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Research

Simplified Triangulation Technique for Renal Access During Percutaneous Nephrolithotomy: Description of a Novel Technique

Perkütan Nefrolitotomi Sırasında Renal Erişim için Basitleştirilmiş Triangülasyon Tekniği: Yeni Bir Tekniğin Tanımı

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ABSTRACT

Objective: Determination of the correct point and angle of puncture is the first and most important step in percutaneous nephrolithotomy. In this study, we presented our first clinical results of a new fluoroscopy-guided triangulation puncture technique.

Methods: A total of 50 patients who met the inclusion criteria were evaluated retrospectively between January 2015 and December 2017. Preoperative and postoperative features, data on percutaneous renal access, success, and complication rates were examined.

Results: Of 50 patients who underwent percutaneous nephrolithotomy, the mean age was 39.9±11.8 years and the mean body mass index was 26±4 kg/m^2. The mean stone burden was 587.7±198.5 mm^2. The mean operation time was 74.3±15.6 min and the mean fluoroscopy time was 3.6±1.1 min. Intraoperative or postoperative complications were detected in 9 patients. On the 1st postoperative day, the stone-free rate was 80% and clinically insignificant residual fragment was 12%.

Conclusion: This technique provided the correct point and angle of puncture with minimal complication rates. However, further investigations and comparisons with other techniques should be conducted to examine the efficacy and reliability of this method in detail.

Keywords: Percutaneous nephrolithotomy, simplified triangulation technique, renal access, kidney stones

ÖZ

Amaç: Perkütan nefrolitotomide ilk ve en önemli adım, ponksiyon noktasının ve açısının doğru belirlenmesidir. Bu çalışmada, yeni bir floroskopi yardımlı triangülasyon ponksiyon tekniğinin ilk klinik sonuçlarını sunmayı amaçladık.

Gereç ve Yöntem: Ocak 2015 ile Aralık 2017 arasında dahil edilme kriterlerini karşılayan toplam 50 hasta retrospektif olarak değerlendirildi. Ameliyat öncesi ve sonrası özellikler, perkütan renal erişim verileri, başarı ve komplikasyon oranları incelendi.

Bulgular: Perkütan nefrolitotomi uygulanan 50 hastanın yaş ortalaması 39,9±11,8 yıl ve ortalama vücut kitle indeksi 26±4 kg/m^2 idi. Ortalama taş yükü 587,7±198,5 mm^2 idi. Ortalama operasyon süresi 74,3±15,6 dk ve ortalama floroskopi süresi 3,6±1,1 dk idi. Toplam 9 hastada intraoperatif veya postoperatif komplikasyon görüldü. Postoperatif 1. günde taşsızlık oranı %80 ve klinik olarak önemsiz rezidüel fragman %12 idi.

Sonuç: Bu teknik, minimum komplikasyon oranları ile doğru ponksiyon noktası ve açısını sağladı. Bununla birlikte, bu yöntemin etkinliğini ve güvenilirliğini ayrıntılı olarak incelemek için daha fazla araştırma ve diğer tekniklerle karşılaştırmalar yapılmalıdır.

Anahtar Kelimeler: Perkütan nefrolitotomi, basitleştirilmiş triangülasyon tekniği, renal erişim, böbrek taşları

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INTRODUCTION

The idea of percutaneous nephrolithotomy (PCNL) was first introduced in 1950 when a percutaneous needle was used for renal puncture for treating hydronephrosis (1). Percutaneous removal of kidney stones was first introduced in 1976 by Fernström and Johansson (2). Today, it is the gold standard treatment for kidney stones greater than 2 cm (3).

Percutaneous renal access is the most important step that affects the success and complication rate of the surgery (4,5). Various radiological modalities such as ultrasonography (USG) and computed tomography (CT) are used in clinical practice to provide access to the collecting system, but the most commonly used imaging technique is C-arm fluoroscopy. Fluoroscopy-guided percutaneous renal access can be achieved by monoplanar or biplanar techniques (triangulation, eyes of the needle/bull's eye) (6). However, all fluoroscopic approaches face the same limitation, which is the difficulty of the two-dimensional approach to the three-dimensional renal anatomy (7). Performing percutaneous renal access more systematically, which is the most challenging aspect of PCNL, can overcome these limitations and help shorten the learning curve and radiation exposure, especially for surgeons at the beginning of the learning curve.

