of torque to a stiff nephroscope. The authors also advocate for utilising of numerous tracts instead of relying only on a single tract for the majority of the surgical procedure. The torque effect shown by instruments is dependent upon both their diameter and length. Based on the lever principle, it may be seen that longer instruments exert a larger force on the kidney. Hence, it is suggested that careful consideration should be given to the strategic positioning of the first tract during surgical procedures, with the aim of facilitating the extraction of a significant portion of the stone. This approach would thereafter allow for the retrieval of any remaining pieces using smaller or multiple tracts.

Regarding the postoperative fever, we noted that 4 of 24 (16.7%) patients had postoperative fever, 3 patients had low grade fever (below 38.5) and one patient had high grade fever (above 38.5). Caione *et al* [20] stated that only 3 patients of 108 individuals had fever. Mahmood *et al* [13] reported that 23 patients of 134 patients and all cases were managed by appropriate antibiotics and antipyretics. Sebaey *et al* [21] reported that 2 patients of 50 children that underwent mini-PCNL developed post-operative fever.

Hypothermia was absent in all of our participants. This outcome is explained by the fact that operative room temperature was maintained within normal. We used warmed normal saline for irrigation. Furthermore, we covered parts of the body that are not in the operative field. Unsal *et al* [6] reported that no patient had hypothermia during PCNL in 44 patients. Aldaqadossi *et al* [22] reported also that no patient had hypothermia during PCNL in 122 patients.

None of our patients had urine leakage. El-Nahas *et al* [10] reported that 3 patients of 50 patients had urine leakage. Aldaqdossi *et al* [22] reported that 3 patients of 121 children had urine leakage.

No patient of our cases had colon injury. Ozturk *et al* [23] discovered 36 colonic injuries out of 9996 PCNL individuals. Moussavi-Bahar *et al* [24] reported that 2 patients of 671 patients had colon perforation. Mahmood et [13] al reported that no patient had colon injury in 134 pediatric patients.

Regarding the stone free rate, In our study SFR following the initial session PCNL was 87.5%. The residual stones were only in 3 cases. Badway *et al* [22] reported that SFR was to be approximately 84% with PCNL monotherapy. Mahmood *et al* [13] reported that When comparing the stone clearance rate between MPCNL and SPCNL in children, there was no discernible variation (89.5% vs 94.7%). 35 out of 46 children (76%) had total stone removal, according to Brodie *et al*. [25]. Over 80% of the remainder 11 children got their stones removed.

The major limitations of the work were that the sample size in this study appears to be small, and the follow-up period is rather brief, use of different types of nephroscopes, lithotripters and dilators.

Conclusions

PCNL is a safe and efficient method for treating the large renal stones in children. Tract dilation in children is a tailored technique that depends on stone burden, age of the patient, degree of hydronephrosis and availability of instruments. Miniaturization in children is important but optimization is more important.

Financial support and sponsorship: Nil

Conflict of Interest: Nil

References

1. Straub M, Gschwend J, Zorn C. Pediatric urolithiasis: the current surgical management. Pediatr Nephrol. 2010;25:1239-44.
2. Rizvi SAH, Sultan S, Zafar MN, Ahmed B, Aba Umer S, Naqvi SAA, *et al*. Paediatric urolithiasis in emerging economies. Int Surg J. 2016;36:705-12.
3. Rizvi S, Naqvi S, Hussain Z, Hashmi A, Hussain M, Zafar M, *et al*. Management of pediatric urolithiasis in pakistan: experience with 1,440 children. Urol J. 2003;169:634-7.
4. Samad L, Aquil S, Zaidi Z. Paediatric percutaneous nephrolithotomy: setting new frontiers. BJU Int. 2006;97:359-63.
5. Traxer O, Smith TG, Pearle MS, Corwin TS, Saboorian H, Cadeddu JA, *et al*. Renal parenchymal injury after standard and mini percutaneous nephrostolithotomy. J Urol. 2001;165:1693-5.
6. Unsal A, Resorlu B, Kara C, Bozkurt OF, Ozyuvali E. Safety and efficacy of percutaneous nephrolithotomy in infants, preschool age, and older children with different sizes of instruments. Urol J. 2010;76:247-52.
7. Bilen C, Kocak B, Kitirci G, Ozkaya O, Sarikaya S. Percutaneous nephrolithotomy in children: Lessons learned in 5 years at a single institution. Urol J. 2007;177:1867-71.
8. Ganpule AP, Mishra S, Desai MR. Percutaneous nephrolithotomy for pediatric urolithiasis. Indian J Urol. 2010;26:549-54.
9. Salerno A, Nappo SG, Matarazzo E, De Dominicis M, Caione P. Treatment of pediatric renal stones in a western country: a changing pattern. J Pediatr Surg. 2013;48:835-9.
10. El-Nahas AR, Shokeir AA, El-Kenawy MR, Shoma AM, Eraky I, El-Assmy AM, *et al*. Safety and efficacy of supracostal percutaneous nephrolithotomy in pediatric patients. Urol J. 2008;180:676-80.
11. Bujons A, Millán F, Centeno C, Emiliani E, Martín FS, Angerri O, *et al*. Mini-percutaneous nephrolithotomy with high-power holmium YAG laser in pediatric patients with staghorn and complex calculi. J Pediatr Urol. 2016;12:253-5.
12. Jou YC, Shen JH, Cheng MC, Lin CT, Chen PC. Percutaneous nephrolithotomy with holmium: yttrium-

