

# Presentation, Management, Metabolic Evaluation and Long-Term Outcomes of Pediatric Urethral Calculi

Hasan Deliaga

drhasandeliaga@hotmail.com

University of Health Sciences Bursa Medical Faculty

Halil Tosun

Erciyes University Medical Faculty

Bilge Karabulut

University of Health Sciences Ankara Bilkent City Hospital

Huseyin Tugrul Tiryaki

University of Health Sciences Ankara Bilkent City Hospital

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## Research Article

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# **PRESENTATION, MANAGEMENT, METABOLIC EVALUATION AND LONG-TERM OUTCOMES OF PEDIATRIC URETHRAL CALCULI**

## **ABSTRACT**

### **Purpose**

Evidence regarding pediatric urethral calculi is limited, and important questions remain regarding their optimal management, associated metabolic abnormalities, and long-term outcomes. We aimed to comprehensively characterize the clinical presentation, management, metabolic profile, and long-term outcomes of children with urethral calculi treated at a tertiary pediatric referral center.

### **Methods**

Children younger than 18 years with radiologically and/or endoscopically confirmed urethral calculi were retrospectively reviewed. Demographic characteristics, presenting symptoms, imaging findings, stone characteristics, treatment modality, operative outcomes, associated upper urinary tract stone disease, metabolic evaluation, recurrence, and long-term follow-up were analyzed. All patients underwent standardized 24-hour urine metabolic evaluation after spontaneous or surgical stone clearance using age-specific reference values.

### **Results**

Fourteen children (10 boys and 4 girls) with a median age of 4.5 years were included. Acute urinary retention and gross hematuria were the most common presenting symptoms (both 57.1%). Twelve patients (85.7%) had impacted urethral calculi, and six (42.9%) had associated upper urinary tract stones requiring subsequent retrograde intrarenal surgery (n=3) or percutaneous nephrolithotomy (n=3). Endoscopic holmium laser lithotripsy was performed in nine patients, meatotomy in three, and spontaneous stone passage occurred in two. Standardized metabolic evaluation identified hypocitraturia in all patients, hypercalciuria in seven (50.0%), hyperoxaluria in two (14.3%), and cystinuria in one patient with a cystine stone. Urethral stone clearance was achieved in all children. During a median follow-up of 54 months, only one recurrence occurred, and no patient developed urethral stricture, meatal stenosis, persistent voiding dysfunction, or procedure-related complications.

### **Conclusion**

Pediatric urethral calculi frequently represent the presenting manifestation of a broader urinary stone disease rather than an isolated urethral event. Location-adapted minimally invasive management, including in-situ holmium laser lithotripsy for impacted calculi, achieved excellent long-term outcomes without urethral complications. Comprehensive urinary tract imaging, standardized metabolic evaluation, and multidisciplinary follow-up should be considered integral components of the comprehensive evaluation and management of children with urethral calculi.

**Keywords:** Urethral calculi; Pediatric urolithiasis; Holmium laser lithotripsy; Metabolic evaluation; Hypocitraturia; Urinary retention

## **INTRODUCTION**

Among the diverse manifestations of pediatric urolithiasis, urethral calculi remain one of the least frequently encountered and least systematically studied conditions. Pediatric urolithiasis has become increasingly recognized worldwide over the past two decades, with a rising incidence reported across both developed and developing countries [1,2]. Although calculi most commonly arise within the kidney or ureter, urethral calculi represent an uncommon manifestation of pediatric stone disease and account for only a small proportion of urinary tract stones in children [3,4,5]. Despite their rarity, urethral calculi constitute an important urological emergency because they may result in acute urinary obstruction, severe lower urinary tract symptoms, urinary tract infection, and significant patient discomfort. Delayed diagnosis or inappropriate management may lead to urethral injury, persistent obstruction, or unnecessary interventions.

Published evidence regarding pediatric urethral calculi remains limited and consists predominantly of retrospective series and isolated case reports. Acute urinary retention has traditionally been considered the classic clinical presentation; however, hematuria, dysuria, interrupted urinary stream, urinary dribbling, and recurrent urinary tract infection have also been described [3-7]. Similarly, several treatment options have been reported, including spontaneous passage, manual extraction, meatotomy, retrograde manipulation into the bladder followed by cystolithotripsy, urethrolithotomy, and endoscopic lithotripsy [3-7]. Owing to the rarity of the condition and the limited number of reported patients, no standardized diagnostic or therapeutic algorithm has been established, and treatment is generally individualized according to stone location, degree of impaction, and available endoscopic expertise [4,5].

