# The Outcome of Percutaneous Nephrolithotomy Using Intravenous Catheter for Obtaining Percutaneous Access as a Treatment for Renal Stone Disease in Children: A Pilot Study

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**Purpose:** Using percutaneous nephrolithotomy (PNL), it is easy to reach stones in various parts of the kidney via a single access tract. In the current study, we set out to demonstrate that the intravenous catheter is a safe way to gain renal access, and that PNL is safe in children.

**Materials and Methods:** We retrospectively reviewed the medical records of patients who underwent PNL as a treatment for renal stone disease at our center between September 2013 and December 2014. There were no specific exclusion criteria. We used 14 gauge intravenous catheter for renal access in all cases.

**Results:** Eleven of the 32 patients (34.4%) were female and 21 (65.6%) were male. The mean ± SD patient age was 4.7 ± 3.71 years (9 months-16 years). Six patients (18.7%) were infants less than 1 year of age. Fifteen of the stones (46.8%) were located in the right kidney, and 17 of the stones (53.1%) were located in the left kidney. The average stone size was 13.9 ± 4.8 mm (range, 12-28). The average duration of operation was 69.7 ± 10.4 minutes (range, 50-110), and the average duration of fluoroscopy was 2.21 ± 1.06 minutes (range, 1-6). There were complications in 5 of the cases (15.6%).

**Conclusion:** The access and dilatation stages are quite important. We propose that the intravenous catheter is a safe and inexpensive tool for renal access in PNL in pediatric age group patients.

**Keywords:** kidney calculi; surgery; child; minimally invasive surgical procedures; methods; nephrostomy; percutaneous; treatment outcome.

## INTRODUCTION

Urinary stone disease is common in Turkey. A multicenter study reported a prevalence of the disease of 14.8%,[1] and this percentage is even higher in the regions of Turkey with warmer climates, such as Eastern and Southeastern Anatolia. Renal stones in children cause growth and developmental delays, urosepsis, and renal impairment. Due to the high rate of relapse in this age group, minimally invasive methods to treat childhood urinary stone disease are crucial. Studies from Turkey show that the average rate of relapse for renal stone disease in children between the ages of 1 month and 6 years is 15%, and that 37.5% of these patients have a metabolic disorder.[2]

In the past 6 decades, remarkable improvements have been achieved in the treatment of renal calculi. Goodwin and colleagues first inserted a nephrostomy catheter into the kidney of a patient with hydronephrosis in 1955.[3] Not long after, Harris and colleagues reported the first removal of a renal stone percutaneously using a flexible bronchoscope.[4] In 1967, Fernstrom and Johansson performed and described percutaneous nephrolithotomy (PNL).[5] In 1980, their accomplishment was followed by the invention of extracorporeal shock wave lithotripsy (SWL).[6]

PNL is the preferred treatment method for SWL resistant patients. SWL is generally contraindicated for large stones and cystine stones and is not specific for lower calyceal stones. The success rate of PNL is high and its morbidity level is markedly low. The most important stage in PNL is achieving percutaneous access to the kidney. For renal puncture in this stage of the PNL procedure, the intravenous catheter (angiocath) has been described in the literature as highly maneuverable, able to fit comfortably in the palm of the hand, and quite inexpensive.[7] In particular, use of an angiocath decreases

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**Table 1.** Demographics and stone characteristics of patients.

| Variables | Renal Stones (n = 32) |
|---|---|
| Age, years (mean ± SD) | 4.7 ± 3.71 (9 months–16 years) |
| Male/female, no (%) | 21 (65.6) / 11 (34.4) |
| Stone load, mm$^2$ (mean ± SD) | 160 ± 89.7 (120–250) |
| Stone size, mm (mean ± SD) | 13.9 ± 4.8 (12–28) |
| Stone number, mean ± SD (range) | 3.31 ± 2.4 (1-13) |
| Left/right side stone, no (%) | 17 (53.1) / 15 (46.8) |
| Patients with special situations, no (%) | |
| Solitary kidney | 1 (3.1) |
| Hydronephrosis | 12 (32.4) |
| Residual stones after SWL | 3 (9) |
| Stone locations, no (%) | |
| Pelvic stone | 10 (31.2) |
| Middle calyceal stone | 5 (15.6) |
| Lower calyceal stone | 5 (15.6) |
| UPJ stone | 4 (12.5) |
| Multiple calyceal Stones | 8 (25) |

**Abbreviations:** SD, standard deviation; UPJ, ureteropelvic junction.

the risk of complications such as renal tissue damage and extravasation.

