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Management of Pediatric Renal Stones (10-20mm) by Flexible Ureteroscopy (F-URS), Miniaturized Percutaneous Nephrolithotomy (Mini-Perc) or Extracorporeal Shock Wave Lithotripsy (ESWL): Comparative Study

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Abstract

Background: Kidney stones have become much more common in recent years. Renal stones in children are often caused by congenital anatomical abnormalities, metabolic problems, or recurrent urinary tract infections. This is why padiatrics are more likely to have recurrent urolithiasis and need repeated surgical procedures.**Methods:** Subjects for this prospective trial, all of whom had a single renal stone (in the pelvis or lower calyx) measuring 10-20 mm in diameter, were collected and randomly assigned to one of three groups (A; F-URS; B; Mini-Perc; C) (ESWL). The flexible ureteroscope was used to complete the URS procedure. Stones in Groups A and B were fractured or dusted using holmium:YAG laser during mini-Perc, which was conducted using a rigid paediatric nephoscope. Under fluoroscopy's watchful eye, ESWL was carried out with the aid of a piezoelectric lithotripter machine.**Results:** No statistically significant variations in stone location, orientation, size, or density were found. There was a statistically significant difference in operative time between the three groups tested, with group B taking much longer than groups A and C. Group B had a considerably longer fluoroscopy duration compared to groups A and C. There were no noteworthy variations in blood loss or the need for ancillary procedures.**Conclusions:** Treatment of renal stones in children less than 16 years old with ESWL, mini-PCNL, or RIRS is safe and successful.

Keywords: Medical terms to know: Mini percutaneous nephrolithotomy; ESWL; flexible ureteroscopy (F-URS); kidney stones in children (Mini-Per).

1. Introduction

The incidence of kidney stones in children has increased dramatically in recent years (1). Congenital anatomical defects, metabolic issues, and recurrent urinary tract infections are common causes of renal stones in children. Because of this, urolithiasis is more common in youngsters and may need more than one operation to resolve (2).

Extracorporeal shock wave lithotripsy (ESWL) has long been the treatment of choice for children with kidney stones less than 2 centimetres. There are several potential risks, including damage to the developing kidney, the need for many treatments, anaesthetic, steinstrasse formation, low stone-free rates (SFR), and longer recovery times (3).

Retrograde intrarenal surgery (RIRS) and percutaneous nephrolithotomy (PCNL) are two minimally invasive approaches to kidney stone removal that have lately gained popularity (4).

Mini-percutaneous nephrolithotomy (Mini PCNL) has gained popularity as a paediatric endourological therapy since it has less adverse effects than conventional PCN (5). However, owing to the kidneys' enhanced mobility and smaller size, even children with a moderate type of PCNL may have difficulties (6). When many accesses are required for the treatment of different types of stones, complications are more likely to arise (7).

These patients may undergo a single phase of RIRS or many stages depending on the number of stones, their size, and their location (8). Research on the use of RIRS in children is still in its infancy, despite its lengthy history of efficacy in the treatment of upper urinary tract stones in adults (9).

The goal of this research was to compare the efficacy of three different urological procedures: endoscopic stent-guided lithotripsy (ESWL), percutaneous nephrolithotomy (mini-PCNL), and flexible URS (RIRS) (10-20 mm).

2. Patients & Methods

The research was conducted by the Urology Department at Benha University Hospital between April 2021 and March 2023. The research was sanctioned by a moral review board. All minor patients or their guardians signed written informed consent forms.

Inclusion criteria were Teenagers under the age of 20 who have a single renal pelvic or lower calyceal calculus

Exclusion criteria were upper and middle calyceal stones, ureteral stones, and anomalous kidney stone patients aged 16 and above.

Patients were assigned at random to Group A, Group B, or Group C to receive one of three possible treatments. Thirty people were assigned to each treatment group. Group A patients received F-URS, group B patients had mini-perc, and group C patients got ESWL. Some patients required the placement of a JJ stent.

Serum creatinine, KUB, US, and non-contrast computed tomography scan were all part of the preoperative examination. Culture and sensitivity had a role in the management of UTIs.

