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Comparison of miniperc and conventional percutaneous nephrolithotomy in pediatric renal calculi

Çocukluk çağı böbrek taşı olgularında klasik perkütan girişimle miniperk yönteminin karşılaştırılması

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Abstract

Objective: To assess the safety and surgical outcomes of two different percutaneous nephrolithotomy (PNL) procedures (miniperc versus standard PNL) in pediatric renal stone disease.

Materials and methods: Over a 4-year period, a total of 31 consecutive children with a mean age of 10.3 years (range 3.5-16 years) undergoing two different PNL procedures were retrospectively evaluated. Depending on the type of procedure performed, children were divided into two groups: Group 1 (n=17) underwent a miniperc procedure, and Group 2 (n=16) underwent a standard PNL procedure with adult-size instruments. Clinical and surgical parameters including patient demographics, stone profiles, success rates in terms of stone-free status, complication rates, and the need for auxiliary procedures were compared between the groups.

Results: A total of 33 primary PNL procedures performed in 31 children were evaluated. The mean age was significantly lower in children undergoing the miniperc procedure (8.7 vs. 11.8 years old), and the number of accesses made was higher (1.41 vs. 1 port) ($p<0.05$). In addition, operation and fluoroscopy times, rates for blood transfusions, and the mean removal time for the nephrostomy catheter, were all comparable between groups. Similarly, the mean duration of hospitalization, the stone-free rates at 3 months, and the minor complication rates were similar in both groups. No major complications were noted in both approaches.

Conclusions: PNL is a safe treatment choice for pediatric renal stones with satisfactory stone-free rates and minimal complications. Despite the ongoing hesitancy to use adult-size equipment in this specific population during PNL procedures, our findings clearly revealed similar success and complication rates for the two different approaches.

Key words: Children; miniperc; percutaneous nephrolithotomy; stone disease.

Özet

Amaç: Çocukluk çağı böbrek taşı hastalığında iki değişik perkütan nefrolitotomi (PNL) yönteminin (miniperk ve standart PNL) güvenliliğini ve cerrahi sonuçlarını değerlendirmek.

Gereç ve yöntem: Dört yıl boyunca, iki değişik PNL prosedürü uygulanmış ortalama yaşı 10.3 (dağılım 3.5-16) olan 31 çocuk retrospektif olarak değerlendirildi. Uygulanan prosedür tipine göre hastalar iki gruba ayrıldı: Grup 1 (n=17) miniperk uygulanan olgular, Grup 2 (n=16) erişkin nefroskopu ile standart PNL yapılan olgular. İki grup demografik veriler, taş profili, başarı oranları, komplikasyon oranları ve ek prosedür gerekip gerekmediği gibi klinik ve cerrahi parametreler açısından karşılaştırıldı.

Bulgular: Otuz-bir hastaya 33 primer PNL uygulandı. Miniperk uygulanan hastaların ortalama yaşı anlamlı olarak daha küçük (8.7 ve 11.8) ve akses sayısı yüksek bulundu (1.41 ve 1 port) ($p<0.05$). Operasyon ve floroskopi süreleri, kan transfüzyon oranları ve nefrostomi tüpünün alınma süreleri açısından ise karşılaştırılabilir sonuçlar elde edildi. Benzer şekilde hastanede yatış süresi, 3 aylık takipte taşsızlık oranları ve minör komplikasyon oranları açısından anlamlı fark saptanmadı. Her iki prosedürde de majör komplikasyon izlenmedi.

Sonuçlar: Yüksek taşsızlık ve minimal komplikasyon oranı sebebi ile PNL çocukluk çağı taş hastalığında güvenli bir seçenektir. Erişkin tip aletlerin bu hasta grubunda kullanılması ile ilgili çekinceler olmasına karşın, bu çalışmanın bulguları her iki prosedürün de benzer başarı ve komplikasyon oranlarına sahip olduğunu ortaya koymaktadır.

Anahtar sözcükler: Çocuk; miniperk; perkütan nefrolitotomi; taş hastalığı.