In this study, we present our first results of a new fluoroscopy-guided triangulation puncture technique that we used in our clinic, with the aim to demonstrate the feasibility, efficacy, and reliability of this technique.

METHODS

After the approval of the University of Health Sciences Türkiye, Bakırköy Dr. Sadi Konuk Training and Research Hospital Ethics Committee (decision no: 2021-20-02, date: 18.10.2021), we analyzed patients with kidney stones greater than 2 cm or lower calyx stones smaller than 2 cm who underwent PCNL via modified triangulation technique between January 2015 and December 2017. Patients with non-opaque stones, horseshoe kidney, renal anomalies such as ectopic kidney, previous open or percutaneous surgery in the kidney scheduled for surgery, and those requiring multiple or intercostal/upper calyx access were excluded from the study. Written informed consent was obtained from all patients.

All patients underwent blood and urine laboratory tests before the surgical procedure. The stone burden was calculated by multiplying the longest diameter by the perpendicular diameter of the stone (mm^2) by plain radiography. The patients underwent preoperative CT and intravenous pyelography (IVP). The patients with sterile urine culture were administered cefuroxime axetil prophylaxis intravenously for 3 days, starting 1 h before the surgery. Those with proliferation in urine culture were given appropriate antibiotic treatment and underwent the process once the culture was negative. Treatment of patients who used anticoagulants was regulated.

Perioperative and postoperative variables, puncture time (PT), operative time (OT), fluoroscopy time (FT), hematocrit decrease, and stone-free rate (SFR) were determined. PT was defined as the time from the fluoroscopic imaging of the kidney until the time of urine discharge through the needle. Complications were classified according to the modified Clavien Grading System (8).

Plain radiography was performed on the first postoperative day. The nephrostomy tubes of the patients, who were evaluated as stone-free or having clinically insignificant residual fragment (CIRF), were sealed after a lighter urine color was obtained and were removed given that the patient did not feel any pain. An antegrade nephrostogram was performed on patients who were in pain to check that there were no blockages in the passage. CIRF was described as asymptomatic, non-obstructive, non-infectious stones smaller than 4 mm in diameter. All patients were evaluated with IVP 3 months after discharge.

Surgical Technique

The patients were placed in the lithotomy position under general anesthesia and standard 4-6 F ureteral catheters were inserted into the ipsilateral ureter with a 22 F cystoscope. Open-ended ureteral catheters were inserted in some cases, when necessary. 16 F Foley catheters were inserted. Then, the ureteral catheter was fixed to the urethral catheter and the patient was placed in the prone position. After the surgical site was cleaned with an antiseptic solution, a sterile surgical veil set was used to cover the patient, camera, and C-arm fluoroscopy.

Technique of Puncture

Fluoroscopy images were obtained by a C-arm. The C-arm was rotated to 0° from the standard vertical projection. The target stone was marked while nonopacified. The pelvicalyceal system was opacified by the administration of a diluted contrast agent through the ureter catheter. Air was injected in necessary cases to identify the lower pole posterior calyces. Once the lower pole posterior calyx was detected, the C-arm was used to mark the calyx as point A and a line parallel to the vertebra was drawn from this point (Figure 1). Then, the C-arm was rotated 30° toward the surgeon and the targeted calyx was marked as point B

