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Original Article

Comparison of access tecniques in treatment of renal stones with percutaneous nephrolithotomy

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Abstract

Aim: A proper percutaneous renal access is the most crucial step in the procedure. This retrospective study aims to compare the efficacy and safety of monoplanar and biplanar access in PCNL operations.

Material and Methods: The study included a total of 72 patients with single kidney stones larger than 20 mm in diameter, who underwent PCNL surgery between September 2016 and May 2018. The patients were divided into two groups monoplanar access (Group 1) and biplanar access group (Group 2). There were 38 and 34 patients in Groups 1 and 2, respectively. Stone and urinary system characteristics, operation parameters and postoperative findings of all patients were recorded.

Results: There was no statistically significant difference between two groups in terms of mean age, sex and kidney stone size. Mean operation duration was 64.3 ± 21.7 minutes in group 1 and 61.8 ± 27.4 minutes in group 2 (p=0.494). A statistically significant difference was observed between the groups in terms of mean fluoroscopy time, which was 3.46±1.24 minutes in group 1 and 4.45±1.57 in group 2 (p=0.008). The mean puncture time was significantly lower in group 1 (p=0.042). The stone-free rate was 78.9% and 82.3% in groups 1 and 2, respectively (p=0.87). There was no statistically significant difference between the groups in terms of complications (p=0.72).

Conclusion: Both access techniques have been found to similar success and complication rates in PCNL operations. However, the fluoroscopy duration and puncture time are shorter in cases where monoplanar access is established; which may be effective in preferring this technique.

Keywords: Percutaneous nephrolithotomy; monoplanar technique; biplanar technique

INTRODUCTION

Percutaneous nephrolithotomy (PCNL), which was first described by Fernström and Johansson in 1976, is an effective and reliable method used in the surgical treatment of kidney stone disease (1).

PCNL is the first treatment technique for renal stones larger than 2 cm, multiple kidney stones and staghorn stones. Owing to the technological advancements in medicine, PCNL has become the preferred method instead of open surgery in the treatment of kidney stones as a minimally invasive method low operation duration, low morbidity rates and being minimally invasive are the advantages of this procedure (2, 3).

One of the most important steps of a successful PCNL surgery is to determine the correct access point with the correct angle. Radiological imaging methods are needed when creating a percutaneous tract. In general, fluoroscopy is used for this purpose. In the appropriate cases, PCNL can also be carried out under the guidance of computed tomography (CT) and magnetic resonance imaging (MRI). However, ultrasonography or endoscopic methods are also used recently to protect from radiation exposure. Each technique has its own advantages and disadvantages (4-6). Various methods can be used for the renal access, but the most common ones can be listed as monoplanar access, biplanar access (eye of the needle or bull's eye) and triangulation technique (7, 8).

The effects of patient- and stone-related factors, such as success rate, degree of bleeding, complication rate, fluoroscopy duration and operation duration, are being evaluated in most of the studies in the relevant literature (3, 9–11). In recent studies, imaging methods used for guidance during percutaneous renal access by

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urologists or radiologists have also been investigated and results and complications have been compared (12, 13). However, there is a limited number of studies in the literature on the effect of renal access technique.

The aim of this study is to evaluate the effect of monoplanar and biplanar access techniques on operative outcomes.

MATERIAL and METHODS

A total of 72 patients with a single kidney stone larger than 20 mm in diameter underwent PCNL between September 2016 and May 2018. The procedure was applied by the same surgical team. Demographic data, stone and urinary system characteristics (size and location of the stone), operation parameters (operation duration, fluoroscopy duration, site of access, time from access to the appropriate calyx), postoperative findings (length of hospital stay, blood transfusion, complications, stone-free rate) and medical records of the patients were evaluated retrospectively. Stone sizes were recorded by calculating the maximum diameter of the stone with the help of direct urinary system radiographs or non-contrast CT images. Hydronephrosis was graded as grade 0/grade 1 (mild) or grade 3 (moderate)/grade 4 (severe) using USG criteria. Needle puncture time to the renal collecting system was defined as the time from the imaging of the renal collecting system with fluoroscopy to the observation of the presence of an efflux of urine from the needle or serum physiology given through the ureteral catheter. Exclusion criteria were the presence of spinal deformity, local infection at the site of access, neuromuscular disease, coagulation disorder, susceptibility to anesthetic drugs, renal anomaly or solitary kidney, and being under 18 years of age. Patients were divided into two groups according to renal access technique. There were 38 patients in the monoplanar group (group 1) and 34 patients in the biplanar group (group 2). All PCNL operations were performed by the same surgical team at the specified time interval. The groups were compared in terms of demographic data, stone sizes, operation parameters and postoperative findings.

