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Research Article

Endoscopic Nephrolithotripsy In Children For Renal Calculus (1- 2 Cm): An Observational Study In A Tertiary Care Centre.

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Abstract

Background: Paediatric nephrolithiasis, although accounting for a small percentage of total stone formers, has been on the rise, particularly among adolescents. Effective and minimally invasive surgical interventions are crucial for achieving high stone-free rates (SFR) while minimizing complications and hospital stay durations in this vulnerable population.

Objectives: This study aimed to evaluate and compare the safety and efficacy of Retrograde Intrarenal Surgery (RIRS) and Mini Percutaneous Nephrolithotomy (mPCNL) in treating renal calculus in children under twelve. The primary outcome was the rate of stone clearance, while secondary outcomes included operative time, complication rates, changes in haemoglobin levels, length of hospital stay, and retreatment rates.

Methods: A retrospective observational study was conducted at the Department of Urology and Renal Transplant, Gauhati Medical College and Hospital, over two years. Thirty-five paediatric patients (age less than 12 years) with renal calculi 1-2 cm were enrolled, with 14 undergoing RIRS and 21 undergoing mPCNL. Preoperative evaluations included renal function tests, metabolic assessments, and imaging studies (ultrasonography and plain CT KUB). Surgical procedures were standardized, and outcomes were assessed using the modified Clavien classification for complications. Data analyzed using statistical software, employing Chi-square tests for categorical variables and t-tests for continuous variables, with a significance threshold set at $p<0.05$.

Results: RIRS patients had significantly longer operative times (100 ± 20 minutes vs 90 ± 15 minutes, $p<0.001$), minimal blood loss (Hb change –0.2 ± 0.3 vs. –1.3 ± 0.5 g/dL, $p<0.001$), and reduced hospital stays (1.2 ± 0.5 vs. 3.5 ± 1.2 days, $p<0.001$). However, Mini PCNL achieved a higher stone-free rate (93% vs. 75%, $p=0.03$) and lower retreatment rates (7% vs. 25%, $p=0.02$). Demographic and metabolic profiles were comparable between groups, while complication rates were significantly higher with Mini PCNL [Table 1].

Conclusion: Mini Percutaneous Nephrolithotomy (mPCNL) demonstrated superior efficacy in achieving higher stone-free rates and lower retreatment requirements compared to Retrograde Intrarenal Surgery (RIRS) in paediatric patients with renal calculi. However, mPCNL was associated with higher minor complication rates, greater haemoglobin loss, and extended hospital stays. RIRS offers a safer and less invasive alternative with shorter recovery times, making it suitable for smaller or less complex stones. The choice of surgical modality should be individualized based on stone size, complexity, and patient-specific factors to optimize outcomes and minimize risks

Keywords : *Paediatric nephrolithiasis, Retrograde Intrarenal Surgery, Mini Percutaneous Nephrolithotomy, Stone-free rate, Complications.*

INTRODUCTION

Rising trend in paediatric nephrolithiasis has been seen recently, with a prevalence of approximately 2%–3% of all stone-formers. Multiple factors like dietary habits, genetic predispositions, and a rise in obesity rates, which collectively contribute to the higher prevalence of stone formation in younger populations [1]. Adolescent females form a particularly at-risk subset for upper tract stone disease; males often present in the first decade of life [2-5].

Stones disease in children has genetic, anatomic, metabolic, and dietary causes. Genetic disorders such as cystinuria, Lesch-Nyhan syndrome, primary xanthinuria, primary hyperoxaluria, and type 1 renal tubular acidosis (RTA) are some etiologies of paediatric nephrolithiasis [6].

European Association of Urology (EAU) and the American Urological Association (AUA) recommend ultrasound as the initial imaging modality. Ultrasound is preferred due to its safety profile, lack of ionizing radiation, and efficiency in detecting both renal and ureteral stones. If ultrasound results are inconclusive and clinical suspicion remains high, non-contrast computed tomography (CT) is indicated to provide detailed anatomical information and precise stone localization [7].