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Although pediatric urinary stone disease is a relatively rare pathology with an overall incidence of 1% to 2%, it is associated with considerable morbidity, and thus the reported recurrence rates range widely from 3.6% to 67%. Recurrence rates appear to be highest in children with metabolic abnormalities.[1-4]

Technological advancements and the miniaturization of endourological instruments, along with the increasing experience of surgeons, have significantly altered the removal of calculi in this specific population.[5-7] Currently, the majority of stones in children can be managed either with shockwave lithotripsy (SWL), percutaneous nephrolithotomy (PNL) or ureterorenoscopy (URS), or a combination of these modalities, but open surgery is currently needed in a limited percentage of all cases.[1-4,8]

The application of percutaneous approaches in children following the first report of a series regarding PNL in 1985 has resulted in PNL becoming a commonly used technique either as a monotherapy or as a part of other approaches in cases of large stone burdens. The slow acceptance of using this technique in children was due to concerns regarding long-term renal damage, small kidney size, relatively large instruments, radiation exposure, and the risk of major complications, including bleeding. However, as surgeons' experience increased in this field, the results of relatively large surgical series demonstrated that scarring and insignificant loss of renal function after this procedure were expected to be minimal.[9]

While earlier reports of performing PNL in children described the use of adult-size instruments, advancements in instrumentation and the availability of more efficient energy sources for intracorporeal lithotripsy have revolutionized the endourological management of stones in children. As a result of these achievements, in 1997, Helal and coworkers first reported the use of a 15F Hickman catheter access sheath in a 2-year-old child for stone removal from the kidney.[10]

The miniperc technique is believed to have several advantages, including decreased blood loss, increased maneuverability, and shorter hospital stays. As the risk for bleeding complications is related to the number and caliber of tracts used,[11] limited transfusion rates have been reported with this technique.[12,13]

In the present study, our goal was to compare a number of clinical and surgical parameters in children who had undergone two different PNL procedures, either miniperc or conventional PNL, due to renal calculi.

Materials and methods

We retrospectively reviewed all medical and radiographic records of children aged <16 years old who underwent PNL with two different approaches (miniperc versus standard PNL) from January 2005 to September 2009. Demographic features of the cases, stone profiles, procedural details, auxiliary procedures, complications, outcomes, and follow-ups were documented on a standardized data collection form.

Based on the type of PNL performed, the children were divided into two groups as follows: Group 1 (n=17) consisted of children who underwent miniperc procedures for renal stones, and Group 2 (n=16) consisted of children who underwent standard PNL procedures using adult-size instruments. Prior to the dedicated procedure, all children were subjected to biochemical and radiological, tests in the outpatient clinic. Tests for renal functions and urinalysis, along with a culture antibiogram test, were carried out in all cases. The indication for PNL was based on the size of stone and the characteristics of the pelvicalyceal system.

In the first group, following access to the collecting system and placement of a guide wire into the ureter, the tract was gradually dilated to 18F, and a 20F Amplatz sheath (Boston Scientific, Natick, MA, USA) was placed. The mini-PNL procedure was performed using a 17F nephroscope. In the second group, however, the balloon dilation was dilated to 30F, and a 24 Ch adult nephroscope was used through a 30F Amplatz sheath. The nephroscope was passed through appropriate-sized Amplatz sheaths, and the stones were disintegrated with a pneumatic lithotripter while being visualized with a video camera. As the stones were disintegrated, the particles were taken out using stone forceps.

The pelvicalyceal system was examined with the nephroscope and by fluoroscopic imaging. After completion of the procedure, a nephrostomy catheter, of either 12F (miniperc group) or 14F (standard PNL group) in size, was placed into the renal pelvis and fixed to the skin. The gonadal area of each child was properly protected during the entire procedure. While a single procedure was performed in 29 of the cases, a bilateral PNL was performed in 2 cases in different sessions.

The ureteric catheter was removed the next day, and the patient was discharged 3 or 4 days following PNL. The presence of residual fragments was evaluated using either Kidneys, Ureters, and Bladder (KUB) imaging (n=30) or noncontrast helical CT (n=1) where appropriate, and stone particles <3 mm were accepted as clinically insignificant fragments. Small fragments that could not be reached or were missed during PNL procedures (sizes >3 mm) were further managed with SWL. The first follow-up visit was within the first week. Those patients who were stone-free were reassessed 6 months later in the first year following the procedure and then annually, using plain film or ultrasonography, to check for recurrence.

The duration of the procedure was accepted as the time period between needle access to the renal collecting system and placement of the nephrostomy catheter. Patients in both groups were comparatively evaluated with respect to gender, mean age, body mass index (BMI), stone area and volume, stone location, duration of the procedure, number of accesses, stone-free status, and complications. Additionally, blood count values before and after the procedure, blood transfusion rates, mean removal times of nephrostomy catheters, and hospitalization periods were evaluated between the groups.

Statistical calculations were performed with the NCSS 2007 program for Windows. In addition to standard descriptive statistical calculations (mean and standard deviation), an unpaired t-test was used in the comparison of groups, and a chi-square test was performed during the evaluation of qualitative data. Statistical significance level was considered as $p<0.05$.

Results

A total of 33 consecutive PNL procedures in 31 children were evaluated. When demographic data were evaluated, the mean age was significantly lower in children undergoing the miniperc procedure compared with those undergoing the standard PNL procedure (8.74±3.62 [3.5-15] vs. 11.81±3.1 [7-16] years; $p<0.05$). However, there was no significant difference with respect to mean BMI values or sex in the two groups (Table 1).

