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Ureteroscopy for stone disease in the paediatric population: lessons learned and outcomes in a Nordic setting

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Abstract

Introduction: Paediatric stone disease is rare in the Nordic communities. Still, the condition can require surgical intervention in the form of ureteroscopy (URS). Here, we report outcomes achieved at a regional (tertiary) centre.

Patients and methods: Retrospective analysis was performed of consecutive patients (<18 years of age) undergoing URS for stone disease between 2010 and 2021. Outcomes of interest included stone-free rate (SFR) determined using a definition of no residual fragments ⩾ 3 mm on imaging and complications classified according to Clavien–Dindo system.

Results: In total, 23 patients underwent 47 URS procedures for a total of 31 stone episodes. Mean age was 9 (range 1–17) years and male-to-female ratio was 6:17. Overall, 35% had at least one medical comorbidity. Ultrasound determined preoperative stone status in 87%. Mean largest index and cumulative stone sizes were 9 (range 3–40) and 12 (range 3–40) mm, respectively. Overall, 32% had multiple stones. Lower pole was the commonest stone location (39%). No patients underwent elective pre-operative stenting. Ureteral access sheaths were not used in any cases. Access to upper urinary tract at first procedure was successful in 94%. Initial and final SFR was 61% and 90%, respectively. No intra-operative complications were recorded. Overall post-operative complication rate was 17.5%. Urinary tract infection (CD II) was the commonest adverse event (12.5%).

Conclusion: Paediatric URS can be delivered in the setting of a regional centre without compromising outcomes. This includes when carried out by adult endourologists, without routine pre-stenting and omitting use of ureteric access sheath.

Keywords: endourology, laser, lithotripsy, paediatric, ureteroscopy, urolithiasis

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Introduction

Paediatric kidney stone disease (KSD) is rare, and the limited number of epidemiological studies renders it difficult to estimate the true global burden.[1] However, it is recognised that the incidence is rising.[2] Furthermore, across both paediatric and adult age groups, this trajectory is most obvious among adolescent females.[3,4] Although current European Association of Urology (EAU) Guidelines recommend shockwave lithotripsy (SWL) as the first-line treatment option for ureteral stones in children, these recommendations do recognise the increasing role of ureteroscopy (URS) in this special population.[5] This is particularly the case for renal stones when unfavourable factors for SWL are present, such as lower pole location.[6] This shift in the role of URS is largely due to the increasing number of original series, which demonstrate that its safety profile in the setting of this non-indexed patient group has ameliorated in recent years.[7–9] This has been facilitated as a result of increased surgical experience, introduction of newer laser platforms

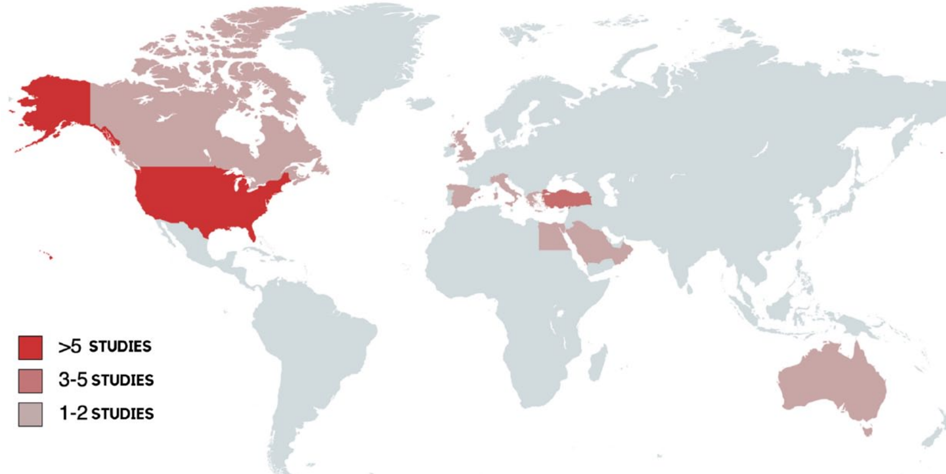

Figure 1. Summary of the number of published original studies on paediatric URS recorded in PubMed between 1 January 2000 and 31 December 2009. Multi-centre international studies excluded.