In the current study, we aimed to demonstrate the outcome of PNL using an angiocath in the treatment of renal stone disease in children, with particular attention paid to the infant patient group, which has been rarely noted in the literature.

## MATERIALS AND METHODS

### *Study Population*

Our study included 32 patients who underwent PNL treatment for renal stone disease at our clinic between September 2013 and December 2014. The medical records of these patients were retrospectively reviewed. The cases were analyzed in terms of gender, age, radiological signs such as stone location and stone area (according to stone protocol computerized tomography), size of sheath used, duration of operation, complications, and treatment results. This study included pediatric patients in whom PNL was indicated and other treatment methods such as SWL were insufficient. There were no specific exclusion criteria. This retrospective study was issued an approval number of 48/2014 by our Human Ethics Committee.

### *Evaluations*

All patients underwent pre-operative studies including

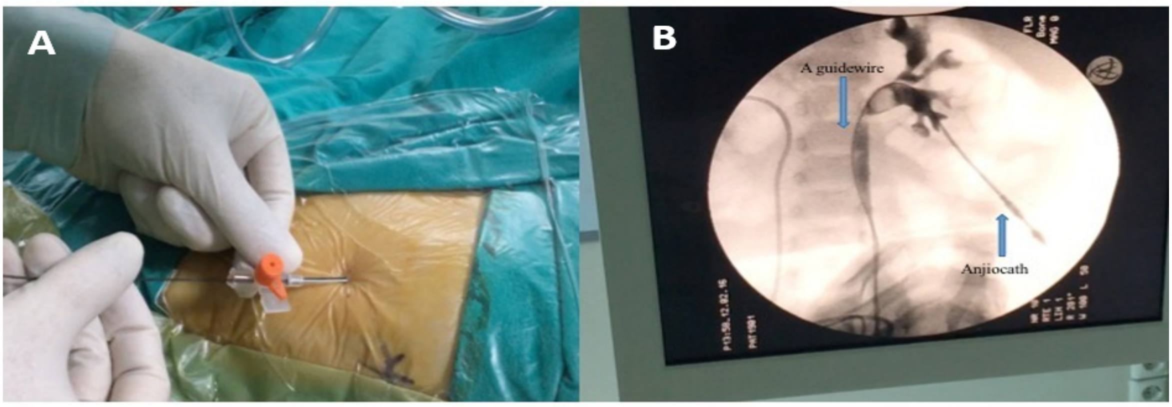


**Figure 1. A)** Guidewire inserted through the sheath of angiocath; **B)** fluoroscopic image of access.

**Table 2.** Intraoperative and postoperative parameters.

| Variables | Renal Stones (n = 32) |
|---|---|
| Initial stone free rate, no (%) | 28 (87.5) |
| Final stone free rate, no (%) | 31 (96.9) |
| Hospital stay, days, mean ± SD (range) | 4.34 ± 1.09 (2–8) |
| Operative time, min, mean ± SD (range) | 69.7 ± 10.4 (50–110) |
| Fluoroscopy time, min, mean ± SD (range) | 4.8 ± 1.06 (2-7) |
| Hemoglobin drop, g/dL, mean ± SD (range) | 0.97 ± 1.9 (2–4.2) |
| PNL size *, no (%) | |
| PNL+12 | 15 (46.8) |
| PNL+14 | 10 (31.2) |
| PNL+18 | 6 (18.7 ) |
| PNL+24 | 1 (3.1) |
| Puncture locations, no (%) | |
| Middle/lower pole calyces | 12 (37.5 ) / 20 (62.5) |
| Infracostal/Supracostal | 25 (78.1) / 7 (218) |
| Significant complications, no (%) | |
| Clavien grade 1 | 4 (12.5) |
| Clavien grade 2 | 1 (3.1) |
| Stone composition, no (%) | |
| Calcium oxalate and/or phosphate | 12 (37.5) / 20 (62.5) |
| Uric acid | 5 (15.6) |
| Struvite | 6 (18.7) |
| Cystine | 5 (15.6) |

**Abbreviations:** SFR, stone free rate; PNL, percutaneous nephrolithotomy; SD, standard deviation.
* PNL classification as described by Tepeler et al.[8]

urinalysis, complete blood count, serum biochemistry, and routine coagulation and serological tests. Additionally, all patients were examined with renal ultrasound (RUS) and noncontrast spiral computerized tomography (NSCT). Scans of 3-mm coronal and reformatted 3-mm axial sections were evaluated on the Dicle University (Diyarbakır, Turkey) picture archiving and communication system (PACS). Maximal stone diameter was measured in two dimensions in the reformatted coronal and axial sections by one reviewer. Preoperative nephrostomy was not used in any patient.

