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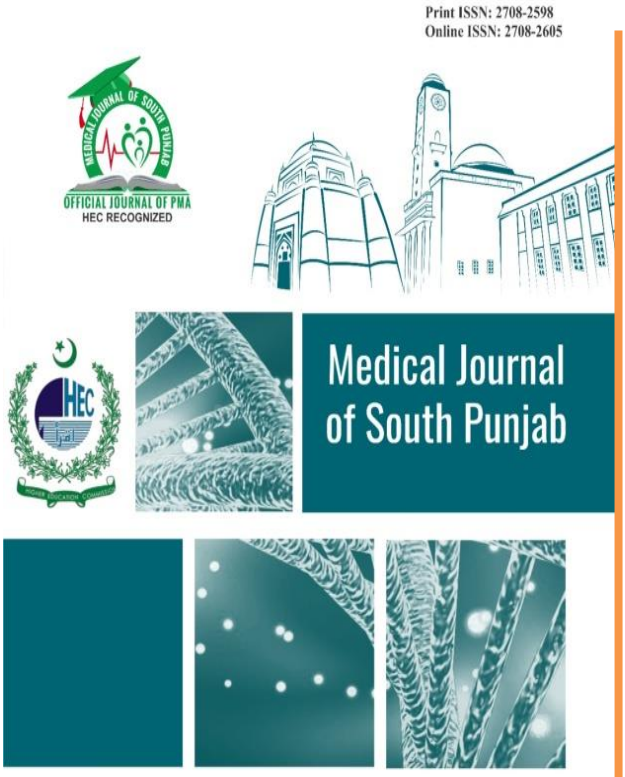

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Original Article

Comparative study of upper pole versus lower pole approach in percutaneous nephrolithotomy for renal pelvis stone clearance

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ABSTRACT

Objective: To compare stone clearance after upper pole and lower pole PCNL and to compare operative duration and complications between the two approaches.

Methods: This randomized controlled trial was conducted at the Department of Urology, Multan Institute of Kidney Diseases, Multan, from January 21, 2025 to July 20, 2025. A total of 202 patients aged 18-60 years with renal pelvis stones measuring 2.0-3.0 cm were randomized into upper pole PCNL (n=101) and lower pole PCNL (n=101) groups. Stone clearance was assessed by CT urography on postoperative day 3. Duration of operation, persistent gross hematuria, and hydropneumothorax were recorded.

Results: Mean age was 40.74±9.58 years. Stone clearance was significantly higher in the upper pole group than in the lower pole group [96 (95.0%) vs 80 (79.2%), p=0.002]. Mean operative duration was longer in the upper pole group (75.59±8.77 vs 70.39±8.12 minutes, p<0.001). Persistent gross hematuria occurred in 10 (9.9%) versus 5 (5.0%) patients (p=0.283), while hydropneumothorax occurred in 4 (4.0%) versus 1 (1.0%) patients (p=0.369).

Conclusion: Upper pole PCNL achieved better stone clearance than lower pole PCNL, although it required longer operative time. Complication rates were comparable between groups.

Keywords: Percutaneous nephrolithotomy, upper pole, lower pole, renal pelvis stone, stone clearance.

1. INTRODUCTION

Kidney stone disease is a common and increasingly important urological problem worldwide. The burden of nephrolithiasis continues to rise and is associated with recurrent pain, infection, repeated hospital visits, and financial cost. Geography, climate, dietary habits, obesity, and metabolic risk factors all influence disease occurrence, making stone disease especially relevant in South Asian stone-belt populations[1].

For renal stones larger than 2 cm, percutaneous nephrolithotomy (PCNL) remains the recommended first-line treatment because it offers high stone-free rates and can manage a larger stone burden in a single session[2,3]. Technical refinements in tract design, optics, energy sources, and miniaturized systems have further improved safety and broadened its use[4-6]. Even so, successful clearance after PCNL still depends on stone size, location, anatomy, and, importantly, the quality and direction of calyceal access[7].

