Journal of Pediatric Urology (xxxx) xxx xxx

Outcome of conservative management of small renal stones in prepubertal children

Amr Hodhod [a,b,*], Wael M Moneir [a], Abdulwahab Alhams [a], Tariq Burki [a,b], Yasser Jamalalail [a,b], Fayez Almodhen [a,b], Abdullah Alsufyani [a], Abdullah Alaqeel [a], Ahmed Alshammari [a,b]

[a]Pediatric Urology Division, King Abdullah Specialized Children's Hospital, King Abdulaziz Medical City, National Guard Health Affairs, Riyadh, Saudi Arabia

[b]King Abdullah International Medical Research Center, National Guard Health Affairs, Riyadh, Saudi Arabia

* Correspondence to: Pediatric Urology Division, King Abdullah Specialized Children's Hospital, King Abdulaziz Medical City, National Guard Health Affairs, Riyadh, 14611, Saudi Arabia, Tel.: +966 11 801 1111
amrwuk@yahoo.co.uk
(A. Hodhod)

Keywords
Stone; Pediatric; Conservative management

Received 5 March 2025
Revised 17 July 2025
Accepted 25 July 2025
Available online xxx

Summary

Introduction
Renal stones are relatively uncommon in the pediatric population. This study aimed to evaluate the utility of conservative management of small renal stones in prepubertal children.

Patients and methods
A retrospective chart review was conducted for children (≤12 years old) with small renal stones (3–10 mm) from 2016 to 2023 who underwent conservative management. Management included periodic renal ultrasonography, every 6 months, in addition to good hydration. Stones were confirmed by two consecutive ultrasounds. We recorded the patient's demographics and ultrasound findings (stone side, size, laterality, location, number, and associated hydronephrosis). Surgical intervention was indicated if recurrent loin pain, recurrent UTI, or worsening hydronephrosis (obstructing stone). Nephrolithiasis was considered resolved if stones were not visualized on 2 consecutive ultrasounds. Moreover, we evaluated conservative management outcomes for those presented during infancy (<12 months) versus later.

Results
We included 52 patients (65renal units) who presented at a median age of 46.1months (5.3–155.1). Seventy-five percent of patients had incidental renal stones. The median stone size was 4 mm (3–10). Forty-six percent of stones were in the lower calyx. The majority (70.8 %) had no hydronephrosis at presentation. During a median follow-up of 39months, 15patients with 17units (26.2 %) were documented stone-free. Ten patients (19.2 %) had symptomatic stone events, all measured ≥4 mm. Of them, 6 patients (6 units) underwent surgical interventions, and 4 patients (4 units) experienced complications. A ROC curve analysis identified a stone size cutoff of 4 mm (sensitivity 100 % and 29 % specificity) that could be associated with symptomatic stone events. Using a multivariate Cox regression model, stone size was the only significantly associated factor with subsequent surgical intervention ($p = 0.007$). 19 % (10patients,12units) presented during infancy. Notably, the incidence of stone-free rate was significantly higher during infancy compared to older children (58.3 % vs 18.9 %, respectively).

Discussion
During a 39-month follow-up, 4 patients developed complications (2recurrent pain and 2 experienced UTI), supporting the safety of conservative management of small renal stones. This study is limited due to its retrospective design and the reliance on ultrasound as the main imaging method. To minimize that, all ultrasound images were carefully reviewed by two pediatric urologists. Moreover, renal stones were confirmed using strict criteria, which required detection in two consecutive ultrasounds.

Conclusion
Although 26.2 % of units had spontaneously resolved nephrolithiasis, surgical intervention was only required in 11.5%of patients, all of whom had renal stones≥4 mm. Infants had higher spontaneous resolutions without complications, suggesting that conservative management may be especially effective in this subgroup.

https://doi.org/10.1016/j.jpurol.2025.07.029
1477-5131/

Introduction

The prevalence of pediatric stone disease varies globally, with higher incidence in endemic areas such as Thailand and Turkey [1–3]. Recent studies indicate that the incidence of urolithiasis in children has been increasing over the past few decades [1,4]. This rise places a greater burden on healthcare systems due to increased hospital admissions, emergency visits, and medical and surgical treatments [5,6].