### *Procedures*

The PNL procedure was performed by three surgeons. PNL was classified for each procedure as described by Tepeler and colleagues, using the size of the external sheath as a criterion.[8] PNL access was performed using a 14 gauge angiocath in the lithotomy position, as described by Penbegul and colleagues (**Figure 1**).[7] For this procedure, a 3 French (F) ureteral catheter was placed into the ureteropelvic region of the supine patient, after which the patient was placed in the prone position, and renal access was obtained using an angiocath and fluoroscopy. Diluted (40%–50%) contrast medium was injected into the collecting system to confirm the puncture. Then, after removing the needle, a 0.038 inch hydrophilic guide wire was passed through the outer sheath into the renal unit. The tract was mechanically dilated to 12 F over the guide wire. A 12 F working sheath was placed in the pelvicaliceal system. The stones were visualized using a rigid nephroscope (9.5 F nephroscope; Karl Storz, Tuttlingen, Germany) and fragmented with pneumatic lithotripsy. Many reports in the literature describe pneumatic and laser lithotripsy. Stone fragmentation with pneumatic lithotripsy is cheaper and faster than laser lithotripsy via PNL. Therefore, we preferred pneumatic lithotripsy in all of our patients, which allowed the fragmented stones to be removed by forceps and the turbulence of fluid flow. During the procedure, if extravasation was noted, an 8 F nephrostomy catheter was passed through the working

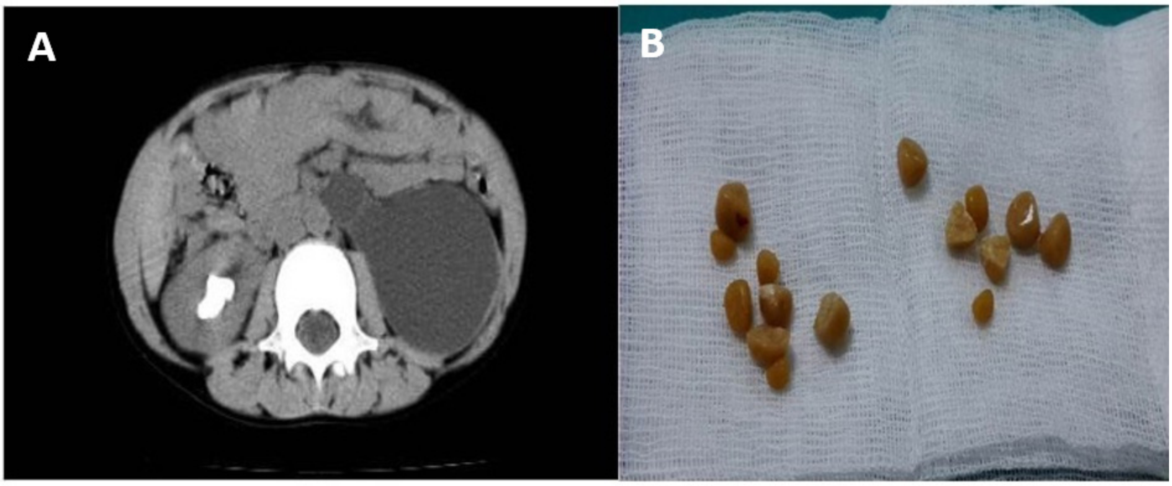


**Figure 2. A)** Preoperative computerized tomography scan view of a 5-year old patient with solitary kidney and 13 stones; **B)** cystine stones removed from the same case.

channel into the renal collecting system, and its placement was confirmed by administering contrast. Twelve hours post-surgery, the ureteral and Foley catheters were removed. The nephrostomy catheter was removed after RUS confirmed the absence of a urinoma. Patients with no complications were discharged from the hospital on the second post-operative day and were prescribed oral anti-inflammatories. The initial stone-free rate (SFR) is defined as a stone-free or asymptomatic state and a clinically insignificant residual stone of ≤ 4 mm on RUS at 24–48 hours post-PNL. The final SFR is the same as the initial SFR at 1 month post operatively and after any repeat PNL or auxiliary procedures. Collected stones were sent for analysis.

### *Statistical Analysis*

Data were reported as numbers and percentages or as means ± SD as appropriate (**Tables 1 and 2**). Analyses were conducted using PASW Statistics software (Statistical Package for the Social Science (SPSS Inc, Chicago, Illinois, USA, version 18.0).