Recent evidence highlights the importance of access planning. In a Pakistani series of 422 procedures, the overall stone-free rate after PCNL was 75.82%, and lower calyceal stones and larger stone size were linked with residual fragments[8]. Ayub et al. reported high clearance with both supracostal and subcostal access (93.8% vs 90.6%), emphasizing that tract selection can influence efficacy and morbidity[9]. Ozgur et al. also identified larger stone size and volume as predictors of residual stones after PCNL[10].

Despite the established role of PCNL, the optimal calyceal approach for renal pelvis stone clearance remains insufficiently defined in our local setting. Because upper and lower pole access differ in tract orientation, ease of entry into the renal pelvis, and potential complication profile, determining the more effective route may improve stone clearance while preserving safety. Therefore, this study compared upper pole and lower pole PCNL in patients with renal pelvis stones.

2. METHODOLOGY

This randomized controlled trial was conducted at the Department of Urology, Multan Institute of Kidney Diseases, Multan, over six months after approval by the College of Physicians and Surgeons Pakistan and the institutional ethical review committee (CPSP/REU/URO-2023-346-1652; January 21, 2025). The study ran from January 21, 2025 to July 20, 2025. Sample size was calculated with the W.H.O. Sample Size Calculator using a 95% confidence level, 10% absolute precision, and expected stone clearance rates of 96.8% for upper polar PCNL and 85.7% for lower polar PCNL, yielding 202 patients (101 in each group)[11]. Eligible patients were enrolled consecutively and randomized by a computer-generated number method.

Patients aged 18-60 years of either gender with renal pelvis stones measuring 2.0-3.0 cm were included. Patients were excluded if they had pelviureteric junction obstruction, ureteric stones, solitary functioning kidney, previous open surgery on the ipsilateral kidney, retro-renal colon, untreated urinary tract infection, bleeding diathesis or recent anticoagulant use, chronic kidney disease, chronic liver disease, severe chronic obstructive pulmonary disease, congestive cardiac failure, or pregnancy.

After written informed consent, baseline variables including age, gender, body mass index, kidney involved, and stone size were recorded on a structured proforma. Group A underwent upper polar PCNL and Group B underwent lower polar PCNL. All procedures were performed under general anesthesia by a consultant urologist with more than five years of post-fellowship experience. After cystoscopy and ureteric catheterization, patients were placed supine. Pelvicalyceal anatomy was outlined with retrograde pyelography under fluoroscopy, and the selected calyx was punctured according to

group allocation. The tract was dilated over a guidewire using Amplatz dilators, and a 26 Fr Amplatz sheath was placed. A 24 Fr nephroscope was used for visualization. Stones were fragmented with a pneumatic lithotripter, fragments were removed with triradiate forceps, and a 6 Fr Double-J stent was inserted after endoscopic and fluoroscopic confirmation of clearance.

Operative duration was recorded by an observer blinded to study details. Postoperatively, patients were managed according to institutional protocol, and persistent gross hematuria and hydropneumothorax were documented. CT urography on postoperative day 3 assessed stone clearance. Data were analyzed in SPSS version 26.0. Continuous variables were summarized as mean±SD or median with interquartile range, and categorical variables as frequency and percentage. Chi-square test was used for categorical outcomes, and independent-sample t test for duration of operation. A p-value ≤0.05 was considered significant.

3. RESULTS

Baseline demographic and clinical characteristics are shown in Table 1. Mean age was 39.56±9.82 years in the upper pole group and 41.92±9.23 years in the lower pole group. Mean body mass index was 25.83±3.04 and 25.89±3.43 kg/m², while mean stone size was 2.45±0.22 and 2.56±0.22 cm, respectively. A male comprised 68.3% of the sample, 54.0% of patients were from rural areas, and kidney laterality was nearly balanced.

