Original Article – Pediatric Urology

Effect and Results of Retrograde Intrarenal Surgery in Pediatric Patients According to Stone Size and Location

Çocuk Hastalarda Böbrek Taşı Boyutu ve Yerleşimine Göre Retrograd İntrarenal Cerrahinin Etkisi ve Sonuçları

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Abstract

Objective: We aimed to evaluate the effects and results of RIRS according to the location and size of kidney stones in the pediatric population.

Materials and Methods: A total of 32 pediatric patients with upper urinary tract stones with 40 renal units were investigated in terms of stone size and location. Stone location, gender, stone size, stone Hounsfield unit, preoperative stenting, access sheath size, complication, length of hospital stay, and stone-free rates were retrospectively analyzed . Patients were divided into two groups. The first group patients who had stones smaller than 2cm, and the second group who had stones larger than 2 cm.

Results: The mean age of the patients in Group 1 was determined as 10,8 (4-17) years, and the mean age of Group 2 was determined as 15,1 (10-17) years. The age difference was statistically significant (p: 0,003). There was no statistically significant difference in gender distribution (p: 0,289). The average stone size of Group 1 was measured as 12,6 mm (11-17), and the Group 2 stone size was measured as 25,2 mm (20-43) on average. In terms of operation times, the average operation time in Group 1 was 48 (30-70) minutes, and the average operation time in Group 2 was 65 (40-95) minutes, and a statistically significant difference was observed (p: 0.015). In the first group, the stone-free rate in a single session was 76.3%, and in the second group, the stone-free rate in a single session was 62%. There was no statistically significant difference between the groups in terms of stone-free rates (p: 0,295).

Conclusion: RIRS is a method that can be used safely and effectively in pediatric patients with kidney stones smaller than 2 cm, with high stone-free rates. Although; the stone-free rate was lower in stones larger than 2 cm compared to those smaller than 2 cm, this difference was not statistically significant.

Keywords: upper urinary system stones, pediatric urolithiasis, retrograde intrarenal surgery, stone free rate

Özet

Amaç: Bu çalışmada, pediatrik popülasyonda böbrek taşı lokalizasyonu ve boyutuna göre RIRC etkilerini ve sonuçlarını değerlendirmeyi amaçladık.

Gereçler ve Yöntemler: Üst üriner sistem taşına sahip toplam 32 pediatrik hasta ve 40 renal ünite, taş boyutu ve lokalizasyonu açısından incelendi. Taş lokalizasyonu, cinsiyet, taş boyutu, taşın Hounsfield ünitesi, preoperatif stentleme, erişim kılıfı boyutu, komplikasyonlar, hastanede kalış süresi ve taştan tamamen kurtulma oranları retrospektif olarak analiz edildi. Hastalar taş boyutuna göre iki gruba ayrıldı. Birinci grup, 2 cm'den küçük taşlara sahip hastaları; ikinci grup ise 2 cm'den büyük taşlara sahip hastaları içermektedir.

Bulgular: Renal ünite bazında değerlendirildiğinde, Grup 1 hastalarının ortalama yaşı 10,8 (4-17) yıl, Grup 2 hastalarının ortalama yaşı ise 15,1 (10-17) yıl olarak belirlendi. Yaş farkı istatistiksel olarak anlamlıydı (p: 0,003). Cinsiyet dağılımında istatistiksel olarak anlamlı bir fark saptanmadı (p: 0,289). Grup 1'in ortalama taş boyutu 12,6 mm (11-17), Grup 2'nin taş boyutu ise ortalama 25,2 mm (20-43) olarak ölçüldü. Operasyon süresi açısından, Grup 1'in ortalama ameliyat süresi 48 (30-70) dakika, Grup 2'nin ise 65 (40-95) dakika olup, istatistiksel olarak anlamlı bir fark bulundu (p: 0,015). İlk grupta tek seansta taşsızlık oranı %76,3, ikinci grupta ise %62 olarak belirlendi. Taşsızlık oranları açısından gruplar arasında istatistiksel olarak anlamlı bir fark yoktu (p: 0,295).

Sonuç: RIRS, 2 cm'den küçük böbrek taşlarına sahip pediatrik hastalarda yüksek taşsızlık oranları ile güvenli ve etkili bir yöntem olarak kullanılabilir. 2 cm den büyük taşlardan taşsızlık oranları 2 cm den küçük taşlara kıyasla düşük olsa da verilerimizde istatistiksel anlamlı olarak saptanmamıştır.