Previous studies have primarily focused on the acute management of urethral obstruction, whereas considerably less attention has been directed toward associated upper urinary tract stone disease, metabolic abnormalities, recurrence, and long-term urethral outcomes. Although comprehensive metabolic evaluation is recommended for all children with urinary stone disease, its role has rarely been systematically reported in dedicated pediatric urethral stone series [1,2,8]. Likewise, evidence regarding the long-term safety of contemporary minimally invasive management remains scarce [3-6]. Consequently, important questions persist regarding the overall clinical spectrum of pediatric urethral calculi, their relationship with broader urinary stone disease, and the durability of current treatment strategies.

Therefore, the aim of the present study was to characterize the clinical presentation, stone characteristics, diagnostic evaluation, treatment strategies, metabolic findings, and long-term outcomes of children treated for urethral calculi at a tertiary pediatric referral center. Particular emphasis was placed on the management of impacted urethral calculi using location-adapted minimally invasive techniques, the evaluation of associated urinary tract stone burden, and the role of standardized metabolic assessment in the comprehensive management of these patients.

## **MATERIALS AND METHODS**

Following approval by the Institutional Review Board (Approval No: 2024-TBEK 2026/09-23), the medical records of all consecutive children diagnosed with urethral calculi between

January 2000 and June 2026 at the department of pediatric urology were retrospectively reviewed. Children younger than 18 years with radiologically and/or endoscopically confirmed urethral stones were eligible for inclusion. Patients with incomplete medical records or inadequate follow-up were excluded. Because of the rarity of pediatric urethral stones, all consecutive eligible patients during the study period were included to minimize selection bias.

Demographic characteristics including age and sex, presenting symptoms, symptom duration, laboratory findings, imaging studies, stone characteristics, treatment modality, operative details, postoperative outcomes, associated upper urinary tract stone disease, metabolic evaluation results, recurrence, and follow-up data were extracted from the medical records. Stone characteristics included anatomical location, maximum stone diameter, impaction status, and stone composition. Stone size was defined as the maximum diameter measured on preoperative imaging or, when unavailable, during endoscopic evaluation or extraction. An impacted urethral stone was defined as a calculus that could not be spontaneously voided and remained fixed within the urethra, resulting in complete or partial urinary obstruction and requiring active intervention. Stone location was classified as the external urethral meatus, penile urethra, membranous urethra, or prostatic urethra.

The diagnosis of urethral calculi was established by physical examination together with imaging studies selected according to the clinical presentation. Ultrasonography was performed in all patients, while plain radiography and computed tomography were obtained when clinically indicated. Diagnostic cystoscopy was performed in patients undergoing endoscopic intervention or when the diagnosis remained uncertain after initial imaging.

Treatment was individualized according to stone location, stone size, degree of obstruction, and clinical presentation. Stones located at the external urethral meatus were managed by spontaneous passage or meatotomy when necessary. Proximal or impacted urethral calculi were treated endoscopically. Our preferred strategy was controlled in-situ fragmentation using a low-energy holmium:YAG laser rather than intentional retrograde manipulation of impacted stones into the bladder whenever technically feasible. Laser lithotripsy was performed using a 270- $\mu$ m laser fiber with pulse energy of 0.2–0.3 J, frequency of 30–40 Hz, and long-pulse mode. At the completion of the procedure, a urethral catheter was placed according to the surgeon's discretion and removed after an appropriate postoperative period. The choice of treatment modality was determined by stone location, degree of impaction, urethral anatomy, and surgeon preference.

Retrieved stones underwent standard compositional analysis. Following spontaneous or surgical stone clearance, all patients underwent standardized metabolic evaluation using a 24-hour urine collection. Urinary calcium, oxalate, citrate, uric acid, cystine, and other routinely assessed metabolic parameters were analyzed according to institutional pediatric stone protocols. Age-specific reference values were used for interpretation. Metabolic evaluation was performed after complete resolution of the acute stone episode to avoid potential interference from acute obstruction or infection. Patients with abnormal metabolic findings were subsequently evaluated and managed by the pediatric nephrology team using individualized medical therapy and preventive recommendations.

The primary outcome measures were successful urethral stone clearance, procedure-related complications, and stone recurrence. Successful urethral stone clearance was defined as complete removal or spontaneous passage of the urethral calculus without residual urethral fragments requiring additional intervention. Complete urinary tract stone-free status was evaluated separately during follow-up because several children had concomitant upper urinary tract calculi requiring subsequent treatment. Secondary outcomes included clinical presentation, stone characteristics, associated upper urinary tract stone disease, metabolic abnormalities, additional stone-related interventions, and long-term urethral outcomes. Procedure-related complications included urethral injury, meatal stenosis, urethral stricture, persistent voiding dysfunction, urinary tract infection, and any additional intervention related to the primary procedure.