Surgical technique

In both groups, 6-Fr ureteral catheter was inserted into the respective ureter with a cystoscope and then fixed to a 16-Fr Foley catheter. The patients were then placed in the prone position. The operation time was defined as the period starting from the access to the collecting system to the removal of the percutaneous system from the kidney in both groups.

Monoplanar Technique

In prone position, the C-arm X-ray machine was situated in a flat position (90°). If direct stone image was not to be targeted, the calyceal stones were determined by administering an opaque material through the ureteral catheter. The calyx to be inserted was targeted and the 18-gauge needle was placed with a 30-degree angle by entering through the appropriate skin area. When the needle was inserted into the kidney and fluoroscopy showed that the needle was in the kidney, the inner sheath of the needle was removed and its position was confirmed with the presence of an efflux of urine. Once the needle was found to be in the targeted calyceal stones, the needle was advanced 0.038-inch guidewire and placed into the kidney.

Biplanar Technique (eye of the needle or bull's eye)

The fluoroscopy C-arm was rotated to 30° towards the surgeon to ensure that the C-arm axis was in the same plane with the kidney. This makes the posterior calyxes be seen at 90° in a directly vertical position. After the calyx was identified, the skin area was marked with a hemostat clamp. An 18-gauge needle was inserted into the determined calix and it was brought to the same plane with the fluoroscopy of 30° to ensure that the needle was seen as a point. The needle was advanced in this position and the fluoroscopy was then rotated to 90° to determine the distance of the needle to the kidney. The needle was then appropriately inserted into the kidney. Similarly, a 0.038-inch guidewire was advanced through the needle to the renal collecting system.

After proper access was achieved in both groups, the site of access was dilated by using Amplatz dilators up to 30 Fr and 30 Fr sheath was placed. The renal collecting system was entered with a 26 Fr nephrostomy tube and the stones were broken with pneumatic lithotriptor and extracted with grasper. Stone-free status was confirmed by either direct nephroscopy or fluoroscopy. Following the completion of the operation, a 14 Fr nephrostomy tube was placed and proper positioning was checked via fluoroscopy. Stones of ≤4 mm were accepted as clinically insignificant fragments in direct urinary system graph (DUSG) taken following the operation. Intra-operative and post-operative complications were graded according to the Clavien-Dindo Classification.

Statistical analysis

Data collections were performed using the IBM SPSS version 20.0 (IBM Inc., Chicago, IL, USA). Independent Samples t-test was used for comparison of measurable variables, Mann Whitney U test was used for the comparison of nonparametric values between groups, and Pearson chi-square test was used for categorical variables. A p value of <0.05 was considered statistically significan.

RESULTS

There was no statistically significant difference between the groups in terms of demographic and preoperative data (Table 1). In the monoplanar group (Group 1, n = 38), the mean age of the patients was 48.3±14.3 years, male/female ratio was 25/13, and mean stone size was 237.42±67.46 mm2. In the biplanar group (Group 2, n = 34), the mean age of the patients was 44.1±15.7 years, male/female ratio was 26/8, and mean stone size was 248.24±74.4 mm2. There was no statistically significant difference between the groups in terms of hydronephrosis

Table 1. Patients demographics and stone characteristics for each group			
	Group 1 (Monoplanar)	Group 2 (Biplanar)	P value
Patients, n	38	34	
Mean(SD) age, years	48.3±14.3	44.1±15.7	0.608
Gender, male:female	25:13	26:8	0.429
Mean(SD) stone size, mm^3	15.07±2.37	15.43±2.50	0.589
Laterality, right:left	20:18	18:16	1.000
Site of stone, n			0.865
Pelvis	16 (42.1%)	15 (44.1%)	0.779
Upper calyx	1 (2.6%)	2 (5.8%)	0.584
Middle calyx	6 (15.7%)	4 (11.7%)	0.184
Lower calyx	15 (39.4)	13 (38.2%)	0.768
Degree of hydronephrosis			0.748
Nil or mild	20 (52.7%)	18 (52.9%)	
Moderate or severe	18 (47.3%)	16 (47.1%)	

