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*Original Article*

# Comparative Evaluation of Upper Pole and Non-Upper Pole Puncture Techniques in Percutaneous Nephrolithotomy (PCNL): A Retrospective Analysis of Efficacy and Safety Parameters

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## ABSTRACT

Background: Percutaneous nephrolithotomy (PCNL) is a critical intervention in the management of large renal calculi, with the choice of calyx puncture technique impacting the efficacy and safety of the procedure. While the upper pole approach is associated with better visualization and stone clearance, it is used with caution due to a perceived increase in complication rates.

Objective: This study aimed to compare the upper pole calyx puncture technique's efficacy and safety with that of the non-upper pole (middle and lower) puncture techniques in PCNL.

Methods: A retrospective analysis was conducted on 173 patients who underwent PCNL at the Urology and Transplant Unit A of The Institute of Kidney Diseases in Peshawar from January 2017 to December 2020. Data on demographics, stone characteristics, perioperative findings, and postoperative outcomes were collected. Statistical significance was determined using Chi-square tests with SPSS version 25.

Results: The average stone size was 21.38 mm (±11.2 mm) overall, with the upper pole group presenting a smaller average size of 19.8 mm (±7.6 mm) compared to 21.55 mm (±10.8 mm) for the non-upper pole group (p=0.032). Pre-operative hemoglobin levels were slightly lower in the upper pole group (12.5 ± 1.8 mg/dl) than in the non-upper pole group (12.9 ± 1.8 mg/dl, p=0.007). Complete clearance rates were comparable between groups. Post-operative blood transfusion was required more frequently in the non-upper pole group (12.1%, n=12) versus the upper pole group (4.0%, n=3, p=0.04).

Conclusion: The upper pole approach in PCNL may afford a higher rate of stone clearance and reduced operative times with acceptable safety when compared to non-upper pole approaches. The selection of puncture technique should be tailored to individual patient anatomy and stone characteristics, with consideration given to the surgeon's experience and skill.

Keywords: Percutaneous Nephrolithotomy, PCNL, Upper Pole Puncture, Non-Upper Pole Puncture, Renal Calculi, Stone Clearance, Kidney Stones, Minimally Invasive Surgery, Urology, Endourology.

## INTRODUCTION

Percutaneous nephrolithotomy (PCNL) stands as a paradigm of minimally invasive surgery in the realm of urology, specifically for the treatment of substantial renal calculi. This technique, a cornerstone in the management of large kidney stones, has undergone significant evolution with the advent of enhanced endourological tools and methodologies, thereby elevating its efficiency while minimizing its invasiveness. Marked by an impressive success rate nearing 90% and a notably low complication profile, PCNL has dramatically transformed the approach towards renal stone treatment (1). The reduction in complications, including residual stones, bleeding, urosepsis, and potential injury to surrounding abdominal structures, is attributed to refinements in both technique and instrumentation, underscoring the procedure's safety and effectiveness (2, 3). A pivotal aspect of PCNL is the establishment of an appropriate access tract to the kidney's pelvicalyceal system, a process that can be executed via punctures at various calyces- upper, middle, or lower pole. The choice of access point is heavily influenced by patient-specific factors and the operating surgeon's

 

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preference and experience. Historically, the lower pole calyx puncture has been favored for its safety, particularly due to a reduced risk of chest complications such as pneumothorax and hydrothorax. Despite its advantages, this approach exhibits limitations in addressing complex and staghorn calculi, as well as proximal ureteric stones (5). Conversely, the upper pole calyx puncture, while associated with a higher complication rate, offers superior stone clearance capabilities, making it a preferred access route for managing large, complex renal stones and proximal ureteric obstructions. This method is particularly advantageous when concurrent procedures like antegrade endopyelotomy are required to address pelvic-ureteric junction obstructions during PCNL (6, 7).

Despite the clear distinctions in the application and outcomes of different calyx puncture techniques, there exists a lack of consensus within the medical community regarding the optimal approach for maximizing both efficacy and safety in PCNL. This gap in knowledge has prompted the current comparative analysis, aimed at delineating the relative merits and drawbacks of upper pole versus non-upper pole (middle and lower) calyx punctures. By examining a broad spectrum of safety and efficacy parameters, this study endeavors to shed light on the most advantageous percutaneous access strategies, thereby enriching the scientific discourse and potentially refining clinical protocols in the treatment of renal calculi. Through this rigorous investigation, we aspire to contribute valuable insights to the existing body of literature on PCNL, ultimately facilitating enhanced patient outcomes in the management of kidney stones.