Despite significant advancements in treating urolithiasis and establishing multiple best practice guidelines, there is still no clear consensus specifically addressing pediatric urolithiasis due to insufficient evidence [4]. Furthermore, ambiguity persists regarding both conservative and interventional approaches for managing urinary stones in children [7,8]. In general, conservative management is considered the first-line approach for children with small, asymptomatic stones (<4–5 mm), with a potential for spontaneous passage [1,9].

The course of asymptomatic kidney stones is not well-defined. While some patients may experience stone-related events and need surgical intervention, many may remain symptom-free or pass the stones spontaneously. This would be clinically valuable for both patients and physicians to make more informed decisions when choosing active surveillance [10,11].

In the present study, we evaluated the outcomes of small renal stones in prepubertal children managed conservatively, including stone-free status at the end of follow-up and the rate of change to surgery. We believe that with this knowledge, we can provide more informed guidance to patients on the available treatment options.

Patients and methods

After approval by our institutional ethical board, we conducted a retrospective review of patients' charts who presented with stone disease at ≤ 12 years of age between January 2016 and June 2023. We included prepubertal children initially assigned for conservative management with small renal stones (3–10 mm). Our exclusions included patients who required initial surgical or endoscopic management at initial presentation, were lost to follow-up, or had follow-up of <6 months.

Our institution is a tertiary center in a metropolitan area with a population of approximately 8 million people, including 2.5 million children. The travel time to the hospital ranges from 15 to 45 min.

We collected the patient's demographics, mode of presentation, and method of diagnosis. Stone-related data were recorded, including laterality, side, location, size, and number of stones. Due to the risk of radiation exposure, renal stones were diagnosed and evaluated by ultrasound. Renal stones were confirmed by a repeat ultrasound within 3 months, to avoid artefact-related misdiagnosis. A renal stone is defined as an echogenic focus within the renal collecting system, which is associated with a posterior acoustic shadow and/or twinkle artifact on Doppler imaging. Stone size was obtained by ultrasound. In cases of multiple stones, the size of the biggest stone was obtained. All ultrasound studies, including stone measurements, were reviewed by 3 pediatric urologists. The Society for Fetal Urology system was used to grade hydronephrosis if present. Computed tomography (CT) studies were avoided unless the diagnosis with ultrasound was inconclusive.

Conservative management was recommended—after discussing the risks and benefits with parents—if the renal stone size was ≤10 mm, provided the stone was non-obstructing and the patient was asymptomatic or had only one episode of mild flank pain or microscopic hematuria. Conservative management included adequate hydration and periodic follow-up with renal ultrasound. Emergency instructions were given to all patients in case of loin pain, urinary tract infection, or gross hematuria.

Patients were followed up at 6-month intervals if clinically stable; otherwise, closer follow-up with further investigations was arranged. Low-dose CT without contrast was requested if there was recurrent pain, UTI, or worsening hydronephrosis. We reviewed and recorded follow-up data regarding the number, size, and location of renal stones. Stone-free status was considered if the stone was not visualized in two consecutive follow-up ultrasounds (with 4–6 months intervals). Complications during follow-up were systematically documented. These included clinically confirmed UTI and renal/abdominal pain attributable to the stone. Subsequent surgical/endoscopic management was indicated for patients who developed recurrent loin pain, recurrent UTI, or had worsening hydronephrosis (obstructing stone). Preoperatively, non-contrast low-dose CT was ordered to better assess stone size and location.

Our primary objective was to evaluate the outcomes of conservative management in this specific age group, focusing on stone-free status at the end of follow-up and rate of change to surgery. Our secondary objectives were to compare the characteristics of patients with symptomatic stone events to those who remained asymptomatic throughout follow-up. Symptomatic stone events were considered when stones that were complicated during follow-up (developed renal colic or UTI) or when requiring surgical/endoscopic management. Moreover, we evaluated possible stone size cutoffs associated with symptomatic stone events and subsequently compared the outcome based on a selected stone size cutoff. Finally, the outcomes were analyzed according to age groups (infantile versus non-infantile).

