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Outcomes of ureteroscopy for management of stone disease in early and late childhood over a 15-year period

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Abstract

Background: Although paediatric ureteroscopy is widely performed, there is still a lack of data and outcomes in early childhood. In this two-centre study, we compared the outcomes of ureteroscopy for stone disease management in early and late childhood and provide outcomes for the same.

Methods: Data was retrospectively collected on consecutive patients from two tertiary paediatric endo-urology European centres over a 15-year period (2006–2021). Patients were split into two groups, namely, early childhood (age ⩽ 9 years) and late childhood (age 9 to ⩽16 years). Outcomes including stone-free rate (SFR) and complications were compared between these two groups.

Results: A total of 148 patients underwent 184 procedures (1.2 procedure/patient) during the study period (66 in early childhood and 82 in late childhood). The mean age in early and late childhood groups were 5.6 and 13.3 years, and a male: female ratio of 1.6:1 and 1.1:1, respectively. The SFR and complications in early and late childhood groups were 87.8% and 90.2% ($p = 0.64$) and 5.7% and 4.1%, respectively.

Conclusion: Paediatric ureteroscopy and laser stone fragmentation achieves good results in both early and late childhood with comparable SFRs, although the complications and need for second procedure were marginally higher in the early childhood group. Our study would set up a new benchmark for patient counselling in future, and perhaps this needs to be reflected in the paediatric urolithiasis guidelines.

Keywords: kidney calculi, laser, paediatric, stent, ureteroscopy, urolithiasis

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Introduction

The first reported case of ureteroscopic treatment for stone disease in a paediatric case was in the year 1988 by Ritchey *et al.*[1] Since then, over the last three decades, there have been multiple enhancements in the field of paediatric urology with more specialised surgeons operating in medium- and high-volume centres, improved technology for surgical equipment, increased awareness and timely recognition of possible complications enabling early intervention, to name a few.[2–4] However, there is still a lack of data for paediatric ureteroscopy for kidney stone disease (KSD), and there is continued evolution of the technique with focus on treatment effectiveness and complications, especially with regard to younger children.

In their study regarding neurological development, Le *et al.*[2] defined late childhood as those beyond 9 years of age with substantial brain maturation happening towards adulthood. The Centres for Disease Control and Prevention (CDC)[3] describe 9–11 years as latter part of middle childhood and

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describe teenage years as beginning from 12 years onwards. There is also an anatomical difference between urethra and ureteral diameter and incidence of anatomical abnormalities; we therefore used 9 years as hallmark for our study with adolescence-related physiological and physical changes occurring with progression of age in this cohort. The changes being in the form of growth spurts, fat deposition, muscular hypertrophy, and hormonal pathway activation and maturation.

Paediatric ureteroscopy is specialised due to the minimisation of equipment, anaesthetic challenges, and developmental and anatomic abnormalities which are common in children with kidney stones.[5–11] The outcome of intervention is variable between centres based on their experience, expertise and choice of chosen intervention. In a study of 54 patients, Gedik *et al.*[5] achieved a stone-free rate (SFR) of 77.8% in population age range of 1–16 years and Kim *et al.*[6] demonstrated a SFR of 98.5% in 170 patients with age ranging from 0.2 to 18.1 years in their study. This indicates the variation in outcomes with similar interventions in different centres and differing patient population.

In this two-centre study, we compared the outcomes of ureteroscopy for stone disease management in early and late childhood to contribute to progression of surgical management and provide data for safety and efficacy for the same. We hypothesise that the role of ureteroscopy and laser stone fragmentation (URSL) is safe and effective across all age groups of paediatric patients.

Materials and methods

Data was collected on consecutive patients from two tertiary paediatric endo-urology European centres [University Hospital Southampton (UHS), United Kingdom, and Fundació Puigvert (FP), Barcelona, Spain] operating independently of each other. The study was registered as an audit with UHS audit committee (audit number 6901) and was approved by the FP Hospital Ethics Committee, and retrospective data was collected from both centres. A valid written informed consent was obtained from all the patients/parents/legal guardians for their data to be utilised in this study. This was further analysed using electronic health records and cross-checked with patient correspondence and discharge summary. The operating teams were trained in paediatric ureteroscopy, with medical and surgical expertise in order to provide best possible patient care.

