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ORIGINAL PAPER

Comparison of a 4.5 F semi-rigid ureteroscope with a 7.5 F rigid ureteroscope in the treatment of ureteral stones in preschool-age children

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Abstract The aim of this study was to compare the success and complication rates of a 4.5 F ureteroscope with a 7.5 F ureteroscope in the treatment of urolithiasis in preschool-age children. We retrospectively reviewed 69 ureteroscopy (URS) procedures in a pediatric population (40 boys, 29 girls). We divided the patients into two groups according to the type of ureteroscope used: group 1 ($n = 42$, Storz 7.5 F) and group 2 ($n = 27$, Wolf 4.5 F). We statistically compared all the procedures performed in both groups regarding patient age, complication rates, whether the procedure was therapeutic, and whether we used a guidewire. Additionally, in cases with ureteral stones, we also compared the stone clearance rate and the necessity of X-ray imaging between the two groups. The mean patient age was 56.04 months in group 1 and 47.48 months in group 2 ($p = 0.057$). The stone-free rate was 78.6 % in group 1 and 92.6 % in group 2 ($p > 0.05$). However, when we compared the stone-free rates for patients younger than 3 years, the rate was 66.7 % in group 1 and 93.8 % in group 2 ($p < 0.05$). The difference was not statistically significant for patients between the ages of 4 and 7 years. The success and failure rates revealed better outcomes for treatment of ureteral stones with a 4.5 F ureteroscope. We recommend the use of the mini-ureteroscope, especially in infants and preschool-age children.

Keywords Ureteroscopy · Children · Ureterolithiasis

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Introduction

Urolithiasis is a serious and general problem in the world. The prevalence of this disease increased especially in the fourth quarter of the twentieth century for both adults and pediatric population worldwide [1].

Akinci et al. [2] reported that the prevalence of urolithiasis is 14.8 % in Turkey and that the disease is endemic in this region. In southeastern Anatolia of Turkey, the prevalence of the disease is highest [3]. Similarly, the prevalence of urolithiasis is higher in childhood like as in adults in the regions discussed above [4].

Endoscopic lithotripsy for the treatment of urinary stone in children is a major technique, because of the development of small-diameter endoscopes, improvement of the lithotripsy techniques, and age and size-adapted equipment. Although URS is performed frequently in children due to urolithiasis, there is lack of published data focused on URS in young children [5]. In fact, the URS procedure that is performed in children is not as well standardized as in the adult population. However, there are still many controversies on the use of adult rigid ureteroscopes, because it can lead to potential complications such as ureteral trauma, ischemia, formation of stenosis, and development of vesicoureteral reflux as a result of dilatation of narrow ureteral orifices [6, 7]. Also, younger children had a higher rate of repeated URS. Therefore, small calibers of semi-rigid or flexible ureteroscopes have also been recommended by some authors for pediatric URS [6, 8].

In spite of everything, URS in the pediatric age group requires greater technical skill and a higher level of endosurgical expertise [9].

In our literature review, we have not found studies that compared pediatric URS in the preschool-age children. Due to the controversy on pediatric URS procedures in the literature, we aimed to assess and compare the safety and efficacy of 7.5 F rigid and 4.5 F semi-rigid ureteroscopes for the use of ureter calculi in preschool-age pediatric population.

Materials and patients

The study was performed under the ethical principles of the Declaration of Helsinki and approved by the local ethical committee of our institution. Informed consent was obtained from all patients' parents due to the risk involved in the operation.

A total of 69 patients, 40 boys (10 months–6 years) and 29 girls (11 months–6 years), who were scheduled for ureteroscopic treatment of ureteral calculi were included in the study. The subjects were divided into two groups according to the type of ureteroscope used: Group 1 ($n = 42$, Storz 7.5 F, between January 2007 and January 2010) and group 2 ($n = 27$, Ultra Thin Uretero-Renoscope 4.5 Fr, Richard Wolf GmBH, Knittlingen, Germany, between January 2010 and January 2012).

The patients who had postural orthopedic disease, coagulation disorders, active urinary tract infection, ipsilateral ureteral stricture, previous ureteral reimplantation surgery, and previous ureteral stent placement were excluded. All the procedures were performed by one of three different urologists who were interested in pediatric endo-urology.