Table-1: Baseline demographic and clinical characteristics of patients undergoing upper pole versus lower pole PCNL (n=202)

Variables	Upper pole PCNL (n=101)	Lower pole PCNL (n=101)	Total (n=202)
Age (years), mean ± SD	39.56 ± 9.82	41.92 ± 9.23	40.74 ± 9.58
Body mass index (kg/m²), mean ± SD	25.83 ± 3.04	25.89 ± 3.43	25.86 ± 3.23
Stone size (cm), mean ± SD	2.45 ± 0.22	2.56 ± 0.22	2.51 ± 0.23
Gender			
Male	70 (69.3%)	68 (67.3%)	138 (68.3%)
Female	31 (30.7%)	33 (32.7%)	64 (31.7%)
Place of residence			
Rural	55 (54.5%)	54 (53.5%)	109 (54.0%)
Urban	46 (45.5%)	47 (46.5%)	93 (46.0%)
Kidney involved			
Right	49 (48.5%)	53 (52.5%)	102 (50.5%)
Left	52 (51.5%)	48 (47.5%)	100 (49.5%)

Stone clearance was significantly higher in the upper pole group than in the lower pole group [96 (95.0%) vs 80 (79.2%), p=0.002]. Mean operative duration was also higher with upper pole access (75.59±8.77 vs 70.39±8.12 minutes, p<0.001). Persistent gross hematuria occurred in 10 (9.9%) versus 5 (5.0%) patients, and hydropneumothorax in 4 (4.0%) versus 1 (1.0%) patient; neither difference was statistically significant (Table 2).

Table-2: Comparison of outcomes between upper pole and lower pole PCNL groups (n=202)

Variables	Upper pole PCNL (n=101)	Lower pole PCNL (n=101)	Total (n=202)	p-value
Stone clearance				
Yes	96 (95.0%)	80 (79.2%)	176 (87.1%)	0.002
No	5 (5.0%)	21 (20.8%)	26 (12.9%)	
Duration of operation (minutes), mean ± SD	75.59 ± 8.77	70.39 ± 8.12	72.99 ± 8.80	<0.001
Persistent gross hematuria				
Yes	10 (9.9%)	5 (5.0%)	15 (7.4%)	0.283
No	91 (90.1%)	96 (95.0%)	187 (92.6%)	
Hydropneumothorax				
Yes	4 (4.0%)	1 (1.0%)	5 (2.5%)	0.369
No	97 (96.0%)	100 (99.0%)	197 (97.5%)	

Stratified analysis showed consistently higher stone clearance with upper pole access, reaching significance in patients aged 40-60 years, in both sexes, in rural

residents, in patients with body mass index ≥25 kg/m², in stones measuring 2.6-3.0 cm, and in right-sided stones (Table 3).

Table-3: Stratified comparison of stone clearance between upper pole and lower pole PCNL groups (n=202)

Stratification variable	Upper pole PCNL Stone clearance Yes n (%)	Upper pole PCNL Stone clearance No n (%)	Lower pole PCNL Stone clearance Yes n (%)	Lower pole PCNL Stone clearance No n (%)	p-value
Age group					
18–39 years (n=92)	49 (94.2%)	3 (5.8%)	32 (80.0%)	8 (20.0%)	0.052
40–60 years (n=110)	47 (95.9%)	2 (4.1%)	48 (78.7%)	13 (21.3%)	0.009
Gender					
Male (n=138)	66 (94.3%)	4 (5.7%)	55 (80.9%)	13 (19.1%)	0.017
Female (n=64)	30 (96.8%)	1 (3.2%)	25 (75.8%)	8 (24.2%)	0.027
Place of residence					
Rural (n=109)	54 (98.2%)	1 (1.8%)	44 (81.5%)	10 (18.5%)	0.004
Urban (n=93)	42 (91.3%)	4 (8.7%)	36 (76.6%)	11 (23.4%)	0.054
BMI group					
<25.0 kg/m² (n=72)	35 (100.0%)	0 (0.0%)	32 (86.5%)	5 (13.5%)	0.054
≥25.0 kg/m² (n=130)	61 (92.4%)	5 (7.6%)	48 (75.0%)	16 (25.0%)	0.007
Stone size group					
2.0–2.5 cm (n=100)	59 (98.3%)	1 (1.7%)	36 (90.0%)	4 (10.0%)	0.154
2.6–3.0 cm (n=102)	37 (90.2%)	4 (9.8%)	44 (72.1%)	17 (27.9%)	0.027
Kidney involved					
Right (n=102)	47 (95.9%)	2 (4.1%)	38 (71.7%)	15 (28.3%)	0.001
Left (n=100)	49 (94.2%)	3 (5.8%)	42 (87.5%)	6 (12.5%)	0.305