Collection of data was spread over a period of 15 years from June 2006 to January 2021, and a total of 184 ureteroscopies were performed in 148 patients. Patients were divided into two groups, namely, early childhood (age ⩽ 9 years) and late childhood (age 9 to ⩽16 years).[2,3] Data regarding patient age, sex, initial presentation, mode of initial investigation, co-existing anatomical and metabolic anomalies, date of surgery, pre- and post-operative stenting, operative duration, access sheath use, intra-operative complications, postoperative complications (within 30 days), SFR, re-intervention and follow-up imaging were recorded.

Procedural details have previously been extensively detailed and discussed.[7–9] Stone diagnosis was established by ultrasound scan or plain KUB XR and during follow-up, a renal USS (Ultrasound Scan) was done to confirm the stone-free status. A multidisciplinary team (MDT) discussed all cases. SFR was defined as endoscopically stone free and radiologically stone free (defined as fragments < 2 mm) at follow-up, 2 to 4 months post-procedure. During the procedure, a 4.5 F (Richard Wolf, USA) semirigid and 7.5 F Flex X2 fURS (Karl Storz Endoscopy Ltd., UK) was used, with a Holmium: YAG laser (100, 60 or 20 W Lumenis, USA) for fragmentation using a 272-lm laser fibre (Lumenis, Inc.). The use of intra-operative access sheath and post-procedural stent was surgeon-dependent, and a stone fragment was extracted and sent for crystallographic analyses.

The data was anonymised and analysed using excel (Microsoft, USA) and SPSS (IBM® SPSS® version 27). Chi-square test was used in SPSS to obtain the statistical significance in the form of p value and excel was used to obtain medians, standard deviation, range and percentage. A p value of < 0.05 was considered statistically significant.

Results

A total of 148 patients underwent 184 procedures (1.2 procedure/patient) during the study period (Table 1), with 66 patients in early childhood group and 82 patients in late childhood group. The mean age in early and late

Table 1. Pre-operative demographics of patients undergoing URSL procedure for both groups.

Demographics	Early childhood (⩽9 years)	Late childhood (9 to ⩽16 years)
Number of patients	66	82
Number of procedures	87	97
Procedure/patient	1.2	1.1
Median age ± SD (range)	6 ± 2.23 (0.8–9 years)	14 ± 1.98 (9.1 to ⩽16 years)
Male: female	1.6:1	1.1:1
Incidence of metabolic anomalies	28 (38.3%)	29 (32.9%)
Incidence of anatomical anomalies	17 (23.2%)	14 (15.9%)
Median stone size ± SD (range) in mm	9.0 ± 4.6 (3–30)	9.0 ± 6.87 (3–60)
Stone location – Ureteric: renal (multiple stones)	1:1.1 (28)	1:1.5 (37)
Renal pelvis	23	23
Upper renal pole	9	18
Middle renal pole	15	15
Lower renal pole	31	39
Proximal ureter/PUJ	3	8
Mid-ureter	3	3
Distal ureter/VUJ	23	23
Inter-diverticular	0	1
NOS	10	4

NOS, not otherwise specified; PUJ, pelvi-ureteric junction; SD, standard deviation; URSL, ureteroscopy and laser stone fragmentation; VUJ, vesico-ureteric junction.

childhood groups were 5.6 and 13.3 years, and a male: female ratio of 1.6:1 and 1.1:1, respectively. The median stone size in both groups was 9.0 mm. The clinical presentations in early and late childhood groups were with pain (40.9% *versus* 70.7%), infection (19.6% *versus* 12.1%), haematuria (24.2% *versus* 21.9%) and acute kidney injury (0% *versus* 1.2%), with some having multiple symptoms, and 51.5% *versus* 24.3% being asymptomatic in the two groups, respectively.