4.5 F Wolf ureteroscopy 3 F

The 4.5 F scope had a 6° lens with a movable offset eyepiece and a 3.3 F central channel. A 150-μ laser probe and 3 F helical basket catheter were used with this scope. The 4.5 F tip diameter increased gradually to 6.5 F toward the eyepiece. We named this instrument as "Mini-URS'' [10]. In our literature review, it is the smallest semi-rigid ureteroscopy instrument.

7.5 F Storz ureteroscopy

The 7.5 F scope had a 12° lens with an angled offset eyepiece and a 5.5 F central channel. The 7.5 F tip diameter increased gradually to 11 F toward the eyepiece. A 273-μ laser probe and 5 F, 0 tip, 4-wire flat or 5-wire helical basket were used with the 5 F instrument.

The distal endings of both ureteroscopes that are used in the study are shown in Fig. 1.

All URS interventions that were performed to patients were compared in terms of patients' age and gender, lateralization of the procedure, stone size, stone numbers, and the presence of preoperative hydronephrosis for both groups.

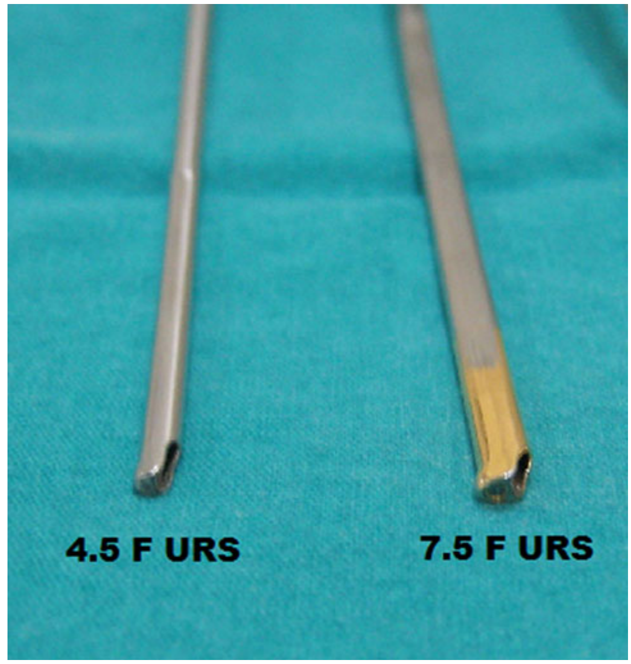

Fig. 1 Distal endings of both ureteroscopes

Also, patients who had ureteral calculi were assessed for the location of calculi, and the necessity of a stone extractor was compared. Group 1 (7.5 F, *n* 42) and group 2 (4.5 F, *n* 27) were compared with each other in terms of operative time, use of basket, postoperative stent placement, passive dilatation, success rates, re-URS rates, and complication rates. The complication and stone-free rates were also evaluated both intraoperatively and postoperatively.

All patients were evaluated by urine analysis and urine culture when needed. Patients who have positive urine cultures were treated with appropriate antibiotics before surgery. All the children were administered with a third-generation cephalosporin for prophylaxis prior to the procedures.

The surgical technique for URS in children was similar to that in adults [11]. All ureteroscopic procedures were performed under general anesthesia. The children were placed in the lithotomy position on an endoscopy table allowing the use of fluoroscopy when necessary. Ureteral access sheaths were not used in any of the cases. To minimize heat loss during the operation, the irrigation solution was warmed to body temperature. After passing the ureteroscope from the urethra and locating the ureteral orifice, the ureteroscope was introduced into the ureteral orifice with the guidance of a 0.035/0.038-in. standard soft guidewire or a 3 F ureteral catheter under hydrodilation. Patients who had urinary calculi on the other side of the urinary system were excluded from the study. In cases with ureteral calculi, the stones were fragmented with holmium:YAG laser (StoneLight, Minnetonka, MN, ABD). A probe of 150 or 273 μm was selected according to the stone size. Fragments were extracted using a stone basket or grasper. The decision to place a ureteric stent postoperatively was based on the duration of the procedure, stone burden, and degree of ureteral trauma. Stone fragments were left either for spontaneous passage (break'n'leave) or removed with grasping instruments depending on the size of the fragments. A temporary 3 F or 4 F ureteral catheter or 4.8 F or 3.3 F 12- to 16-cm double-J stent was placed postoperatively when necessary to avoid ureteral damage. The decision for stenting was made based on the duration of the procedure and the degree of visible ureteral trauma or edema at the end of the procedure. In children in whom URS was not possible due to inability to introduce the ureteroscope, it was performed 3 weeks later (re-URS).