4. DISCUSSION

In this study, upper pole PCNL produced a significantly higher stone clearance rate than lower pole PCNL (95.0% vs 79.2%), although operative time was longer with upper pole access. The higher clearance is clinically plausible because the superior calyx often provides a straighter tract to the renal pelvis and better alignment with the long axis of the collecting system, allowing easier nephroscope passage, more efficient fragment retrieval, and less intrarenal torque. Our findings are close to those of Amaresh et al[11], who reported complete clearance in 96.8% of superior-access cases and 85.7% of inferior-access cases. Memon et al[12] reported the opposite pattern, with complete clearance of 74.1% in the upper calyceal group and 81.6% in the lower calyceal group. In contrast, Mazumder et al[13] found success rates of 89.5% and 75.7%, Karki and Bhusal[14] reported clearance of 91.3% and 75.0%, and Mishra et al[15] observed rates of 86.96% and 75.93% for upper and lower access, respectively. These differences probably reflect variation in stone burden, case selection, access planning, and surgeon experience.

The longer operative time seen in our upper pole group differs from Amaresh et al[11], who found shorter operating time with superior access, and from Karki and Bhusal[14] and Mishra et al[15], who reported either slightly shorter or nearly identical durations between groups. A likely explanation is that although upper pole access can simplify intrarenal manipulation after tract creation, puncture of a more cephalad calyx may require slower and more cautious fluoroscopic guidance to reduce the risk of pleural injury. In our series, that additional care may have increased total operative time despite the higher stone clearance.

Safety outcomes in our study were acceptable. Persistent gross hematuria and hydropneumothorax were more frequent with upper pole access, but the differences were not statistically significant. Kunwar et al[16], in 101 supracostal PCNL cases, reported pleural injury in 2.97% and hydrothorax requiring chest tube in one patient. Ali et al[17] reported an overall complication rate of 2% in 399 PCNL procedures, with hydrothorax occurring predominantly after upper pole puncture. Mazumder et al[13] observed thoracic complications in two upper-access cases, whereas transfusion-requiring bleeding occurred in three upper-access and five lower-access cases. Karki and Bhusal[14] also found a higher rate of thoracic complications with upper puncture than lower puncture (30.4% vs 6.8%). Together, these studies support the view that upper pole access can improve efficacy but requires careful tract planning and postoperative vigilance for thoracic events.

Meta-analytic evidence is not completely uniform. Ma et al[18] showed that superior calyceal access was associated with fewer failed clearances (OR 0.64, 95% CI 0.47-0.88), fewer additional punctures (OR 0.35, 95% CI 0.24-0.51), and shorter operative time. Huang et al[19], however, found no significant difference in pooled stone-free rate between upper pole and other pole single-puncture PCNL (OR 1.38, 95% CI 0.94-2.03; p=0.22).

Broader complication data reported by Singh et al[20] showed an overall PCNL complication rate of 21.9%, with hematuria among the common early postoperative events and higher morbidity in patients with larger stone burden, longer operative time, staghorn stones, and multiple punctures.

5. CONCLUSION

Upper pole PCNL achieved better stone clearance than lower pole PCNL, although it required longer operative time. Complication rates were comparable between groups.

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