Prior to the PNL procedure, 2 patients in the miniperc group and 1 child in the standard PNL group had undergone SWL management for calculi located in the kidney, and 1 case in the first group had a history of pyelolithotomy. All cases had undergone PNL in our department. At baseline, 76.5% and 62.5% of the patients in Group 1 and Group 2, respectively, displayed hydronephrosis in their collecting systems, along with renal calculi. None of these parameters, which are outlined in Table 2, revealed any statistical significance between the two groups.

Table 1. Demographics of patients in the miniperc and conventional percutaneous nephrolithotomy (PNL) groups (mean±SD or %)

		Miniperc (n=17)	Conventional PNL (n=16)	p value
Age (year)		8.74±3.62	11.81±3.1	0.014
Body-mass index (kg/m²)		21.92±3.63	19.31±1.72	0.08
Gender	Female	47.1	43.8	0.849
	Male	52.9	56.3	

Table 2. Hydronephrosis, previous open surgery and shockwave lithotripsy (SWL) in the miniperc and conventional percutaneous nephrolithotomy (PNL) groups (%)

	Miniperc (n=17)	Conventional PNL (n=16)	p value
Hydronephrosis	76.5	62.5	0.383
Previous open surgery	5.9	0.0	0.325
Previous SWL	11.8	6.3	0.582

Regarding stone location, the calculi were located in the right kidney in 12 cases and in the left kidney in 5 cases in the miniperc group, while these values were 9 and 7 in the standard PNL group cases, respectively. The blood count values (e.g., hematocrit, hemoglobin) and the need for blood transfusions were found to be comparable in both groups without any statistical significance. An evaluation of the duration of the surgical procedure revealed that, except for the number of accesseses made (1.41±0.71 and 1.0±0 in miniperc and conventional PNL groups, respectively; $p<0.05$), the fluoroscopy times and mean removal times of nephrostomy catheters were similar for both groups (Table 3). Finally, the durations of hospitalizations, stone-free rates at a 3-month follow-up, and minor complication rates did not reveal any significant statistical differences between the groups (Table 3). No major complications were noted either during or after these two different surgical approaches.

Discussion

Technological advancements, miniaturization of endourological instruments, and increasing experience of surgeons have significantly altered the methods used for removal of calculi in this specific population.[5-7] In the present study, we aimed to compare a number of clinical and surgical parameters in children who had undergone two different PNL procedures, either miniperc or conventional PNL, due to the presence of renal calculi.

This study demonstrated that either miniperc or conventional PNL is a safe management choice in the complete removal of pediatric renal stone disease, with satisfactory stone-free rates and minimal complications. Based on these comparable surgical outcomes by two different PNL approaches in which standard and miniperc procedures demonstrated the same success and complication rates, we believe that both PNL approaches can be used in managing pediatric renal calculi.

Urinary stones, the prevalence of which varies widely among geographic regions, are being recognized more frequently in children, and the incidence has decreased significantly over the past 100 years. The disease is still an endemic problem, especially in certain developing regions of the world, such as the Far East and to a certain extent in the Middle East and Turkey.[7] Pediatric nephrolithiasis is quite challenging in terms of management because of the smaller size of the urinary tract and the greater risk for stone recurrence. Children bear a higher risk of metabolic and infectious causes of stone disease and a longer lifetime risk for recurrence, particularly in cases with residual fragments. Complete stone clearance should become the absolute objective, and clinically insignificant residual fragments should be avoided.

In order to select the most appropriate treatment modality, one should consider the location, composition, and size of the stone(s), the anatomy of the collecting system, the presence of obstruction, and the presence of infection in the urinary tract.

Similarly to treatment for adults, while SWL is the first choice to treat for the majority of the stones located in the renal cavities, current evidence supports the use of, PNL as a valuable management alternative in larger and complex calculi in this specific population.[14-16] At the same time, miniaturizations of endoscopes and advances in energy sources for stone

Table 3. Surgical parameters in the miniperc and conventional percutaneous nephrolithotomy (PNL) groups (mean±SD or %)

	Miniperc (n=17)	Conventional PNL (n=16)	p value
Stone burden (mm²)	718.51±760.35	956.06±1553.49	0.817
Operation time (min)	135.88±62.86	111.69±40.09	0.200
Fluoroscopy time (min)	7.42 ±6.58	5.68±3.72	0.360
Number of ports	1.41±0.71	1.0±0.0	0.028
Blood transfusion rate	11.8	6.3	0.582
Removal of nephrostomy (day)	3.0±1.46	3.13±1.82	0.829
Stone-free rate	76.5	81.3	0.737
Hospital stay (day)	5.35±2.21	5.09±2.26	0.763

fragmentation have facilitated the use of this approach in children, with highly satisfactory stone-free rates. PNL has reported clearance rates of approximately 90%, even with complex calculi, in children.[17] As a result, age no longer seems to be accepted as a limiting factor for performing PNL in children.

