Original Article

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Safety and Efficacy of Bull's-Eye versus Triangulation Technique for Percutaneous Nephrolithotomy in Bangladesh

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ABSTRACT

Background: *Percutaneous Nephrolithotomy (PCNL) has underwent considerable evolution, which has been driven by advances in access techniques, instrumentation and endoscopic technology. Renal access can be achieved by ultrasonography, fluoroscopy and Computed Tomography guidance. Access under fluoroscopy can be achieved by 'Triangulation' or 'Eye of the needle' (Bull's eye) techniques. This study was conducted to evaluate the safety and efficacy of both these techniques.*

Materials and methods: *This quasi experimental study was conducted at the Department of Urology, Chittagong Medical College Hospital, Chattogram. A total 136 patients were selected with renal calculi (2-4cm), considering the inclusion and exclusion criteria. Among these, half of the patients were included in group A (Bull's-eye technique) and rest of the patients were in group B (Triangulation technique) using Simple random table. After proper counseling and written informed consent, all patients underwent PCNL under general anesthesia. On postoperative day 2, a plain X-ray was obtained to document stone clearance. Close follow up and recording was done to search for any complications. Stata (V.16) software was used for the analysis.*

Results: *The baseline characteristics (Age, sex, BMI, stone size and stone location) of the patients in group A and group B were almost similar. In the present study, stone free rate was 92.64% in group A and 91.18% in group B (p=0.75), statistically insignificant between groups according to stone size and stone location. Mean access time of group A was 1.69±0.49 mins and that of group B was 2.22±0.24 mins. The mean fluoroscopy time (Min) for access in group A was 1.00±0.26 mins and the that of group B was 1.47±0.56 mins. Both access time and fluoroscopy time for access were significantly lower in Bull's-eye techniques for PCNL (p<0.05). The mean total fluoroscopy time (Min) of group A was 4.80±0.58 mins and that of group B was 5.24±0.35 mins (p<0.05), which was statistically significant. In present study, mean total procedure time was 91.64±29.83 mins in group A and that was 96.09±31.39 min in group B, which was not statistically significant (p = 0.378). Mean hospital stay period in group A and group B were 3.57±0.82 days and 3.36±0.73 days respectively, which was not statistically significant (p=0.126).Perioperative complications were occurred in both groups, but no significant difference. Post-operative pain and analgesic requirements were almost similar.*

Conclusion: *'Bull's-eye' technique for renal access in PCNL is as fruitful as 'Triangulation' technique with potential advantages in terms of less access time and fluoroscopy time. Both access techniques were associated with similar operative times, hospitalization times and success and complication rates.*

Key words: Bull's-eye technique; Percutaneous nephrolithotomy; Triangulation technique.

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Introduction

Now a days, urinary tract stone accounts for the third largest number of Urological cases after urinary tract infection and prostate problems.[1] In earlier times, upper urinary tract stone had the same prevalence with bladder stone, but now the prevalence of upper urinary tract stone has increased significantly to 90%.[2] The lifetime prevalence of kidney stone disease is estimated up to 15%, varying according to age, gender, race, and geographic location.[3]

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Now-a-days in the management of renal stone, Extracorporeal Shock Wave Lithotripsy (ESWL), Retrograde Intrarenal Surgery (RIRS) and Percutaneous Nephrolithotomy (PCNL) have been used, instead of open surgery.[3] PCNL is the treatment of choice for renal calculi greater than 2 centimeters in diameter and also for smaller stones (10–20 mm) of the lower renal pole when unfavorable factors for ESWL exist according to the updated European Association of Urology (EAU) guidelines.[4]

Initially the procedure was done only in prone position and fluoroscopy guided. However, recently use of ultrasonography alone or along with fluoroscopy has been used for percutaneous renal access.[5] Various modifications in the position of patient have also been described to overcome some limitations and drawbacks of the percutaneous renal access in prone position.[6] Despite these changes, fluoroscopy guided access in prone position is still the most commonly used technique for PCNL.[7]