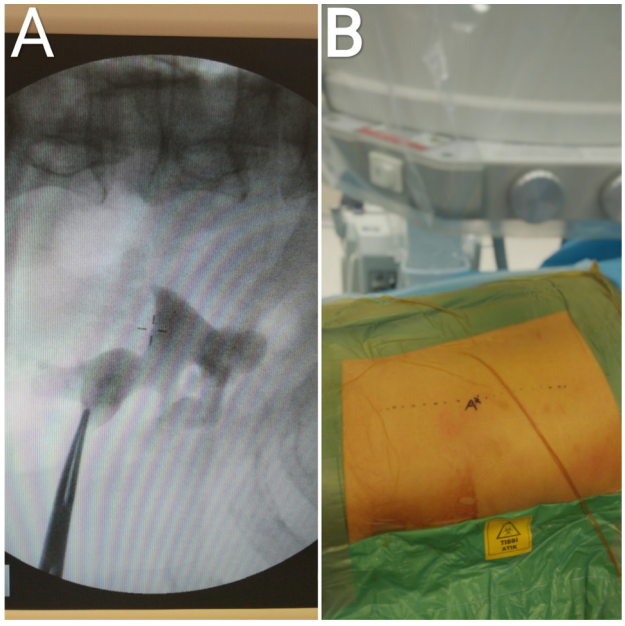

Figure 1. A) Fluoroscopic view of the renal calyceal system, opacified by contrast material, at an angle 0°. The targeted posterior calyx of the lower pole is marked using the tool. B) The targeted calyx is marked as point A, from which a line is drawn parallel to the vertebra

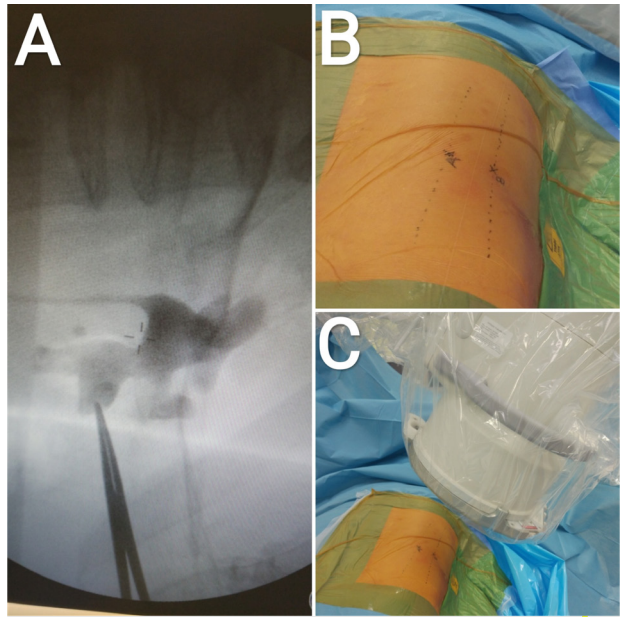

Figure 2. A) Fluoroscopic view of the renal calyceal system, opacified by contrast material, at an angle 30°. The targeted posterior calyx of the lower pole is marked using the tool. B) The targeted calyx is marked as point B, from which a line is drawn parallel to the vertebra. C) 30° fluoroscopic angle

and a line parallel to the vertebra was drawn from this point (Figure 2). The C-arm was rerotated to a position of 0°. The 18 G percutaneous needle was positioned at point A and from this point, the straight line was drawn according to the targeted caliceal direction until it intersected the B line. The point, where the line along the targeted calyx intersected the B line, was determined as the point of puncture (C) (Figure 3). While the C-arm was positioned at 0°, a 15-cm, 18 G two-part trocar needle (Percutaneous Access Needle, Boston Scientific, USA) was used to enter the target calyx. The C-arm was angled at 30° to confirm entry into the system when needed. A guidewire (Sensor TM Guide Wire, Boston Scientific, USA) was inserted into the pelvicalyceal system through the needle. After the tract was dilatated, a 30 F amplatz sheath (Boston Scientific, USA) was positioned. A 26 F rigid nephroscope was used. A pneumatic lithotripter (Vibrolith, Elmed, Türkiye) was used for stone fragmentation. The presence of residual stones was determined by fluoroscopy, endoscopy, and antegrade nephrostogram. The procedure was completed by placing a 14 F nephrostomy tube. Antegrade double J ureteral stents were placed in some cases, when necessary. The tubeless procedure was not performed in any cases.

Statistical Analysis

The demographic and operative data of the patients are presented as mean ± standard deviation. Statistical analysis was performed using the SPSS 13.0 software. The chi-square test was used to compare the ratios and a p-value less than 0.05 was accepted as statistically significant.