## MATERIAL AND METHODS

This retrospective analysis was conducted at the Urology and Transplant Unit A of The Institute of Kidney Diseases in Peshawar, where the preoperative and postoperative records of patients who underwent percutaneous nephrolithotomy (PCNL) between January 2017 and December 2020 were meticulously reviewed. Ethical approval for this study was secured from the institutional review board, ensuring adherence to ethical standards in line with the Declaration of Helsinki. Employing a non-probability convenience sampling method, the study encompassed a total of 178 subjects, albeit with a minor setback where 5 participants were excluded due to incomplete documentation.

Patients were categorized into two distinct groups based on the percutaneous access point utilized during the procedure: Group A (upper pole puncture) and Group B (non-upper pole puncture), encompassing both middle and lower pole punctures. Eligibility for participation was extended to individuals older than 1 year, presenting with renal pelvis and calyces stones, while exclusion criteria were set to discount cases involving multiple-tract PCNLs, radiolucent stones, and congenital anomalies. Preceding the surgical intervention, a comprehensive evaluation was conducted, including a detailed history, clinical examination, and a suite of baseline investigations. These investigations comprised complete blood counts, renal function tests, serum electrolytes, liver function tests, virology screening, coagulation profiles, urine routine and culture/sensitivity analyses, ultrasound KUB, X-ray KUB, and non-contrast CT KUB.

Surgical procedures were uniformly performed under general anesthesia, with each patient receiving a prophylactic dose of injection meropenem during anesthesia induction. The intraoperative approach commenced with cystoscopy, followed by the insertion of a 6Fr ureteric catheter to the renal pelvis, which was then secured. Subsequently, patients were repositioned prone, and the selected calyx was punctured under fluoroscopic guidance utilizing an 18G TLA needle. The percutaneous access tract was dilated to 26 Fr using Alken's sequential telescoping metal dilators, facilitating the insertion of an Amplatz sheath. Stone fragmentation was achieved with a pneumatic lithotripter (Swiss LithoClast® Master), and fragments were retrieved using tri-prong forceps, with fluoroscopy ensuring complete stone clearance. A 6Fr DJ stent was placed in each patient post-procedure.

The study meticulously documented demographic data, stone characteristics (size and density), and procedural specifics, including the calyx punctured and operative findings. Notably, the change in hemoglobin levels (preoperative to 12 hours postoperative) was recorded, alongside postoperative radiographic clearance and any complications encountered. Follow-up evaluations were conducted one month post-procedure, including ultrasound and X-ray KUB prior to DJ stent removal, with findings duly recorded.

Data was analyzed using SPSS version 25 and Excel 2013, with results presented in tables and figures. Statistical significance was determined using the Chi-square test, with a p-value of less than 0.05 denoting statistical significance.

## RESULTS

In a comparative analysis of percutaneous nephrolithotomy (PCNL) approaches, the study delineated outcomes between the upper pole and non-upper pole punctures, as represented in Tables 1 and 2. Regarding stone size, the overall mean was 21.38 mm with a standard deviation of 11.2 mm. The upper pole group presented a slightly smaller mean stone size of 19.8 mm (± 7.6 mm), in contrast to the non-upper pole group, which had a mean stone size of 21.55 mm (± 10.8 mm), with the difference being statistically significant (p=0.032). Pre-operative hemoglobin levels, which averaged 12.8 mg/dl (± 1.8 mg/dl) across all participants, were marginally lower

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in the upper pole group (12.5 ± 1.8 mg/dl) compared to the non-upper pole group (12.9 ± 1.8 mg/dl), a difference that was statistically significant (p=0.007).

