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Original Research

In the Treatment of Lower Pole Kidney Stones Between 1-2 cm in Children, Which is the Best Approach? Retrograde Intrarenal Surgery or Mini Percutaneous Nephrolithotomy

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Abstract

Objectives: Kidney stones are treated with many methods, but there is no consensus on which method should be preferred for 1-2 cm lower renal stones. In our study, we aimed to investigate the results of mini (Percutaneous Nephrolithotomy) PCNL and (Retrograde Intrarenal Surgery) RIRS in lower renal pole 1-2 cm stones.

Methods: Twenty-four mini PCNL and 55 RIRS patients were included in the study. Demographic data of the patients and information about stones on Non-Computed Tomography (NCCT) were recorded. Stone-free status (SFR), need for additional treatment and complications of both methods were compared.

Results: Operative time was 55.2±20.8 min in mini PCNL and 70.7±36.5 min in RIRS, which was statistically significantly lower (p=0.002). Length of hospital stay was 2.4±1.5 days in the mini PCNL and 1.3±0.7 days in the RIRS, which was statistically significantly longer (p=0.011). In the postoperative 1st month and 3rd month stone-free rates (SFR) were higher in the mini PCNL group. While the 1st month SFR was 91.6% and 54.5%, the 3rd month stone-free rates were 95.8% vs. 69.1%, respectively (p<0.001). The need for re-treatment was statistically lower in the mini PCNL group (p<0.001). In terms of complications, the incidence of complications was 16.6% (pain in 2 patients, fever in 1 patient, need for blood transfusion in 1 patient) in the mini PCNL group and 21.8% (pain in 2 patients, fever in 8 patients, sepsis in 2 patients) in the RIRS group. There was a significant difference between the two groups (p=0.008).

Conclusion: Mini PCNL has a higher SFR, less need for re-treatment and fewer complications

Keywords: Flexible ureterorenoscopy, kidney stone, mini PCNL, retrograde intrarenal surgery

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Approximately 2-3% of stone disease is reported in pediatric patients and its prevalence has recently been reported to increase up to 10.6%.[1] Increasing incidence of stones has become a major health concern.[2] Minimally invasive methods are applied for kidney stones requiring surgery due to technological advances.[3] Retrograde Intrarenal Surgery (RIRS) and Percutan Nephrolithotomy (PCNL) are treatment options for kidney stones, but there is no

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consensus on which method should be preferred for 1-2 cm.[4-6] While the advantage of flexible urethroscopy is less renal damage and bleeding, the disadvantage is the need for Double J (D-J) stent placement and the possibility of re-intervention and ureteral injury. Although the possibility of renal damage and bleeding is higher in PCNL procedure, this situation has been minimized with improved instruments (mini PCNL, super mini PCNL).[4-6] The aim of this retrospective study was to compare the efficacy and safety of mini PCNL and RIRS for lower pole 1-2 cm kidney stones in children

Methods

This study was approved by the Ethical Review Committee of Izmir Tepecik Training and Research Hospital (No: 2024/02-06, Date: 04.03.2024). Artificial intelligence (AI) assisted technologies (such as Large Language Models [LLMs], chatbots or image generators, ChatGPT) were not used in the study. All procedures performed in the study involving human participants were conducted in accordance with the ethical standards of the institutional and/or national research committee and the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

We retrospectively analyzed the clinical data of patients under 18 years of age who underwent mini PCNL and RIRS at Izmir Tepecik Training and Research Hospital between January 2018 and December 2023. In order to perform stone operation in children, a specialized experience is required. Since there may be more complications in stone surgery in pediatric patients than in normal people, this study consists of cases performed by specialists with at least 5 years of surgical experience in stone surgery. Inclusion criteria were (1) under 18 years old, (2) patients with no anatomical urinary tract abnormalities, (3) 1-2 cm lower pole kidney stones and patients who will undergo surgery for this stone for the first time (4) urine culture-negative patients. Exclusion criteria were (1) acute pyelonephritis, (2) previous history of stone surgery, (3) <1 cm or >2 cm kidney stone. After inclusion and exclusion criteria, 65 patients undergoing mini PCNL and 24 patients underwent RIRS were included in the study.