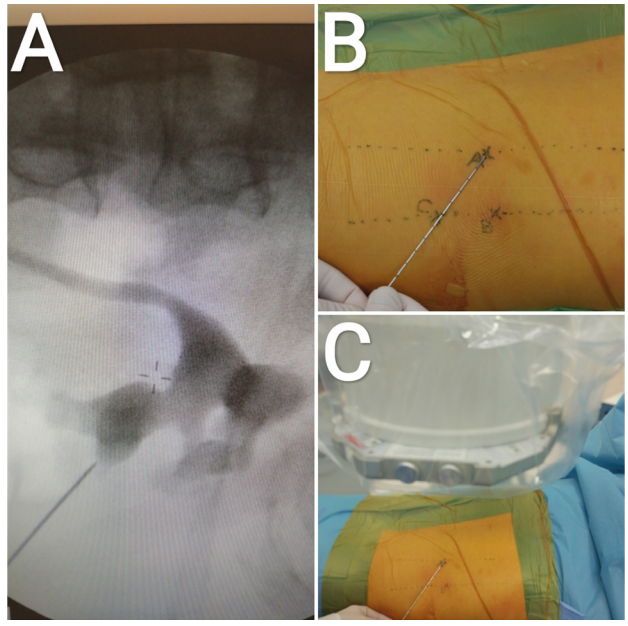

Figure 3. A) Fluoroscopic view of the renal calyceal system, opacified by contrast material, at an angle 0°. The needle is placed in accordance with the angle of the targeted lower pole of the posterior calyx. B) The point where the needle intersects the line drawn from point B is marked as point C (puncture point). C) 90° fluoroscopic angle

RESULTS

The mean age of the patients was 39.9±11.8 years. Twenty-nine patients (58%) were male and 21 (42%) were female.

The mean body mass index was 26±4 kg/m^2. Twenty-six of the stones were in the left kidney and 24 were in the right kidney. The mean stone burden was calculated as 587.7±198.5 mm^2.

All patients were operated using single access. The mean OT was 74.3±15.6 min. The mean PT and FT were determined as 1.6±0.7 and 3.6±1.1 min, respectively. The preoperative and postoperative hemoglobin, urea, and creatinine values were determined as 14.8±2.1 g/dL and 12.6±1.5 g/dL (p=0.0001), 28.1±4.3 mg/dL and 27.6±5.6 mg/dL (p=0.19), and 1±0.7 mg/dL and 1±0.5 mg/dL (p=0.442), respectively. The mean nephrostomy time and hospital stay were 2.2±0.9 and 2.4±0.8 days, respectively. On the 1st postoperative day, the SFR was 80% and CIRF was 12%. According to the modified Clavien classification, 6 (12%) patients had Clavien 1 (fever), 2 (4%) had Clavien 2 (blood transfusion) and 1 (2%) had Clavien 3 (urine leakage requiring double J stent) complications. The SFR was 90% and CIRF was 6% on the 3rd postoperative month. One patient underwent ureterorenoscopy and 1 patient received extracorporeal shock wave therapy as an additional treatment. The preoperative, intraoperative and postoperative data are shown in Table 1 and 2.

Table 1. Preoperative, intraoperative and postoperative data

Mean age (years; SD)	39.9±11.8
BMI (kg/m^2; SD)	26±4
Stone burden (mm^2 ; SD)	587.7±198.5
Hounsfield unit (mean; SD)	1000.9±260.9
Mean operation time (mn; SD)	74.3±15.6
Punction time (mn; SD)	1.6±0.7
Floroscopy time (mn; SD)	3.6±1.1
Stone-free rate (n; %)	
Postoperative day 1	40 (80%)
Postoperative 3rd month	45 (90%)
CIRF (n; %)	
Postoperative day 1	6 (12%)
Postoperative 3rd month	3 (6%)
Complications according to Clavien (n; %)	
Grade 1 (fever)	6 (12%)
Grade 2 (ERT)	2 (4%)
Grade 3 (urinary leakage)	1 (2%)
Total	9 (18%)
Nephrostomy time (day; SD)	2.2±0.9
Hospital stay (day; SD)	2.4±0.8

BMI: Body mass index, CIRF: Clinically insignificant residual fragment, ERT: Erythrocyte replacement therapy, SD: Standard deviation