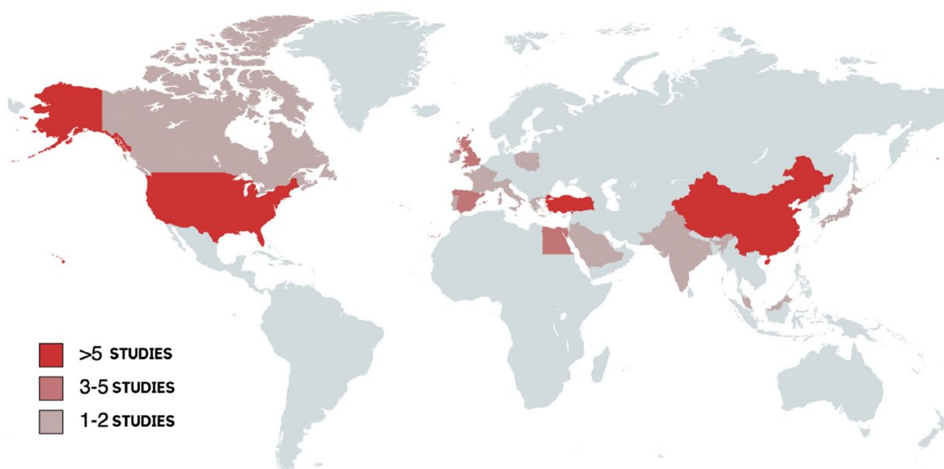

Figure 2. Summary of the number of published original studies on paediatric URS recorded in PubMed between 1 January 2010 and 31 December 2019. Multi-centre international studies excluded.

and new technologies, such as next-generation ureteroscopes.[10,11] There exist a range of practice patterns and areas of debate in paediatric URS, such as the role of elective and planned pre-operative stenting prior to definitive stone treatment, use of ureteral access sheath (UAS) and optimal follow-up regimes.[12–16] Most published reports originate from a relatively small pool of nations with large population sizes (Figures 1 and 2).[8,9,17–20] Outcomes from smaller nations remain under-reported.

Our aim was to report outcomes associated with paediatric URS for KSD at our centre and determine what lessons could be learned regarding these abovementioned points of debate. The primary outcome was stone-free rate (SFR), while secondary outcomes of interest included balloon dilatation, length of hospital stay and complications.

Methods

Retrospective analysis was performed of consecutive patients (<18 years of age) undergoing URS for stone disease between 2010 and 2021 at Haukeland University Hospital (HUH), a tertiary centre in Western Norway. All patients below 18 years of age were eligible and there were no exclusion criteria to minimise selection bias. All

URS procedures were performed under general anaesthesia (GA) and using the same technique we have described previously for adult patients.[21] Instrumentation consisted of paediatric semi-rigid (4.5/6Ch; Richard Wolf Medical Instruments, Vernon Hills, IL, USA) or a flexible ureteroscope (8.4Ch URF-V3 or 7.95Ch P7; Olympus, Tokyo, Japan) according to stone location. Routine method for stone clearance was fragmentation and retrieval with basket or graspers. Fragments were collected and sent for composition analysis wherever possible. Laser modality employed was Ho:YAG (Medilas H Solvo 30 W; Dornier MedTech, Weßling, Germany), and TFL (Soltive Premium 60 W; Olympus, USA) in the final 18-month period. Post-endoscopic stenting was performed at the discretion of the surgeon. 4.7 Fr stents were employed and removed 3–4 weeks later under GA. At this time, a further check URS was performed if deemed necessary by the surgeon to identify any residual fragments. Check procedures of this kind have been included in the total number of procedures reported in this study. However, where additional fragments (of any size) were identified and retrieved, this has also been included in the calculation of the total number of URS procedures that the patient required to be determined stone-free. If no stone was identified at the time of *initial* URS, this was termed a 'negative' URS and indicates spontaneous passage between the time of diagnosis and treatment.[22] A patient was considered to have had a new stone episode if imaging had confirmed stone-free status (SFS) and at least 6 months had passed. Performed in the setting of a university teaching hospital, surgeries were performed by faculty endourologists ($n=2$), attendings ($n=3$) or residents ($n=5$) under their direct supervision.