Table 1: Comparative Analysis of Upper and Non-Upper Pole Approach in PCNL

| Variables | Overall (n=173) | Upper Pole (n=74) | Non-Upper Pole (n=99) | p-value |
|---|---|---|---|---|
| Size of the stone (mm) | 21.38 ± 11.2 | 19.8 ± 7.6 | 21.55 ± 10.8 | 0.032* |
| Pre-operative Hb (mg/dl) | 12.8 ± 1.8 | 12.5 ± 1.8 | 12.9 ± 1.8 | 0.007* |
| Complete Clearance (%) | 80.3 (n=139) | 79.7 (n=59) | 80.8 (n=80) | 0.433 |
| Post-operative Hb (mg/dl) | 11.5 ± 1.5 | 11.3 ± 1.6 | 11.5 ± 1.4 | 0.006* |
| *p-value < 0.05 is significant. | | | | |

Table 2: Post-operative Outcomes between Upper and Non-Upper Pole Approach in PCNL

| Variables | Overall (n=173) | Upper Pole (n=74) | Non-Upper Pole (n=99) | p-value |
|---|---|---|---|---|
| Redo PCNL in residual stones (%) | 8.1 (n=14) | 9.5 (n=7) | 7.1 (n=7) | 0.688 |
| Lithotripsy for residual stones (%) | 11.6 (n=20) | 12.2 (n=9) | 11.1 (n=11) | 0.661 |
| Post-operative blood transfusion (%) | 8.7 (n=15) | 4.0 (n=3) | 12.1 (n=12) | 0.040* |
| Chest intubation (%) | 1.8 (n=3) | 4.0 (n=3) | 0% (n=0) | 0.130 |
| Abdominal drain placement (%) | 1.2 (n=2) | 0% (n=0) | 2.0 (n=2) | 0.258 |
| *p-value < 0.05 is significant. | | | | |

The rate of complete stone clearance did not differ significantly between the two groups, with 79.7% (n=59) in the upper pole group and 80.8% (n=80) in the non-upper pole group achieving complete clearance, resulting in a non-significant p-value of 0.433. Post-operative hemoglobin levels showed a significant decrease in the upper pole group (11.3 ± 1.6 mg/dl) versus the non-upper pole group (11.5 ± 1.4 mg/dl) with a p-value of 0.006.

Further post-operative outcomes, as detailed in Table 2, revealed that 9.5% (n=7) of the upper pole group required redo PCNL for residual stones, compared to 7.1% (n=7) in the non-upper pole group; however, the difference was not statistically significant (p=0.688). The need for lithotripsy for residual stones was slightly higher in the upper pole group at 12.2% (n=9) against 11.1% (n=11) in the non-upper pole group, again showing no significant difference (p=0.661). Notably, the requirement for post-operative blood transfusion was significantly lower in the upper pole group at 4.0% (n=3), as opposed to 12.1% (n=12) in the non-upper pole group, which was statistically significant (p=0.04). Instances of chest intubation were reported at 4.0% (n=3) for the upper pole and 0% (n=0) for the non-upper pole approaches, and abdominal drain placement was reported in 2.0% (n=2) of the non-upper pole cases with no cases in the upper pole group; however, these differences were not statistically significant with p-values of 0.130 and 0.258, respectively.