Optimal renal access is necessary for ensuring a successful and complication-free percutaneous nephrolithotomy. Antegrade fluoroscopy-guided percutaneous renal access in the prone position is commonly performed using either the Bull's eye technique or the Triangulation technique.[8] The correct angle and depth for puncture of the desired calyx is obtained by focusing the position of the tip of the needle and adjusting by using the Cs arm fluoroscopy in the antero-posterior and vertical direction (In the Bull's eye technique) and oblique direction (In the Triangulation technique).[7] The advantage of the triangulation technique over the Bulls-eye technique is that the needle cannot be passed too deeply due to continuous monitoring of depth of advancement. Also, this technique alone fulfills the five criteria of a successful puncture. The disadvantage of the triangulation technique is that, it is difficult to maintain at the same time both medio-lateral and cephalo-caudal planes. Because both are not being monitored simultaneously as in the 'Bulls-eye' technique. During using a C-arm fluoroscopy unit, Complex visual spatial skills are required, especially by the beginner. Multiple attempts along with excessive use of fluoroscopy are needed. This is also the aspect which has the steepest learning curve for a urologist getting trained in percutaneous nephrolithotomy. Usually, during the learning curve the problem comes in the assessment of depth with the C arm in the oblique position. Whether the needle is superficial or deep to the calyx has to be ascertained by the surgeon and adjustments made accordingly.[9] Complications associated with a faulty puncture include failure to complete the procedure, obtaining less than optimal access, bleeding, and injury to the surrounding structures.

In Bangladesh, due to recent advancement of endourology, PCNL is frequently done for retrieval of renal stone. Making a puncture is the first step in PCNL and can be described as the key step for any percutaneous procedure and the adequacy of the access directly influences the success and complication rates of this procedure. Two techniques are commonly used to insert the puncture needle into the collecting system, i.e. the Bull's eye technique and the Triangulation technique. The prime objective of the study is to evaluate the safety and efficacy of the both techniques.

Materials and methods

This quasi-experimental study was carried out at the Department of Urology, Chittagong Medical College Hospital, Chattogram, Bangladesh from April 2019 to April 2020.

A total of (68+68) 136 patients were selected with renal calculi, considering the inclusion and exclusion criteria. Among these, half of the patients were included in group A (Bull's-eye technique) and rest of the patients were in group B (Triangulation technique). based on random number table.

Aged 18 years or more and with normal renal function who provided consent to enter the study were selected by consecutive sampling method. Patients or attendants who denied formal consent, pregnant, patients with congenital anomalies (Pelvi-ureteric junction obstruction, bifid pelvis, megaureter, horseshoe kidney, etc.), associated distal ureteric or lower urinary tract stone or stricture, patients with single kidney, renal malformation., anatomical abnormality that hampers patient positioning, i.e., scoliosis., patients with history of previous open surgery and PCNL of that kidney were excluded from the study. A predesigned case record form was used for data collection. After proper counseling and a detailed explanation of the procedure, written informed consent was taken from all patients.

Prophylactic antibiotics (1g ceftriaxone) were given intravenously at the time of induction of anesthesia and continued for 2 days. Initially, on lithotomy position, a 6 Fr ureteric catheter was placed transurethrally over the guidewire under fluoroscopic guidance. Patient was placed in prone position with two pillows one under each flank. Pelvicalyceal system of the targeted kidney was opacified with diluted Iopamidol 370 (1:3) under fluoroscopy. Initial puncture was decided on retrograde pyelogram findings. Percutaneous access was created using an 18 G access needle into the selected calyx either by Bull's-eye or Triangulation technique. A guide wire was placed into the collecting system. The nephrostomy tract was dilated by gradual dilatation technique with metallic alkane dilators (Karl Storz) and a 28 Fr Amplatz sheath was positioned into the renal collecting system (Rusch Medical). The stone was disintegrated using pneumatic lithotripter (Karl Storz,

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model-27630020). Nephroscope (26 Fr, Karl Storz) with forceps was used to retrieve stones from calyces. Once complete clearance was confirmed fluoroscopically and endoscopically, a 6 Fr JJ stent was placed antegradely. On completing the procedure, the Amplatz sheath was removed after keeping a nephrostomy tube in situ. Intramuscular injection of pethidine was used as analgesics in immediate postoperative period according to .5 to 2 mg/kg body weight.

On postoperative day 1, Hb% was estimated. On postoperative day 2, a plain X-ray was obtained to document stone clearance. Nephrostomy tube was removed if the urine was not hemorrhagic and stone clearance achieved. The Foley's catheter was removed on 2nd postoperative day. The JJ stent was removed after 6 weeks. The nephrostomy tube was left in place, if a second PCNL session due to residual stones was planned. Re–PCNL, URS/RIRS and ESWL were considered as accessory treatment alternatives when indicated. Close follow up and recording was done to search for any complications encountered in immediate postoperative period. Any need for blood transfusion was recorded. Postoperative pain was measured using Numerical Rating Scale (NRS) for pain at 24 hours post-procedure. Patient was discharged with advices of X-ray KUB region after 3 weeks and advices for removal of JJ stent if no complication arises.