Data collection and statistical analysis were performed using the Statistical Package for the Social Sciences (SPSS version 26). Time-dependent outcomes, including patients presented to ER, complications, surgical interventions, and stone-free units, were analyzed using Kaplan–Meier curve/Log-rank test. Categorical data were displayed using numbers and percentages and evaluated using the chi-squared test. Moreover, continuous data were presented in medians and ranges and compared using the Mann–Whitney U test. We used a Receiver Operating Characteristic Curve (ROC) to evaluate stone size cutoffs associated with symptomatic stone events. Using the Cox proportional hazards regression, univariate and multivariate analyses were used to evaluate possible associated factors with the risk of subsequent surgical intervention. Following the

Please cite this article as: Hodhod A et al., Outcome of conservative management of small renal stones in prepubertal children, Journal of Pediatric Urology, https://doi.org/10.1016/j.jpurol.2025.07.029

univariate analysis, parameters with a $p \leq 0.1$ were included in the multivariate analysis. A p-value of <0.05 was considered statistically significant.

Results

Out of 187 patients who presented with renal stones to our center, we excluded 135 patients who did not meet our inclusion criteria (Supplementary Fig. 1). Finally, we included 52 patients (65 renal units) with a median stone size of 4 mm (3–10) (Supplementary Fig. 2).

Table 1 presents patients' demographics. Thirty-nine patients (75 %) had incidentally discovered renal stones. The presence of renal stones was confirmed sonographically by the detection of twinkle artifact (50 units), posterior acoustic shadow (1 unit), and both (14 units). Forty-six renal units (70.8 %) of 36 patients had no hydronephrosis on initial ultrasound. Sixteen units (24.6 %) of 13 patients had congenital hydronephrosis (9 as SFU grade 1, 4 grade 2, and 3 as grade 3). Three units (4.6 %) of three patients had hydronephrosis related to stones (all were SFU grade 1). Nine patients (11 units) underwent imaging evaluation with non-contrast low-dose CT. Of these, 6 patients (11.5 %) had subsequent surgical intervention. Two patients had bilateral non-obstructive stone disease accompanied by hydronephrosis. One patient had flank pain, and a CT was performed at presentation. Interestingly, there was no significant difference between stone size measured by ultrasound (median = 5 mm, range 3–10 mm) and CT (median = 6 mm, range 3–12 mm) (p = 0.2).

At a median follow-up of 39 months, 9.2 % of units (6 patients) had endoscopic management, while 26.2 % of units (15 patients) had resolved stones, as shown in two consecutive ultrasound studies (Table 2).

Successful conservative management

Seventeen units (15 patients) (26.2 %) had documented stone-free status at a median follow-up of 34.1 months (11.5–104.1). The median number of follow-up visits was 5 (2–13). Of these patients, 5 patients (33.3 %) were male. Five units (29.4 %) had hydronephrosis (3 had grade 1 hydronephrosis, 2 had grade 2). The median initial stone size was 4 mm (3–8). Eleven units (64.7 %) of 9 patients had multiple renal stones. Forty-seven percent (8 units) were lower calyceal stones. Four patients (4 units) experienced complications managed conservatively without subsequent intervention. Of them, 2 patients experienced 2 episodes of loin pain/discomfort, and 2 had a single UTI episode.

Surgical intervention

A total of 6 patients (11.5 %) with 6 units, three males and three females, underwent surgical intervention after initial conservative management. All had unilateral renal stones. They presented at a median age of 50.8 months (20.6–137.4) and had a median initial stone size of 6.5 mm (4–10). Four patients had no hydronephrosis at presentation and were discovered incidentally. Interestingly, five

Table 1 Patients' demographics and ultrasound findings at presentation.