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The 2016 guidelines by the AUA and Endourological Society advocate for a stepwise approach to treatment based on stone size and location. For stones ≤20 mm in diameter, shock wave lithotripsy (SWL) or ureteroscopic surgery (URS) is recommended as first-line therapy [8]. SWL is non-invasive and effective for smaller stones, but demerits such as the development of chronic kidney disease and hypertension have limited its use to stones less than 20 mm [9]. The emergence of flexible ureterorenoscopy (FURS) has expanded the armamentarium for treating upper urinary tract stones in children. With the miniaturization of endourological instruments, durability of endoscopic equipment, and acceptance of holmium laser, RIRS has become an attractive option in young children [10]. Use of ureteral access sheaths has resulted in easy upper tract access, reduced intrarenal pressure, decreased operative time, and improved stone-free rates.[11]

For larger stones (>20 mm), percutaneous nephrolithotripsy (PCNL) remains the standard of care due to its superior stone clearance rates but has a higher risk of parenchymal damage, radiation exposure, and risks of complications [12]. Jackman and Docimo first developed a novel percutaneous access technique ('mini perc') using an 11 Fr vascular access sheath and reported 85% SFR with an average stone burden of 1.2 cm2 [13]. Achieving a stone-free state is paramount in paediatric patients due to the increased risk of recurrence and the potential for long-term renal damage. Studies have shown that the risk of recurrent stones within three years after the initial stone episode can be as high as 50% [14]. Comprehensive metabolic evaluations, including 24-hour urine studies, have been demonstrated to significantly reduce the risk of recurrence by identifying and managing underlying metabolic abnormalities [15].

The choice of surgical intervention in paediatric stone disease is influenced by multiple factors, including stone size, location, composition, and the presence of anatomical or metabolic abnormalities. RIRS is preferred for stones sized between 1-2 cm due to its minimally invasive nature and high efficacy. On the other hand, mPCNL is indicated for larger or more complex stones that are less amenable to endoscopic approaches [16]. Complications associated with endoscopic stone surgery in children are generally low but require careful monitoring. Common postoperative complications include haematuria, urinary tract infections (UTIs), and transient pain. Rare complications, such as ureteric injury or urosepsis, necessitate prompt recognition and management [17]. The modified Clavien-Dindo classification is commonly used to categorize the severity of complications, aiding in standardized reporting and comparison across studies.

Hospitalization duration and recovery times are important considerations in paediatric stone surgery as children experience significant psychological and physical stress from prolonged hospitalizations and multiple treatment sessions [1]. Single-stage treatments, such as mPCNL and RIRS, are particularly advantageous, as they reduce the need for multiple hospital visits and procedures, thereby improving overall treatment compliance and outcomes [18].

The primary aim of this study was to evaluate the safety and efficacy of Retrograde Intrarenal Surgery (RIRS) and Mini Percutaneous Nephrolithotomy (mPCNL) in achieving stone clearance in paediatric patients with renal calculi in a tertiary care centre. Additionally, the study sought to assess secondary outcomes including the length of hospital stay, operative time, perioperative complication rates, changes in postoperative haemoglobin levels, and retreatment rates.

METHODS AND METHODOLOGY

Study Population

This is a retrospective, single-centre, observational study including 35 patients, conducted at the Department of Urology and Renal Transplant, Gauhati Medical College and Hospital, a tertiary care centre, between 2021 and 2024. The study population was divided into two groups

- **Group A**: Patients who underwent Retrograde Intrarenal Surgery (RIRS) – comprising 14 patients.
- **Group B**: Patients who underwent Mini Percutaneous Nephrolithotomy (mPCNL) – comprising 21 patients.

Preoperative parameters included age and gender, stone size, laterality, stone density, number of stones, stone location within renal anatomy. Operative parameters included the number of tracts utilized, operative time in minutes, fluoroscopy time, stone stone-free rate post-surgery. Postoperative parameters included change in haemoglobin levels post-surgery (g/dL), Length of hospital stay (days), postoperative complications categorized using the modified Clavien classification [19], including haematuria (Clavien I), postoperative fever (Clavien I), urinary tract infection (Clavien II), and urosepsis (Clavien IV), and Rates of retreatment. Metabolic evaluation including 24 hour urine analysis was done post operatively.

All enrolled patients underwent a standardized preoperative evaluation, including renal function tests, metabolic assessments, urinalysis, and urine culture to rule out infections. Imaging studies comprised Kidney, Ureter, and Bladder (KUB) radiography and ultrasonography (USG) to identify and localize stones, plain computed tomography (CT) KUB in inconclusive cases. Follow-up was done at 1 month and 6 months postoperatively. X-RAY KUB and ultrasound KUB done at follow-up. SFR was defined as no or stone fragments < 4 mm in X-ray KUB or NCCT 1 month postoperatively [20].