p < 0.05 values are statistically significant;
SD=standard deviation; n: number

degree (p=0.748). The mean operation duration was 64.3±21.7 minutes and the mean hemoglobin decrease was 4.6±2.1 mg/dL in the Group 1. In Group 2, the mean operation duration was 61.8±27.4 minutes and the mean hemoglobin decrease was 4.7±2.2 mg/dL. The mean fluoroscopy duration was 3.46±1.24 and 4.45±1.57 minutes in Groups 1 and 2, respectively and statistically significant difference was observed between the groups in this regard (p=0.008). There was no statistically significant difference between the groups in terms of stone-free rates (78.9% and 82.3% in Groups 1 and 2, respectively) (p=0.87). Mean length of hospital stay was 3.2±1.2 days and 3.4±1.3 hours in Groups 1 and 2, respectively. When the groups were compared in terms of needle puncture time to the collecting system, this time was found to be significantly lower in Group 1 (p=0.041). Complications of the groups were determined according to the modified Clavien classification system and no statistically significant difference was observed between the groups in this regard (p=0.72). One patient in both groups underwent blood transfusion and one patient in each group underwent Double-J stenting due to prolonged urinary drainage. None of the patients had major vessel and visceral organ injuries. Preoperative and postoperative findings are presented in Table 2.

Table 2. Comparision of intraoperative and postoperative variables in the two study groups			
Variables	Group 1 (Monoplanar)	Group 2 (Biplanar)	P value
Operation time, min (mean±SD)	64.3±21.7	61.8±27.4	0.494
Floroscopy screening time, min (mean±SD)	3.46±1.24	4.45±1.57	0.008
Puncture time (min)	1.06±0.26	2.02±0.45	0.041
Entrance calix, n (%)			
Lower	27 (71.1%)	25 (73.5%)	0.41
Middle	10 (26.3%)	8 (23.5%)	0.15
Upper	1 (2.6%)	1 (2.9%)	0.58
Stone-free rates (%)	30 (78.9%)	28 (82.3%)	0.87
Hemoglobin drop g/dl (mean±SD)	4.6±2.1	4.7±2.2	0.082
Hospital stay (day) (mean±SD)	3.2±1.2	3.4±1.3	0.87
Complications (n)	6 (15.8%)	5 (14.7%)	0.72
Grade I			
Fever	2 (5.2%)	1 (2.9%)	
Grade II			
Blood transfusion	1 (2.6%)	1 (2.9%)	
Urine leakage	1 (2.6%)	1 (2.9%)	
Urinary tract infection	1 (2.6%)	1 (2.9%)	
Grade III			
Double J placement	1 (2.6%)	1 (2.9%)	

p < 0.05 values are statistically significant;
SD=standard deviation; n: number

DISCUSSION

Percutaneous nephrolithotomy is a treatment modality used for the kidney stones larger than 2 cm, multiple kidney stones and staghorn stones. Thanks to technological advancements in medicine, PCNL has become a minimally invasive method preferred instead of open surgery in the treatment of kidney stones (14). This procedure is usually performed under general anesthesia. However, recent studies have described PCNL operations performed under epidural, intravenous sedation and local anesthesia (15).

Radiological imaging methods are needed for the creation of percutaneous tract. Fluoroscopy is generally used for this purpose. In appropriate cases, CT and magnetic resonance imaging (MRI) can also be benefited. Furthermore, USG or endoscopic methods have been used recently to protect the patient from radiation (16). Each technique has its own advantages and disadvantages. Fluoroscopy is the most commonly preferred method by urinary surgeons in PCNL procedures. Most of the urologists are familiar with the use of fluoroscopy; it demonstrates radiopaque stones clearly; opaque material can be used to detect stone localization and calyx to be entered; and it shows anatomical details very well. These are the most important advantages of fluoroscopy (16, 17). The greatest disadvantage is that both the patient and the surgical team are exposed to radiation. In USG-guided PCNL procedures, renal access success rates have been reported to be 88%-99%, whereas complication rates have been reported between 4-8% (17, 18). There is no radiation, the structure of the tissues between the kidney and the skin and the position of the surrounding organs can be clearly understood, and no contrast agent is required. These can be listed as the most important advantages of USG-guided renal access. In a study by Yan et al. (19), PCNL was performed for a total of 705 patients under the guidance of only USG and stone-free rates four weeks after PCNL surgery were reported as 92.6% for single kidney stones and 82.9% for staghorn and multiple stones. Kawahara et al. (20) reached the calyx through antegrade route via flexible ureteroscope (URS) and ensured a retrograde dilatation after the needle was exited through the skin via a penetrating wire. Another alternative is CT-guided access particularly for complex cases. This method may be particularly preferred for the following cases: patients with morbid obesity, splenomegaly or hepatomegaly, skeletal anomalies (e.g. scoliosis, kyphosis), patients with a history of major abdominal surgery, and those with minimal or no hydronephrosis (21).