Parameter		Finding
Gender	**Male** n (%)	23 (44.2)
	Female n (%)	29 (55.8)
Age at presentation median (range)		46.1 months (5.3–155.1)
Presentation	**Incidental** n (%)	39 (75)
	Pain n (%)	8 (15.4)
	Microscopic hematuria n (%)	5 (9.6)
Positive family history of stone disease n (%)		10 (19.2)
History of prematurity n (%)		11 (21.2)
History of postnatal furosemide administration n (%)		8 (15.4)
Laterality	**Unilateral** n (%)	39 (75)
	Bilateral n (%)	13 (25)
Side of stone	**Right** n (%)	31 (47.7)
	Left n (%)	34 (52.3)
Number of stones	**Single** n (%)	31 (47.7)
	Multiple n (%)	34 (52.3)
Stone size median (range)		4 mm (3–10)
Location of stone	**Lower calyx** n (%)	30 (46.2)
	Middle calyx n (%)	8 (12.3)
	Upper calyx n (%)	6 (9.2)
	Renal pelvis n (%)	4 (6.1)
	Scattered n (%)	17 (26.2)
Hydronephrosis grade	**Total** n (%)	19 (29.2)
	Grade 1 n (%)	12 (18.4)
	Grade 2 n (%)	4 (6.2)
	Grade 3 n (%)	3 (4.6)
Patients had non-contrast low dose CT scans n (%)		9 (17.3)

Please cite this article as: Hodhod A et al., Outcome of conservative management of small renal stones in prepubertal children, Journal of Pediatric Urology, https://doi.org/10.1016/j.jpurol.2025.07.029

Table 2 Follow-up characteristics and outcomes of conservatively managed renal stones.

Parameter		Finding
Follow-up duration median (range)		39 months (6.2–106.53)
Number of follow-up visits median (range)		5 (2–15)
Number of ER visits median (range)		0 (0–3)
Follow-up status	**Stone free** n (%)	17 (26.1)
	Stable n (%)	37 (56.9)
	Change location n (%)	7 (10.8)
	Increase number n (%)	3 (4.7)
	Decrease number n (%)	1 (1.5)
Last stone size median (range)		3.5 mm (3–10)
Last stone number[a]	**Single** n (%)	20 (47.6)
	Multiple n (%)	22 (52.4)
Last stone location[a]	**Lower calyx** n (%)	18 (42.9)
	Middle calyx n (%)	7 (16.7)
	Upper calyx n (%)	7 (16.7)
	Scattered n (%)	10 (23.8)
Change to surgery n (%)		6 (9.2)
Complications managed conservatively	**None** n (%)	61 (93.8)
	Pain n (%)	2 (3.1)
	UTI n (%)	2 (3.1)

[a] Out of 42 units who are still under follow up (neither disappeared or changed to surgical management).

patients (83.3 %) had a single renal stone. Three patients (5.75 %) demonstrated progressive or newly developed hydronephrosis. Spiral CT confirmed stone migration to the ureter. Consequently, endoscopic management via ureteroscopy with laser fragmentation was elected. At the time of ureteroscopy, one of these patients had further stone migration into the bladder, which was managed by cystolitholapaxy. The remaining three patients (5.75 %) had persistent renal stones and developed recurrent loin pain. This was associated with either newly developed hydronephrosis in two patients (grade 2 in both) or progression of pre-existing hydronephrosis in one patient (from grade 1 to grade 2). They underwent retrograde intrarenal surgery (RIRS), using flexible ureteroscopy and laser fragmentation. None had ureteropelvic junction obstruction or ureteral stricture.

Univariate analysis showed that renal stone size, single renal stones, and non-lower calyceal stones were associated with subsequent surgical intervention (Supplementary Table 1). Using the multivariate Cox proportional hazards

Table 3 Comparison of clinical and radiological characteristics between stones that remained asymptomatic during follow-up and symptomatic stone events.

Parameter		Stones remained asymptomatic 42 patients (55 units)	Symptomatic stone events * 10 patients (10 units)	P Value
Age at presentation *months* median (range)		45.2 (5.3–148.9)	76.4 (20.6–155.1)	0.05
Gender	**Male** n (%)	18 (42.9)	5 (50)	0.68
	Female n (%)	24 (57.1)	5 (50)	
Side of stone	**Right** n (%)	25 (45.5)	6 (60)	0.4
	Left n (%)	30 (54.5)	4 (40)	
Initial stone size *mm* median (range)		4 (3–10)	5.5 (4–10)	0.01
Multiple renal stones n (%)		32 (58.2)	2 (20)	0.03
Bilateral renal stones n (%)		13 (30.9)	0	0.04
Presence of hydronephrosis n (%)		15 (27.3)	4 (40)	0.4
Lower calyx stone n (%)		25 (45.5)	5 (50)	0.8
Follow-up duration *months* median (range)		45.2 (6.2–106.53)	43.6 (6.7–93.7)	0.56

*Symptomatic Stone Events: Patients who had symptomatic episodes leading to ER visits, hospital admissions, or required surgical intervention.

