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A comparison of micro-PERC and retrograde intrarenal surgery results in pediatric patients with renal stones

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Summary

Introduction
With advancements in endoscopic surgery, open surgical techniques for urinary system stones have paved the way for the application of less invasive treatment modalities in patients with pediatric kidney stone disease. These treatment options include extracorporeal shock wave lithotripsy (ESWL), percutaneous nephrolithotomy (PCNL), and retrograde intrarenal surgery (RIRS).

Objective
We aimed to compare the efficacy and safety of RIRS and micro-PCNL techniques in the surgical treatment of kidney stones in pediatric patients.

Study design
A total of 48 pediatric patients, who underwent RIRS or micro-PERC for pediatric kidney stone disease, were retrospectively analyzed. Urinalysis, urine culture, serum creatinine (Cr), blood urea nitrogen (BUN), calcium, phosphorus, parathyroid hormone, 24-hour urine sample, complete blood count (CBC), urinary system X-ray, kidney ureter bladder (KUB), and urinary system ultrasonography (USG) test results were evaluated prior to the procedure. Intravenous pyelography (IVP), non-contrast computed tomography (CT), and renal scintigraphy evaluations were also performed, if necessary. The patients were divided into two groups: micro-PERC group ($n = 25$) and RIRS group ($n = 23$). Data relating to the duration of the operation, duration of fluoroscopy, length of hospitalization, complication rates, and stone-free rates were recorded.

Results
The mean ages of the micro-PERC and RIRS groups were 4 ± 2.3 and 10.9 ± 3 years, respectively ($p = 0.001$). However, the mean stone sizes were 12.2 ± 2.8 and 13.7 ± 3.5 mm, respectively ($p > 0.05$). The mean duration of operation was 75.1 ± 18.9 min in the micro-PERC group and 62.3 ± 15.3 min in the RIRS group ($p > 0.05$). In addition, the mean duration of fluoroscopy was 115 ± 35.4 s in the micro-PERC group and 39.9 ± 15.3 s in the RIRS group. The stone-free rates in the micro-PERC and RIRS groups following the procedure were reported to be 84% (21/25) and 82.6% (19/23), respectively ($p > 0.05$). In terms of the degree of preoperative hydronephrosis between the groups, the rates of mild and moderate–severe disease were 76% (19 out of 25) and 24% (6 out of 25), and 69.5% (16 out of 23) and 30.4% (7 out of 23) in the micro-PERC and RIRS groups, respectively.

Conclusion
In recent years, technological developments in minimally invasive procedures, such as micro-PERC and RIRS, have facilitated choices made by urologists in the effective and safe first-line treatment in pediatric patients.

Table Demographic data of patients and operatives.

	micro-PERC	RIRS	*p*
Patients, *n*	25	23	–
Age (mean ± SD)	4 ± 2.3	10.9 ± 3	0.001
Stone size, mm	12.2 ± 2.8	13.7 ± 3.5	>0.05
Fluoroscopy time, s (mean ± SD)	115 ± 35.4	39.9 ± 15.4	0.001
Stone-free rate, %	84	82.6	>0.05

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Introduction

Pediatric urinary system stone disease is endemic and frequently encountered in Turkey and certain regions of the Far East with an incidence ranging from 0.1% to 5% [1]. The recurrence risk has been reported to increase in case of comorbidities, such as anatomical and metabolic abnormalities and infectious diseases [2]. With the advancements in endoscopic surgery, open surgical techniques for the urinary system stones have paved the way for the application of less invasive treatment modalities in patients with pediatric kidney stone disease. These treatment options include extracorporeal shock wave lithotripsy (ESWL), percutaneous nephrolithotomy (PCNL), and retrograde intrarenal surgery (RIRS) [1]. Since 2007, the use of RIRS for the treatment of pediatric kidney stones has particularly increased [3].

Micro-PCNL, which has been developed in parallel with the technological developments in urologic surgery, is applied differently from the standard PCNL and mini-PCNL techniques. First described by Bader et al. [4] in 2010 at the American Urology Association (AUA) meeting held in San Francisco, micro-percutaneous nephrolithotomy (micro-PERC), or the all-seeing needle technique as it is otherwise known, has many advantages, such as being conducted under the direct visual guidance, single and correct calyx accessibility, and no need for dilatation or multiple maneuvers. Therefore, the duration of both the operation and the fluoroscopy can be shortened, and complications, such as bleeding and perforation, which may develop during the dilatation stage, are avoided [5].