The success of treatment was defined as stone-free status after a single intervention without auxiliary procedures. The overall stone-free rate was defined as stone-free status with or without auxiliary procedures in 1 month. Stone-free status was determined by direct visualization of the involved ureter following lithotripsy or by follow-up imaging, including ultrasound and plain radiography. Patients with nonopaque stones were evaluated with ultrasonography or computed tomography at the same intervals. Most extracted calculi were sent for analysis and additional medical therapy was provided if necessary. Children were not routinely evaluated for postoperative reflux unless they had a symptomatic urinary tract infection.

Statistical analysis results were analyzed with Chi-square and Mann–Whitney *U* test (SPSS 15.0 software), and *p* value less than 0.05 was considered to be statistically significant.

All the parameters were statistically compared between the groups using one-way ANOVA, independent t and Chi-square tests (NCSS 2007). The values were provided as mean ± standard deviation of the mean (SD). A *p* value of ≤0.05 was considered as significant.

Results

A total of 69 patients, 40 boys and 29 girls, were included in the study. The number of patients in group 1 was 42, while in group 2 it was 27. The mean patient age in groups 1 and 2 was 56.04 months (14 months–7 years) and 47.48 months (10 months–7 years), respectively ($p = 0.057$). The localization of stones in group 1 was 27 on the right and 15 on the left ureter, while 17 were in the right ureter and 10 in the left ureter in group 2 ($p = 0.91$). In group 1, 33 stones were located in the distal ureter, 5 in the mid ureter and 4 in the proximal ureter, whereas in group 2, 21 were distal, 4 middle and 2 proximal. The size of calculi and the duration of operation times were similar for both groups (7.18/7.23 mm). The demographic data of both groups are summarized in Table 1.

Table 1 The demographic and preoperative data of patients

	7.5 F URS *N* = 42	Mini-URS *N* = 27	*p* value*
Patient's age (month)	56.04 ± 23.50	47.48 ± 26.69	0.057
Stone size (mm)	7.18 ± 1.64	7.23 ± 2.05	0.75
Male/female	24/18	16/11	0.862
Stone number (single/multiple)	37/5	24/3	0.92
Lateralization (right/left)	27/15	17/10	0.911
Stone localization			
Lower ureter	33	21	0.908
Mid-ureter	5	4	
Upper ureter	4	2	
Preop hydronephrosis	35/42	22/27	0.843
History of stone disease	11	4	0.264

* $p > 0.05$ NM

Table 2 Stone-free rates according to age groups

Age (years)	7.5 F URS *N*/total (%)	Mini- URS *N*/total (%)	*p* value
0–3	12/18 (66.7)	15/16 (93.8)	**0.050**
4–7	21/24 (87.5)	10/11 (90.9)	0.769
Overall stone-free rate	33/42 (78.6)	25/27 (92.6)	0.120

The respective rates of stone-free status (success) were 78.6 % in group 1 and 92.6 %, in group 2. There was no statistical difference between the two groups overall in terms of stone-free rates. However, when the stone-free rates were compared for ages under 3 years, the rate was 66.7 % in group 1 and 93.8 % in group 2 and the difference was statistically different ($p = 0.05$). But, the stone-free rates between the age of 4 and 7 years were 87.5 % and 90.9 %, and there was no statistical difference between the two groups ($p = 0.76$). The stone-free rates according to age groups for both groups are shown in Table 2.

Ureteroscopic access was successfully achieved for 35 URS procedures in group 1. Passive dilatation was performed in seven patients in whom ureteral access was not achieved. A ureteral stent was placed and re-URS successfully performed 3 weeks after the placement of a ureteral DJ stent. Ureteroscopic access was achieved in all the patients (27 procedures) in Group 2 ($p = 0.025$). The URS procedure was ended for ten patients in goup 1 and three patients in group 2 due to complications such as bleeding, false route and ureteral perforation. Re-URS was performed in those patients 3 weeks after the first intervention. In

Table 3 The operative data of patients according to groups

	7.5 F URS $N = 42$	Mini-URS $N = 27$	p value
Hydrodilatation (n)	32	20	0.542
Passive dilatation (n)	7	0	**0.025**
Lithotripsy usage (n)	33	22	0.769
Basket usage (n)	14	10	0.753
X-ray requirement (n)	20	4	**0.005**
Postop stent placement			
DJ stent	12	5	0.753
Ureteral catheter	19	13	
Operative time (min)	53	46.5	0.653
Engagement time (s)	Unknown	50	–
Duration of hospital stay (days)	2.6	2.2	0.542
Guidewire used (n)	40	21	**0.027**