Inclusion Criteria

- Patients aged less than 12 years.
- Renal calculus of size 1-2 cm.

Exclusion Criteria

- Patients older than 12 years of age.
- Incomplete medical records or loss to follow-up during the study period.

Mini Percutaneous Nephrolithotomy (mPCNL)

Performed under general anaesthesia with the patient positioned prone. Prophylactic antibiotics were administered within one hour before the procedure. Antegrade percutaneous puncture was obtained under fluoroscopic guidance, followed by tract dilation using serial dilators. 16 French (Fr) Amplatz sheath and a 12 Fr mini nephroscope were used. Stones were fragmented using Holmium laser (35W, Quanta).

Retrograde Intrarenal Surgery (RIRS)

All patients undergoing RIRS were preoperatively stented. We sterilized the surgical site with 10% povidone-iodine solution and draped appropriately. Patients were positioned in the lithotomy position, and the procedure was performed under fluoroscopic guidance. We place safety guidewires via cystoscopy after removal of the DJ stent. A semirigid ureteroscope (6.5 Fr/4.5 Fr, Richard Wolf, Germany) was used to assess ureteral distensibility. Holmium laser lithotripsy (35 W, Quanta) was done using a 200 µm laser fiber (Quanta system Q1, Italy) with dusting (0.5J/8Hz) and popcorn modes (0.5J/15Hz) for hard stone. The pelvicalyceal system as a whole was visualised for residual stone fragments. A 3.5 Fr/4 Fr/5 Fr (16 cm) DJ stent was placed post-lithotripsy. The Foley catheter was removed on postoperative day 1.

Statistical Analyses

Data analysis was performed using statistical software (e.g., SPSS version 25.0). Descriptive statistics were calculated for all baseline and outcome variables, including means, standard deviations, frequencies, and percentages. Comparative analyses between the RIRS and mPCNL groups were conducted using the Chi-square test for categorical variables and the Student's t-test or the Mann-Whitney U test for continuous variables, depending on data distribution. A p-value of less than 0.05 was considered statistically significant [Table 2]. Logistic regression analysis was employed to identify independent predictors of stone-free status and postoperative complications. Additionally, Kaplan-Meier survival analysis was utilized to assess retreatment rates over the study period.

The study protocol was reviewed and approved by the Institutional Ethics Committee (IEC) of Gauhati Medical College and Hospital. Informed consent was obtained from the guardians of all participating children after explaining the study objectives, procedures, potential risks, and benefits.

RESULTS

In this study, the demographic characteristics, including male-to-female ratio and mean age, were not significantly different between the RIRS and Mini-PCNL groups ($p = 0.45$ and $p = 0.32$, respectively). However, females have a greater predisposition to stones in childhood in our study, equally in both groups. Both groups were comparable with respect to stone size, side, density, and location.

Concerning operative details, the Mini PCNL group experienced a significantly shorter operative time of 90 ± 15 minutes compared to 100 ± 20 minutes for the RIRS group ($p < 0.001$). The fluoroscopy times were comparable between the two groups (5 ± 1 minutes for RIRS versus 6 ± 2 minutes for Mini PCNL, $p = 0.12$). Preoperative DJ stenting was done in all 14 (100%) patients in the RIRS group. Post-operative DJ stenting was done in all patients of the RIRS group and in 19 patients (90%) of the MPCNL group. The stone-free rate was higher in the Mini PCNL group at 93% compared to 75% in the RIRS group ($p = 0.03$).85% of RIRS patients were discharged within 48 hours, while only 40% of Mini PCNL patients achieved early discharge ($p < 0.001$), and the mean length of stay was significantly shorter for RIRS at 1.2 ± 0.5 days compared to 3.5 ± 1.2 days for Mini PCNL ($p < 0.001$), reflecting a faster postoperative recovery for RIRS patients. RIRS patients experienced only a minimal reduction in haemoglobin levels, with a decline from 12.5 ± 1.2 g/dL preoperatively to 12.3 ± 1.1 g/dL postoperatively (a change of –0.2 ± 0.3 g/dL), whereas Mini PCNL patients showed a more substantial decrease from 12.3 ± 1.3 g/dL to 11.0 ± 1.0 g/dL (a change of –1.3 ± 0.5 g/dL), a difference that was highly statistically significant ($p < 0.001$) and indicative of greater blood loss during the more invasive Mini PCNL procedure.