Because the study was designed as a descriptive retrospective case series, statistical analyses were primarily descriptive. Continuous variables are presented as median with interquartile range (IQR) and/or range as appropriate, whereas categorical variables are reported as frequencies and percentages. Formal comparative analyses and multivariable statistical testing were not performed because of the limited sample size and the descriptive nature of the study. Statistical analyses were performed using IBM SPSS Statistics version 22.0 (IBM Corp., Armonk, NY, USA).

## RESULTS

### Patient characteristics and clinical presentation

Fourteen children with urethral calculi were included in the study. The cohort consisted of 10 boys (71.4%) and 4 girls (28.6%), with a median age at presentation of 4.5 years (range, 8 months–8 years). The median follow-up duration was 54 months (range, 8–72 months).

Acute urinary retention and gross hematuria were the most frequent presenting manifestations, each occurring in 8 patients (57.1%). Five children (35.7%) presented with urinary tract infection, while four (28.6%) complained of urinary dribbling. The median duration of symptoms before presentation was 1 day (range, 1–3 days), and the median interval between admission and definitive treatment was 12 hours (range, 8–24 hours).

**Table 1.** Baseline demographic and clinical characteristics of children with urethral calculi (n = 14)

### Patient Characteristics

| Variable                | Value                            |
|-------------------------|----------------------------------|
| Number of patients      | 14                               |
| Male sex, n (%)         | 10 (71.4)                        |
| Female sex, n (%)       | 4 (28.6)                         |
| Age at diagnosis, years | 4.5 (IQR 2.1–5.4), range 0.7–8.0 |

| Variable                   | Value                      |
|----------------------------|----------------------------|
| Follow-up duration, months | 54 (IQR 39–60), range 8–72 |

### Clinical Presentation

| Variable                            | Value                     |
|-------------------------------------|---------------------------|
| Acute urinary retention             | 8 (57.1)                  |
| Hematuria                           | 8 (57.1)                  |
| Urinary tract infection             | 5 (35.7)                  |
| Dribbling                           | 4 (28.6)                  |
| Symptom duration, days              | 1 (IQR 1–2), range 1–3    |
| Time to definitive treatment, hours | 12 (IQR 8–24), range 8–24 |

### Stone characteristics and diagnostic evaluation

The median urethral stone diameter was 6.75 mm (range, 4–11 mm). Twelve patients (85.7%) had impacted urethral calculi requiring active intervention. The most frequent stone location was the external urethral meatus (42.9%), followed by the prostatic urethra (28.6%), penile urethra (21.4%), and membranous urethra (7.1%).

Eight children (57.1%) had isolated urethral stones, whereas six (42.9%) had concomitant upper urinary tract calculi. Among these, three patients had bilateral staghorn calculi, two had right renal stones, and one had a left renal stone.

Ultrasonography was performed in all patients. Computed tomography was obtained in eight children (57.1%), plain radiography in six (42.9%), and diagnostic cystoscopy in nine (64.3%). Representative radiological, clinical, and endoscopic appearances of urethral calculi in the study cohort are shown in Fig. 1.

**Table 2.** Stone characteristics, associated stone burden and diagnostic evaluation

### Stone Characteristics

| Variable               | Value                          |
|------------------------|--------------------------------|
| Stone size, mm         | 6.75 (IQR 5.0–8.8), range 4–11 |
| Impacted stones, n (%) | 12 (85.7)                      |

### Stone location

- External urethral meatus 6 (42.9)

| Variable             | Value    |
|----------------------|----------|
| • Penile urethra     | 3 (21.4) |
| • Membranous urethra | 1 (7.1)  |
| • Prostatic urethra  | 4 (28.6) |

#### Associated Urinary Tract Stone Burden

| Variable                                    | Value    |
|---------------------------------------------|----------|
| Isolated urethral stone                     | 8 (57.1) |
| Urethral stone + right renal stone          | 2 (14.3) |
| Urethral stone + left renal stone           | 1 (7.1)  |
| Urethral stone + bilateral staghorn calculi | 3 (21.4) |

#### Diagnostic Evaluation

| Variable              | Value    |
|-----------------------|----------|
| Ultrasonography       | 14 (100) |
| Plain radiography     | 6 (42.9) |
| Computed tomography   | 8 (57.1) |
| Diagnostic cystoscopy | 9 (64.3) |

#### Treatment and operative outcomes

Treatment was selected according to stone location and clinical presentation. Endoscopic holmium laser lithotripsy was performed in nine patients (64.3%), meatotomy in three (21.4%), and spontaneous stone passage occurred in two (14.3%).

Endoscopic lithotripsy was performed using a standardized low-energy protocol with a 270- $\mu$ m laser fiber, pulse energy of 0.2–0.3 J, frequency of 30–40 Hz, and long-pulse mode. The median operative time was 45 minutes (range, 30–60 minutes), and postoperative urethral catheterization was maintained for a median of one day (range, 1–2 days).