The mean operative duration for early and late childhood was 86.2 and 82.4 min, respectively. There was no significant difference in pre- or post-operative stent rates in early and late childhood groups (42% and 51.5%, $p = 0.25$; and 43.1% and 45.3%, $p = 0.63$). Ureteric access sheath (UAS) was used 21.5% and 24.7% in early and late childhood, respectively ($p = 0.46$). The SFRs in early and late childhood were 87.8% and 90.2%, respectively ($p = 0.64$) (Table 2). The most common stone composition was calcium oxalate in both the groups. Intra-operative minor ureteric mucosal injury was seen in three patients in early childhood and one patient in late childhood, respectively, which was managed with ureteric stent insertions. Post-operative complications were noted in 5.7% and 4.1% in early and late childhood, respectively (Table 2). These were all Clavien I/II complications except one Clavien IV complication in early childhood who had a

Table 2. Post-operative outcomes of patients of both age groups undergoing URSL.

Demographics	Early childhood (⩽9 years)	Late childhood (9 to ⩽16 years)	*p* value
UAS use	19 (21.5%)	24 (24.7%)	0.46
Pre-operative stent	37/88 (42%)	50/97 (51.5%)	0.25
Post-operative stent	38/88 (43.1%)	44/97 (45.3%)	0.63
Stone-free rate	87.87%	90.24%	0.64
Complications			
Intra-operative			
Overall intra-operative complications	4/87 (4.5%)	2/97 (2.0%)	0. 903
Ureteric injury (stent inserted)	3	1	0.267
Intra-operative bleeding causing rescheduling of procedure	0	1	0.176
Post-operative			
Overall post-operative complications	5/87 (5.7%)	4/97 (4.1%)	0.296
Haematuria	1	0	0.292
Fever	1	1	0.945
Post-operative sepsis	1	2	0.619
Urine retention requiring catheterization	2	1	0.504

UAS, ureteric access sheath; URSL, ureteroscopy and laser stone fragmentation.

post-op sepsis with brief intensive care admission (Table 2).

Discussion

This study demonstrates the safety of performing URS for renal stone disease across all paediatric age groups with our SFR comparable with previously published data[5–13] and an overall post-operative complication rate of 7% across all age groups. All the ureteric injuries (1.6%) were of grade 1 classification and were managed conservatively with stent insertion.

Ureteroscopy seems to have evolved itself as the most favoured treatment strategy balancing the clinical efficacy with safety perhaps in contrast to shock wave lithotripsy (SWL) and percutaneous nephrolithotomy (PCNL), respectively.[7–14] With the advancement in technology providing smaller size equipment for URS and more surgeons trained in paediatric endo-urology operating in high-volume centres, it is emerging as a frontline alternative. Our study used fragmentation and stone dusting for treatment and reflects a SFR of 87.8% in early childhood and 90.2% in late childhood with minimal associated morbidity. Rob *et al.*[12] in their systematic review found an overall SFR of 90.4% ranging from 58% to 100% from studies from medium- to high-volume centre. The overall complication rate in this study[12] was recorded at 11.1% with 69% and 31% as Clavien Dindo (CD) 1 and CD 2–3, respectively. Other series and systematic reviews have also commonly commented on CD complication of ⩽ 3 for paediatric URSL.[12–17]

The European Association of Urology (EAU) urolithiasis guidelines[18] includes all the three modalities (SWL, URS and PCNL) for active intervention of renal stone disease, with SWL and fURS offering a SFR of 70–90% and 76–100%, respectively. SWL is the first choice of treatment for paediatric stone disease though it often requires sedation or general anaesthetic in this population for patient positioning and tolerability of the procedure. It is often associated with renal colic, steinstrasse, sepsis and transient hydronephrosis, and may not always be successful. In their follow-up post SWL *versus* URS, Tejwani *et al.*[19] found that patients receiving SWL for stone treatment required more additional procedures to be rendered stone free as compared with the URS cohort. PCNL is an alternative option for stones > 2 cm and complex renal stones. With the advent of micro-PCNL, the morbidity associated with PCNL has reduced. Post-operative bleeding and organ injury are the most dreaded complication with PCNL, with Bhageria *et al.*[20] reporting a transfusion rate of 9%. Other complications associated with PCNL are fever, sepsis, hydrothorax, pneumothorax and perinephric collection.