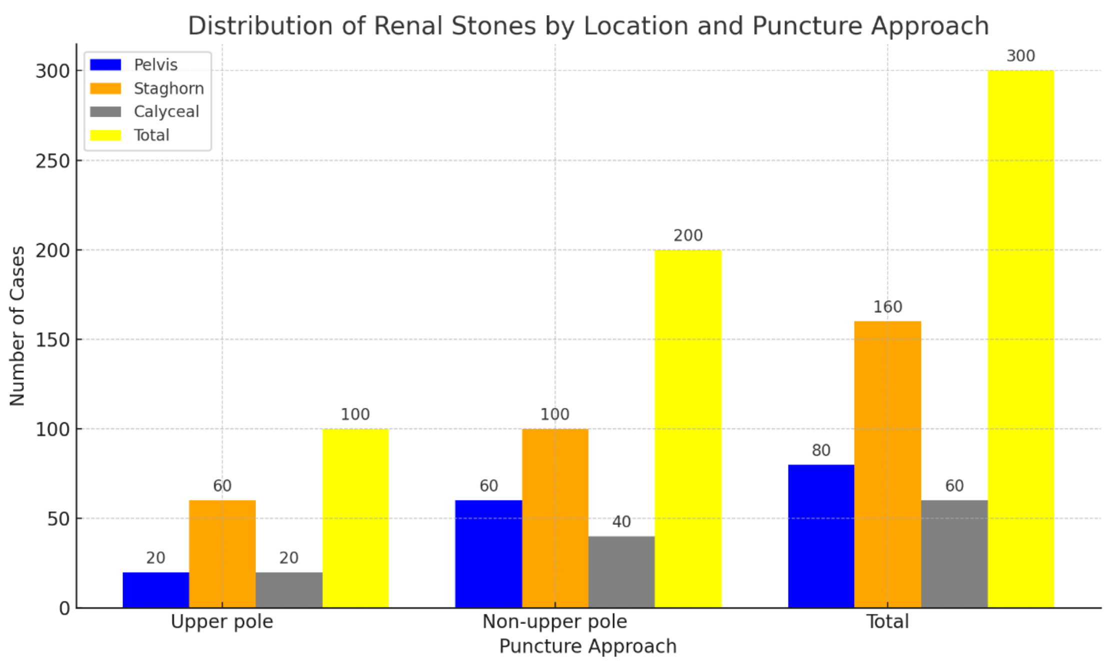


*Figure 1 Distribution of Renal Stones by Location and Puncture Approach*

The bar graph titled "Distribution of Renal Stones by Location and Puncture Approach" illustrates the number of renal stone cases stratified by the stone's location within the kidney and the surgical approach used. For the upper pole approach,

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there were approximately 20 pelvis stones, 60 staghorn stones, and 20 calyceal stones, summing to an estimated total of 100 cases. The non-upper pole approach had about 60 pelvis stones, 100 staghorn stones, and 40 calyceal stones, leading to an estimated total of 200 cases. Overall, combining both approaches, the graph shows around 80 pelvis stones, 160 staghorn stones, and 60 calyceal stones, with a grand total of approximately 300 cases. The graph employs different colors to represent each stone type, with blue for pelvis stones, orange for staghorn stones, grey for calyceal stones, and yellow for the cumulative total.

## DISCUSSION

In the modern resurgence of minimally invasive surgical techniques, the efficacy of percutaneous nephrolithotomy (PCNL) is heavily contingent upon the optimal selection of the calyx for access to facilitate stone clearance. The upper pole access is lauded for its direct tract, which enhances the visualization of the kidney's internal structures, a strategic advantage highlighted in recent studies (8, 9). The upper pole's anatomical position, resting over the iliopsoas muscle, presents a more posterior alignment conducive to a straighter entry, thus facilitating the manipulation of the nephroscope and potentially reducing operative time and renal parenchymal damage (10). Despite these advantages, the current study revealed that the difference in clearance rates between the upper pole and non-upper pole approaches was not statistically significant, diverging from other findings in the literature (13). This could suggest that clearance rates might be less about access point and more influenced by the surgeon's proficiency.

Conversely, the inferior calyceal approach is often marred by challenges such as guidewire kinking and potential under-dilatation due to its angulation and the need for greater torque, which can obscure calyceal and ureteral visualization (11, 12). Although the clearance rate for the lower pole approach was found to be comparable, contingent on the surgeon's expertise, challenges in antegrade stenting through lower pole access were observed.

Focusing on postoperative outcomes, patients who underwent the non-upper pole approach exhibited a higher incidence of blood transfusion, which the study attributed to increased renal parenchymal injury, a result aligning with existing literature emphasizing the risks associated with the lower pole approach (14). Thoracic complications, notably prevalent in supracostal approaches, were also observed in this study, particularly with upper pole access. This is anatomically explained by the oblique reflection of the parietal pleura at the midpoint of the 12th rib posteriorly, which increases the risk of hydrothorax due to inadvertent fluid entry (15-17). Additionally, the study found that excessive manipulation during lower pole access might lead to perforation in the pelvicalyceal system, resulting in fluid accumulation within the peritoneal cavity, necessitating abdominal drain placement.

The study’s design as an observational cohort precludes randomization, introducing potential biases in patient selection and outcomes assessment. The reliance on X-ray KUB for postoperative evaluation, while a common practice in the literature and a cost-effective method, especially in developing regions, may not detect all residual stones compared to the more sensitive non-contrast CT scans (18-20).

## CONCLUSION

The findings of this study underscore the upper pole approach in percutaneous nephrolithotomy (PCNL) as a viable option that offers efficient stone clearance with manageable complications, suggesting that in appropriately selected cases, it could enhance patient outcomes with shorter operative times and fewer punctures. However, the inherent risks, particularly thoracic complications, necessitate careful consideration. Conversely, the non-upper pole approach, while avoiding certain thoracic risks, presents its own challenges, notably in visualizing the pelvicalyceal system and a higher propensity for renal parenchymal injury. These insights have significant implications for healthcare, emphasizing the need for judicious surgical planning and the potential to refine PCNL techniques to improve patient safety and treatment efficacy in the management of renal calculi.

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