Extracorporeal shockwave lithotripsy: Pethidine sedation anaesthesia was used for SWL, and it was given as an IV bolus 10 minutes before the surgery. Under fluoroscopic supervision, SWL was done using a piezoelectric lithotripter (Piezolith 3000 plus, Richard Wolf GmbH, Pforzheimer Strabe 32,75438 Knittlingen, Germany). The shock waves were sent out at a rate of 60–90 per minute, with an energy level of 8–10 kV. After 3000 shock waves were applied during each session, the stone was either totally destroyed or the session was over. Repeat therapy was administered if there was still a piece of stone visible on (KUB) radiography and USG 1 week after each session.

Mini-Perc Technique: Under general anaesthesia, a 5-Fr ureteral catheter is inserted retrogradely into the ureter while in the lithotomy posture. Under fluoroscopic guidance, the urologist percutaneously inserted an 18-gauge needle while the patient lay on his or her back. Twelve to twenty Fr Amplatz dilators were used to dilate the intestines. A rigid paediatric nephroscope (Storz miniperc 16.5 Fr, 12°, 22 cm) was inserted via an 18 Fr Amplatz sheath into the ureter to get access to the pelvicalyceal system. All patients' stones were effectively shattered and powdered by the holmium:YAG laser (Luminis Pulse 30H, Germany). No signs of fracture were seen on postoperative fluoroscopic imaging, hence the procedure was considered a success. Percutaneous nephrolithotomy (PNL) necessitates the insertion of a nephrostomy tube, which is often withdrawn between postoperative days 1 and 2, following which the patient is allowed to go home.

F-URS Technique: After putting the children to sleep, an endoscopic table fitted with a fluoroscopic camera was used to position them in the lithotomy position. Rigid ureteroscopy was used to implant a hydrophilic guidewire into the renal pelvis under fluoroscopic guidance. Urethral dilation was performed using Teflon dilators as big as 14 Fr. For two weeks prior to undergoing RIRS, a DJ stent was implanted after the detection of a narrow ureter. After advancing a 0.035/0.038-inch safety guidewire into the renal pelvis, a ureteral access sheath (9.5/11.5 Fr, 35 cm) was placed. The ureteral access sheath has become the standard because surgeons prefer it when treating younger children and those with a heavy stone burden, which necessitates many ureteroscope passes. Patient's urinary tract is entered by a ureteral access sheath or a flexible ureteroscope (Boston Scientific LithoVue TM 7.7/9.5Fr, 68cm). The ureter was hydrodilated using a manual irrigation pump during the ureteroscopy procedure. If a stone was too big to pass on its own, a holmium:YAG laser would shatter it into smaller pieces. Although cutting was not routine, sometimes the residual fragments were removed with tipless nitinol baskets in order to examine the stones. In order to better see the lower pole stones before undergoing lithotripsy, they were sometimes basketed to a more favourable position in the upper calix. A double-J stent, of the surgeon's choosing, will be placed at the end of the treatment and will be removed 7-28 days later while the patient is under local anaesthesia.

3. Results

This study analysed cases of paediatric kidney stones treated at Benha University Hospital using either flexible ureteroscopy, micro PCNL, or shock wave lithotripsy.

Thirty patients were randomly assigned to one of three groups: Group A, which had flexible ureteroscopy; Group B, which underwent minor percutaneous nephrolithotomy; and Group C, which underwent shock wave lithotripsy.

Age (P = 0.649) and gender (P = 0.951) did not significantly vary across the groups (Table 1).

The results for location, orientation, size, and density were all inconclusive (P = 0.388, 0.721, 0.091, and 0.143, respectively) (Table 2).

Table (1) General characteristics of the studied groups

	Group A (n = 30)	**Group B (n = 30)**	**Group C (n = 30)**	**P-value**
Age (years)	13 ±2	12 ±3	12 ±2	0.649
Sex				
Males	18 (60)	18 (60)	17 (56.7)	0.951
Females	12 (40)	12 (40)	13 (43.3)	

Data were presented as mean ±SD or number (percentage)

Table (2) Stone characteristics of the studied groups

	Group A (n = 30)	**Group B (n = 30)**	**Group C (n = 30)**	**P-value**
Site				
Pelvis	17 (56.7)	16 (53.3)	21 (70)	0.388
Lower calyx	13 (43.3)	14 (46.7)	9 (30)	
Side				
Right	14 (46.7)	15 (50)	12 (40)	0.721
Left	16 (53.3)	15 (50)	18 (60)	
Size (cm)	1.3 ±0.4	1.4 ±0.2	1.3 ±0.4	0.091
Number				

Single	30 (100)	30 (100)	30 (100)	-
Density (HU)	791 ±139	798 ±135	784 ±126	0.143

* Significant; Data were presented as mean ±SD or number (percentage)

The operative times of the two groups were statistically different. Group B took much longer (99 minutes, 13 seconds) than either Group A (83 minutes, 7 seconds) or Group C (83 minutes, 7 seconds) (78 21 minutes) (Figure 1) and (Table 3).