The primary endpoint of the study was to determine the SFR and complication rates of SMP and RIRS methods at 1st and 3rd months postoperatively. The secondary endpoint was to compare the preoperative and postoperative results of both surgical methods.

Urine cultures were performed before both procedures. The procedure was planned after the urine culture was negative. Patients undergoing the procedure received a single dose of antibiotic prophylaxis before the operation.

Stone size was determined as the maximum diameter of the stone. In the case of more than one stone, the total stone size was obtained by summing the long axes of the stones. Stone volume was obtained by multiplying the triaxial dimensions of the stone and dividing by two ($x \times y \times z/2$). Stone density was measured using bone windows on a Non-Contrast Computerized Tomography (NCCT) image.

For mini PCNL, the operative time was defined as the time from the time the nephrostomy needle was inserted into the collecting system until the skin was closed, while for RIRS it was defined as the time from the time the URS was inserted through the mea to the placement of the D-J stent.

SFR was evaluated by fluoroscopic evaluation at the end of the procedure. No nephrostomy catheter or D-J stent was placed in completely tubeless PCNL. Nephrostomy tube and/or D-J stent were placed if there were any residual stones, extravasation and bleeding. SFR was assessed with Kidney–Ureter–Bladder graphy (KUB) or NCCT in imaging studies performed at 1st and 3rd months after surgery. Residual fragments <4 mm were defined as clinically insignificant residual fragments.

Duration of surgery, nephrostomy tube and/or D-J stent placement, intra-postoperative complications and postoperative hemoglobin (Hb) decline were recorded. Complications were evaluated using the Clavien grading system.[7]

Endoscopic Procedure

Mini PCNL

All PCNLs were performed in supine position. The patient was first placed in the lithotomy position under general anesthesia. In this position, a 5F ureteral catheter was placed into the renal pelvis. The selected calyx was identified under fluoroscopic guidance and a 0.035-inch guidewire was inserted into pelvicaliceal system through a needle into the calyx. A nephrostomy tract was created with metal dilators (16F) accompanied by the guide wire. Fragmentation of the stone burden was accomplished using a Holmium: YAG laser with a laser fiber up to 365 lm and/or pneumatic (Vibrolith®, Elmed, Ankara, Türkiye) lithotripter. Stone fragments were suctioned through the oblique tube under the influence of negative pressure suction and pressure regulation of the pressure ventilator. Larger fragments were collected with forceps or baskets. After removal of the stones, the SFR was evaluated by endoscopic and fluoroscopic imaging. D-J stent was placed in the presence of inaccessible small fragments, bleeding, and edema. A nephrostomy tube was placed in patients with significant bleeding or extravasation.

RIRS

In the lithotomy position, a 0.035-inch guidewire was inserted under rigid ureterorenoscopy (URS) guidance. A ureteral access sheath (9.5F, 35 cm, Boston Scientific, USA) was placed with the guidewire. The stone localized in the lower kidney pole was accessed with a flexible URS. This 1-2 cm stone in the lower renal pole was fragmented with Holmium: YAG laser. D-J stent was placed in each patient and removed after 1-3 months.

Statistical Method

The data were evaluated in the statistical package program IBM SPSS Statistics 25.0 (IBM Corp., Armonk, New York, USA). Categorical variables were presented as frequency (%). Continuous variables were expressed as mean±standard deviation (SD). Categorical variables were given as frequency and percentage. The relationship between categorical variables was evaluated with the Pearson Chi-Square test. Mann Whitney U test was used to compare two groups of independent continuous variables where the normal distribution assumption was not met. A value of $p<0.05$ was considered statistically significant.