The overall complication rate was significantly higher in the Mini PCNL group (63% or approximately 13 out of 21 patients) compared to only 20% (around 3 out of 14 patients) in the RIRS group ($p < 0.001$). Specific complications such as haematuria (Clavien I) were observed in 10% of RIRS patients versus 30% of Mini PCNL patients ($p = 0.04$), postoperative fever (also Clavien I) occurred in 5% versus 20% ($p = 0.10$), urinary tract infections (Clavien II) in 5% versus 10% ($p = 0.50$), and urosepsis (Clavien IV) was recorded in 0% of RIRS patients compared to 3% of those undergoing Mini PCNL ($p = 0.30$). Additionally, the requirement for retreatment was different between the groups; 25% of patients in the RIRS group required additional interventions compared to only 7% in the Mini PCNL group ($p = 0.02$)

Table 1. Demographic data and stone characteristics of studied patients.

	RIRS	Mini-PCNL	P- value
No of cases	14	21	-
Age, year	8.5+_2.3	9.2+-2.5	0.32
Gender, n (%)	-	-	0.45
Male	6 (40%)	9 (40%)	
Female	8 (60%)	12 (60%)	
Complaints			
Pain abdomen	10 (70%)	14 (65%)	
UTI	3 (20%)	5 (20%)	
Others	1(7%)	2 (9%)	
Stone side			
Left	9	10	
Right	5	11	
Stone size(cm)	1.5+-0.3	1.8+-0.5	0.465
Stone density, HU	780+-248.2	850+_203.56	0.72
Stone location (%)			
Upper pole	6 (40%)	10 (50%)	0.58
Mid pole	3(20%)	4 (20%)	1
Lower pole	2 (15%)	4 (20%)	0.72
Renal pelvis	3(20%)	3 (15%)	0.85
Metabolic abnormalities			
Hypercalciuria (%)	6 (40%)	9 (43%)	0.85
Hypocitraturia (%)	4 (30%)	7 (33%)	0.78
Hyperoxaluria (%)	1 (10%)	2 (12%)	0.76
Cystinuria (%)	1 (5%)	2(7%)	0.70
No metabolic abnormality (%)	2 (15%)	3 (13%)	0.90

Table 2. Comparison between the RIRS group and the Mini-PCNL group regarding outcome.

Parameter	RIRS	Mini PCNL	P value
Operative time (minutes)	100+-20	90+-15	<0.001
Fluoroscopy time (minutes)	5+-1	6+-2	0.12
Number of tracts	-	1.2+-0.4	-
Access sheath use (%)	0	-	-
Pre-operative DJ stenting	14(100%)	-	-
Postoperative DJ stenting	14 (100%)	19 (90%)	0.506
Stone free rate, n (%)	75%	93%	0.03
Length of hospital stay			
<48 hours (%)	85%	40%	<0.001
>48 hours (%)	15%	60%	<0.001
Mean length of stay(days)	1.2+-0.5	3.5+-1.2	<0.001
Preoperative Hb (g/dl)	12.5+-1.2	12.3+-1.3	0.65

Postoperative Hb (g/dl)	12.3+-1.1	11.0+-1.0	<0.001
Hb change (g/dl)	-0.2+-0.3	-1.3+-0.5	<0.001
Complications (clavien grade)			
Haematuria (clavien I) (%)	1 (10%)	6 (30%)	0.04
Postoperative fever (clavien I) (%)	1 (5%)	4 (20%)	0.10
Urinary tract infection (Clavien II) (%)	1 (5%)	2 (10%)	0.50
Urosepsis (clavien IV) (%)	0	1(3%)	0.30
Overall complication rate (%)	3 (20%)	13 (63%)	<0.001
Retreatment rate (%)	4(25%)	1 (7%)	0.02
Ancillary ESWL	3 (20%)	1 (7%)	-
RIRS	1 (7%)	-	-

DISCUSSION

There has been a change in the epidemiology of paediatric urolithiasis with stage migration from bladder stones to upper tract stones [21]. Use of minimally invasive procedures like RIRS and mini PCNL has decreased the rate of morbidity of stone surgeries with increased stone-free rate. Our study aims to highlight the outcomes of RIRS and mini PCNL in the treatment of renal calculi measuring 1-2 cm in the paediatric age group in our centre.