Currently, the main goal of the surgical treatment of pediatric kidney stone diseases is to remove the stones using minimally invasive procedures while preventing any injury by the stones (calculi) to the urinary system, and to prevent the recurrence of the calculi. In this study, we aimed to compare the efficacy and safety of RIRS and micro-PCNL techniques in the surgical treatment of kidney stones in pediatric patients.

Materials and methods

A total of 48 pediatric patients who underwent RIRS or micro-PERC for pediatric kidney stone disease between January 2015 and April 2016 were retrospectively analyzed. Urinalysis, urine culture, serum creatinine (Cr), blood urea nitrogen (BUN), calcium, phosphorus, parathyroid hormone, 24-hour urine sample, complete blood count (CBC), urinary system X-ray, kidney ureter bladder (KUB), and urinary system ultrasonography (USG) test results were evaluated prior to the procedure. Intravenous pyelography (IVP), non-contrast computed tomography (CT), and renal scintigraphy evaluations were also performed, if necessary.

The patients were divided into two groups: micro-PERC group ($n = 25$) and RIRS group ($n = 23$). Children of school age underwent RIRS in the presence of retro-colon and abnormal rotation of the kidney, whereas micro-PERC was used in preschool children in whom the renal access sheath entry was considered to be inadequate. Following the procedure, stone-free rates were evaluated with KUB in opaque stones, or Ultrasonography (USG) in non-opaque stones, at postoperative week 2.

Data relating to the duration of the operation, duration of fluoroscopy, length of hospitalization, complication rates, and stone-free rates were recorded. The Clavien complication classification system [6] was used to assess the complications.

Written informed consent was obtained from each patient. The study protocol was approved by the institutional Ethics Committee.

Micro-PERC technique

Under general anesthesia and in the lithotomy position, a 3F ureteralcystoscope-guided catheter was advanced to the renal pelvis through the ureteral orifice. A 16-gauge all-seeing needle (PolyDiagnost, Germany) under fluoroscopic guidance was inserted into the stone-containing calyx or pelvis, in the prone position. A three-path connector was attached to the proximal end. One of the lateral channels of the connector was used as a telescope and the other for the irrigation. In addition, a laser fiber was directed from the central channel. The holmium: yttrium aluminum garnet (Ho:YAG) laser (AMS StoneLight Holmium Laser System, Brookfield, WI, USA) was used as the lithotripsy tool. The ureteral catheter was removed within 12—24 h following the fragmentation of the stones. The stone particles were then left to pass spontaneously.

Retrograde intrarenal surgery technique

A 0.035-inch safety guide was placed in the renal pelvis, accompanied by cystoscopy or rigid ureterorenoscopy (URS) and under the fluoroscopic or direct visual guidance, in the lithotomy position under general anesthesia. The ureteral access sheath (9.5/11.5F, 35 cm, Boston Scientific, Natick, MA, USA) was advanced through this guidewire under fluoroscopic guidance. The stone was accessed at its site through a flexible URS (Olympus URF-P6, Singapore), and fragmented using a Ho:YAG laser (StoneLight Laser Therapy System). No routine basket extraction was performed for residual fragments. At the discretion of the surgeon, a JJ stent was applied at the end of the operation and extracted within approximately 10—14 days.

Statistical analysis

Statistical analysis was performed using the SPSS v11.5 software (SPSS Inc., Chicago, IL, USA). The chi-s test was used to evaluate the success rate and postoperative complications between the groups, and the Mann—Whitney *U* test was used to assess the length of hospital stay, fluoroscopy, and the operation times between the groups. Categorical variables were presented as frequency (%), while continuous variables were expressed in mean ± standard deviation (SD). A p value < 0.05 was considered statistically significant.

Results

Of 48 patients, the mean age was 7.3 ± 4.4 (range 1—15) years. The mean stone size was 12.95 ± 3.15 (range 6—18) mm. The micro-PERC group comprised 18 (72%) patients

with a history of ESWL, and the RIRS group comprised 17 (73%) patients. The mean ages of the micro-PERC and RIRS groups were 4 ± 2.3 and 10.9 ± 3 years, respectively ($p = 0.001$). However, the mean stone sizes were 12.2 ± 2.8 and 13.7 ± 3.5 mm, respectively ($p > 0.05$).