Results

No difference was found in the comparison of demographic data (age, gender, BMI). There was no difference between the groups in the preoperative NCCT evaluations (stone density, stone size, etc). The mean length of stone volume was 330.6±80.8 mm^3 in the mini PCNL and 270.6±60.2 mm^3 in the RIRS, but this difference was not statistically significant. Table 1 shows the preoperative demographic and NCCT data of the patients.

Operative time was 55.2±20.8 min in the mini PCNL and 70.7±36.5 min in the RIRS, which was statistically significantly lower (p=0.002). The mean length of hospital stay was 2.4±1.5 days in the mini PCNL and 1.3±0.7 days in the RIRS, which was statistically significantly longer (p=0.011). After the procedure was completed, 41.6% of the patients in the mini PCNL were placed with only a nephrostomy tube, 20.8% with only a D-J stent, 4.1% with both, and 33.3% without a total tubeless. In the RIRS, a D-J stent was inserted in all patients. Hb decrease in postoperative follow-up was statistically higher in the mini PCNL (1.1±0.8 vs. 0.4±0.2) ($p<0.001$). Postoperative 1st and 3rd month SFR were higher in the mini PCNL. While the 1st month SFR was 91.6% and 54.5%, the 3rd month SFR was 95.8% vs. 69.1%, respectively ($p<0.001$). The re-treatment need was statistically lower in the mini PCNL ($p<0.001$). Mini PCNL was performed on 6 patients in the RIRS due to inaccessibility of the stone 1-3 months after RIRS procedure. In the RIRS group, D-J stent was placed in 3 patients due to ureteral orifice stenosis and RIRS was performed again in the following period. URS was performed in 2 patients in the RIRS group after the fragments remained in the ureter. Follow-up decision was taken for 1 patient in the mini PCNL group and 5 patients in the RIRS group because of the localization of the stones, which were considered to be insignificant. Intraoperative and postoperative results are described in Table 2.

Table 1. Demographic and preoperative NCCT data of the patients

	Mini PCNL (n=24)	RIRS (n=55)	p
Age (years)	10.3±5.7	11.7±6.1	0.763
BMI (kg/m^2)	18.3±3.9	17.7±2.8	0.651
Gender (n, %)			
Female	8 (33.3)	18 (32.7)	0.817
Male	16 (66.6)	37 (67.3)	
Stone number (n, %)			
Single	21 (87.5)	50 (90.9)	0.785
Multiple	3 (12.5)	5 (9.1)	
Stone side (n, %)			
Right	13 (54.1)	38 (69.1)	0.216
Left	11 (45.9)	17 (30.9)	
Stone Density (HU)	968±310	886±279	0.337
Stone Size (mm)	16.4±3.7	13.1±2.8	0.09
Stone Volume (mm^3)	330.6±80.8	270.6±60.2	0.04
Stone Density (HU)	968±310	886±279	0.337

BMI: Body MassIndex.

The incidence of complications was 16.6% (pain in 2 patients, fever in 1 patient, need for blood transfusion in 1 patient) in the mini PCNL and 21.8% (pain in 2 patients, fever in 8 patients, sepsis in 2 patients) in the RIRS. There was a significant difference between the two groups (p=0.008). Clavien 1 complications were higher in the mini PCNL and Clavien 2 complications were higher in the RIRS. Clavien 3 complications were observed only in the RIRS group. Clavien 4 and 5 complications were not observed in both groups. Table 3 shows the postoperative complications of the two groups.