Proper renal access from the right place is one of the most important steps of a successful PCNL surgery. Although the first renal access are usually performed by urologists as in our clinic, this procedure can also be performed by radiologists in some clinics. In a study by Watterson et al. (22), failed renal access with complications was reported to be seen at a rate of 27% when performed by radiologists, however, it decreased to 8% when performed by urologists. Similarly, stone-free rate has been reported to be 61% when the procedure is performed by radiologists and 86% when done by urologists (22). In a study by Tomaszewski et al. (12), complication rates were found to be the same in both groups whereas stone-free rates were significantly higher in the group in which renal access procedure was performed by urologists.

The selection of the most suitable tract is very important. The preferred approach is the posterior calyceal pathway. Posterior calyxes are usually directed towards the avascular space between the anterior and posterior branches of the renal artery (Brodel's bloodless line). An entry through the posterior calyx prevents injury to the large branches of the renal artery. Thus, major vascular structures surrounding the renal pelvis are avoided and trans-parenchymal access allows the catheter to stabilize in the proper position (23).

Given the literature, there are two techniques described for renal access under fluoroscopic guidance in PCNL surgeries. One of these techniques is the biplanar (eye of the needle) and the other is the triangulation technique (8). In the study by Abdallah et al. using a biological model, no significant difference was found between in the both techniques in terms of operative time. However, it was found that the mean fluoroscopy time was significantly lower in the biplanar technique (24). In another study comparing to these techniques, it was found that blood loss was significantly less in the triangulation technique. The authors thought that this difference was due to a better alignment of the access tract with the infundibulum. They found that no statistically significant difference between the groups in terms of hospitalization times, operative times and success rates (17).

In monoplanar technique, unlike biplanar method, C-arm device was turned to 90 degrees without giving 30 degree angle, so that the kidney was accessed. In the present study, we compared the outcomes of monoplanar and biplanar methods for the treatment of kidney stones with PCNL and found out that both techniques have comparable stone-free and complication rates. However, biplanar access was associated with increased scopy times and puncture times. This result was consistent with the findings of Dede et al. (25). In our study, SFRs were similar between groups (78.9 % vs 82.3 %, respectively). When complications were considered, there were no significant differences between two techniques. These findings were similar to studies by Dede et al. They found that these techniques had similar hospitalization times, operative times, stone-free and complication rates (25).

In another study conducted by Hatipoğlu et al. showed that monoplanar access technique was associated with decreased puncture time and minimized direct exposure of the surgeon to radiation, had high success rates (26). Similar to that study, we observed significant decrease in puncture time in monoplanar group.

Puncture time analysis was performed in various studies. One of these modified access techniques is described by Li et al (27). They compared a modified puncture technique and standard PNL, and the puncture times they attained were 7 and 17 min, respectively. In our study the mean puncture time in the monoplanar group was 1.06 min, which was shorter than in their study.

Studies comparing lateral floroscopic projections with anteroposterior projections show that the former exposes the patient and the operating room staff to radiation doses of three to seven times higher (28). The fluoroscopic projections at an angle of 30 degrees were not needed in the monoplanar method. In our study, when using the monoplanar technique, our average fluoroscopy screening time was significantly shorter than when we used the biplanar technique.

Major limitation of our study is its retrospective nature. Other limitations are the relatively low number of patients, being a single center experience and the control of residual stones with DUSG. Also, we did not compare of body mass index.

CONCLUSION

In conclusion, the SFRs in both monoplanar and biplanar techniques are high and complications are low. Monoplanar method is an effective and safe procedure for the treatment of renal stones, being considered as an alternative to biplanar technique in this lithiasic range. However, the prolonged scopy and puncture times are the main disadvantages of biplanar access technique. Further high-quality, multicenter randomized-controlled trials are needed to confirm our results.

Competing interests: The authors found that the conflict of interest did not fully coincide.

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Ethical approval: This study was approved by the Institutional Ethics Committee and conducted in compliance with the ethical principles according to the Declaration of Helsinki.

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