Table(3) Operative characteristics of the studied groups

	Group A (n = 30)	Group B (n = 30)	Group C (n = 30)	P-value
Operative time (min)	83 ±7 [a]	99 ±13 [b]	78 ±21 [a]	<0.001*
Fluoroscopy time (sec)	49 ±7 [a]	103 ±11 [b]	85 ±13 [c]	<0.001*
Blood loss (gm/dl)	0 (0)	1 (3.3)	0 (0)	1.0
Auxiliary procedure need	5 (16.7)	3 (10)	7 (23.3)	0.644

* Significant; Data were presented as mean ±SD or number (percentage); Different small letters indicate significant ±difference

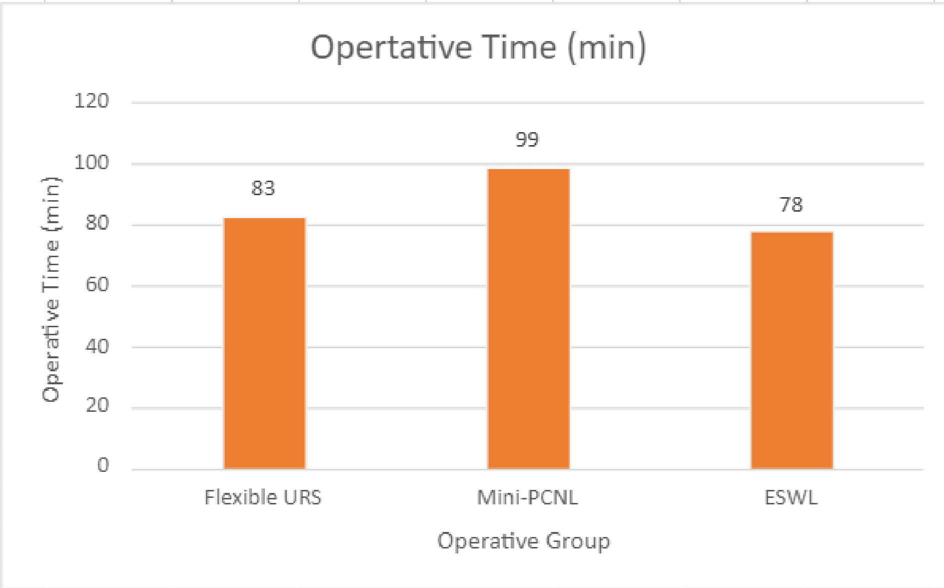

Fig. (1) Operative time of the studied groups

The amount of time spent under fluoroscopy differed significantly between the two groups (P 0.001). When compared to groups A (49.7 seconds) and C (85.13 seconds), group B took significantly longer to finish the exercise in a post hoc study. What's more, it was noticeably higher in group C compared to group A. (Figure 2), Table 3, etc.