SFR was defined as no residual fragments ⩾ 3 mm on follow-up imaging [plain x-ray (XR), ultrasound (US) or non-contrast computed tomography (NCCT)] performed at 3–6 months. Choice of imaging modality was determined on a case-by-case basis. Cases where initial URS was unsuccessful due to access failure were still included in the calculation of initial SFR. Secondary outcomes of interest included balloon dilatation, length of hospital stay and complications. The latter were registered within 30 days of the procedure. These were graded according to Clavien–Dindo (CD) system. Additional information collected included baseline demographics and results of stone composition analysis.

Results

Between 2010 and 2021, a total of 23 patients underwent 47 URS procedures for a total of 31 stone episodes (Table 1). Mean age was 9 (range 1–17) years and male-to-female ratio was 6:17. Urinary tract infection (UTI; 48%) and flank pain (35%) were the commonest initial presentations. Overall, 43% of the sample had at least one medical comorbidity. Mean largest index and cumulative stone sizes were 9 (range 3–40) and 12 (range 3–40) mm, respectively. Out of the 31 stone episodes, 32% had multiple stones. The commonest stone locations were the lower pole ($n=12$, 39%) and renal pelvis ($n=9$, 29%).

Table 2 lists the outcomes of the URS procedures. No patients underwent planned prestenting. Access to the upper urinary tract at the time of the first procedure was successful in 94% ($n=29$) of cases. Balloon dilatation (12 mmHg) was required in 16% ($n=5$) of cases. All these cases requiring balloon dilatation were for short distal ureteral segments (<5 mm). UAS was not used in any cases. Bilateral same session URS was performed in one case. With the exception of one case, all URS procedures were carried out in the elective setting. Initial and final SFR associated with URS was 61% and 90%, respectively. In total, 10% ($n=3$) of patients were not rendered stone-free by URS alone. All of these patients ($n=3$) underwent auxiliary treatment in the form of percutaneous nephrolithotomy (PCNL). All patients who were not deemed stone-free as a result of URS had large stone burdens (more than 2.5 cm) and abnormal renal anatomy. When including auxiliary treatments, the overall SFR was 100% and mean number of surgical procedures to achieve SFS was 1.3 (range 1–4). No intra-operative complications were recorded. The overall post-operative complication rate related to URS procedures where stone treatment performed was 17.5% (Table 3). Mean length of hospital stay was 2 (range 0–10) days. The longest stay of 10 days was recorded in a patient with a complex medical history and bilateral stone burden who underwent staged treatment during the same admission. UTI (CD II) was the commonest adverse event (12.5%). No admissions to intensive care or mortalities were recorded. No cases were lost to follow-up. No late sequelae were identified on imaging at follow-up to suggest iatrogenic ureteric stricture

Table 1. Baseline characteristics.

Demographic	Total
Total number of patients	23
Total number of stone episodes	31
Total number of URS procedures	47
Semi-rigid URS only	12
Semi-rigid + flexible URS	35
Male: female ratio	6:17
Mean age (range)	9 (1–17)
Initial presentation:	
UTI	11 (48%)
Flank pain	8 (35%)
Haematuria	2 (8.5%)
Incidental	2 (8.5%)
Medical comorbidity	10 (43%)
One	4 (17%)
Two or more	6 (26%)
Abnormal anatomy:	6 (26%)
PUJO obstruction	5 (22%)
Duplex system	1 (4%)
Pre-op imaging:	
US	12 (52%)
US + XR	8 (35%)
NCCT	3 (13%)
Mean size of index stone (range)	9 (3–40) mm
Mean cumulative stone size (range)	12 (3–40) mm
Single	21/31 (68%)
Multiple	10/31 (32%)
Stone location	
Distal ureter	4 (13%)
Mid-ureter	4 (13%)
Upper ureter	0
Renal pelvis	9 (29%)
Lower pole	12 (39%)
Mid-pole	2 (6%)
Upper pole	0

URS, ureteroscopy; UTI, urinary tract infection; US, ultrasound; XR, X-ray; NCCT, non-contrast computed tomography.

Table 2. Summary of results.