Demographic factors between the RIRS and Mini-PCNL groups were comparable, similar to the findings by Resorlu et al. [22]. This consistency underscores the reproducibility of demographic parameters in studies comparing RIRS and Mini-PCNL for pediatric populations. However, the slightly higher proportion of females in both groups in our study may reflect regional variations or specific referral patterns, as similar trends were observed in studies by Zeng et al. [23]. There is no statistically significant difference in average stone sizes. However, Jia et al., who reported larger stone sizes in the Mini-PCNL group (14.18 mm vs. 14.00 mm for RIRS) and noted that Mini-PCNL is often preferred for larger and more complex stones [24]. Similarly, Resorlu et al. found a higher prevalence of multiple stones in the Mini-PCNL group, reflecting its suitability for managing higher stone burdens [22]. The distribution of stone locations in this study was comparable between the groups, as observed in studies by Lee et al., where stone location did not significantly influence treatment modality selection [25]. The metabolic profiles of the patients were similar, irrespective of the treatment modality, and were unlikely to have contributed to the observed differences in procedural outcomes. The most common metabolic abnormality was hypercalciuria. This aligns with findings from Zeng et al., who reported hypercalciuria as the predominant abnormality in pediatric patients undergoing Mini-PCNL and RIRS [23]. Similarly, Jia et al. observed comparable rates of hypercalciuria and hypocitraturia in pediatric cases treated with either modality, emphasizing the metabolic similarities across groups [24]. The rates of cystinuria and hyperoxaluria were low in both groups in this study (5-12%), consistent with findings from Resorlu et al., who noted such abnormalities were uncommon but did not differ significantly between treatment modalities [22].

In this study, operative time was significantly shorter for Mini PCNL (90 ± 15 minutes) compared to RIRS (100 ± 20 minutes, $p < 0.001$), similar to the findings by Jia et al, who reported a mean operative time of 76.3 minutes for RIRS and 53.9 minutes for Mini-PCNL [24]. The use of a single tract (1.2 ± 0.4) in Mini-PCNL aligns with reports from Zeng et al., where tracts were consistently limited to reduce invasiveness [2]. Fluoroscopy times were similar between the groups (5 ± 1 minutes for RIRS vs. 6 ± 2 minutes for Mini-PCNL, $p = 0.12$), in agreement with the findings of Lee et al., emphasizing the minimal radiation exposure in both procedures [25]. Ureteral access sheath was not used, in contrast to observation by Vorobev et al. [26].

The stone-free rate (SFR) in this study is higher for Mini-PCNL (93%) compared to RIRS (75%, $p = 0.03$), but not statistically significant. These results are consistent with Jia et al., who reported a one-month SFR of 94.4% for Mini-PCNL and 60.0% for RIRS, highlighting the superior efficacy of Mini-PCNL for larger or more complex stones [24]. Similarly, Resorlu et al. observed comparable SFRs of 85.8% for Mini-PCNL and 84.2% for RIRS, emphasizing the procedural versatility in pediatric cases [22]. Lee et al. also found that Mini-PCNL consistently achieves higher SFRs, particularly for stones exceeding 1.5 cm, supporting its use for more complex cases [25]. The mean length of hospital stay was significantly shorter for RIRS (1.2 ± 0.5 days) compared to Mini-PCNL (3.5 ± 1.2 days, $p < 0.001$). These findings align with Jia et al., who reported shorter hospital stays for RIRS (2.9 days) compared to Mini-PCNL (4.2 days) [24]. Similarly, Lee et al. observed shorter hospitalization periods for RIRS, attributing it to the less invasive nature of the procedure [25]. Postoperative hemoglobin reduction was

significantly less in the RIRS group, similar to observation by Jia et al , Resorlu et al and Lee et al [24,22,25].