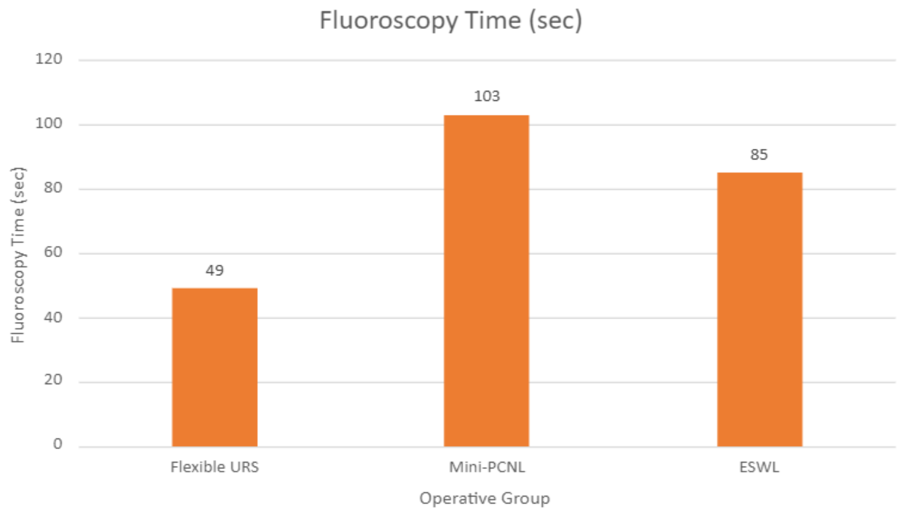

Fig. (2) Fluoroscopy time of the studied groups

Neither the amount of blood lost nor the requirement for a secondary surgery changed significantly (P = 1.0 and P = 0.644, respectively). (Table 3).

Overall, there was a large disparity in the median duration of hospital stays across the groups (P 0.001). Post hoc analysis showed that group C patients spent significantly less time in the hospital (median = 12 hours) compared to patients in groups A and B (median = 36 and 48 hours, respectively) (Table 4, Figure 3).

The rates of stone-freedom (P = 0.657), pain ratings (P = 0.135), complications (P = 0.519), or kinds of complications (P = 0.847) did not vary significantly between the two groups. (Table 4).

Table (4) Outcome of the studied groups

	Group A (n = 30)	Group B (n = 30)	Group C (n = 30)	P-value
Hospital stay (hours)	36 (36 - 48) [a]	48 (36 - 72) [a]	12 (12 - 12) [b]	<0.001*
Stone free rate	26 (86.7)	27 (90)	25 (83.3)	0.657
Pain score	3 (1 – 6)	3.5 (1 – 7)	3 (1 – 5)	0.135
Complications	8 (26.7)	12 (40.0)	6 (20)	0.519
Complications type				
GI	5 (62.5)	6 (50)	3 (50)	0.847
GII	3 (37.5)	5 (41.7)	2 (33.3)	
GIII	0 (0)	1 (8.3)	1 (16.7)	

* Significant; Data were presented as median (min-max) or number (percentage)

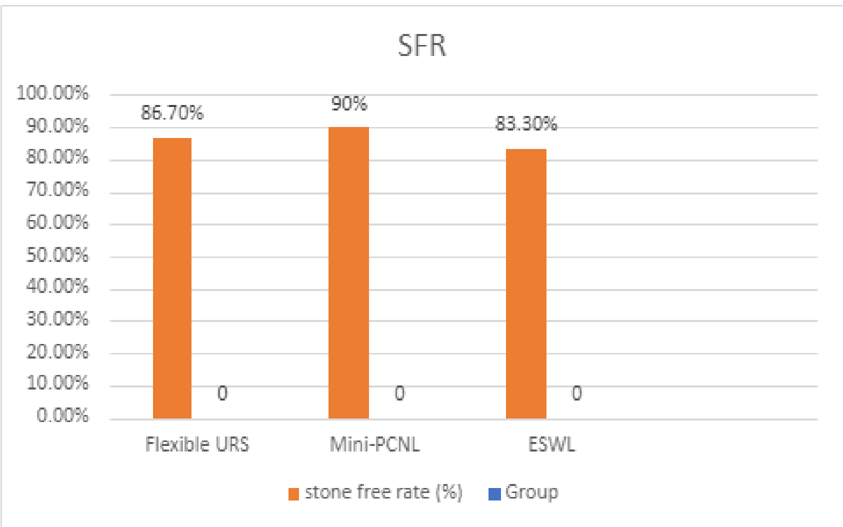

Fig. (3) Stone-free rate in the studied groups

4. Discussion

In particular, we were interested in comparing the efficacy of endoscopic stent-withdrawal lithotripsy (ESWL), percutaneous nephrolithotomy (mini-PCNL), and flexible URS (RIRS) for treating kidney stones in children (10-20 mm).

When comparing the initial SFR between RIRS and mini-PCNL, we found no statistically significant changes (86.7 percent and 90 percent in the RIRS and mini-PCNL groups, respectively). Both approaches had comparable results in terms of the number of residual stones that required further treatment. This agrees with the results of a research that compared the effectiveness of RIRS and mini-PCNL in treating kidney stones in children with a diameter of 10-30 millimetres. The SFR for those receiving RIRS was 84%, while those receiving mini-PCNL saw an increase to 86%. According to the results of this investigation, the RIRS success rate drops significantly when dealing with stones bigger than 20 mm (1). In addition, the SFR for RIRS was 79.7 percent and 80.9 percent after mini-PCNL for stones larger than 2 centimetres (2). In contrast, another study found that the SFR for RIRS in the treatment of paediatric stones was lower (75%) than that of mini-PCNL (84.4%). (3).