## RESULTS

The current study had a male-to-female ratio of 18 to 14 (**Table 1**). The mean age of the patients was 4.7 ± 3.7 years (range, 9 months to 16 years). Fifteen patients had a stone in the right kidney (46.8%) and 17 had a stone in the left kidney (53.1%). In terms of the location of stones, 10 cases exhibited stones in the renal pelvis (31.2%), 5 cases in the middle calyx (15.6%), 4 cases in the ureteropelvic junction (12.5%) and 5 cases in the lower calyx (15.6%); in 8 (25%) cases, stones were located in multiple calyces. The average size and area of the stones were 13.9 ± 4.8 mm and 160 ± 89.7 mm2, respectively. There was hydronephrosis in 12 patients, 3 patients had histories of failed SWL procedures, and 1 patient had a solitary kidney. None of the patients had anatomical abnormalities.

A single access tract was used to remove stones in all patients. Supracostal access was utilized in 7 cases, while infracostal access was used in 25 cases. Renal stones were accessed through the middle calyx in 12 cases and through the lower calyx in 20 cases. We operated on 15 of the patients (46.8%) using a 12 F access sheath, and 6 of these cases (40%) were infants (< 1 year). In 10 cases (31.2%), the stone's area was greater than 180 $mm^2$ and the PNL procedure was performed using a 14 F sheath to decrease the duration of the procedure. In six cases (18.7%), the stones were struvites greater than 220 $mm^2$ and the PNL procedure was performed using an 18 F sheath. In one case, NSCT identified multiple stones in the right kidney, and during the procedure we found 13 stones in multiple calyces. In this case, the procedure was started with a 12 F sheath; however, the stones moved continuously due to the turbulence of the liquid flow and the stone fragments were unusually large, which necessitated a 24 F sheath. The larger stones were removed using pneumatic lithotripsy and the remaining 11 stones were removed with forceps (**Figure 2**). Operation time is considered as the time between the first renal puncture to the completion of stone removal. The average duration of the operation was 69.7 ± 10.4 minutes (range, 50–110 minutes), and the average duration of fluoroscopy was 2.21 ± 1.0 minutes (range, 1–6 minutes). The average hemoglobin (Hb) decrease in the post-operative follow-up was 0.97 ± 1.9 g/dL (range, 2–4.2 g/dL). According to the modified Clavien classification,[9] complications were identified in only five cases (15.6%). In four of five cases, grade 1 urinary extravasation, hematuria, and pain developed, and an 8 F nephrostomy catheter was placed. On the second post-operative day, in both patients the nephrostomy catheter was initially clamped and a RUS check was performed, and when extravasation was excluded the nephrostomy catheter was removed. A grade 2 complication was observed in only 1 of 5 cases that developed complications. In this final case, pain and hematuria continued for more than 2 days postoperatively. The patient's Hb values decreased from 12.6 g/dL to 7.6 g/dL, and an erythrocyte suspension was administered. In the follow up of all 5 cases, no problems were identified (**Table 2**).

On the second postoperative day, standing direct abdominal radiography and RUS were performed on all patients to measure the preliminary success rate. These demonstrated initial SFR kidneys in 28 patients (87.5%). Anti-inflammatories were prescribed for all patients and all were fully hydrated. After the final SFR, the success rate for eliminating renal stones was 96.9% (31 out of 32 patients) (**Table 2**). In only one case, a 6 mm stone was found in the lower calyx. The treatment regimen was continued without any change for 3 months.

Chemical analyses of the stones revealed calcium-oxalate and/or phosphate in 16 cases, uric acid in 5 cases, struvite in 6 cases, and cystine in 5 cases.

## DISCUSSION

Urinary stone disease is especially prevalent in certain regions of the world. In Turkey, 5% of all patients seen in pediatric urology clinics suffer from urinary stone disease, and the overall prevalence of the disease in Turkey is 14.8%. Both the incidence and relapse rate of urinary stone disease are quite high in Turkey, as is the case in much of the world. The incidence is higher in regions with warmer climates, such as Eastern and Southeastern Anatolia.[1] According to the current protocol for treating urinary stone disease, various minimally invasive treatments can be used, including SWL, ureterorenoscopy (URS), retrograde intrarenal surgery (RIRS), micro-PNL, and PNL.[10]