For data analysis, we utilized Stata (version 16; StataCorp, College Station, TX, USA). Using a histogram, a normal Q-Q plot, and the Kolmogorov-Smirnov test, the normality of continuous data were determined. Continuous variables were expressed as mean (± Standard deviation) and range (Minimum-maximum). Categorical variables were expressed as frequency (Percentages). Independent sample t test was used to test the mean differences of continuous variables between study groups. Chi-square test or Fisher's exact test were used to determine the association between two categorical variables. $p<0.05$ was considered as statistical significance. A two-tailed p-< 0.05 was regarded as statistically significant.

This study was approved by the Institutional Review Board (IRB) of Chittagong Medical College (Approval number: CMC/PG/2019/722).

Results

A total of 136 patients underwent Percutaneous Nephrolithotomy (PCNL) were included in the study. Table I shows both groups were comparable with age and sex distribution. Majority of the renal stones was found in the age range 28-37 years in group A and 48-57 years in group B. The mean age of Group A and Group B were 40.8±11.1 and 44.1±12.2 years respectively. The lowest and highest age in Group A was 18 and 64 years respectively and those in Group B were 21 and 64 years respectively. Age categories were almost homogenously distributed in both age groups (p=0.104). Moreover, groups were homogenously distributed irrespective of sex (p=0.35) and BMI (p=0.07) which were not statistically significant.

Table I Comparison of demographic characteristics between two groups of patients (n=136)

Variables (Unit)		Group A (n=68)	Group B (n=68)	p value
Age (Years)	18-27	12 (17.65%)	11 (16.18%)	
	28-37	25 (36.75%)	17 (25%)	0.104
	38-47	17 (25%)	14 (20.59%)	
	48-57	10 (14.72%)	22 (32.25%)	
	>57	4 (5.88%)	4 (5.88%)	
	Mean ±SD	40.8±11.1	44.1±12.2	0.712
Sex	Male	45 (66.18%)	50 (73.53%)	0.35
	Female	23(33.82%)	18(26.47%)	
BMI (Kg/m^2)	Mean ±SD	25.97±3.53	27.13±4.52	0.07

BMI: Body Mass Index. SD: Standard Deviation.

Data are expressed as frequency (Percentage) if not otherwise mentioned.

Stone characteristics with respect to their size and location of involvement are shown in Table II. Mean size of the stones were 3.0±0.6 cm in group A and the size of the stones were 2.9±0.4 cm in group B. Calculated p value was 0.103 which is not significant. Most of the stones were located in lower and middle calyx in both groups. Stone in different calyceal location was not statistically significant in between two groups.

Table II Comparison of preoperative stone characteristics between two groups of patients (n=136)

Variables (Unit)		Group A (n=68)	Group B (n=68)	pvalue
Stone size(cm)	2.0-3.0	35 (51.47%)	47 (69.12%)	0.103
	3.1-4.0	33 (48.53%)	21 (30.88%)	
	Mean ±SD	3.0±0.6	2.9±0.4	0.712
Stone Location	Upper calyx	6 (8.82%)	9 (13.23%)	0.167
	Middle calyx	18 (26.47%)	19 (27.94%)	
	Lower calyx	30 (20.3%)	23 (15.64%)	
	Pelvis	10 (14.71%)	12 (17.65%)	
	Partial staghorn	4 (2.72%)	5 (3.4%)	

Data are expressed as frequency (Percentage) if not otherwise mentioned.

Highest stone clearance was noted in lower calyceal and pelvic stone, whereas lowest stone clearance was

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noticed for upper calyceal stone in both groups. But stone clearance rate was not statistically significant between groups according to stone size and stone location.