Please cite this article as: Hodhod A et al., Outcome of conservative management of small renal stones in prepubertal children, Journal of Pediatric Urology, https://doi.org/10.1016/j.jpurol.2025.07.029

model, stone size was the only associated factor with surgical intervention following initial conservative management (p = 0.007).

Symptomatic stone events

A total of 10 patients (10 units) were identified to have symptomatic stone events (4 had complications without intervention, and 6 had surgical interventions) (Table 3). This cohort presented at a median age of 76.4 months. Notably, symptomatic stone events were predominantly unilateral, with only 2 units with multiple stones (p = 0.04 and 0.03, respectively). They had a median initial stone size of 5.5 mm (4–10), which was significantly larger than those who remained asymptomatic (p = 001).

Ten patients (19.2 %) presented to the ER. Of these, 2 had abdominal pain attributable to stone disease, and 2 others experienced UTI with positive urine culture and received appropriate antibiotic treatment. All four patients were managed conservatively without further interventions. The remaining 6 patients had ER visits unrelated to their stone disease.

Using ROC curve analysis (Supplementary Fig. 3), we were able to identify a stone size cutoff of 4 mm (sensitivity 100 % and 29 % specificity) that could be associated with symptomatic stone events (AUC = 0.71; CI = 0.544–0.878; p = 0.035). Accordingly, we categorized patients into two groups according to the initial size of the stone: patients with $<$4 mm stones or those with $\geq$ 4 mm stones (Table 4). There were no significant differences in terms of ER visits and stone-free rate (p = 0.49 and 0.8, respectively). All patients who underwent subsequent surgical interventions or complications had a stone size $\geq$ 4 mm, compared to none with a stone $<$4 mm (p = 0.04 and 0.08 respectively, using Log-rank test).

Infantile vs non-infantile stones

Nineteen percent (10 patients with 12 units) presented during infancy, while the remaining (42 patients with 53 units) presented later (Supplementary Table 2). The initial stone size, laterality, presence of multiple stones, associated hydronephrosis, follow-up duration, and follow-up visits were comparable in both groups. Notably, the incidence of stone-free rate was significantly higher during infancy compared to older children (58.3 % vs 18.9 %, respectively; p = 0.026). Moreover, none of the infantile stones had subsequent intervention or were associated with complications during follow-up.

Discussion

As pediatric stone disease becomes more prevalent, attention to this patient population is increasingly necessary. Consequently, significant efforts should be made to identify the most suitable management strategy. With the increased use of radiologic investigations, more asymptomatic renal stones are found incidentally. While 75 % of renal stones in our group were discovered incidentally, forty-six percent of those stones were in the lower pole with a median size of 4 mm. These findings highlight the importance of enhancing the treatment of asymptomatic and small renal calculi to improve the outcomes and reduce the costs of unnecessary interventions.

The definition of renal stone, which is a candidate for conservative management, is not widely agreed upon for the pediatric population. The latest pediatric guidelines from the European Association of Urology (EAU) recommended conservative management as the primary treatment option for infantile stones $<$3 mm and lower pole calyx stones of less than 10 mm size [12]. While the American Urological Association (AUA) guidelines recommend observation for asymptomatic and non-obstructing renal stones [4]. Due to the costs and potential risks of the later procedures, conservative management is often recommended for asymptomatic kidney stones [13].

The investigation of pediatric stone disease involves various approaches. Ultrasound examination is commonly used as the initial imaging modality. CT scans are infrequently used at the start of evaluating nephrolithiasis in children due to the high risk of radiation exposure. To address this concern, protocols utilizing low-dose CT without contrast have been developed specifically for pediatric patients and are mainly recommended when the

Table 4 Comparison of conservative management outcomes based on the initial size of renal stone.