In terms of the degree of preoperative hydronephrosis between the groups, the rates of mild and moderate–severe disease were 76% (19 out of 25) and 24% (6 out of 25), and 69.5% (16 out of 23) and 30.4% (7 out of 23) in the micro-PERC and RIRS groups, respectively. In the micro-PERC group the following stones were located: three in the upper calyx, five in the middle calyx, one in the renal pelvis, and 16 in the lower calyx. In the RIRS group, the following stones were located: two in the upper calyx, six in the middle calyx, and 15 in the lower calyx.

Based on the opacity of the stones, 52% had opaque stones, 36% had semi-opaque stones, and 12% had non-opaque stones in the micro-PERC group. These rates were 52.1%, 39.1, and 8.6% in the RIRS group. Demographic characteristics of the both patient groups are shown in Table 1. Furthermore, the mean duration of operation was 75.1 ± 18.9 min in the micro-PERC group and 62.3 ± 15.3 min in the RIRS group ($p > 0.05$). In addition, the mean duration of fluoroscopy was 115 ± 35.4 s in the micro-PERC group and 39.9 ± 15.3 s in the RIRS group. These results show that the duration of fluoroscopy was statistically significantly longer in the micro-PERC group ($p < 0.001$). The stone-free rates in the micro-PERC and RIRS groups following the procedure were reported to be 84% (21/25) and 82.6% (19/23), respectively ($p > 0.05$). Operative and postoperative data are shown in Table 2.

Table 1 Demographic data.

	micro-PERC	RIRS
Patients, *n*	25	23
Age (mean ± SD)	4 ± 2.3	10.9 ± 3
Stone size, mm	12.2 ± 2.8	13.7 ± 3.5
Hydronephrosis, *n* (%)		
Nil or mild	19/25 (76)	16/23 (69.5)
Moderate or severe	6/25 (24)	7/23 (30.4)
Radiopacity, %		
Opaque	52	52.1
Semi-opaque	36	39.1
Non-opaque	12	8.6

Table 2 Operative and postoperative data for patients.

	micro-PERC	RIRS	*p*
Operation time, min (mean ± SD)	75.1 ± 18.9	62.3 ± 15.3	>0.05
Fluoroscopy time, s (mean ± SD)	115 ± 35.4	39.9 ± 15.4	0.001
Hospitalization time, days (mean ± SD)	2.1 ± 0.6	2.2 ± 0.4	>0.05
Complications, *n* (%)			
Clavien I–II	3 (12)	4 (17.3)	
Clavien III–V	–	–	–
Stone-free rate, %	84	82.6	>0.05

According to the Clavien complication classification system, postoperative fever developed in two (8%) patients and renal colic in three (12%) patients in the micro-PERC group. In the RIRS group, postoperative fever was reported in four (17.3%) patients, renal colic in four (17.3%) patients (Clavien I), and sepsis in one (4.3%) patient (Clavien II). The patients in both groups received conservative treatment. Based on the weight of the stones, a JJ stent was applied perioperatively in one patient in the micro-PERC group and in four patients in the RIRS group, and were extracted 2 weeks after the operation. Decreased hemoglobin levels requiring blood transfusion were not reported in any of the group patients. The mean duration of hospitalization was 2.1 ± 0.6 and 2.2 ± 0.4 in the micro-PERC group and RIRS group, respectively ($p > 0.05$).

Discussion

Minimally invasive procedures play a major role in the treatment of pediatric urinary system stone disease. This is due to the high recurrence risk and because it is accompanied by a high incidence of conditions, such as anatomical and metabolic abnormalities, and by infectious diseases [2]. The efficacy and safety of PCNL has already been proven in adults [7]. When the procedure was first used, urologists were reluctant to use adult instruments in the management of pediatric patients with kidney stones. This was due to the potential risks, such as bleeding, major complications associated with sepsis, the fear of exposure to radiation, and parenchymal injury from the fluoroscopy. Recently published extensive retrospective studies demonstrated a 90% success rate for PCNL; however, complications such as high postoperative fever (30%) and bleeding requiring blood transfusion (24%) were reported [8–10].