Successful urethral stone clearance was achieved in all patients during the initial episode. Because of associated upper urinary tract stones, three children subsequently underwent retrograde intrarenal surgery and three underwent percutaneous nephrolithotomy.

**Table 3.** Treatment characteristics and outcomes of children with urethral calculi

| Initial Treatment                                    | Value                       |
|------------------------------------------------------|-----------------------------|
| Endoscopic laser lithotripsy                         | 9 (64.3)                    |
| Meatotomy                                            | 3 (21.4)                    |
| Spontaneous stone passage                            | 2 (14.3)                    |
| <b>Endoscopic Laser Lithotripsy Characteristics*</b> |                             |
| Laser fiber diameter                                 | 270 $\mu$ m                 |
| Pulse energy                                         | 0.2–0.3 J                   |
| Pulse frequency                                      | 30–40 Hz                    |
| Pulse width                                          | Long pulse                  |
| Operative time, min                                  | 45 (IQR 45–60), range 30–60 |
| Postoperative catheterization, days                  | 1 (IQR 1–1), range 1–2      |

### **Treatment Outcomes**

|                                                   |          |
|---------------------------------------------------|----------|
| Successful urethral stone clearance               | 14 (100) |
| Additional upper urinary tract stone intervention | 6 (42.9) |
| └ Retrograde intrarenal surgery (RIRS)            | 3 (21.4) |
| └ Percutaneous nephrolithotomy (PNL)              | 3 (21.4) |

Laser and perioperative characteristics refer only to the nine patients undergoing endoscopic laser lithotripsy. Values are presented as n (%) unless otherwise indicated.

### **Metabolic evaluation and long-term outcomes**

Stone analysis demonstrated calcium oxalate composition in 13 of the 14 patients (92.9%), while one child had a cystine stone.

All patients underwent standardized 24-hour urine metabolic evaluation after spontaneous or surgical stone clearance. Hypocitraturia was identified in all patients (100%), hypercalciuria in seven (50.0%), hyperoxaluria in two (14.3%), and cystinuria was confirmed in the patient with a cystine stone.

Complete urinary tract stone-free status at final follow-up was achieved in 12 patients (85.7%). During a median follow-up of 54 months, only one patient experienced stone recurrence. No patient developed urethral stricture, meatal stenosis, persistent voiding dysfunction, or any procedure-related complication.

**Table 4.** Stone composition, metabolic evaluation and long-term outcomes

## Stone Composition

| Variable                              | Value     |
|---------------------------------------|-----------|
| Calcium oxalate monohydrate/dihydrate | 12 (85.7) |
| Calcium oxalate monohydrate           | 1 (7.1)   |
| Cystine                               | 1 (7.1)   |

## Metabolic Evaluation

| Variable                              | Value    |
|---------------------------------------|----------|
| Standardized 24-hour urine evaluation | 14 (100) |
| Hypocitraturia                        | 14 (100) |
| Hypercalciuria                        | 7 (50.0) |
| Hyperoxaluria                         | 2 (14.3) |
| Hyperuricosuria                       | 0        |
| Positive cystinuria test              | 1 (7.1)  |

## Long-term Outcomes

| Variable                                                    | Value     |
|-------------------------------------------------------------|-----------|
| Complete urinary tract stone-free status at final follow-up | 12 (85.7) |
| Stone recurrence                                            | 1 (7.1)   |
| Urethral stricture                                          | 0         |
| Meatal stenosis                                             | 0         |
| Procedure-related complications                             | 0         |

## DISCUSSION

Pediatric urethral calculi remain an uncommon manifestation of urinary stone disease, and consequently the available evidence is largely limited to retrospective series and isolated case reports [3-6]. The present study provides a comprehensive contemporary evaluation of children with urethral calculi by integrating clinical presentation, stone characteristics, management strategy, metabolic findings, and long-term outcomes. Several important observations emerged. First, the clinical presentation was heterogeneous and extended beyond acute urinary retention. Second, almost half of the children had concomitant upper urinary tract calculi requiring additional intervention, suggesting that urethral stones frequently represent the presenting

manifestation of a broader urinary stone disease rather than an isolated urethral event. Third, standardized metabolic evaluation identified abnormalities in every patient. Finally, location-adapted minimally invasive treatment achieved complete urethral stone clearance without urethral stricture, meatal stenosis, or procedure-related complications during long-term follow-up.