Anahtar kelimeler: üst üriner sistem taşları, pediatrik ürolitiazis, retrograd intrarenal cerrahi, taşsızlık oranı

Introduction

Childhood (<18 years) urinary system stones are seen with a frequency of 1%-2% in the society. In recent years, the incidence of pediatric stones has increased especially in adolescence due to carbonhydrate-rich diet, high salt consumption and sedentary lifestyle. In younger children, kidney stones are less common and are more likely to occur due to metabolic and anatomical reasons and can recur more frequently and earlier [1]. Today, with technological advances, the miniaturization of endoscopic instruments and the development of non-invasive methods, high success can be achieved in pediatric stone surgery, especially in difficult cases [2]. In pediatric patients with stone size larger than 5 mm have a lower probability of spontaneous passage and need treatment [3]. Among these treatments, extracorporeal shock wave lithotripsy (ESWL) is a non-invasive treatment that has been used safely and successfully in adults for a long time and it is known that children respond better to ESWL treatment than adults [4,5]. In addition, with the development of technology and the increased access to miniature instruments, methods such as retrograde intrarenal surgery (RIRS), ureterorenoscopy

(URS), and percutaneous nephrolithotomy (PNL) can be applied in pediatric patients successfully. In these operations, in addition to surgical instruments, factors such as the location of the stone, its size and the Hounsfield unit (HU) may also affect stone-free rates. Although ESWL is considered the first choice for treatment of stones up to 20 mm, the fact that the procedure is performed under general anesthesia and requires multiple sessions may limit the use of ESWL in children due to low success in metabolic stones (cystine) [6,7]. On the other hand, there are studies about the safe use of RIRS even in infant patients <1 year old [7].

Although mini PNL seems to be more successful than retrograde intrarenal surgery in terms of stone-free rates in stones between 10 mm and 20 mm and larger than 20 mm, RIRS can be recommended as an alternative for stones larger than 20 mm [8]. With technological advances, thin instruments, image quality and the development of instruments with increased deflection ability, the preference for retrograde intrarenal surgery for most stones in all localization of the kidneys is increasing. In this study we aimed to examine the effects and results of retrograde intrarenal surgery according to the location and size of kidney stones in pediatric population.

Material and Methods

After obtaining ethical approval from the Clinical Research Ethics Committee (Date: 09.04.2025 No: 2025/380), between 2018 and 2024 totally 32 patients under the age of 18 years and 40 renal units who underwent retrograde intrarenal surgery were included in the study. Patients were divided into 2 groups according to stone size. There were 25 renal units with a size of less than 20 mm in the first group and there were 15 renal units with a size of more than 20 mm in the second group.

In addition, demographic data of the patients, stone localization, age, gender characteristics, HU of the stones, preoperative ureteric double J (JJ) stenting, use of access sheath, and stone-free rates were retrospectively analyzed.

Before the operation, computed tomography and ultrasonographic images of the patients were examined. The patients' operation information was examined from the hospital database and records were obtained. After the operation, the patients' follow-up ultrasonography and direct urinary system radiographs were investigated.

Operations were performed using 4.5/6.5 Fr ultrathin semi-rigid ureterorenoscope (Richard Wolf, Germany) and fiberoptic reusable flexible ureteroscope (Karl Storz Flex-X2, Germany). Stones were broken with 30W holmium- YAG laser (Litho, Quanta, Milano, Italy), 9.5/11.5 Fr access sheath (Plastimed, Istanbul, Turkey) was used. JJ stents (Plastimed, Istanbul, Turkey) appropriate to the age and height of the patients were used.

All data were calculated using IBM SPSS Version 23.0 statistical package program (IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp). Continuous variables were found as mean ± standard deviation (median, minimum, maximum) values and categorical variables were found as numbers and percentages. Mann-Whitney U test was used to compare continuous variables between two groups, and Chi-square test and Fisher's exact chi-square test were used to compare categorical variables. Statistical significance level was accepted as "$p<0.05$".

Results

According to the stone size, the patients were divided into 2 groups, the mean age of the first group was 10.8 (4-17) years, and the second group was 15.1 (10-17) years, and the age difference was statistically significant (p: 0.003). No statistically significant difference was found in terms of gender distribution of the patients (p: 0,289). According to the renal unit, the number of patients with stones smaller than 20 mm was 25, and the number of patients with stones larger than 20 mm was 15. [**Table 1**]

While lower calyceal stones were most frequently seen in group 1 (40%), renal pelvis stones were most frequently seen in group 2 (40%). There was no statistically significant difference in terms of stone location in both groups. (p: 0.294) [**Table 2**]

Preoperative JJ stents were placed for passive dilatation in 17 renal units (68%) in the first group and in 8 renal units (53.3%) in the second group. RIRS procedures of these patients were planned to later sessions. No statistically significant difference was observed between the two groups in terms of stent placement (pre-stenting) for passive dilatation of the ureter before the procedur (p: 0,315). During RIRS, access sheaths were used during surgery in 18 renal units (72%) in the first group and in 13 renal units (86.6%) in the second group. No statistically significant difference was observed between the groups in terms of access sheath use (p: 0,122). According to the size of the stone, the stone-free rate in a single session was detect as 76.3% in the first group and 62% in the second group and no statistically significant difference was observed (p: 0,295). The average HU of the stones were measured as 844.9 (min: 233-max: 2100) in the first group; and the average HU was 795 (min: 210-max: 2015) in the second group, and no statistically significant difference was observed between the stone-free rates in terms of HU between the two groups. (p: 0,340) [**Table 3**]