Table III Stone clearance rate according to stone size and stone location

		Group A (n=68)		Group B (n=68)		p value
		Cleared	Clearance rate	Cleared	Clearance rate	
Stone size (cm)	2.0-3.0	33	94.28%	45	95.74%	0.76
	3.1-4.0	30	90.91%	17	80.95%	0.29
Stone location	Upper calyx	4	66.67%	6	66.67%	1.00
	Middle calyx	17	94.44%	17	89.47%	0.58
	Lower calyx	33	97.06%	27	96.43%	0.89
	Pelvis	9	90%	12	100%	0.26
Total clearance rate			92.64%		91.18%	0.75

Table IV shows that, mean access time (Min) of group A (n=68) was 1.69±0.49 mins and the mean access time (Min) of group B (n=68) was 2.22±0.24 mins. Access time were significantly lower in Bull's-eye techniques for PCNL ($p<0.001$). The mean fluoroscopy time of access (Min) of group A(n=68) was 1.00±0.26 mins and the mean fluoroscopy time of access (Min) of group B(n=68) was 1.47±0.56 mins. Fluoroscopy time of access were significantly lower in Bull's-eye techniques for PCNL ($p<0.001$). The mean procedure time (Min) of group A was 91.64±29.83 and the mean procedure time (Min) of group B was 96.09±31.39. Total procedure time was not significant between the groups. The mean total fluoroscopy time (Min) of group A was 4.80±0.58 mins and the mean total fluoroscopy time (Min) of group B was 5.24±0.35 mins. Fluoroscopy time was significantly lower in group A ($p<0.001$).

Table IV Comparison of per-operative outcome between two groups of patients (n=136)

Variables (Unit)	Group A(n=68)	Group B (n=68)	p value
Access time (Min) Mean ±SD	1.69±0.49	2.22±0.24	<0.001
Fluoroscopy time of access (Min) Mean ±SD	1.00±0.26	1.47±0.56	<0.001
Total procedure time (Min) Mean ±SD	91.64±29.83	96.09±31.39	0.378
Total fluoroscopy time (Min) Mean ±SD	4.80±0.58	5.24±0.35	<0.001

Figure 1 shows the complication in two groups. Fever was observed in 7.35% and 11.76% patients respectively in group A and group B. This difference in the fever incidences between groups were not statistically significant (p=0.382). Similar non-significant trends were observed for \sepsis, urine leakage and blood transfusion.

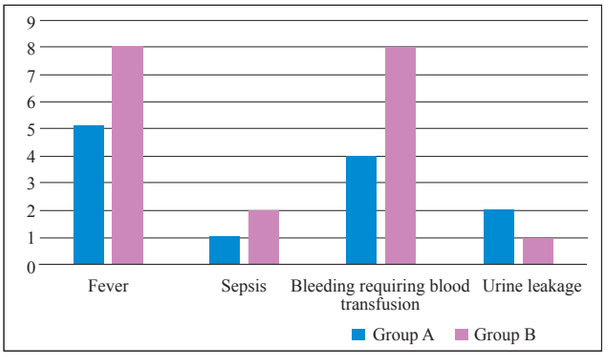

Figure 1 Comparison of complications between two groups (n=136)

Mean hemoglobin drop in group A was 1.00±0.38gm/dl and in group B was 0.90±0.43gm/dl. Pain intensity was measured by Numerical Rating Scale (NRS). On comparison to pain mean score of NRS was 6.65±0.96 and 6.79±1.01 in group A and group B, respectively. Mean Analgesic requirement (Inj. Pethidine) in group A was 67.64±10.52 mg and that of group B was 70.09±10.90 mg. Days in hospital in post-operative period in group A and group B were 3.57±0.82 and 3.36±0.73, respectively. Mean hemoglobin drop, difference of pain score, analgesic requirements and duration of hospital stay was not statistically significant between two groups (Table V).

Table V Comparison of post-operative outcome between two groups (n=136)

Variables	Group A(n=68)	Group B (n=68)	p value
Mean hemoglobin drop (gm/dl)	1.00±0.38	0.90±0.43	0.18
Mean pain in NAS	6.65±0.96	6.79±1.01	0.37
Mean pethidine requirement (mg)	67.64±10.52	70.09±10.90	0.23
Mean length of hospital stay (Days)	3.57±0.82	3.36±0.73	0.126

NRS : Numerical Rating Scale.

Discussion

Mean age ± SD of Group A was 40.8±11.1 (Range 18-64) and that of Group B was 39.45±11.14 (Range 21-64) years. Majority of the renal stones was found in the age range 28-37 years in group A and 48-57 years in group B. Age categories were almost homogenously distributed in both age groups. The age range of present study is comparable with the study done by Budak et al. in 195 patients who compared effects of renal access techniques on the stone-free rate of one-stage PCNL and the influence on outcomes.[10] Mean age of their study was 50.4 years and 47.4 years in 'Eye of the

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Needle' (EN) Technique and Triangulation Technique (TT) respectively. Tepeler et al. compared ''Triangulation'' and the ''Eye of the Needle'' techniques in terms of success and complication rates.[11] Mean age of their study was 46.9 ± 13.2 years and 44.1 ± 16.1 years in 'Eye of the Needle' (EN) Technique and Triangulation Technique (TT) respectively. In our study, the age group is much less in comparison to these studies, which may be due to geographical and racial variation of the people of Bangladesh.