The main indications for PNL in children include stones refractory to SWL, large and complex stones for which multiple SWL sessions are required, and anatomical abnormalities (e.g., spinal or renal). PNL is primarily indicated in staghorn stones, renal pelvic stones of greater than 20 mm, and stones of greater than 10 mm located in the lower pole of the kidney.[18,19]

Since the pediatric series first reported by Woodside et al.[20] in 1985, PNL has become a technique as monotherapy or as part of a multimodal approach for children with large stone burdens. The previous reluctance to perform PNL in children was due to concerns regarding long-term renal damage, small kidney size, relatively large instruments, radiation exposure, and the risk of major complications, such as bleeding. However, the first use of a 15F access sheath[10] in a 2-year-old child led to the application of mininephroscopes that may circumvent all of the concerns described above.

The scientific logic behind using a smaller caliber percutaneous tract and nephroscope was the belief that this approach would be less injurious to the kidney. Underdilation of the small pediatric kidney, along with the use of relatively smaller instruments, was expected to be effective in preventing bleeding and renal trauma during PNL in children.[10,13,15,21] Related to this subject, Desai et al.[22] reported significant blood loss in pediatric cases with tract dilatation of more than 24F in comparison to dilatation of up to 22F. Thus, the potential advantages of miniperc include smaller tracts and intrarenal incisions, single step dilatation and sheath placement, and good working access, as well as a lower cost. In a recent review, based on their relatively large number of cases analyzed, Lahme et al.[21] stressed that PNL in children should be performed as miniperc.

In the earlier stages of PNL in children, there were some concerns about risks to renal reserve and technical difficulties in young children.[23] However, the pooled data from different centers concerning the use of adult-sized instruments in these cases clearly showed the safety of this procedure, with high stone-free rates and acceptable complications.[13,17,21,24] Regarding the damage to the treated kidney, PNL was again found to be unlikely to give rise to scarring in children.[25] In contrast to these data, Güneş et al.[7] reported a significant increase in complications in children aged less than 7 years old when using adult-sized equipment. To summarize, most studies demonstrate minimal scarring and insignificant loss of renal function after PNL. Radioisotope scans before and after PNL showed unchanged differential function and no evidence of significant renal scars.[23,25-28] Dwaba et al.[25] reported no scarring using dimercaptosuccinic acid (DMSA) renal scanning and stabilization or improved function with diethylene triamine pentaacetic acid (DTPA) renal scanning after PNL.

Despite its possible advantages over the standard PNL procedure, a principal concern for the use of the miniperc in children is the high probability of longer operation times and longer anesthesia duration due to the need to disintegrate the stone into smaller particles in order to pass them through the smaller Amplatz sheath channel.

Taking all these facts into account, in this present study, we aimed to evaluate the efficacy of the two different above-mentioned PNL procedures (miniperc vs. standard approach) in children. Evaluation of our data showed similar success rates and complication rates in both groups, and no major complications were observed.

Based on the significant difference with respect to the mean age value of both groups, although it may be possible to remove the stones with adult-sized instruments with similar complication rates, we believe that it may be more logical to operate on younger children using the miniperc procedure in an attempt to limit possible injury to the growing kidney in this specific population.

Limitations of our current study include the relatively small number of patients in both groups, the lack of renal functional evaluation by scintigraphic methods, and the relatively shorter follow-up period, which were found to be factors that should be taken into account in future trials. However, we believe that, despite all these limitations and based on the very limited comparative data published so far, our findings will be noteworthy in planning percutaneous approaches, especially in favor of miniperc in children, particularly when concerning very young patients.

As a conclusion, similar to its use in the adult population, PNL is a safe and effective procedure for the management of nephrolithiasis in children. Outcomes and morbidity rates have improved with the development of smaller endoscopic instruments and refined techniques using smaller access sheaths. Although the miniperc procedure may provide some theoretical advantages to minimizing the extent of trauma in the treated kidney and lowering the complication rates, our results did clearly show that the standard PNL procedures with adult-sized instruments may also be performed in these cases in a safe and successful manner when this equipment and/or the necessary experience is lacking. However, in cases which the size of the kidney is small, particularly in younger children, it is preferable to perform miniperc procedures to limit possible complications.

Conflict of interest

No conflict of interest was declared by the authors.

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