Acute urinary retention has traditionally been regarded as the hallmark presentation of pediatric urethral calculi, particularly in children with impacted anterior urethral stones. Salman et al. reported urinary retention as the predominant symptom among children with anterior urethral calculi, whereas posterior stones more commonly presented with urinary dribbling [3]. Similarly, Akhtar et al. described urinary retention as the principal indication for intervention in children with impacted urethral stones [4]. Nevertheless, our findings demonstrate that the clinical spectrum is considerably broader. Although urinary retention remained one of the most frequent presenting symptoms, gross hematuria occurred with equal frequency, while urinary tract infection and urinary dribbling were also commonly encountered. These observations indicate that urethral calculi should be considered in the differential diagnosis of persistent lower urinary tract symptoms or unexplained hematuria even in the absence of complete urinary obstruction [3-5].

Stone location has important implications for both symptomatology and treatment selection. Previous pediatric series have reported variable anatomical distributions, reflecting differences in referral patterns and inclusion criteria. Salman et al. demonstrated distinct clinical manifestations according to stone location [3], whereas Akhtar et al. reported predominance of anterior urethral impaction [4]. In contrast, our cohort demonstrated a broader anatomical distribution involving the external urethral meatus, penile, membranous, and prostatic urethra. Furthermore, unlike the majority of previously published pediatric series [3,4,6], our study also included female patients, all of whom presented with calculi at the external urethral meatus. Although definitive conclusions cannot be drawn because of the limited sample size, these findings illustrate the anatomical diversity of pediatric urethral calculi encountered in contemporary practice and support individualized treatment according to stone location rather than a uniform management strategy.

The management of pediatric urethral calculi has evolved considerably over the past three decades. Historically, manual extraction, meatotomy, urethrolithotomy, and retrograde manipulation into the bladder followed by cystolithotripsy represented the principal treatment options [3-7]. Improvements in pediatric endoscopy and holmium laser technology have progressively shifted management toward minimally invasive approaches, although no universally accepted treatment algorithm currently exists [9,10]. In the present study, treatment selection was primarily determined by stone location and degree of impaction. Stones located at the external urethral meatus were managed by spontaneous passage or meatotomy when appropriate, whereas impacted proximal calculi were preferentially treated by in-situ holmium laser lithotripsy. We intentionally avoided routine retrograde displacement of impacted stones into the bladder whenever technically feasible, favoring controlled fragmentation under direct vision to minimize unnecessary urethral manipulation while allowing complete stone clearance. Although our study was not designed to compare treatment modalities, the absence of urethral

injury, stricture formation, or meatal stenosis during long-term follow-up supports the safety of this urethra-preserving strategy. Based on our clinical experience and the available literature, a practical location- and impaction-based approach to the evaluation and management of pediatric urethral calculi is proposed in Fig. 2.

One of the most clinically relevant observations in the present study was the high prevalence of associated upper urinary tract calculi. In a contemporary systematic review of urethral calculi, coexistent bladder or upper urinary tract calculi were reported in 16.8% of cases [5]. In our cohort, six of 14 children (42.9%) had concomitant upper urinary tract calculi, and all six required subsequent stone-directed intervention, including retrograde intrarenal surgery in three and percutaneous nephrolithotomy in three. Although direct comparison with previous reports is limited by differences in age distribution, study design, and patient selection, our findings highlight the considerable associated stone burden in this pediatric population. Urethral calculi in children should therefore not necessarily be regarded as isolated obstructive lesions but may represent the presenting manifestation of more extensive urinary stone disease. Accordingly, evaluation should not end with successful urethral stone removal; complete assessment of the urinary tract is warranted to identify associated calculi requiring additional treatment and long-term surveillance [1,5].

Comprehensive metabolic evaluation represents another major strength of the present study. Current pediatric urolithiasis guidelines recommend systematic metabolic investigation because recurrence is frequently driven by underlying metabolic abnormalities rather than by the initial stone event itself. Nevertheless, dedicated pediatric urethral stone series have rarely reported standardized metabolic assessment. All children in our cohort underwent 24-hour urine evaluation after complete resolution of the acute episode using age-specific reference values. The prevalence and pattern of metabolic abnormalities vary considerably across pediatric stone populations and geographic regions. Gourel et al. reported hypercalciuria in 50%, hyperoxaluria in 50%, and hypocitraturia in 23% of children with urolithiasis [8]. In our cohort, hypocitraturia was identified in all patients, while hypercalciuria was present in 50% and hyperoxaluria in 14.3%; cystinuria was additionally confirmed in the child with a cystine calculus. The universal presence of hypocitraturia in our series is noteworthy and may reflect the highly selected nature of children presenting with urethral calculi rather than the metabolic profile of the general pediatric stone population. More importantly, these results reinforce current recommendations that every child presenting with urethral calculi should undergo comprehensive metabolic evaluation followed by individualized nephrology-guided preventive management [1,2,8].