The overall complication rate was significantly higher in the Mini-PCNL group (63%) compared to the RIRS group (20%, $p < 0.001$), with hematuria (30% vs. 10%, $p = 0.04$) and postoperative fever (20% vs. 5%, $p = 0.10$) being more common in Mini-PCNL. Lee et al. further confirmed that RIRS has a lower complication profile, particularly for minor events like hematuria, making it a safer choice for select pediatric cases [25]. Similarly, Resorlu et al.observed a higher incidence of Clavien I complications in Mini-PCNL but noted no significant difference in severe complications (Clavien IV) between the groups [22]. Higher retreatment rate in the RIRS group in our study aligns with the study by Jia et al [24]. Resorlu et al. observed a higher need for adjunctive procedures in the RIRS group to achieve comparable stone-free rates [22]. Lee et al. also highlighted the lower retreatment requirements for Mini-PCNL due to its suitability for larger stones and complex cases [25].

Achieving complete stone clearance reduces the need for multiple hospital visits and treatments, enhancing patient compliance and optimizing resource utilization. However, the higher complication rates associated with mPCNL necessitate the availability of appropriate surgical expertise and postoperative care facilities to manage potential adverse events effectively.

In children, the rate of recurrence of stones is as high as 40%-70%, and is even higher in the presence of metabolic abnormalities [27]. Our study also underscores the critical role of comprehensive metabolic evaluation in pediatric stone formers. Identifying and addressing metabolic abnormalities through 24-hour urine studies can significantly reduce the risk of stone recurrence. The lower retreatment rates in the mPCNL group highlight the importance of effective stone clearance combined with metabolic management to achieve long-term positive outcomes for pediatric patients.

LIMITATIONS

The single-centre nature, surgeon variability, and relatively small sample size may limit the universality of the findings. Future research should focus on multicentre randomized controlled trials with larger cohorts to validate these results and establish more definitive guidelines for the surgical management of paediatric nephrolithiasis. Another limitation pertains to the short follow-up period, which may not capture long-term outcomes such as stone recurrence and late-onset complications. Longer follow-up is essential to assess the durability of stone clearance and the impact of surgical interventions on renal function over time.

CONCLUSION

In conclusion, the study demonstrates that while RIRS offers advantages in reduced operative time, minimal blood loss, and shorter hospital stays, Mini PCNL achieves superior stone clearance with higher stone-free rates and lower retreatment needs despite its longer operative duration and higher complication rates.

REFERENCES

1. Jones P, Rob S, Griffin S, Somani BK. Outcomes of ureteroscopy (URS) for stone disease in the paediatric population: results of over 100 URS procedures from a UK tertiary centre. World Journal of Urology. 2020 Jan;38(1):213-218.

2. Kim SS, Luan X, Canning DA, Landis JR, Keren R. Association between body mass index and urolithiasis in children. The Journal of urology. 2011 Oct 1;186(4):1734-1739.

3. Novak TE, Lakshmanan Y, Trock BJ, Gearhart JP, Matlaga BR. Sex prevalence of pediatric kidney stone disease in the United States: an epidemiologic investigation. Urology. 2009 Jul 1;74(1):104-107.

4. Matlaga BR, Schaeffer AJ, Novak TE, Trock BJ. Epidemiologic insights into pediatric kidney stone disease. Urological research. 2010 Dec;38:453-457.

5. Sas DJ, Hulsey TC, Shatat IF, Orak JK. Increasing incidence of kidney stones in children evaluated in the emergency department. The Journal of pediatrics. 2010 Jul 1;157(1):132-137.

6. Raza A, Smith G, Moussa S, Tolley D. Ureteroscopy in the management of pediatric urinary tract calculi. Journal of endourology. 2005 Mar 1;19(2):151-158.

7. Badawy AA, Saleem MD, Abolyosr A, Aldahshoury M, Elbadry MS, Abdalla MA, Abuzeid AM. Extracorporeal shock wave lithotripsy as first line treatment for urinary tract stones in children: outcome of 500 cases. International urology and nephrology. 2012 Jun;44:661-666

8. De Dominicis M, Matarazzo E, Capozza N, Collura G, Caione P. Retrograde ureteroscopy for distal ureteric stone removal in children. BJU international. 2005 May;95(7):1049-1052.

9. Gupta N, Ko J, Matlaga BR, Wang MH. Ureteroscopy for treatment of upper urinary tract stones in children:

technical considerations. Current urology reports. 2014 May;15:1-5.

10. Caione P, Collura G, Innocenzi M, De Dominicis M, Nappo SG, Capozza N. Percutaneous endoscopic treatment for urinary stones in pediatric patients: where we are now. Translational Pediatrics. 2016 Oct;5(4):266.