Discussion

Over the years, the development of flexible ureteroscopes (f-URS) and fiberoptic systems, and the simultaneous use of the laser technologies have enabled the successful retrograde fragmentation of kidney stones. It was first described by Huffman et al. in 1983 with the fragmentation of kidney stones using a rigid rod-lens structured ureteroscope and an ultrasonic lithotripter, and in 1990 Fuchs et al. published the first series of RIRS using f-URS [9,10]. ESWL, RIRS and PNL are recommended in the treatment of urinary system stone diseases in children

As a minimally invasive technique, ESWL was initially used in adults, but it was not initially applied to pediatric patients because it was thought to have a negative effect on child development. ESWL can be performed with high stone-free success rates, especially for stones smaller than 10 mm, depending on the type, size, location and urinary system structure of the stone [11]. ESWL is recommended as the primary treatment method for lower pole stones smaller than 10 mm and other upper system stones smaller than 2 cm in children [12]. However, although ESWL provides success up to 75-92% in pediatric patients, studies have shown that stone-free rates after ESWL for stones <10 mm are 100%, while this rate decreases to 66.6% for stones larger than 20 mm [13]. There are also studies suggesting that there may be negative effects on kidney development after ESWL in pediatric patients [14].

Although the length of hospital stay and complication rates are lower after ESWL, the possibility of additional interventions is higher after ESWL. In a recent prospective study by Mokhles et al., the results of ESWL and RIRS treatments for 10-20 mm stones in preschool children were compared and the overall stone-free rates were found to be 93% and 96% respectively [6]. According to this result, ESWL is recommended for stones up to 20 mm. The fact that the procedure requires general anesthesia in repeated sessions in children, is associated with renal scarring, hypercalciuria, hypertension and chronic renal failure in the long term, and stones such as cystine stones do not respond adequately to treatment limits the use of this technique in children [6,15]. In addition, while patients who underwent ESWL required multiple sessions, very few patients who underwent RIRS required additional interventions later on [16]. In this study, it was stated that medium-sized stones in children under 6 years of age could be broken safely with RIRS. Another method for the treatment of kidney stones in children is percutaneous nephrolithotomy. With technological developments, Mini-PNL using small instruments between 11Fr-20Fr and recently Micro-PNL using a 4.8Fr nephroscope can be successfully performed. In a meta-analysis of 7 studies, 280 micro-PNL and 259 RIRS patients were compared and although stone-free rates were found to be higher in patients who underwent PNL, overall complication rates were found to be higher. Desai et al. reported that intraoperative bleeding during PNL is related to the diameter of the tract and should not exceed 22Fr in children [17]. Mini, ultramini and micro modifications are used to reduce the risk of complications, and despite all modifications and high success, major risks, organ injuries, urosepsis, severe bleeding are seen up to 10% [18].

Today, with endoscopic developments, the RIRS technique has become widely used in many centers. Many studies have shown that ureterorenoscopy in children does not carry significant risks such as ureteral stricture and reflux. RIRS is applied in children with stone-free rates between 60% and 100% depending on the location and burden of the stone. In large series of publications, it has been reported that lower pole calyx stones up to 20 mm in size can be broken with a 94% stone-free rate with multiple additional attempts without the use of an access sheath [19]. In our study, lower calyceal stones were detected in 14 patients and were treated with a stone-free rate of 61.2% as a result of a single intervention.

In a study conducted by Smaldone et al. examining 100 patients, the average age was 13.2 years, the average stone size was 8.2 mm, and stones located in the upper pole, pelvis and lower pole were broken with a 92% stone-free rate [20]. In our study, stone-free rates were found to be 76.3% in the first group and 62% in the second group according to stone size, and no statistically significant difference was found (p: 0,295). In the literature, it has been reported that stone-free rates depend on the size of the stone, regardless of its localization, and that additional intervention may be required, especially for stones larger than 6 mm [21]. Complication rates are low in retrograde intrarenal surgery and perforation has been reported between 0-4% in many studies [22]. In our study, no perforation developed in the patients. Although there is not enough data on the routine use of preoperative JJ stents, no significant difference was observed in terms of stone-free rates and complications in their preoperative use in retrospective studies [23]. Hubert and Palmer have shown that previously inaccessible ureters in pediatric patients can be accessed by passive dilation with a JJ stent [24]. In our study, preoperative JJ stent placement (prestenting) was applied to 25 renal units for passive dilatation of the ureter before the procedure. When the patients who underwent passive dilatation and those who did not undergo it were examined in terms of stone-free status and complications, no statistically significant difference was observed between the two groups of patients. Another controversial issue is the use of access sheath. There are discussions about the possibility that the use of thick access sheaths may impair ureteral blood circulation. There are studies showing that a safer wide-lumen access sheath can be used by performing passive dilatation before using the access sheath, thus providing a wider view [25]. In the study conducted by Smaldone et al., 54% of the patients underwent preoperative passive dilatation and 24% of the patients used access sheath. As a result of the study, no correlation was found between passive dilatation or access sheath use and complications [20]. In our study, access sheath was used in 31 patients. No statistically significant difference was found in terms of stone-free and complications.