Long-term outcome data following pediatric urethral calculi remain scarce. In the present study, complete urethral stone clearance was achieved in every patient, recurrence occurred in only one child, and no patient developed urethral stricture, meatal stenosis, persistent voiding dysfunction, or procedure-related complications during a median follow-up of 54 months. The favorable urethral safety profile observed in our series is also consistent with the broader pediatric experience demonstrating the safety of Ho:YAG lithotripsy when performed with appropriately sized instruments and controlled energy delivery [9,10]. These findings suggest that location-adapted minimally invasive treatment provides durable outcomes while preserving urethral integrity. Nevertheless, continued surveillance remains essential because recurrence is

primarily determined by the underlying metabolic predisposition rather than the initial urethral intervention [1,2].

This study has several limitations. Its retrospective design, relatively small sample size, and single-center setting limit the generalizability of the findings and preclude meaningful comparative statistical analyses. Nevertheless, these limitations largely reflect the rarity of pediatric urethral calculi. The study also possesses several important strengths, including standardized treatment by a dedicated pediatric urology team, complete 24-hour metabolic evaluation in every patient, detailed characterization of associated urinary tract stone burden, and a relatively long follow-up period focusing specifically on long-term urethral outcomes. These features provide a comprehensive contemporary perspective on the diagnosis, management, and follow-up of children with urethral calculi.

## CONCLUSION

Pediatric urethral calculi are uncommon but clinically important because they may present with a broad spectrum of lower urinary tract symptoms and frequently represent more extensive urinary stone disease. Management should be individualized according to stone location and degree of impaction. In-situ low-energy holmium laser lithotripsy provided complete urethral stone clearance without long-term urethral complications in appropriately selected patients. Comprehensive imaging of the entire urinary tract and standardized metabolic evaluation should be integral components of the evaluation of these children, as associated upper urinary tract calculi and treatable metabolic abnormalities are common. Long-term multidisciplinary follow-up is warranted to reduce recurrence and preserve urinary tract health.

## REFERENCES

1. Tekgül S, et al. European Association of Urology and European Society for Paediatric Urology Guidelines on Paediatric Urinary Stone Disease. *Eur Urol Focus*. 2022;8(3):833–839. doi:10.1016/j.euf.2021.05.006.
2. Cao B, Daniel R, McGregor R, Tasian GE. Pediatric nephrolithiasis. *Healthcare (Basel)*. 2023;11(4):552. doi:10.3390/healthcare11040552.
3. Salman AB. Urethral calculi in children. *J Pediatr Surg*. 1996;31(10):1379–1382. doi:10.1016/S0022-3468(96)90833-7.
4. Akhtar J, Ahmed S, Zamir N. Management of impacted urethral stones in children. *J Coll Physicians Surg Pak*. 2012;22(8):510–513.
5. Morton A, Tariq A, Dunglison N, Esler R, Roberts MJ. Etiology and management of urethral calculi: a systematic review of contemporary series. *Asian J Urol*. 2024;11(1):10–18. doi:10.1016/j.ajur.2021.12.011.
6. Gadelkareem RA, et al. Experience of a tertiary-level urology center in the clinical urological events of rare and very rare incidence. VI. Unusual events in urolithiasis: 1. Long-standing urethral stones without underlying anatomical abnormalities in male children. *Urol Int*. 2018;101(1):85–90. doi:10.1159/000488398.

7. Kamal BA, Anikwe RM, Darawani H, Hashish M, Taha SA. Urethral calculi: presentation and management. *BJU Int.* 2004;93(4):549–552. doi:10.1111/j.1464-410X.2003.04660.x.
8. Gouru VR, Pogula VR, Vaddi SP, Manne V, Byram R, Kadiyala LS. Metabolic evaluation of children with urolithiasis. *Urol Ann.* 2018;10:94–99.
9. 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. *Urol Res.* 2012;40(6):751–755. doi:10.1007/s00240-012-0495-x.
10. Wollin TA, Teichman JMH, Rogenes VJ, Razvi HA, Denstedt JD, Grasso M. Holmium:YAG lithotripsy in children. *J Urol.* 1999;162(5):1717–1720. doi:10.1016/S0022-5347(05)68222-5.

## FIGURE LEGENDS

**Fig. 1 Representative radiological, clinical, and endoscopic appearances of pediatric urethral calculi.** (A) Axial computed tomography image demonstrating a urethral calculus in a female patient (asterisk). (B) Clinical appearance of an impacted calculus at the external urethral meatus in another female patient. (C–D) Representative endoscopic appearances of impacted urethral calculi in two male patients before in-situ Ho:YAG laser lithotripsy.