Discussion

There is no consensus on the management of renal lower pole stones because they are more challenging to reach compared with renal stones in other localizations.[8] It is important to provide SFR in pediatric patients due to more underlying genetic factors and more recurrence.[9] ESWL, RIRS and PCNL may be considered as treatment options for 1-2 cm renal lower pole stones; however, ESWL is not pre-

Table 2. Comparison of patients peroperative and postoperative results

Variables	Mini PCNL (n=24)	RIRS (n=55)	p
Mean operating time (min)	55.2±20.8	70.7±36.5	0.002
Mean postoperative hospital stay (days)	2.4±1.5	1.3±0.7	0.011
Mean (SD) hemoglobin drop, g/dL	1.1±0.8	0.4±0.2	0.001
Blood transfusion rate (n, %)	1 (4.1)	0	NA
Tube			
Nephrostomy tube only	10 (41.6)	-	NA
Ureteral stent only	5 (20.8)	55 (100)	
Total tubeless	8 (33.3)	-	
Nephrostomy tube and Ureteral stent	1 (4.1)	-	
SFR at 1 month			
Yes	22 (91.6)	30 (54.5)	0.000
No	2 (8.4)	25 (45.5)	
SFR at 3 months			
Yes	23 (95.8)	38 (69.1)	0.000
No	1 (4.1)	17 (30.9)	
Re-treatment rate			
Yes	0 (0.0)	12 (21.8)	0.00
No	24 (100)	43 (78.2)	
Type of re-treatment procedure			
Follow	1	5	0.00
RIRS	0	3	
URS	0	2	
ESWL	0	1	
Mini PCNL	0	6	

SFR: Stone Free Rate; RIRS: Retrograde Intrarenal Surgery; URS: Ureterorenoscopy; ESWL: Electroshock Wave Therapy; PCNL: Percutaneous Nephrolithotomy.

Table 3. Comparison of postoperative complications of both groups

Complication	Mini PCNL (n=24)	RIRS (n=55)	p
Clavien Grade I			
Pain	2 (8.3)	2 (3.6)	0.001
Clavien Grade II			
Fever (>38.5 °C)	1 (4.1)	8 (14.5)	0.001
Blood transfusion rate	1 (4.1)	0	NA
Clavien Grade 3			
Sepsis	0	2 (3.6)	NA
Total	4 (16.6)	12 (21.8)	0.008

ferred by most clinicians because of the failure to complete SFR and the need for additional re-treatment.[4,8]

Regarding ESWL treatment in pediatric patients, Demirkesen et al.[10] 126 patients and reported the results of ESWL for upper and middle pol-renal pelvis and lower pol stones. In their study, they found ESWL success rate of 80% in renal pelvis stones, 65% in upper and middle pol stones and 62% in lower pol stones. In our study, we preferred RIRS or mini PCNL in this patient group because of the lower success rate for lower pol stones and the larger stone size (1-2 cm) of the patients. In addition, compared to RIRS, PCNL also provides higher SFR, although more complications, more blood loss and longer hospitalizations have been reported.[11]

In order to overcome the disadvantages of PCNL, it has been aimed to perform operations with a thinner access sheath. With technological advances, small PCNL techniques have been developed.[12] Bilen et al.[12] evaluated three different sizes of PCNL access sheaths (14 Fr, 20 Fr and 26 Fr). They reported that the rate of postoperative complications and the rate of patients requiring blood transfusion were lower in patients using the lower access sheath (14 Fr). In our study, we used mini PCNL with a 16F sheath in patients undergoing PCNL.

RIRS is a difficult surgical procedure in the presence of a narrow infundulopelvic angle and a long calyx in lower pole stones.[8] In order to improve the SFR and to overcome the related procedural failure, instruments called baskets, which allow the stone to be carried to other parts of the kidney and fragmentation, have been developed.[13] In a systematic review, Karim et al.[14] examined the influence of lower pol

calcicial anatomy, i.e. infundibular pelvic angle, infundibular length and infundibular width on success and reported that the SFR ranged between 78% and 88% and that the infundibular pelvic angle was the most important factor in treatment outcomes. In their meta-analysis, Kang et al.[15] reported that the SFR of kidney stones treated with RIRS was approximately 66.7-94.1%. Other important factor affecting SFR include stone size. Jiao et al.[16] reported the safety and efficacy of mini PCNL and RIRS. They reported that mini PCNL was more effective than RIRS, especially in the lower pole between 1 and 2 cm kidney stones. In our study, we performed RIRS on a pediatric patient with 1-2 cm lower pole kidney stones. Our SFR rate was 54.5% in RIRS patients at 1st month follow-up and 69.1% at 3rd month follow-up. Compared to mini PCNL, the SFR rate was lower. As a result, we can conclude that mini PCNL is a more feasible treatment option to achieve SFR in lower pole kidney stones.