Majority 45 (66.18%) patients were male in group A and 50 (73.53%) in group B. Male female ratio was 1.9:1 in group A and 2.78:1 in group B. Tepeler et al. studied on 80 patients with no statistically significant differences between the two groups in terms of male/female ratio.[11] In this study, this sex discrimination may be due to our female are less aware about their health and in our setting, facilities are limited to serve female patients in comparison to male.

In present study, access performed on lower pole, mid-pole, upper pole and pelvis in 34, 18, 6 and 10 patients in group A and 28, 19, 9 and 12 patients in group B. There was no statistically significant difference in terms of calyces that were targeted between the two groups, similar to Tepeler et al. (15, 8, 1 and 16 patients in group A and 17, 3, 3 and 17 patients in group B).[11] In this study, stone free rate was 92.64% in group A and 91.18% in group B (p=0.75). The success rate of stone clearance in a study conducted by Budak et al. was 73.6% with Bull's eye technique and 71.2% in triangulation technique.[10] Tepeler et al. found that overall stone free rate was 80% with Bull's eye technique and 82.5% in triangulation technique.[11] In both studies stone clearance were inferior to this study findings but in all studies there was no significant difference in either technique of renal access. In our setting, stone clearance were superior. This was may be due to use of plain x-ray rather than CT scan of KUB region. In plain X-ray, radiolucent stones are not visible and the resolution is not as distinct as CT scan.

In this study, mean access time of group A was 1.69±0.49 mins and the mean access time of group B was 2.22±0.24 mins. The mean fluoroscopy time (Min) for access in group A was 1.00±0.26 mins and the mean fluoroscopy time (Min) for access in group B was 1.47±0.56 mins. Both access time and fluoroscopy time for access was significantly lower in Bull's-eye techniques for PCNL (p<0.001). The mean total fluoroscopy time (Min) of group A was 4.80±0.58 mins and the mean total fluoroscopy time (Min) of group B was 5.24±0.35 mins. Fluoroscopy time was significantly lower in group A (p<0.001). Budak et al. suggested that the eye of the needle technique may be superior to triangulation technique in terms of fluoroscopic time, but the difference did not reach statistical significance in their study.[10,11] Tepeler et al. found no significant difference in terms of fluoroscopic screening time (p = 0.32) in either group.[11] Abdallah et al. reported that both techniques were associated with similar learning curves and that the TT was associated with a longer fluoroscopic screening time.[12] These findings are compatible to this research.

In present study, mean total procedure time was 91.64±29.83 mins in group A and that was 96.09±31.39 min in group B. The difference was not statistically significant (p= 0.378). Similar results were described by Tepeler et al. and Budak et al.[10,11] Tepeler et al. showed mean operation time was 67.4±22.9 mins and 64.8±29.7 mins in 'eye of the needle' technique and triangulation technique respectively (p=0.52).[11] In study done by Budak et al. found mean operation time was 100 mins and 102.5 mins in 'eye of the needle' technique and triangulation technique respectively (p=0.242).[10] The findings show much variation in both groups in comparison to Tepeler et al. but almost compatible with Budak et al. study [10,11]

In this present study, 5 patients in group A and 8 patients in group B developed fever (p=0.382), one patient in group A and 2 patients in group B developed sepsis (p=0.559). All of these patients were treated successfully by antibiotics and supportive care. Urine leakage through the nephrostomy tube site was seen in 2 patients in group A and one patient in group B (p=0.559), which stopped spontaneously after 48 hours. To compensate excessive per operative bleeding, blood transfusion was required in 4 patients in group A and 8 patients in group B (p=0.227). No patient required any intervention or any other procedures to treat complications. Tepeler et al. found that the complication rate was somewhat higher in the bull's eye technique group but the difference was not statistically significant.[11] They showed 2 patients developed fever, 2 patients required blood transfusion, 1 patient developed urinary leakage and 1 patient had urosepsis in bull's eye technique group while 1 patient developed fever, 2 patients required blood transfusion, 1 patient developed urinary leakage in triangulation technique. Similar to other studies, this study could not show any significant difference between the groups in terms of complications.