The HU, which shows the stone density is another modality that shows the success of the treatment as well as the size and intrarenal localization of the stone. In the study conducted by Quizad et al., the HU of 50 patients was measured and the threshold value was determined as 970, and the success rate after ESWL treatment for stones with HU <970 was 96%, and for stones with HU>970, the success rate was 36% [26]. The HU value of the stones can also affect the PNL results. Gücük et al. found that HU values of stones in 179 patients who underwent PNL were an independent factor affecting PNL success [27].

In a multicenter study, it was determined that stone size and localization were predictive factors for residual fragments in retrograde intrarenal surgery, independent of stone density [28]. In our study, the effect of stone density on stone-free rates was not found to be statistically significant. Similarly, stone size was also not found to have a significant impact on stone-free outcomes in the pediatric population.

In a study by Türedi and colleagues comparing conventional access sheaths with suction-assisted access sheaths, higher stone-free rates were reported with the use of suction-assisted access sheaths. However, this study did not evaluate stone-free rates specifically in patients with stones larger than 2 cm. Investigating stone-free rates in this patient group would provide clearer insight into the benefits of suction-assisted access sheaths for stones over 2 cm [29]. In our study, data from 15 renal units with stones larger than 2 cm treated using conventional access sheaths may serve as a reference for future evaluations of patients treated with suction-assisted access sheaths.

In the current studies in the literature, we see that especially medium-sized stones can be successfully broken with retrograde intrarenal surgery in preschool children. Although our study was conducted with a small number of patients, it supports the fact that retrograde intrarenal surgery can be used safely and effectively with low complication rates in the pediatric population. Future studies could be designed to compare outcomes in pediatric patients with stones larger than 2 cm with those in whom suction-assisted access sheaths were utilized, to better evaluate the effectiveness and safety of this approach in managing larger stone burdens.

Conclusion

According to the results of our study, RIRS can be safely performed in children with low complication rates. However, in cases of lower pole and large-sized stones, surgical success rates tend to decrease and may require additional interventions. Stone-free rates were found to be high in stones smaller than 20 mm, and due to its low complication rates, RIRS can be safely used in the pediatric population. With the advancement of technology, the miniaturization of instruments, improved maneuverability, the use of suction-assisted access sheaths, and enhanced image quality, we believe that RIRS may also become a first-line treatment option for stones larger than 2 cm.

Ethics Committee Approval: Ethical approval for this study was obtained from Mersin University Clinical Research Ethics Committee (Date: 09.04.2025 No: 2025/380).
Informed Consent: An informed consent was obtained from all the patients.
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Table 1. Distribution of patients according to age, gender and stone size

Stone size	**Group 1 (n: 25)** **<20 mm**	**Group 2 (n:15)** **>20 mm**	**P value**
Girl	12 (%48)	10 (%66,7)	
Boy	13 (%52)	5 (%33,3)	
Age	10,8 (4-17) year	15,1 (10-17) year	**0,003**
Stone size mm	12,6 (11-17)	25,2 (20-43)	**0,012**
Operation time	48 (30-70) min	65 (40-95) min.	**0,015**
Stone free rate	76,3%	62%	0,295

Table 2. Distribution of stones according to localization

Renal unit	**Group 1 (n:25)**	**Group 2 (n:15)**
Renal pelvis	6 (24%)	6 (40%)
Upper calyx	3 (12%)	-
Middle calyx	2 (8%)	1 (67,7%)
Lower calyx	10 (40%)	4 (26,7%)
Proximal ureter	3 (12%)	-
Multiple	1 (4%)	4 (26,6%)

Table 3. Number of renal units of stones, Hounsfield units and stone-free rate, use of prestenting and acces sheaths

Renal units	Group 1 (n=25)	Group 2 (n=15)	P value
Operation time	48,88±8,75	65,66±17,58	**0,015**
Acces sheat	18 (72%)	13 (86,6%)	0,122
Prestenting JJ	17 (68%)	8 (53,3%)	0,315
HU (Hounsfield Unit)	844,9 (min:233-max :2100)	795 (min:210-max: 2015)	0,340
Stone free rates	76,3%	62%	0,295