Due to the low efficacy of RIRS, additional procedures may be needed. Jia et al.[17] compared the results of RIRS and super mini PCNL in 1-2 cm kidney stones in children and reported that no additional treatment was required in patients who underwent super mini PCNL, while 16% of patients who underwent RIRS required URS or RIRS and 4% required ESWL. It is remarkable that 6 patients in the RIRS group in our study could not reach the stone and required mini PCNL operation in another session. In 1 of them, the procedure could not be performed due to ureteric orifice stenosis, and in 5 of them, access to the lower polic calyces with a flexible ureterorenoscope was not available due to the narrow infundibulopelvic angle.

The operation time varies depending on many factors such as stone density, composition, size and volume, and localization.[11] Prolonged operation time increases the possibility of complications. Especially prolonged intrarenal pressure may lead to an increased risk of postoperative fever and urosepsis.[18] Gao et al.[11] compared 9 studies on operation time in their meta-nalysis and reported that the operation time was shorter in patients who underwent mini PCNL compared to RIRS. In our study, the operation time was found to be statistically significantly shorter in patients undergoing mini PCNL compared to RIRS.

Renal hemorrhage is one of the most worrying complications during PCNL.[19] Since renal parenchymal integrity is not disrupted in RIRS patients, severe hemorrhage is generally not observed.[8] Sabnis et al.[19] found that the decrease in Hb between RIRS and mini PCNL was higher in the mini PCNL group compared to RIRS. In our study, the mean Hb level was 1.1±0.8 g/dL in the mini PCNL and 0.4±0.2 g/dL in the RIRS and was higher in the mini PCNL. Only 1 patient required blood transfusion.

Less length of hospital stay is one of the success criteria in the postoperative period. Shorter hospitalization periods also reduce the cost of healthcare services.[20] Chen et al.[21] compared the results of RIRS and PCNL in pediatric patients in their randomized controlled study and found a shorter hospital stay in the RIRS. Another study showed that the hospital stay was significantly shorter in RIRS compared to PCNL for renal stone; however, the hospital stay was significantly shorter in patients who were treated with totally tubeless PCNL.[21-23] In our study, although the proportion of patients who underwent total tubeless treatment was high, the duration of hospitalization was found to be higher in the mini PCNL group.

There are different opinions about both operative techniques in terms of complications.[3,12,24,25] Gao et al.[11] reported no difference between the RIRS and mini PCNL groups in terms of complications. In another study, PCNL was reported to have higher complication rates than RIRS, and with the reduction of access sheath size, PCNL complications were similar to RIRS.[24] Li et al.[3] reported 12% fever and 3% sepsis in the RIRS group and 10% fever and 6.7% bleeding in the PCNL group. In another study, the total complication rate was reported as 12.5% in the mini PCNL group and 8.3% in the RIRS group.[25] In our study, Clavien 2 and 3 complications were found to be higher in the RIRS group, whereas Clavien 1 complication was found to be higher in the mini PCNL group. Clavien 4 and 5 complications were not detected in both groups. There were 14.5% cases of postoperative fever (Clavien II) in the RIRS group and 8.2% in the mini PCNL. One case of postoperative urosepsis (Clavien III) was reported in 3.6% of patients in the RIRS group and recovered after treatment. In the mini PCNL patient group, 1 patient required blood transfusion, and complications such as interventional embolization, colon injury and pleural injury were not seen.