Mean hospital stay period in group A and group B were 3.57±0.82 days and 3.36±0.73 days respectively which was not statistically significant (p=0.126). Both Tepeler et al. and Budak et al. also found no significant difference in length of hospital stay between Bull's-eye technique and triangulation technique for PCNL (p=0.978 and p=0.26 respectively).[10,11]

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Limitation

One of the major limitations of the present study was its non-randomize design and small sample size. Patients were selected from a single center and it is only generalizable to those who present to a hospital for care. Access attempts were not considered.

Conclusion

In conclusion, the present study has demonstrated that, 'Bull's-eye' technique for renal access in PCNL is as efficacious as 'Triangulation' technique with potential advantages in terms of less access time and fluoroscopy time. Both access techniques were associated with similar operative times, hospitalization times, analgesics requirement, stone clearance rates and complication rates. So, as per the result of this study, the choice of access for PCNL can be allowed on operating surgeon.

Recomendation

Large scale multi center study with proper randomization is needed.

Disclosure

All the authors declared no competing interests.

References

1. McAninch JW, Lue TF. Smith & Tanagho's General Urology. 19th ed. McGraw Hill. 2020.

2. Antonelli JA, Beardsley H, Faddegon S, Morgan MSC, Gahan JC, Pearle MS et al. A Novel Device to Prevent Stone Fragment Migration During Percutaneous Lithotripsy: Results from an In Vitro Kidney Model. J Endourol. 2016;30(11):1239–1243.
https://pubmed.ncbi.nlm.nih.gov/27758111/.

3. Rahman M, Monowar-Ul-Hoque M, Mohammad K, Karim M, Bari AA, Asad A et al. Miniaturization of PCNL; Necessity or What? Bangladesh Journal of Urology. 2020;23(1):11–16.
https://www.banglajol.info/index.php/BJU/article/view/50283.

4. Türk C, Pet ík A, Sarica K, Seitz C, Skolarikos A, Straub M et al. EAU Guidelines on Interventional Treatment for Urolithiasis. Eur Urol. 2016;69(3):475–482.
https://pubmed.ncbi.nlm.nih.gov/26344917/.

5. Corrales M, Doizi S, Barghouthy Y, Kamkoum H, Somani B, Traxer O. Ultrasound or Fluoroscopy for Percutaneous Nephrolithotomy Access, Is There Really a Difference? A Review of Literature. J Endourol. 2021;35(3):241–248.
https://pubmed.ncbi.nlm.nih.gov/32762266/.

6. Patel RM, Okhunov Z, Clayman R v., Landman J. Prone Versus Supine Percutaneous Nephrolithotomy: What Is Your Position? Curr Urol Rep. 2017;18(4).
https://pubmed.ncbi.nlm.nih.gov/28247328/.

7. Sharma G, Sharma A. Determining the angle and depth of puncture for fluoroscopy-guided percutaneous renal access in the prone position. Indian Journal of Urology. 2015;31(1):38.
https://www.indianjurol.com/article.asp?issn=0970-1591.

8. Chowdhury P, Nayak P, David D, Mallick S. Mini access guide to simplify calyceal access during percutaneous nephrolithotomy: A novel device. Indian J Urol. 2017;33(4):319–322.
https://pubmed.ncbi.nlm.nih.gov/29021658/.

9. Sharma GR, Maheshwari PN, Sharma AG, Maheshwari RP, Heda RS, Maheshwari SP. Fluoroscopy guided percutaneous renal access in prone position. World Journal of Clinical Cases : WJCC. 2015;3(3):245.
https: //pmc/articles/PMC4360496/.

10. Budak S, Yucel C, Kisa E, Kozacioglu Z. Comparison of two different renal access techniques in one-stage percutaneous nephrolithotomy: triangulation versus "eye of the needle." Ann Saudi Med 2018;38(3):189.
https: //pmc/articles/PMC6074309/.

11. Tepeler A, Arma an A, Akman T, Polat EC, Ersöz C, Topakta R et al. Impact of percutaneous renal access technique on outcomes of percutaneous nephrolithotomy. J Endourol. 2012;26(7):828–833.
https://pubmed.ncbi.nlm.nih.gov/22283962/.

12. Abdallah MM, Salem SM, Badreldin MR, Gamaleldin AA. The use of a biological model for comparing two techniques of fluoroscopy-guided percutaneous puncture: A randomised cross-over study. Arab J Urol. 2013;11(1):79.
https: //pmc/articles/PMC4442951/.