Parameter	Stone $<$4 mm 14 patients (16 units)	Stone$\geq$ 4 mm 38 patients (49 units)	P Value
Age at presentation median (range)	32.2 months (5.6–125.5)	47.4 (5.4–155.1)	0.24
Multiple renal stones n (%)	8 (50)	26 (53.1)	0.83
Bilateral renal stones n (%)	2 (14.3)	11 (28.9)	0.28
Lower calyceal stones n (%)	7 (43.8)	23 (46.9)	0.82
Presence of hydronephrosis n (%)	3 (18.8)	16 (32.7)	0.29
Follow-up visits median (range)	3 (2–11)	6 (2–15)	0.12
Follow-up duration median (range)	23.2 months (6.2–82.6)	39.3 months (6.4–106.5)	0.17
Patients had ER visits n (%)[a]	2 (14.3)	8 (21.1)	0.49
Complications managed conservatively n (%)[a]	0	4 (8.2)	0.08
Change to surgery n (%)[a]	0	6 (12.2)	0.04
Symptomatic stone events n (%)[a]	0	10 (20.4)	0.022
Units documented stone free n (%)[a]	4 (25)	13 (26.5)	0.8

[a] Assessed using the Kaplan–Meier curve/Log-rank test.

Please cite this article as: Hodhod A et al., Outcome of conservative management of small renal stones in prepubertal children, Journal of Pediatric Urology, https://doi.org/10.1016/j.jpurol.2025.07.029

patient exhibits symptoms, and the presence of a stone is suspected but not confirmed through ultrasound examination [14]. We adopted this approach when investigating our patients to avoid any unnecessary radiation exposure.

Many previous studies reported favorable outcomes of conservative management. Baştuğ et al. obtained data from 2513 children with urolithiasis, of which 95 % had kidney stones. They reported 80.3 % stone passage after a year's follow-up on conservative follow-up [15]. Their reported passage rate is much higher than our results (21.5 %) and was achieved over a significantly shorter duration than our 34-month median follow-up. This discrepancy may be partly attributed to the fact that in Baştuğ's cohort, around half of the stone passages were observed in infants and cases of stones <3 mm. Similarly, Dangle et al. reported a conservatively managed cohort of mixed renal (45 patients) and ureteric stones (72 patients) [16]. While including some patients with 2 mm stones, they concluded that stones with an average size of 3.5 mm were more likely to pass spontaneously. In our study, we excluded stones <3 mm to go with the most recent guidelines.

The management of lower pole stones is a topic of significant debate, making the decision-making process quite challenging [17]. In one of the largest cohorts evaluating the natural history of renal stones, Öner et al. included 337 pediatric patients. They found that 64.3 % of the lower pole stones and 75.8 % of the upper-middle pole stones improved with follow-up [18]. Dos Santos et al. described that lower pole stones are less likely to require surgery. In their study, only 21.4 % of stones required intervention, while 53.6 % resolved spontaneously [19]. Interestingly, Telli et al. reported a progressive stone disease in about two-thirds of their pediatric cohort with lower pole stones and less than 10 % stone-free rates with conservative management [20]. Our findings indicated that although non-lower calyceal stones were associated with subsequent surgical intervention in the univariate analysis, stone size was the only associated factor of surgical intervention using the COX multivariate regression model.

In our study, 11.5 % of patients needed surgical intervention after initial conservative management. This change in the management plan was due to pain or stone migration. On the other hand, Zu'bi and coworkers reported a 34.5 % intervention rate in renal stones with 6 mm median initial size. While indications of surgery were not clearly mentioned, their study aimed to assess stone growth and stone-related surgeries based on the underlying metabolic condition, which may explain the rapid growth and subsequent surgeries in certain metabolic profiles [21].