Initial SFR rates were comparable across one-session ESWL (70%) and RIRS (86.6%) in a 2014 study (P=0.117). (4). After three sessions of ESWL, SFR was higher in ESWL, but we did not find a statistically significant difference between ESWL and RIRS (83.3 percent vs. 86.7 percent).

Mini-PCNL had a much higher SFR (88.9%) after the first session than ESWL (55.6%) in two trials comparing the two interventions for children (one published in 2018 and the other in 2022). Third ESWL session and second look at mini-PCNL both resulted in an increase in SFR, but the gains were not statistically significant (92.59 percent vs. 88.89 percent and 96.6 percent vs. 93.75 percent) (5, 6). Our SFR findings for mini-PCNL and ESWL were not significant.

In a study including 90 paediatric patients, the SFR for mini-PCNL was 95.6% and the SFR for RIRS was 88.9%; there was no statistically significant difference between the two groups (P=0.238) (7). Our investigation found no significant difference, despite the SFR being lower than in this study due to our smaller sample number (60 vs 90).

A study conducted in 2012 found that although the average operate time for a mini-perc was 30 minutes, the average operative time for a RIRS was 76.3 minutes (range, 15-165). (1). There was a statistically significant difference between the two groups, just as we discovered, although their study period was substantially shorter.

The operative time (mean SD) for RIRS was 40.78 minutes compared to 27.35 minutes for ESWL in a study including 60 preschool kids in 2014 (P>0.0001). While the other study only measured operational time after a single treatment session, we did so after three ESWL and one RIRS session (thus, our study is longer) (4). There was a statistically significant difference between the ESWL and RIRS (one session) groups in terms of operational time (operating time (mean SD) was 60.8 11.5 minutes in the RIRS group and 39.5 9 minutes in the ESWL group (P = 0.03)). (8).

According to the study, neither the RIRS nor the ESWL groups had any major adverse effects, and no children in either group required blood transfusions (4). Our results are in line with this research.

Two studies done in 2022 and 2020 found no statistically significant difference in the rate of complications between mini-PCNL and ESWL. (5, 6). The complication rate between min-PCNL and ESWL was not significantly different.

In a study conducted in 2012, researchers observed that there was no statistically significant difference in the complication rates between the min-PCNL and RIRS groups (P=0.071). (1). Only 15.6% of the mini-PCNL group and 6.7% of the RIRS group had no major issues (grade IV or V) (7). This rate is lower than what was found in the present study.

There was a statistically significant difference (P=0.01) in the complication rates of the mini-PCNL group (52.5%; 21/40) and the RIRS group (27.4%; 27/73). (2). It's possible that a larger sample size and larger stones contributed to the higher complication rate in the mini-PCNL group compared to our study.

When comparing the frequency with which each group required adjunctive procedures, there was no statistically significant difference (P = 0.654). Research showing no difference between mini-PCNL and ESWL in the usage of an auxiliary technique is consistent with these results (5).

There was no statistically significant difference between the RIRS and mini-PCNL auxiliary procedure rates (11.1% vs. 4.4%, respectively, (P=0.238)) in a study done in 2022. (7). Our findings showed no statistically significant difference between RIRS and mini-PCNL.

The 2018 study found that the length of hospital stay was significantly different between mini-PCNL and ESWL (mean SD: 63.711.09 hours vs. 4.890.97 hours, respectively; P=0.000). (5). In our study, we found that mini-PCNL was linked to a lengthier time spent in the hospital.

Patients who had Mini-PCNL stayed in the hospital for an average of 4.5 1.5 days (range, 1-7 days; longer stays were seen for patients who suffered complications), whereas ESWL was an outpatient procedure (6). According to the data we gathered, the typical duration of stay for mini-PCNL was just 48 hours (36-72 hours).

5. Conclusion

Treatment of renal stones in children less than 16 years old with ESWL, mini-PCNL, or RIRS is safe and successful.

6. Conflict of interest:

No authors mentioned any potential bias.

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