The limitation of this study is that it was a retrospective and single-center study. In addition, a uniform examination method was not used for SFR evaluation in post-operative controls to reduce radiation exposure.

Conclusion

This study demonstrated that both mini PCNL and RIRS are safe and feasible surgical options for the treatment of 1-2 cm lower pole kidney stones; however, a higher SFR was found in the mini PCNL. In addition, the need for re-treatment was lower in mini PCNL. In our study, the incidence of complications in mini PCNL was found to be low and is different from other studies. This study will contribute to the literature and may shed light on future studies. More studies on this subject are needed because the incidence of calculi in pediatric patients is lower than in adults.

Disclosures

Disclosures Ethics Committee Approval: The study was approved by the University of Health Sciences, Izmir Tepecik Training and Research Hospital Non-Interventional Ethics Committee (Decision No: 2024/02-06, Date: 04.03.2024).

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References

1. Ranabothu S, Bernstein AP, Drzewiecki BA. Diagnosis and management of non-calcium-containing stones in the pediatric population. Int Urol Nephrol 2018;50:1191–8. [CrossRef]
2. Tokgöz H. Minimally invasive method in urologic surgery: ureterorenoscopy in all aspects. Med Bull Sisli Etfal Hosp [Article in Turkish] 2009;43:96–100.
3. Li Z, Lai C, Shah AK, Xie W, Liu C, Huang L, et al. Comparative analysis of retrograde intrarenal surgery and modified ultra-mini percutaneous nephrolithotomy in management of lower pole renal stones (1.5-3.5 cm). BMC Urol 2020;20:27. [CrossRef]
4. Simayi A, Lei P, Tayier T, Aimaier A, Xiao'an Z, Alimu Y. Comparison of super-mini versus mini percutaneous nephrolithotomy for the treatment of upper urinary tract stones in children: a single centre experience. Pediatr Surg Int 2021;37:1141–6. [CrossRef]
5. Pillai SB, Chawla A, de la Rosette J, Laguna P, Guddeti R, Reddy SJ, et al. Super-mini percutaneous nephrolithotomy (SMP) vs retrograde intrarenal surgery (RIRS) in the management of renal calculi ≤ 2 cm: a propensity matched study. World J Urol 2022;40:553–62. [CrossRef]
6. Awedew AF, Seman YS, Yalew DZ, Wondmeneh YC, Yigzaw WA. Efficacy and safety of surgical treatment for 1-2 cm sized lower pole of renal stone: network meta-analysis of randomized control trials. Urolithiasis 2023;51:82. [CrossRef]
7. Zhang XJ, Zhu ZJ, Wu JJ. Application of clavien-dindo classification system for complications of minimally ınvasive percutaneous nephrolithotomy. J Healthc Eng 2021;2021:5361415. [Retracted] [CrossRef]
8. Zeng G, Zhang T, Agrawal M, He X, Zhang W, Xiao K, et al. Super-mini percutaneous nephrolithotomy (SMP) vs retrograde intrarenal surgery for the treatment of 1-2 cm lower-pole renal calculi: an international multicentre randomised controlled trial. BJU Int 2018;122:1034–40. [CrossRef]
9. Tasian GE, Copelovitch L. Evaluation and medical management of kidney stones in children. J Urol 2014;192:1329–36. [CrossRef]
10. Demirkesen O, Onal B, Tansu N, Altintaş R, Yalçin V, Oner A. Efficacy of extracorporeal shock wave lithotripsy for isolated lower caliceal stones in children compared with stones in other renal locations. Urology 2006;67:170–5. [CrossRef]