In their paediatric patient cohort of 11 patients, Utanğaç *et al.*[21] had a SFR of 100% with no intraoperative complications and one episode of self-resolving post-operative haematuria. In a larger patient cohort of 100 patients analysed retrospectively, Smaldone *et al.*[22] achieved a SFR of 91% with one patient requiring ureteral re-implantation due to ureteric stricture formation on follow-up. In a study of 30 paediatric patients treated for KSD, Ferretti *et al.*[23] found an overall SFR of 93.3% when including re-intervention and a low rate of major complications. Similarly, Nerli *et al.*[24] in their study of 77 patients less than 60 months of age while suggesting URS as first line of treatment for paediatric urolithiasis found a SFR of 94.8% with an overall complication rate of 12.9%.

A systematic review by Pietropaolo *et al.*[25] found a rising trend in active surgical intervention utilising URS and PCNL for paediatric urolithiasis as witnessed by improving outcomes. We can see the progress in URS since 1997, when al Busaidy *et al.*[26] reported on 50 ureteroscopies in paediatric cases with 8.5, 9.5 and 11.5 Fr ureteroscopes and recorded two episodes of ureteric perforation with three failed procedures requiring utero-lithotomy. In practice, today with equipment downsizing to 4.5 Fr ureteroscopes available for paediatric cases if any resistance is encountered, a patient can be stented and scheduled for another definitive future procedure to avoid any untoward trauma. UAS is also helpful in gaining access to ureter and kidneys in cases where the operating surgeon deems it fit to attempt usage. In their twin-surgeon model, Somani and Griffin[27] have described the advantage of having two surgeons and the involvement of an MDT to improve URS outcomes. With easy access to miniaturised instrument, courses for training and newer lasertripsy methods like 'pop-dusting',[28] URS can be safely used in paediatric cases in appropriately equipped centres where staff are well trained to aide early recognition of intra- and post-operative complications. With advent in technology, cost-effectiveness and more research available on URS, improved outcomes can be expected and perhaps equivocal findings when compared with adult population.[29] In the management of upper urinary tract stones in children, Freton *et al.*[30] showed that fURS provided a higher single-session SFR compared with SWL, despite having more complex urinary stones, without increasing the morbidity. With the advent of smaller ureteroscopes, high powered laser and digital technology, fURS seem to be pushing the boundary in treating larger renal stones using 'dusting and pop-dusting' technique.[28]

Our article is based on retrospective data, and due to small number of patients, it was not possible to perform a multivariate analysis, but this has been a consecutive series of patients with data collected and analysed by neutral third party not involved in the original study. However, failure to access during the primary URS procedure was not uniformly captured, which has been shown to be higher for the early age group patients.[31] It is the largest observational study comparing outcomes of URSL in early and late childhood. This will set an important benchmark in counselling patients although studies should also look at standardising outcome measures such as SFR and looking at cost and quality of life of patients. The future paediatric urolithiasis guidelines should factor in patient age for recommendations of any surgical treatment, as the choice of treatment and outcomes could be influenced by the age. Based on our results, perhaps ureteroscopy could become a first-line treatment for paediatric urolithiasis in the late childhood.

Conclusion

Paediatric URSL achieves good results in both early and late childhood with comparable SFRs, although the complications and need for second procedure were marginally higher in the early childhood group. Our study would set up new benchmark for patient counselling in future, and perhaps this needs to be reflected in the paediatric urolithiasis guidelines. Future prospective randomised studies are needed to corroborate our results.

Declarations

Ethics approval and consent to participate
The study was registered as an audit with the University Hospital Southampton audit committee (audit number 6901) and was approved by the FP Hospital Ethics Committee. A valid written informed consent was obtained from all the patients/parents/legal guardians for their data to be utilised in this study.

Consent for publication
Not applicable.

Author contributions
Mriganka Sinha: Data curation; Formal analysis; Methodology; Project administration; Visualization; Writing – original draft; Writing – review & editing.

Amelia Pietropaolo: Conceptualization; Data curation; Formal analysis; Supervision; Writing – review & editing.

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Bhaskar K Somani: Conceptualization; Software; Supervision; Validation; Writing – original draft; Writing – review & editing.

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Availability of data and materials
Due to the possibility of compromising the privacy of research participants, the data supporting this study are not publicly available. However, they can be obtained from the corresponding author BS at bhaskarsomani@yahoo.com upon reasonable request.

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