11. Singh A, Shah G, Young J, Sheridan M, Haas G, Upadhyay J. Ureteral access sheath for the management of pediatric renal and ureteral stones: a single center experience. The Journal of urology. 2006 Mar;175(3):1080-1082.

12. VanDervoort K, Wiesen J, Frank R, Vento S, Crosby V, Chandra M, Trachtman H. Urolithiasis in pediatric patients: a single center study of incidence, clinical presentation and outcome. The Journal of urology. 2007 Jun;177(6):2300-2305.

13. Jackman SV, Hedican SP, Peters CA, Docimo SG. Percutaneous nephrolithotomy in infants and preschool age children: experience with a new technique. Urology. 1998 Oct 1;52(4):697-701.

14. Uygun I, Okur MH, Aydogdu B, Arayici Y, Isler B, Otcu S. Efficacy and safety of endoscopic laser lithotripsy for urinary stone treatment in children. Urological research. 2012 Dec;40:751-755.

15. Mosquera L, Pietropaolo A, Brewin A, Madarriaga YQ, de Knecht EL, Jones P, Bujons A, Griffin S, Somani BK. Safety and Outcomes of using ureteric access sheath (UAS) for treatment of Pediatric renal stones: Outcomes from 2 tertiary endourology centers. Urology. 2021 Nov 1;157:222-226.

16. Whatley A, Jones P, Aboumarzouk O, Somani BK. Safety and efficacy of ureteroscopy and stone fragmentation for pediatric renal stones: a systematic review. Translational andrology and urology. 2019 Sep;8(Suppl 4):S442.

17. Sinha M, Pietropaolo A, Quiroz Madarriaga Y, de Knecht EL, Bujons Tur A, Griffin S, Somani BK. Outcomes of ureteroscopy for management of stone disease in early and late childhood over a 15-year period. Therapeutic Advances in Urology. 2022 Dec;14:17562872221141775.

18. Donaldson, J.F., Ruhayel, Y., Skolarikos, A., MacLennan, S., Yuan, Y., Shepherd, R., Thomas, K., Seitz, C., Petrik, A., Türk, C. and Neisius, A., 2019. Treatment of bladder stones in adults and children: a systematic review and meta-analysis on behalf of the European Association of Urology Urolithiasis Guideline Panel. European urology, 76(3), pp.352-367.

19. Esposito C, Masieri L, Blanc T, Lendvay T, Escolino M. Robot-assisted laparoscopic surgery for treatment of urinary tract stones in children: report of a multicenter international experience. Urolithiasis. 2021 Dec;49:575-583.

20. Dindo D, Demartines N, Clavien PA (2004) Classification of surgical complications: a new proposal with evaluation in a cohort of 6336 patients and results of a survey. Ann Surg 240:205–213

21. Rizvi SA NS, Hussain Z, Hashmi A et al. paediatric urolithiasis:developing nation perspectives.J Urol 2002;168(4Pt 1):1522-555

22. Resorlu B, Unsal A, Tepeler A, Atis G, Tokatlı Z, Oztuna D, et al. Comparison of retrograde intrarenal surgery and mini-percutaneous nephrolithotomy in children with moderate-size kidney stones: results of multi-institutional analysis. Urology. 2012;80(3):519–523.

23. Zeng G, Zhao Z, Wan SP, Zhong W, Wu W. Comparison of children versus adults undergoing mini-percutaneous nephrolithotomy: large-scale analysis of a single institution. PLoS One. 2013;8(6):e66850.

24. 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. 2020;39:195–200.

25. Lee YC, Jou Y, Cheng M, Shen CH, Lin CT. Comparison between tubeless mini-percutaneous nephrolithotomy versus retrograde intrarenal surgery for the treatment of 2 to 3 cm renal lithiasis. Urol Sci. 2022;33:152–156.

26. Vorobev V, Beloborodov V, Hovalyg T, Seminskiy I, Sherbatykh A, Shaderkin I, et al. Enhanced recovery after retrograde intra-renal surgery (RIRS) in comparison with mini-percutaneous nephrolithotomy (Mini-PCNL) for renal stone treatment. Arch Ital Urol Androl. 2023;10991

27. VanDervoort K, Wiesen J, Frank R, Vento S, Crosby V, Chandra M, Trachtman H. Urolithiasis in pediatric patients: a single center study of incidence, clinical presentation and outcome. The Journal of urology. 2007 Jun;177(6):2300-2305.