Renal stones in children cause growth and developmental delays, urosepsis, and renal impairment. Due to the high rate of relapse in this age group, minimally invasive methods to treat childhood urinary stone disease are crucial. PNL is the most common endourology treatment method. Its many advantages include: shortened hospital stays, decreased complication rates, high stone-free success rates, and the capacity to reach almost any calyx when entered from the right access point.[11] PNL is known to be an appropriate treatment for pelvic stones larger than 1.5 cm, pole stones larger than 1 cm, and cystine stones larger than 1 cm in children.[2] The effectiveness and reliability of PNL in pediatric patients has been proven by various studies. Etemadian and colleagues concluded that PNL using adult sized instruments was relatively safe in children, with a SFR of 67%.[12] In another study, the SFR was determined to be 87.5%, and following additional procedures such as SWL, URS, and re-PNL, a final success rate of 98% was achieved.[13]

One study reported that the risk of bleeding complications increases as the diameters of the renal access tract and the nephroscope increase.[14] This study demonstrates that the risk of complications is determined by the operative technique (e.g., the access method), the number of tracts, the tract dilatation method, and tract diameter.[14]

Bilen et al. showed that, when 20-26 F access sheaths were used, more blood transfusions were needed; however, use of 14 F access sheaths did not necessitate transfusions.[15] Given that in pediatric cases the collecting tubules are shorter and the kidney is smaller, the smallest possible instruments and tracts should be used to prevent major complications such as bleeding and renal damage.[16] Desai and colleagues emphasize that it is quite safe to operate using access sheaths smaller than 14 F in preschool-aged children, and that the rate of complications such as bleeding and parenchymal damage is low.[17]

Accessing the renal unit is the most important step in PNL. Chiba-type aspiration needles are commonly used for this purpose. Long, flexible needles may be problematic for the surgeon, which may result in higher rates of complications such as bleeding.[18] The use of an Alken guide confers advantages including less radiation exposure and shorter access and operative times in adults, even in the supine position.[19] For patients of all ages, the most important step of PNL is to gain access; for this step, 11 to 15 cm long 18 gauge needles are usually used. For obese patients and adult patients, long needles are preferable due to their longer access tracts; otherwise, we prefer shorter needles because they can easily be orientated and manipulated. In addition, in pediatric cases, a smaller skin incision is occasionally required to overcome difficulties with inserting these needles. While investigating the cost of materials according to the purchase prices of our hospital, we noted that the angiocath, costing only 0.30 Turkish Lira (TL), was less than one hundredth of the price of the percutaneous access needle, which costs 32.20 TL.[18] As a comparison, Bhullar and colleagues developed a highly reliable renal access tool, but the cost was estimated at around $700 (about 1,900 TL).[20] In contrast, in our clinic we used 14 gauge angiocath for renal access in all cases; we regard these tools, which require no preliminary preparation and that provide practical, efficient, inexpensive, and safe access, to be reliable and cost-effective. In our study, the success rate of removing stones with the PNL technique utilizing 12-24 F external sheaths was 96.9%, and the complication rate was 15.6%. In 15 of our 32 patients (46.8%) we were able to use a 12 F sheath, which was the smallest PNL sheath available; 6 of these 15 cases (40%) were infants (< 1 year), an age group which is rarely reported on in the literature. The size of the external sheath can be increased as necessary using the same tract and guide wire. In one of our patients, we started the procedure with a 12 F sheath, and during the operation were able to increase the size to a 24 F sheath to shorten the duration of the procedure and remove the stones successfully.

Our experience has shown that the angiocath can be safely used for renal access in PNL. Using PNL, it is easy to reach stones in different parts of the kidney via a single access tract, making it a minimally invasive treatment. The most significant complications of this procedure are bleeding and extravasation. The indications for PNL are large, complex renal stones, hard stones which are resistant to SWL, such as cystine stones and cases where other endourology treatment methods fail.[21]

PNL is a more effective treatment method for children with renal stones compared to SWL, URS, and RIRS. In PNL, all of the steps following successful access to the renal unit and careful dilatation are easier than in URS or RIRS. In the latter two endourologic methods, a stone can only be reached after passing through the urethra, bladder, and ureteropelvic regions; however, for the PNL technique in pediatric patients, the anatomic distance generally does not exceed 3–5 cm.

PNL is the preferred minimally invasive treatment method for the treatment of renal stones in all pediatric patients, including infants. PNL can be used to treat stones of different sizes and locations. The access and dilatation stages are quite important, and it is crucial to perform PNL with the smallest access sheath possible to ensure a successful treatment outcome.

## CONCLUSIONS

We are of the opinion that PNL has increased our success in treating renal stones in pediatric patients, because using the angiocath for renal access allows us to reach the collecting duct system safely and efficiently. The current study had two limitations: its relatively small sample size and retrospective design. Future prospective studies are required to further compare angiocath to other devices for gaining renal access.

## CONFLICT OF INTEREST

None declared.

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