**Fig. 2 Proposed management algorithm for pediatric urethral calculi.** The algorithm summarizes a location- and impaction-based approach derived from the present clinical experience and available literature. Initial evaluation includes clinical assessment and ultrasonography, with additional imaging or endoscopic assessment when clinically indicated. Management is individualized according to stone location and degree of impaction, followed by assessment and treatment of associated upper urinary tract calculi. Following resolution of the acute stone episode, comprehensive metabolic evaluation using age-specific reference values and individualized preventive management are recommended, together with long-term multidisciplinary follow-up. CT, computed tomography; Ho:YAG, holmium:yttrium-aluminum-garnet; RIRS, retrograde intrarenal surgery; PNL, percutaneous nephrolithotomy; UTI, urinary tract infection.

## Figures

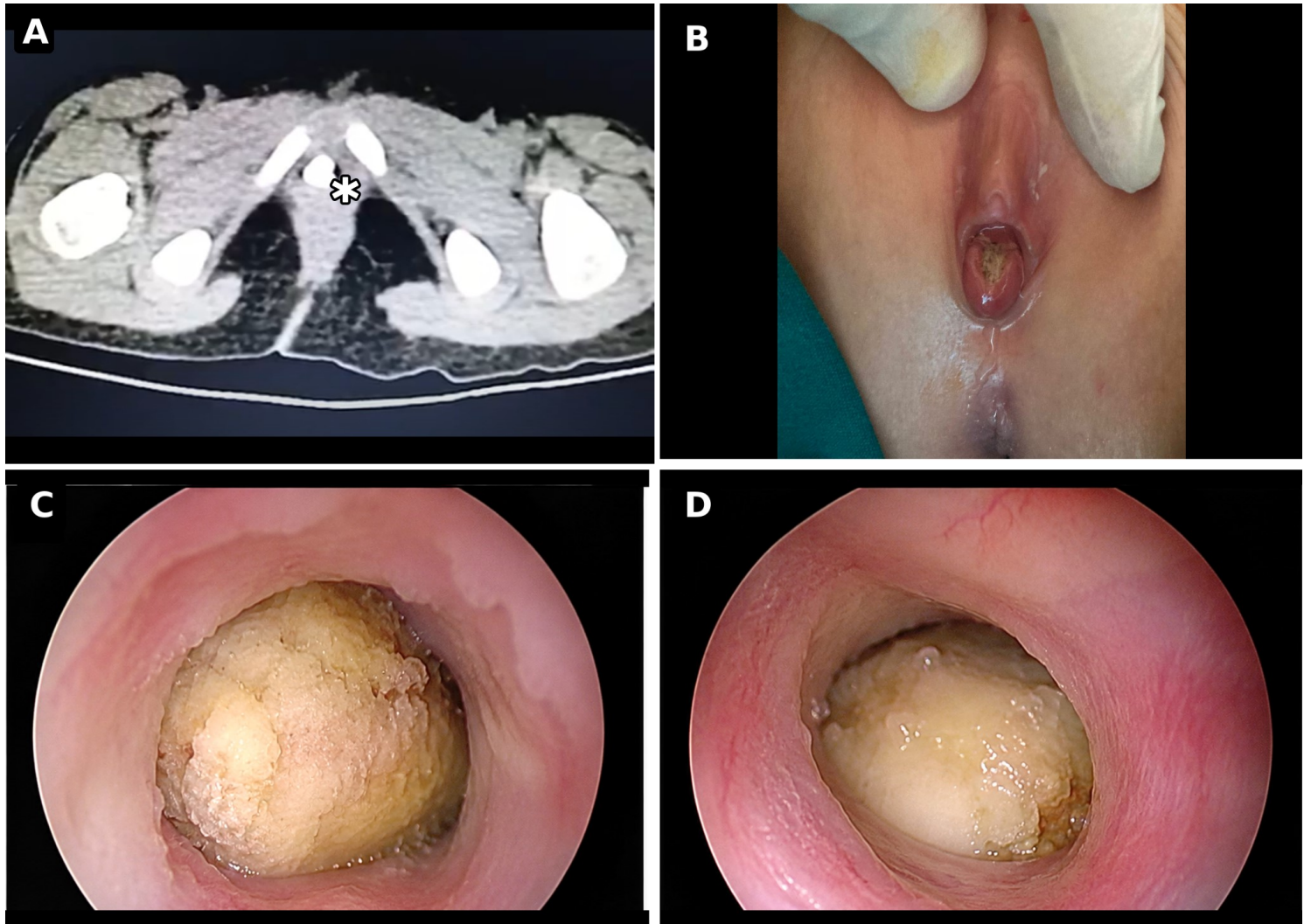


**Figure 1**

**Representative radiological, clinical, and endoscopic appearances of pediatric urethral calculi.** (A) Axial computed tomography image demonstrating a urethral calculus in a female patient (asterisk). (B) Clinical appearance of an impacted calculus at the external urethral meatus in another female patient. (C–D) Representative endoscopic appearances of impacted urethral calculi in two male patients before in-situ Ho:YAG laser lithotripsy.