aluminum-garnet laser and fiber guider-report of 349 cases. Urol J. 2005;65:454-8.
13. Mahmood SN, Aziz BO, Tawfeeq HM, Fakhralddin SS. Mini–versus standard percutaneous nephrolithotomy for treatment of pediatric renal stones: is smaller enough? J Pediatr Urol. 2019;15:664-9.
14. Rashid AO, Amin SH, Kadum A, Abed M, Mohammed SK, Buchholz N, *et al*. Mini-percutaneous nephrolithotomy for complex staghorn stones in children. Urol Int. 2019;102:356-9.
15. Mahmood SN, Falah B, Ahmed C, Fakhralddin S, Tawfeeq H. Is mini percutaneous nephrolithotomy a game changer for the treatment of renal stones in children? Eur Urol Open Sci. 2022;37:45-9.
16. Desai M. Endoscopic management of stones in children. Curr Opin Urol. 2005;15:107-12.
17. Zeren S, Satar N, Bayazit Y, Bayazit AK, Payasli K, Özkeçeli R, *et al*. Percutaneous nephrolithotomy in the management of pediatric renal calculi. J Endourol. 2002;16:75-8.
18. Gunes A, Ugras MY, Yilmaz U, Baydinc C, Soylu A. Percutaneous nephrolithotomy for pediatric stone disease our experience with adult-sized equipment. Scand J Urol. 2003;37:477-81.
19. Aron M, Yadav R, Goel R, Kolla SB, Gautam G, Hemal AK, *et al*. Multi-tract percutaneous nephrolithotomy for large complete staghorn calculi. Urologia internationalis. 2005;75:327-32.
20. Caione P, Collura G, Innocenzi M, De Dominicis M, Gerocarni Nappo S, Capozza N, *et al*. Percutaneous endoscopic treatment for urinary stones in pediatric patients: where we are now. Transl Pediatr. 2016;5:266-74.
21. Sebaey A, Abdelaal A, Elshaer A, Alazaby H, Kadeel W, Soliman T, *et al*. Modified tubeless minimally invasive percutaneous nephrolithotomy for management of renal stones in children: A single-centre experience. Arab J Urol. 2019;17:285-91.
22. Smaldone MC, Docimo SG, Ost MC. Contemporary surgical management of pediatric urolithiasis. Urol Clin North Am. 2010;37:253-67.
23. Öztürk H. Treatment of colonic injury during percutaneous nephrolithotomy. Rev Urol. 2015;17:194-201.
24. Mousavi-Bahar SH, Mehrabi S, Moslemi MK. Percutaneous nephrolithotomy complications in 671 consecutive patients: a single-center experience. Urol J. 2011;8:271-6.
25. Brodie KE, Lane VA, Lee TWJ, Roberts JP, Raghavan A, Hughes D, *et al*. Outcomes following 'mini' percutaneous nephrolithotomy for renal calculi in children. A single-centre study. J Pediatr Urol. 2015;11:120-5.

How to Cite This Article
Elmlegy EAE, Nagla SAE, El-Gamal SAEH, El-Gamal OM. Safety and efficacy of PCNL for the management of renal stones in children. International Journal of Urology Research. 2023;5(1):15-21