Outcome	Total
Access to upper urinary tract on first attempt	29/31 (94%)
Balloon dilatation	5/31 (16%)
Negative URS[a]	1/31 (3%)
Post-operative JJ stent	27/31 (87%)
Initial SFR	19/31 (61%)
Initial SFR (excluding failed initial access)	19/29(66%)
Final SFR [after further URS treatment(s)]	28/31 (90%)
Overall SFR (after auxiliary PCNL)	31/31 (100%
Imaging to determine SFR:	
Plain XR	3/31 (10%)
US	24/31 (77%)
NCCT	4/31 (13%)
Hospital stay (range)	2 (0–10)
Stone composition:	
Calcium oxalate	9
Calcium phosphate	2
Calcium phosphate + MAP	1
Brushite	1
Cystine	2
Uric acid	1
Unknown	8

PCNL, Percutaneous nephrolithotomy; SFR, Stone-free rate; MAP, magnesium ammonium phosphate; XR, X-ray; US, Ultrasound; NCCT, Non-contrast computed tomography.
[a]URS performed but no stone found at time of surgery.

Discussion

In this retrospective series of paediatric URS for stone disease, 61% of patients achieved SFS after a single URS procedure. Among this sample, no patients had undergone elective and planned stenting prior to URS and definitive stone clearance. Those patients who did not achieve SFS after a single URS procedure all had renal stones

Table 3. Summary of complications.

Intra-operative complications	**0**
Post-operative complications[a]	7/40 (17.5%)
Post-operative complications[a]:	
UTI	5/40 (12.5%) (CD II)
Stent migration requiring nephrostomy	1/40 (2.5%) (CD III)
Pyonephrosis requiring nephrostomy	1/40 (2.5%) (CD III)

CD, Clavien–Dindo.
[a]Complications at the time of URS and definitive stone treatment. Check URS, negative URS cases or initial failed access have not been included.

with either a single stone burden > 2 cm or multiple stones with a cumulative burden > 1.5 cm and lower pole location. After additional URS procedures were performed, 90% were rendered stone-free.

Outcomes reported for URS in this setting vary widely.[4] This includes SFRs as high as 100% and complication rates of 0–28%.[4] There are several possible reasons, and consideration of these helps put into context the results reported in our study. Elective pre-operative stenting in the paediatric setting is associated with lower complication rates and significantly higher success rates at time of URS.[23] However, it is associated with disadvantages, such as need for an additional surgical procedure, which carries potential risk of complication(s) and requirement for GA. In some published series, elective pre-operative stenting is performed in 100% of cases.[24] A problem when comparing results with such studies is that often this prior stenting procedure is not included in total number of procedures reported and part of the overall complication rate. In our series, the success rate for first time access to the upper urinary tract was 94%, which includes five patients who required balloon dilatation. In studies where elective pre-operative stenting is routinely performed, initial SFR will be typically higher. In our study, for example, if the failed cases are excluded, the initial SFR would immediately improve from 61–66%. Higher initial SFRs are typically reported in studies where stones > 2 cm have been excluded.[25] The largest stone size in our sample was 4 cm.

While the problems regarding the lack of universal SFR definition have been raised in the adult setting, this issue has received less attention in the paediatric setting.[26,27] An advantage, at least in the adult setting, is the routine use of NCCT. This allows for more accurate assessment of the stone burden both pre-operatively and at follow-up. However, this is more problematic in the paediatric setting, given exposure to ionising radiation.[13] It seems fair to comment, therefore, that true SFR is less accurate in paediatric studies than if NCCT had been used throughout. Robertson *et al.*[28] performed a comparative study analysing results of paediatric patients who had undergone both CT and US for KSD. Their results showed that US had high specificity (97.4%) but only moderate sensitivity (66.7%) for detecting KSD. SFR definitions used in recent studies include (not limited to) no residual fragments < 2, < 3 and < 4 mm.[25,29,30] Moreover, some studies provide no clear definition.[31,32] Future recommendations from guideline and society groups would help standardise outcome reporting to facilitate comparison of results across different studies.

The overall complication rate in this study was 15%. Our sample included a large proportion with large stone burdens, lower pole stones, concurrent anatomical abnormalities, and complex medical backgrounds. It is interesting that in our study, the ratio of females to males was nearly three to one. This supports epidemiological data, which has highlighted the rising incidence of female KSD in this patient group.[3,4] A recent study from National Surgical Quality Improvement Program Pediatric in Canada found that paediatric females are twice as likely to have an unplanned re-admission after URS.[33] Use of UAS is attracting increased attention in the paediatric population.[34] A recent global study revealed that this ancillary device was used routinely in over 50% of cases.[35] However, given the lack of long-term data and potential risks for ureteric injury, it is not part of our routine practice.[4,36] It is possible, however, that use of UAS could have served to reduce risk of infectious complications given this accessory can reduce intra-renal pressure.