The anatomical and physiological characteristics of each stage of pediatric development pose challenges in managing urolithiasis compared to stone disease in adulthood. Pietrow et al. found that children aged ≤10 years were more likely to develop renal stones, which tended to be larger and less likely to pass spontaneously. Kalorin et al. confirmed that younger children are more prone to renal calculi but reported similar stone sizes across age groups. They found that younger patients passed renal stones more frequently than their older peers. Based on those findings, Karolin and her group suggested that asymptomatic children under 10 who do not have a single kidney and with no urinary tract anomalies may be managed conservatively before considering invasive treatments [22,23]. Our data demonstrated a higher incidence of symptomatic stone events for patients presented at a median age of 76.4 months (>6 years). This suggests a higher likelihood of clinically significant stone disease with older age at presentation.

In Baştuğ's cohort, stone resolution was observed in 83 % of infantile stones compared to 77.5 % of non-infantile stones ($p < 0.05$) under conservative management. In our cohort, 7 units (58.3 %) were confirmed as stone-free compared to 10 units (18.9 %) in non-infantile stones. The higher rate of stone resolution reported by Baştuğ's study could be explained by the differences in inclusion criteria. Baştuğ and colleagues included all types of urinary stones and stones equal or less than 3 mm. In contrast, our inclusion criteria were strict to include only kidney stones with a diameter >3 mm.

One limitation of our present study is its retrospective nature. To minimize this limitation, we revised all ultrasound images by expert pediatric urologists. Another limitation was the use of ultrasound examination as the mainstay of initial radiological imaging. However, our definition of confirmed renal stone was strict in terms of two subsequent ultrasounds. Low-dose CT without contrast was avoided or used sparingly during the initial evaluation due to its high risk of radiation [14,24]. Moreover, ultrasound can potentially overestimate stone size due to factors such as the posterior acoustic shadowing and operator dependency. Furthermore, although confirming stone resolution by 2 subsequent ultrasound studies, it does not provide direct evidence of stone passage. However, confirming stone passage can be challenging, particularly in younger children who may not reliably exhibit symptoms associated with passing a stone.

An additional limitation is that some patients who were excluded due to initial surgical intervention might have successfully passed their stones with conservative management. Nevertheless, in most pediatric institutions, surgical decisions are guided by surgeons' clinical judgment, imaging findings, and parents' counseling. Another limitation is that the recorded UTIs may not be attributed to the stones themselves; thus, the reported ones associated with observational management may be conservatively estimated. Lastly, some patients might have sought care at other hospitals, especially for emergencies. However, most patients are typically queried about such events during their subsequent clinic visits. Moreover, we excluded patients who lost follow-up without documented stone passage.

Conclusion

Despite the low percentage of resolved stones in this series, conservative management of small renal stones was shown to be associated with low complications and intervention rates. All patients had subsequent surgical interventions had a stone size of ≥4 mm. Stone size was the only independent predictor of subsequent intervention. Notably, infants demonstrated a significantly higher stone-free rate without complications.

Please cite this article as: Hodhod A et al., Outcome of conservative management of small renal stones in prepubertal children, Journal of Pediatric Urology, https://doi.org/10.1016/j.jpurol.2025.07.029

Ethical standards

The study has been carried out in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments. Inform consent was obtained from all the included patients.

Funding

None.

Conflict of interest

None.