The bold values are stastically significant

Table 4 The intraoperative and postoperative complications of URS procedures for both groups

	7.5 F URS $N = 42$	Mini-URS $N = 27$	p value
Intraoperative complication			**0.018**
Mild hematuria	5	2	
Stone migration	5	1	
Inability reach stone	5	–	
Ureteral laceration	5	3	
Ureteral perforation	3	1	
Urinoma[a]	–	1	
Postoperative complication			**0.023**
Urethral pain	5	2	
Renal colic	3	2	
Mild hematuria	5	3	
Febrile UTI	6	3	
Urinary retention	5	2	
Re-URS	10	3	
Major complications			
Ureteral avulsion	–	–	
Conversion to open surgery	–	–	

The bold values are stastically significant

[a] Placement of percutaneous nephrostomy tube + Re-URS

cases of patients in whom a catheter was used for ureteric access, the ureteroscope was advanced via the 0.035/0.038-in. soft guidewire, which was maintained as a safety wire throughout the procedure and exchanged for a stiffer one (4 F or 3 F ureteral catheter) if necessary. There was statistically significant difference in terms of the rates of using a catheter between both groups ($p = 0.027$). Stone migration to the kidney was seen in five cases (11.9 %) in group 1 and two cases (7.4 %) in group 2. SWL was performed successfully in those patients. Fluoroscopy was required in 20 patients in group 1 and 4 patients in group 2. The difference was statistically significant for both groups ($p < 0.005$). A temporary ureteral catheter or DJ stent was placed in 71 % of all cases. Although most of the catheters were removed the following day, the duration was prolonged in only three patients in the rigid-URS group: two patients who had mucosal laceration and a patient who had minor hematuria during the procedure. The preoperative and postoperative complication rates seem to be higher in group 1 compared with group 2. These rates were statistically significant, $p = 0.018$ and $p = 0.023$, respectively. No other major complication occured during the URS procedures, including ureteral perforation, ureteral avulsion, or gross hematuria. Table 3 shows the operative data and outcomes of URS procedure for both groups.

A slight ureteral laceration occurred in five patients for group 1 and three patients in group 2. A temporary ureteral catheter was placed in those patients and removed 72 hours postoperatively. Ureteral perforation was detected in three patients in group 1 and in a patient in group 2. These patients were also successfully managed with a DJ stent. In one patient, retroperitoneal urinoma was detected and percutaneous nephrostomy tube was placed in this patient. At the follow-up of this patient in the third month after operation, the drainage of the kidney was perfect via IVU and the nephrostomy tube was removed. There was urinary retention in five patients in group 1 and in two patients in group 2; the retention resolved spontaneously. Table 4 shows the intraoperative and postoperative complications of URS procedures for both groups.

Discussion

According to the data in literature, the caliber of the ureteroscope does not have any impact on the success rate of endoscopic treatment of ureteral stone disease in adults and adolescents [12, 13]. However, this issue is not as clear in children who have ureteral stone disease.

When performing a URS procedure in a child, the drawbacks faced by the urologist are: complications such as those seen in adult patients as well as compromising factors in children such as narrow ureter, mobility of ureter, and the relatively large size of equipment [14, 15]. Also, the URS procedure for children poses specific technical challenges which require planning before endoscopy and that may affect the risks and outcomes of surgery, such as a large psoas muscle, the possibility of the presence of an ectopic ureter or ureterocele, and familiarity with different types of ureteral reimplantation [9]. Because of these reasons, endo-urologic procedures for children need excellent expertise of the procedure. According to us, when performing ureteroscopy to children the diameter of urethra must be concluded such as ureter diameter, especially in boys.

Although ureteroscopy has become a widely accepted modality, its use in children has been limited because of the risk of trauma to the urethra, ureterovesical junction and lower ureter [16]. In fact, there have been a number of studies on URS in children, but most of them focused on older adolescents, and only a few series have reported outcomes of ureteroscopies in prepubertal children [9]. There is yet no clear data on the optimal diameter and rigidity of the instrument and the technique used for the pediatric population.