Our study includes treatment of stone burdens up to 4 cm. Patients undergoing URS for large stone burdens (>2 cm) all had more than one complex medical comorbidity. Shared decision was made in each case with the patient family to proceed to URS to reduce the risk profile.

PCNL for larger stone burdens offers advantages regarding achieving SFS in fewer operative sessions.[4] However, the complication profile and length and amount of radiation exposure are worse in comparison with URS although it can be performed under US guidance.[13] Miniaturisation of PCNL has been developed as a method, which may overcome this.[37,38] A recent comparative study comparing URS with mini PCNL reported similar efficacy and rates of adverse events across both treatment methods.[39] As the authors in that study concluded, both techniques should be considered as feasible options when performed in a setting where that centre has built up their experience with that that particular method. Our unit is a tertiary referral centre for adult URS and this lends itself to transferring this expertise to the paediatric setting.[40] Scrutiny of published series reveals that the majority arise from a small pool of nations with common characteristics. Either stone disease is endemic in that country (e.g. Turkey) or it is non-endemic, but the population is large, for example, the United States.[8,9,17–20,23] Furthermore, the procedures in these reports are usually, but not always, performed by paediatric endourologists. Figures 1 and 2 display number of publications (as per PubMed) of original series between 2000 and 2020. This reveals that in the second time period, there are an increasing number of countries reporting their experiences. However, there are still many parts of the world, such as Scandinavia and South America, which lack reports. Our results can therefore represent a valuable addition to the body of literature available and highlight that paediatric URS is safe and feasible even when performed in a country with small population (5.5 million) and where no defined paediatric endourology service exists. This builds on a recent meta-analysis by Rob *et al.*,[25] which found no differences in SFR or complication rates between medium- and high-volume centres. Sforza *et al.*[41] evaluated outcomes when paediatric URS was performed by an experienced adult endourologist. The results showed comparable results with a low complication rate.

The results in this series are gathered from surgeries performed by different surgeons including residents and are therefore not limited by being a single surgeon series. Mean hospital stay in our study was 2 days. It is likely that in countries such as ours where patients travel large distances and often lack urology service covering paediatric care in their home region, this parameter is longer due to the additional caution that is therefore required. The rate of post-operative stenting was relatively high in this study. There is increasing evidence supporting the use of stent on strings, which offers the advantage of removal under local anaesthesia.[42]

Limitations

This study does have several limitations including the single-centre setting, retrospective nature and inclusion of patients from infants to adolescents. TFL was introduced to HUH during the course of 2020. The number of cases performed since then are so few that analysis to measure any treatment effect is not feasible. Recent randomised trial comparing TFL and Ho: YAG in adult setting, found that the former delivers a significantly higher initial SFR and lower operative times.[43] This laser platform may be favourable in paediatric setting, therefore, particularly in regard to achieving SFS within a single operative session and in cases of larger stone burdens. As is the reality in reporting of paediatric URS, a combination of imaging modalities was employed to assess SFR and the majority underwent US. If all patients had undergone NCCT to assess SFR, the result would likely have been lower.

Conclusion

This study performed in a country which is non-endemic for KSD and with a small population, shows that comparable outcomes for paediatric URS are achievable. Further consensus and recommendations are required to standardise reporting of paediatric URS.

Declarations

Ethics approval and consent to participate

The study was formally registered as a clinical audit at Haukeland University Hospital, Bergen, Norway (ID 3038-3038), and therefore neither ethical approval nor patient consent was required.

Consent for publication

Not Applicable.

Author contributions

Patrick Juliebø-Jones: Conceptualization; Data curation; Investigation; Methodology; Project administration; Writing – original draft; Writing – review & editing.

Mathias Sørstrand Æsøy: Conceptualization; Formal analysis; Methodology; Visualization; Writing – review & editing.

Peder Gjengstø: Conceptualization; Data curation; Methodology; Resources; Visualization; Writing – review & editing.

Christian Beisland: Conceptualization; Methodology; Project administration; Supervision; Visualization; Writing – original draft; Writing – review & editing.

Øyvind Ulvik: Conceptualization; Methodology; Project administration; Supervision; Visualization; Writing – original draft; Writing – review & editing.

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Availability of data and materials
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