11. Gao XS, Liao BH, Chen YT, Feng SJ, Gao R, Luo DY, et al. Different tract sizes of miniaturized percutaneous nephrolithotomy versus retrograde intrarenal surgery: a systematic review and meta-analysis. J Endourol 2017;31:1101–10. [CrossRef]
12. Bilen CY, Koçak B, Kitirci G, Ozkaya O, Sarikaya S. Percutaneous nephrolithotomy in children: lessons learned in 5 years at a single institution. J Urol 2007;177:1867–71. [CrossRef]
13. Yildirim Ü, Ezer M, Uslu M, Güzel R, Sarica K. Comparison of dusting and fragmentation methods in the flexible ureteroscopic treatment of kidney lower calyx stones. Urolithiasis 2022;51:21. [CrossRef]
14. Karim SS, Hanna L, Geraghty R, Somani BK. Role of pelvicalyceal anatomy in the outcomes of retrograde intrarenal surgery (RIRS) for lower pole stones: outcomes with a systematic review of literature. Urolithiasis 2020;48:263–70. [CrossRef]
15. Kang SK, Cho KS, Kang DH, Jung HD, Kwon JK, Lee JY. Systematic review and meta-analysis to compare success rates of retrograde intrarenal surgery versus percutaneous nephrolithotomy for renal stones >2cm: an update. Medicine (Baltimore) 2017;96:e9119. [CrossRef]
16. Jiao B, Luo Z, Xu X, Zhang M, Zhang G. Minimally invasive percutaneous nephrolithotomy versus retrograde intrarenal surgery in surgical management of upper urinary stones - a systematic review with meta-analysis. Int J Surg 2019;71:1–11. [CrossRef]
17. Jia H, Li J, Liu B, Zhang P, Yusufu A, Nan Y, et al. Comparison of super-mini-PCNL and flexible ureteroscopy for the management of upper urinary tract calculus (1-2 cm) in children. World J Urol 2021;39:195–200. [CrossRef]
18. Tokas T, Skolarikos A, Herrmann TRW, Nagele U; Training and Research in Urological Surgery and Technology (T.R.U.S.T.)-Group. Pressure matters 2: intrarenal pressure ranges during upper-tract endourological procedures. World J Urol 2019;37:133–42. [CrossRef]
19. Sabnis RB, Ganesamoni R, Doshi A, Ganpule AP, Jagtap J, Desai MR. Micropercutaneous nephrolithotomy (microperc) vs retrograde intrarenal surgery for the management of small renal calculi: a randomized controlled trial. BJU Int 2013;112:355–61. [CrossRef]
20. Ather MH, Sulaiman MN. Flexible ureteroscopy versus miniaturized percutaneous nephrolithotomy for renal stones of 1-2 cm. Fac Rev 2020;9:29. [CrossRef]
21. Chen Y, Deng T, Duan X, Zhu W, Zeng G. Percutaneous nephrolithotomy versus retrograde intrarenal surgery for pediatric patients with upper urinary stones: a systematic review and meta-analysis. Urolithiasis 2019;47:189–99. [CrossRef]
22. Zhang W, Zhou T, Wu T, Gao X, Peng Y, Xu C, et al. Retrograde intrarenal surgery versus percutaneous nephrolithotomy versus extracorporeal shockwave lithotripsy for treatment of lower pole renal stones: a meta-analysis and systematic review. J Endourol 2015;29:745–59. [CrossRef]

23. Shah H, Khandkar A, Sodha H, Kharodawala S, Hegde S, Bansal M. Tubeless percutaneous nephrolithotomy: 3 years of experience with 454 patients. BJU Int 2009;104:840–6. [CrossRef]
24. De S, Autorino R, Kim FJ, Zargar H, Laydner H, Balsamo R, et al. Percutaneous nephrolithotomy versus retrograde intrarenal surgery: a systematic review and meta-analysis. Eur Urol 2015;67:125–37. [CrossRef]
25. Ramón de Fata F, García-Tello A, Andrés G, Redondo C, Meilán E, Gimbernat H, et al. Comparative study of retrograde intrarenal surgery and micropercutaneous nephrolithotomy in the treatment of intermediate-sized kidney stones. Actas Urol Esp 2014;38:576–83. [CrossRef]