There are a few studies that compare the effect of ureteroscopy caliber on the success rates of URS in pediatric patients. Tanriverdi et al. [6] reported a series of pediatric patients who underwent URS procedure with a ureteroscope of 8 F or 6.9 F and reported that there was no effect of ureteroscope diameter on URS success rate. In another series, Yucel et al. [17] reported that there were more complications and low achieving rates when a ureteroscope of 7.5 F in diameter was used in patients who were under the age of 1 year. A review of the literature showed that the stone-free rate of pediatric patients treated with URS lithotripsy was between 77 and 100 % [5, 8, 9]. In the present study, the overall success rates of URS were similar to those in the literature for both groups (78.6, 92.6 %). However, the success rate of URS with mini-URS was much higher under the age of 4 years (93.5 %).

Fluoroscopy is often used during a URS procedure for retrograde pyelography, placement of the guidewire, dilation of ureterovesical junction, and sometimes for the placement of double-J stents. However, the addition of ionizing radiations at each step of the procedure brings in its own risks to the patient and health-care providers [18]. Jamal et al. [19] reported that the dosage of perioperative radiation exposure for the patient during endoscopic stone treatment was 27.6 mGy. Although the dosage of the radiation exposure was not measured objectively in our study, the rate of use of X-ray was significantly higher in group 1 compared with group 2.

The diameter of the normal ureter in the pediatric age group patient is less than 3 mm [20]. So, the instruments which have a diameter of 5 mm or less should pass through the ureteral orifice without any need of dilatation. In the literature, some technical skills for passing through the orifice are determined, such as hydrodistension, self-dilatation, balloon dilatation, and passive dilatation [9, 21–23]. However, it is shown that these interventions may result in ureteral ischemia, the rise of cost, longer operative duration, and vesicoureteral reflux [24]. In a series reported by Bassiri et al. [25], it was shown that the rate of ureteral dilatation significantly decreased by using ureteroscope of smaller size. In another series, the authors reported that passive dilatation of the orifice via ureteral stent also revealed dilatation of the other narrow locations of the ureter, such as physiological ureteral narrowing at the levels of iliac vessels and ureteropelvic junction, and enabled complete evaluation of the entire ureter [21]. In the present study, a 4.5 F ureteroscope is used for the URS procedure. In all of the cases, there was no requirement for ureteral dilatation. In these patients, there was no reflux due to operative procedure, because there was no need of dilatation of the orifice or any trauma to the ureter. For patients who were included in the study, we did not scan for reflux after operation routinely, because there were no recurrent urinary infections in any of the patients. Further studies should be performed to state something clearly for this argument. For the patients in group 1, due to possible complications, such as ureteral stricture and/or postoperative vesicoureteral reflux [9, 22], active ureteral dilatation was not performed in any of the patients. Instead of dilatation, passive dilatation was preferred with preoperative ureteral stent placement for initially inaccessible ureters for the seven patients in Group 1.

Additionally, it is reported that operative time, patient age, institutional experience, orifice dilation, stenting, and stone burden are important risk factors for complications during URS procedure [26]. The success rate of URS is associated with the patients' age, which may be due to the small diameter of urethra or ureter in pediatric patients. For revealing this problem, the usage of URS that has a smaller diameter should be preferred. In our study published recently, we showed that mini-URS is a safe and effective instrument in patients with ureteral calculi under the age of 3 years [10].

During the URS procedure, another technical consideration is the requirement of stent placement [4]. Children cannot tolerate cystoscopy or removal of stent, so the removal of ureteral stents needs additional intervention under general anesthesia. However, it is advised to install ureteral catheter in patients who have complications during the URS procedure, such as ureteral perforation, urine extravasation, hematuria, or damage to the mucosa to prevent side effects of complications [27]. The patient population of this study was too young to tell about their complaints including pain and renal colic. So, to avoid these complaints due to orificial edema, a temporary ureteral catheter was applied to 46.37 % of all patients. Additionally, ureteral DJ stent was installed in six patients who had complications such as ureteral perforation or trauma, stone migration, and hematuria. These stents were removed under general anesthesia after 3 weeks of operation.

Conclusions

On comparing 4.5 F URS with 7.5 F URS, 4.5 F URS has more statistically significant advantages in terms of stone-free rate, low complications, and requirement of fluoroscopy. Mini-URS is an ideal instrument for pediatric patients because of compatibility with the physiological ureteral diameter. Because of these advantages of thinner instrument, it is strongly recommended that urologists use this sophisticated present of technology to us.

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