The all-seeing needle technique or micro-PERC as it is otherwise known, accompanied by the 4.8F micro-sheath, in the absence of an additional tract dilatation, has recently gained popularity in endourological practice because standard and mini-PCNL techniques yield undesired complications. The micro-PERC technique is considered to have major advantages, such as single-access under direct vision and the prevention of potential complications, such as bleeding and organ injury. Nonetheless, certain disadvantages, such as the absence of an appropriate tract diameter and equipment for the extraction of fragmented stones, have been already reported [11]. In patients with fewer stones and in cases where other minimally invasive techniques (ESWL and RIRS) are unlikely to succeed, the micro-PERC technique offers an important option for experienced urologists [11,12]. In our study, the stone weight was small in all patients who underwent the micro-PERC technique with a mean stone diameter of 12.2 ± 2.8 mm.

Furthermore, in the present study, there was no statistically significant difference in either group in terms of the duration of hospitalization. However, the duration of fluoroscopy and consequently exposure to radiation was found to be 115 ± 35.4 s in the micro-PERC group and 39.9 ± 15.3 s in the RIRS group ($p = 0.001$).

Unlike standard PCNL, low hemoglobin counts and the need for blood transfusions were not reported with micro-PERC in previous studies [10,11]. Consistent with these data,

there were no reports of blood transfusions in our patients in the micro-PERC group. In addition, previous reports demonstrated a micro-PERC stone eradication rate ranging from 80% to 90% in pediatric patients [13,14]. The results of our study using micro-PERC showed a stone-free ratio of 84%, which is consistent with the previous study findings.

The treatment of kidney stones with retrograde intrarenal surgery was first described in 1983 [15]. However, the treatment of kidney stones using the retrograde intrarenal surgical techniques only became widely used many years later with the use of fiber optic technology-assisted flexible ureteroscopy and the development of nitinol attachment equipment in combination with the Ho:YAG laser assisted the intracorporeal lithotripsy. Smaldone et al. [16] reported a 91% stone-free ratio in 100 pediatric patients with a mean stone diameter of 8.3 mm with about 52% of the stones located in the kidney. About 9% of these children underwent more than one procedure. These findings indicated a 4.2% complication rate associated with one case of perforation requiring open neocystostomy because of the stricture. Our study reported a stone-free rate of 82.6% in the RIRS group with postoperative complications according to the Clavien classification, whereas minor grade I—II was detected. None of our patients demonstrated ureteral complications and, therefore, all were considered for soft dilatation with JJ stenting at least 14 days before the procedure [16].

There are a few recent studies that compare mini-PERC/micro-PERC and RIRS. One of these, Resorlu et al. [17], reported that mini-PERC and RIRS are highly effective methods of treatment for children with stones up to 2 cm. In another recent study related to comparing micro-PERC and RIRS, Baş et al. [18] reported that micro-PERC and RIRS were highly effective methods for treatment of moderately sized renal stones in children. Current study had similar results with these trials.

Currently, the PCNL is the first-line treatment for stones $>$2 cm in patients with pediatric stone disease. On the other hand, ESWL is primarily recommended for stones $<$2 cm in size. The RIRS is recommended as a second-line treatment for smaller stones (10 mm). Otherwise, repeated endoscopic procedures could increase the risk of residual stones. Also, the PCNL is often considered for lower pole stones of $>$10 mm, and micro-PERC and ESWL are considered as a second treatment of choice [19]. In the present study, no patient in the RIRS or micro-PERC group had a stone diameter of more than 2 cm. Eighteen (72%) patients in the micro-PERC group and 17 (73%) patients in the RIRS group underwent ESWL; however stone-free couldn't be provided.

Our study has certain limitations. The study was retrospective nature. In addition, we could not performed stone analysis, because we used a Ho:YAG laser for disintegration during lithotripsy. Additional randomized controlled studies with a larger series are needed.

Conclusion

In conclusion, in recent years technological developments in minimally invasive procedures, such as micro-PERC and RIRS, have facilitated choices made by urologists in the effective and safe first-line treatment in pediatric patients. Factors such as age of the patient, the diameter of the stone, and anatomy of the urinary system should be considered when choosing the optimal treatment procedure. Our study is one of the first to compare the two methods for the treatment of pediatric kidney stone disease; however, more prospective, large-scale, randomized clinical studies are needed to confirm these findings.

Funding

None.

Conflict of interest

None.

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