## MANAGEMENT ALGORITHM FOR PEDIATRIC URETHRAL CALCULI

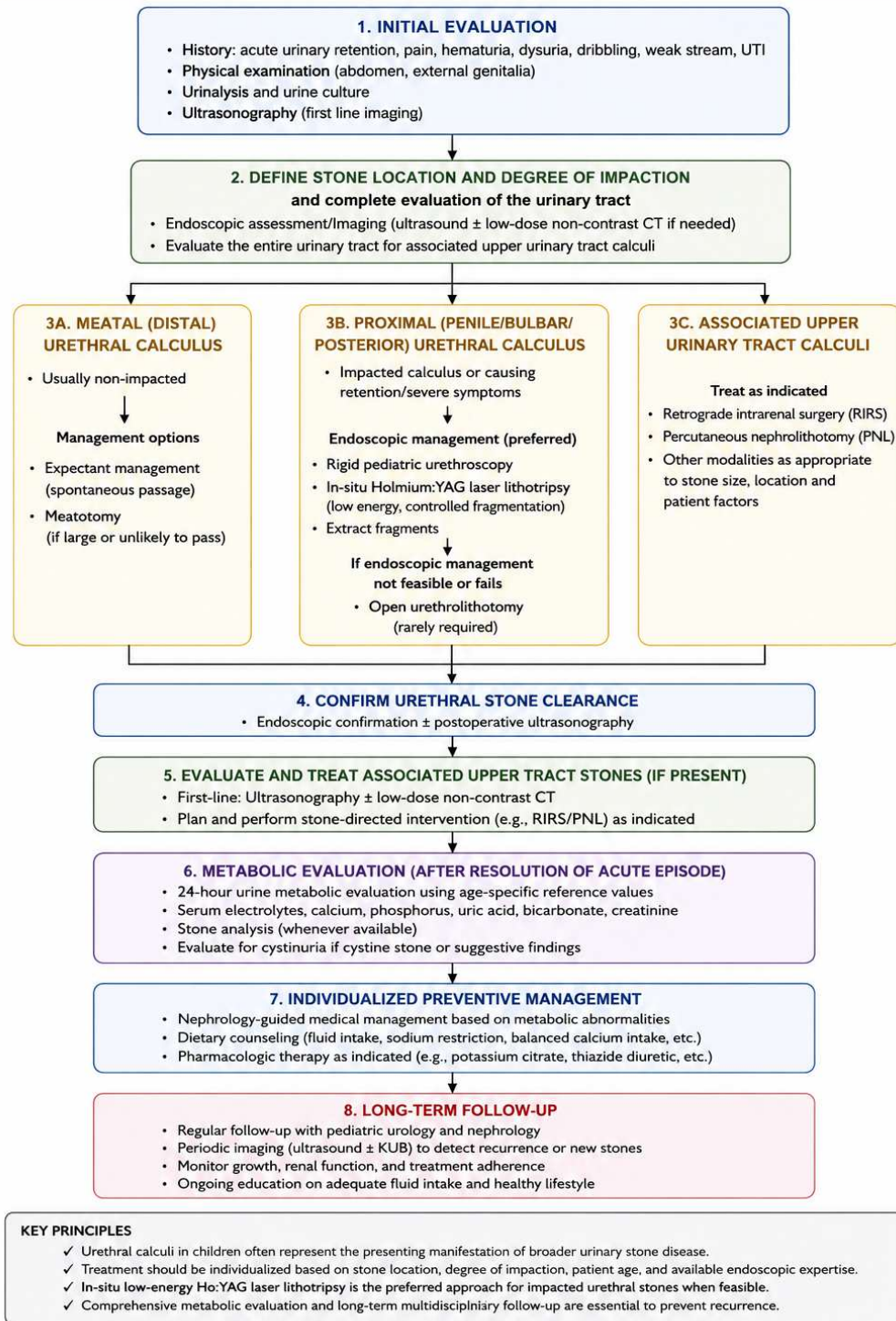


Fig. 2. Proposed management algorithm for pediatric urethral calculi.

Figure 2

**Proposed management algorithm for pediatric urethral calculi.** The algorithm summarizes a location- and impaction-based approach derived from the present clinical experience and available literature. Initial evaluation includes clinical assessment and ultrasonography, with additional imaging or endoscopic assessment when clinically indicated. Management is individualized according to stone location and degree of impaction, followed by assessment and treatment of associated upper urinary

tract calculi. Following resolution of the acute stone episode, comprehensive metabolic evaluation using age-specific reference values and individualized preventive management are recommended, together with long-term multidisciplinary follow-up. CT, computed tomography; Ho:YAG, holmium:yttrium-aluminum-garnet; RIRS, retrograde intrarenal surgery; PNL, percutaneous nephrolithotomy; UTI, urinary tract infection.