References

[1] Zeng G, Zhu W, Somani B, Choong S, Straub M, Maroccolo MV, et al. International Alliance of Urolithiasis (IAU) guidelines on the management of pediatric urolithiasis. Urolithiasis 2024;52(1):124.
[2] Huang WY, Chen YF, Chen SC, Lee YJ, Lan CF, Huang KH. Pediatric urolithiasis in Taiwan: a nationwide study, 1997-2006. Urology 2012;79(6):1355—9.
[3] Ertan P, Tekin G, Oger N, Alkan S, Horasan GD. Metabolic and demographic characteristics of children with urolithiasis in Western Turkey. Urol Res 2011;39(2):105—10.
[4] Guven S, Tokas T, Tozsin A, Haid B, Lendvay TS, Silay S, et al. Consensus statement addressing controversies and guidelines on pediatric urolithiasis. World J Urol 2024;42(1):473.
[5] Carmen Tong CM, Ellison JS, Tasian GE. Pediatric stone disease: current trends and future directions. Urol Clin N Am 2023;50(3):465—75.
[6] Bowen DK, Tasian GE. Pediatric stone disease. Urol Clin N Am 2018;45(4):539—50.
[7] DeCotiis K, Koyle MA. Highlighting the paucity of quality data on pediatric stone disease. Can Urol Assoc J 2019;13(10):342.
[8] Barreto L, Jung JH, Abdelrahim A, Ahmed M, Dawkins GPC, Kazmierski M. Medical and surgical interventions for the treatment of urinary stones in children. Cochrane Database Syst Rev 2019;10(10):CD010784.
[9] Juliebo-Jones P, Keller EX, Tzelves L, Beisland C, Somani BK, Gjengsto P, et al. Paediatric kidney stone surgery: state-of-the-art review. Ther Adv Urol 2023;15:17562872231159541.
[10] Han DS, Cher BAY, Lee D, Rajendran S, Riblet NBV, Pais Jr VM. The Durability of Active Surveillance in Patients with Asymptomatic Kidney Stones: A Systematic Review. J Endourol 2019;33(7):598—605.
[11] Li X, Zhu W, Lam W, Yue Y, Duan H, Zeng G. Outcomes of long-term follow-up of asymptomatic renal stones and prediction of stone-related events. BJU Int 2019;123(3):485—92.
[12] Gnech M, van Uitert A, Kennedy U, Skott M, Zachou A, Burgu B, et al. European Association of Urology/European Society for Paediatric Urology Guidelines on Paediatric Urology: Summary of the 2024 Updates. Eur Urol 2024;86(5):447—56.
[13] Koh LT, Ng FC, Ng KK. Outcomes of long-term follow-up of patients with conservative management of asymptomatic renal calculi. BJU Int 2012;109(4):622—5.
[14] Kovacevic L. Diagnosis and management of nephrolithiasis in children. Pediatr Clin N Am 2022;69(6):1149—64.
[15] Bastug F, Agbas A, Tulpar S, Yildirim ZNY, Cicek N, Gunay N, et al. Comparison of infants and children with urolithiasis: a large case series. Urolithiasis 2022;50(4):411—21.
[16] Dangle P, Ayyash Ot, Shaikh 3rd H, Stephany HA, Cannon GM, Schneck FX, et al. Predicting Spontaneous Stone Passage in Prepubertal Children: A Single Institution Cohort. Journal of endourology / Endourological Society 2016;30(9):945—9.
[17] Alam R, Matlaga BR, Alam A, Winoker JS. Contemporary considerations in the management and treatment of lower pole stones. Int Braz J Urol 2021;47(5):957—68.
[18] Oner N, Bastug F, Ozkan B, Ozcatal M, Karakukcu C. Urolithiasis in children; The importance of stone localization in treatment and follow-up. Urolithiasis 2024;52(1):17.
[19] Dos Santos J, Lopes RI, Veloso AO, Harvey E, Farhat WA, Papanikolaou F. Outcome Analysis of Asymptomatic Lower Pole Stones in Children. J Urol 2016;195(4 Pt 2):1289—93.
[20] Telli O, Hamidi N, Bagci U, Demirbas A, Hascicek AM, Soygur T, et al. What happens to asymptomatic lower pole kidney stones smaller than 10 mm in children during watchful waiting? Pediatr Nephrol 2017;32(5):853—7.
[21] Zu'bi F, Sidler M, Harvey E, Lopes RI, Hojjat A, Naoum N, et al. Stone growth patterns and risk for surgery among children presenting with hypercalciuria, hypocitraturia and cystinuria as underlying metabolic causes of urolithiasis. *J Pediatr Urol* 2017; **13**(4): 357 e1-e7.
[22] Pietrow PK, Pope Jct, Adams MC, Shyr Y, Brock 3rd JW. Clinical outcome of pediatric stone disease. J Urol 2002;167(2 Pt 1):670—3.
[23] Kalorin CM, Zabinski A, Okpareke I, White M, Kogan BA. Pediatric urinary stone disease-does age matter? *J Urol* 2009; **181**(5): 2267—71; discussion 71.
[24] Morrison JC, Kawal T, Van Batavia JP, Srinivasan AK. Use of Ultrasound in Pediatric Renal Stone Diagnosis and Surgery. Curr Urol Rep 2017;18(3):22.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jpurol.2025.07.029.