Table 2. Preoperative and postoperative changes in laboratory parameters

	Preoperative	Postoperative	p
	Mean ± SD	Mean ± SD	
Hemoglobin (g/dL)	14.8±2.1	12.6±1.5	0.0001
BUN (mg/dL)	28.1±4.3	27.6±5.6	0.19
Creatinine (mg/dL)	1±0.7	1±0.5	0.442

BUN: Blood urea nitrogene, SD: Standard deviation

DISCUSSION

At present, many clinical approaches are used to perform renal puncture in PCNL. Appropriate access to the pelvicalyceal system is directly correlated with the success rate of the surgery and the occurrence of complications (6). Many of these techniques mostly include two-dimensional imaging techniques such as fluoroscopy and USG. Studies have shown that these two approaches have similar efficacy and complication rates (9-11). However, the USG approach has some additional advantages: it minimizes radiation exposure, allows imaging of structures between the skin and kidney, distinguishes the anterior and posterior calyxes (11). Despite these advantages of the USG approach, Clinical Research Office of the Endourological Society (CROES) data suggest that the most common fluoroscopic approach is used in PCNL (86.3%) (12).

The gold standard access technique has not yet been defined in PCNL. The ideal tract is the shortest, straight, the direct path along the axis of the calyx through the papilla into the desired calyx. The preferred approach is by way of a posterior calyx (13). The monoplanar and biplanar techniques are the two main techniques that are most frequently used. After detecting the appropriate calyx, Hatipoglu et al. (6) only used the technique of monoplanar access under fluoroscopy on a vertical plane only, where the needle was advanced at an angle of about 30° to the infundibula from a suitable puncture point. Monoplanar access has advantages such as reliability, shortening of PT, and minimizing direct exposure of the surgeon to radiation. However, it has some disadvantages, such as projecting the renal calyx on a vertical plane only and not giving accurate renal depth. However, biplanar access allows the determination of calyceal orientation and the selection of the optimal calyx of entry (14). Triangulation and bull's eye techniques are the major biplanar techniques for achieving appropriate percutaneous renal access (13,14). In the literature, alternative methods have also been defined

in addition to these frequently used access techniques. Cadeddu et al. (15) used a mechanical device they called "PAKY" to facilitate access. Lazarus and Williams (16) described a novel access technique using an apparatus called ''the locator". Li et al. (17) introduced the access technique of 'stereotactic localization'. Again; Bader et al. (18) introduced the access technique called 'all-seeing needle' using optical puncture; Basiri et al. (19,20) introduced the blind puncture and biplanar oblique access techniques and Shergill et al. (21) introduced the 3-finger technique to establish the correct depth. Mues et al. (4) reported that they successfully facilitated the access by rotating the C-arm approximately 30° towards the patient's head for the lower calyx access and rotating the C-arm approximately 20° towards the opposite side of the surgeon for the middle and upper calyceal access. In our study, we present the first results of our technique, which includes the combination of both monoplanar and biplanar techniques, thus providing the advantages of both punctures. The monoplanar access was primarily achieved; however, we used the 30° of angle to verify the depth and location in the calyceal system.

The primary purpose of PCNL is to achieve stone-free status and many studies have focused on SFR. SFR was determined as 68% in a study conducted by The British Association of Urological Surgeons, in which more than 1,000 PCNL cases were evaluated (22). In a prospective study of 1,338 patients conducted by Duvdevani et al. (23), SFR was found 89.1% at discharge, whereas it was found 75.7% in the latest CROES study of 5,803 patients (24). However, in general, the impact of the percutaneous renal access technique on SFR was not taken into considered. Moreover, Tepeler et al. (13) determined the SFR as 80% and 82.5%, respectively, in a study of 80 patients, in which the bull's eye and triangulation techniques were compared. Again, SFR was determined as 73.6% and 71.2%, respectively, in a study of 195 patients, in which Budak et al. (25) compared the bull's eye and triangulation techniques. In a study of 661 patients conducted by Dede et al. (5), patients undergoing monoplanar access were compared with those who underwent biplanar access. The SFR was determined as 79% and 82%, respectively. Again, in the study in which monoplanar access was defined, Hatipoglu et al. (6) determined the success rate on 1st postoperative day as 80.5%. In our study, SFR on 1st postoperative day was 80% and 90% on postoperative third month, which was consistent with the literature, and it was determined that the access technique we described was comparable with the other techniques.

In the literature, researchers have investigated PT and, more importantly, FT and factors that affect them in many studies. The major limitation of renal access under fluoroscopy is radiation exposure. Surgeons are exposed to direct radiation at 30° positions, especially in biplanar access (6). Li et al. (17) calculated the mean PT as 7 and 17 min, respectively, in a study comparing the access techniques of "stereotactic localization" and standard PCNL. In a study using the monoplanar technique, Hatipoglu et al. (6) determined PT as 0.83 min and FT as 4.36 min. Dede et al. (5) determined that monoplanar access leads to shorter PT and FT in a study, which they compared the monoplanar and biplanar access techniques. Tepeler et al. (13) calculated FT time as 3.9 and 3.7 min using the bull's eye and triangulation techniques, respectively. Again, in a study by Budak et al. (25), FT was determined as 2.5 and 2.4 min using the bull's eye and triangulation techniques, respectively. In our study, the mean PT was 1.6±0.7 min and the mean FT was 3.6±1.1 min. Although these values are consistent with the literature, the main component of our technique is the monoplanar access. We use the 30° angle in case of uncertainty for a very short time to verify the depth and location in the calyceal system. Therefore, we think that our method leads to relatively lower radiation exposure compared to biplanar techniques.

In the literature, complications and success rates in PCNL access techniques have been compared with each other in various studies. Tepeler et al. (13) demonstrated that the triangulation technique did not have any advantage except for lower blood loss compared to the bull's eye technique. Dede et al. (5) demonstrated that there was no significant difference in complications between the monoplanar and biplanar techniques. In our first experience with 50 patients, 9 patients (18%) presented with complications, only 1 (2%) of which were the Clavien 3 complication.

It has been proposed that PCNL, to fusion systems used in the prostate biopsy, should provide a 3D image of the kidney during access by combining preoperative CT or magnetic resonance imaging scans with the real-time USG. This technology, which is widely used in the prostate biopsy, can be very effective in PCNL. Additionally, a needle with an inexpensive camera attached will provide kidney access with projection in the future. However, considering the costs and accessibility of all these technological innovations, it is inevitable that fluoroscopy, USG, and their modifications will still be used as standard access techniques.

We believe that the method we have described is easy to understand and easily applicable, especially for surgeons at the beginning of the learning curve. Additionally, we believe that our technique is more systematic than the monoplanar access and the surgeon may be exposed to less radiation

than the biplanar access. Although our current results demonstrate the efficacy and reliability of the method, further studies are needed, including a greater patient population and the learning curve to verify these findings.

Our study has some limitations. The first limitation is the retrospective nature of this study. The second limitation is the limited number of patients due to our meticulousness in patient selection as it is a novel technique. The third one can be considered the absence of a control group. Another limitation is that this technique could not be used in more complex cases requiring multiple access, upper pole entry, or intercostal access.

CONCLUSION

This technique provided the correct point and angle of puncture with minimal complication rates. However, it is necessary that this technique be performed in a larger population and compared with other standard techniques such as the bull's eye, triangulation, and monoplanar techniques.

ETHICS

Ethics Committee Approval: The study protocol was approved by the University of Health Sciences Türkiye, Bakırköy Dr. Sadi Konuk Training and Research Hospital Ethics Committee (decision no: 2021-20-02, date: 18.10.2021).

Informed Consent: Written informed consent was obtained from all patients.

Authorship Contributions

Surgical and Medical Practices: İ.E., T.K., S.K., M.T., Concept: İ.E., K.G.Ş., S.K., M.T., Design: K.G.Ş., M.E., E.Ş., F.A., Data Collection or Processing: K.G.Ş., M.E., E.Ş., F.A., Analysis or Interpretation: İ.E., E.Ş., F.A., A.H., Literature Search: T.K., A.H., Writing: İ.E., M.E., E.Ş., T.K., A.H.

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