Volume 3, Issue 5, 2025

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

EVALUATION OF STONE CLEARANCE RATES IN MINI-PCNL PERFORMED VIA MIDDLE CALYX ACCESS FOR UPPER URETERIC CALCULI

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DOI: https://doi.org/10.5281/zenodo.15868670

Keywords
Mini-PCNL, middle calyx approach, impacted upper ureteric stones, stone clearance, minimally invasive urology.

Article History
Received: 02 April, 2025
Accepted: 23 June, 2025
Published: 12 July, 2025

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Abstract

Urolithiasis is increasingly recognized as a chronic, recurrent, and systemic disorder, with its global prevalence rising in correlation with socioeconomic development and dietary shifts. It remains a major cause of morbidity, with a lifetime prevalence estimated between 5% and 10%. This growing burden underscores the need for more effective and less invasive treatment modalities. Mini-percutaneous nephrolithotomy (mini-PCNL), particularly via the middle calyx approach, has shown promising outcomes in the management of impacted upper ureteric stones due to its high success rates and reduced complication profile. The present study aimed to evaluate the effectiveness of mini-PCNL using the middle calyx approach, focusing on stone clearance rate as the primary clinical outcome. A descriptive case series was conducted at the Department of Urology, Institute of Kidney Diseases, Peshawar, from May 24th, 2024, to November 24th, 2024. A total of 139 patients, aged between 15 and 55 years and of either gender, presenting with impacted upper ureteric stones confirmed on CT KUB were included. All patients underwent mini-PCNL via the middle calyx approach, and postoperative stone clearance was assessed. The mean age of patients was 35.32 ± 11.94 years, with 81 (58.3%) males and 58 (41.7%) females. Stone clearance was successfully achieved in 123 patients, corresponding to an overall clearance rate of 88.5%. The current study concluded that mini-PCNL through the middle calyx approach is a highly effective and minimally invasive option for the treatment of impacted upper ureteric stones, with excellent stone-free rates and broad applicability across diverse patient groups.

INTRODUCTION

Urolithiasis is increasingly recognized as a chronic and systemic disorder with rising global prevalence, closely associated with socioeconomic development and lifestyle changes. It poses a significant health burden, with a lifetime incidence estimated between 5% and 10%, and a high recurrence rate of up to 50%, highlighting its persistent and relapsing nature. The condition has substantial socioeconomic and healthcare implications, adversely affecting patients' quality of life. Recent advancements in urological practice have led to continuous evolution in the management of renal stone disease. According to the European Association of Urology (EAU) and American Urological Association (AUA) guidelines, current therapeutic strategies for renal and proximal ureteric calculi include extracorporeal shock wave

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

lithotripsy (ESWL), flexible ureterorenoscopy (fURS), miniaturized percutaneous nephrolithotomy (mini-PCNL), and conventional percutaneous nephrolithotomy (cPCNL) [1, 2, 3]. The pelviureteric junction (PUJ) represents one of the narrowest anatomical regions within the urinary tract, making it a common site for stone impaction. The PUJ and proximal ureter are identified as the second most frequent locations for impacted ureteric calculi [4]. With advancements in minimally invasive surgical techniques, both morbidity and mortality associated with urolithiasis management have been substantially reduced. Percutaneous nephrolithotomy (PCNL) has emerged as a safe and effective modality for the treatment of impacted upper ureteric stones, demonstrating favorable outcomes with low complication rates [5]. Clinical evidence supports its efficacy, with one study reporting a stone-free rate of up to 93% following PCNL for upper ureteric calculi [6]. Mini-percutaneous nephrolithotomy (mini-PCNL) offers a higher stone clearance rate for ureteric calculi ≥15 mm, with the added advantage of enabling simultaneous management of renal stones. In comparison, ureterorenoscopy (URS) is associated with shorter operative time and reduced hospital stay; however, it often requires increased irrigation flow to enhance visibility and facilitate stone clearance [7] Mini-PCNL, a minimally invasive technique, has gained widespread acceptance for the treatment of complex renal calculi and proximal ureteric stones [8]. Despite its promising outcomes, limited data exist regarding its application specifically for impacted proximal ureteric stones, particularly in terms of achieving optimal stone-free rates. This highlights the need for further clinical evaluation. Given its potential for high efficacy, mini-PCNL may become a preferred approach in the future. The present study aims to share our clinical experience using mini-PCNL via a middle calyceal access approach in the management of impacted upper ureteric calculi.

Materials And Methods

This descriptive case series was conducted at the Department of Urology, Institute of Kidney Diseases, Peshawar, over a six-month period from May 24, 2024, to November 24, 2024. The sample size was calculated using the OpenEpi sample size calculator, based on a previously reported 90% stone clearance rate achieved through the whirlpool mechanism. With a 95% confidence interval and a 5% margin of error, the required sample size was determined to be 139 patients. A consecutive non-probability sampling technique was employed to recruit eligible participants. Inclusion criteria consisted of patients aged 15 to 55 years of either gender presenting with radiologically confirmed impacted proximal ureteric stones ≥15 mm, accompanied by symptoms such as flank pain, nausea, and vomiting, and who were scheduled to undergo mini-percutaneous nephrolithotomy (mini-PCNL). Patients were excluded if they had abnormal coagulation profiles (elevated PT or APTT), recent use of nonsteroidal anti-inflammatory drugs (NSAIDs), active urinary tract infections (as evidenced by the presence of pus cells on urine routine examination), pregnancy, or congenital anomalies of the upper urinary tract including horseshoe kidney, ectopic kidney, and pelvi-ureteric junction obstruction. Individuals with significant axial skeletal deformities such as scoliosis or kyphosis were excluded. These conditions were considered potential confounders that could introduce bias and affect the accuracy of the study outcomes.

Data Collection Procedure

After approval from the College of Physicians and Surgeons Pakistan (CPSP), this study was conducted at the Department of Urology, Institute of Kidney Diseases, Peshawar. Eligible patients were enrolled after informed consent. Clinical evaluation included history, physical examination, and laboratory investigations (urinalysis, CBC, RBS, liver function tests, coagulation profile, and serum creatinine). Radiological assessments included X-ray KUB, pelvic-abdominal ultrasound, and non-contrast CT. All procedures were performed by a CPSP-certified consultant urologist with over five years of experience. Cystoscopy was initially performed in the lithotomy position, followed by ureteric and Foley catheter placement. Retrograde pyelography was carried out before percutaneous access through the middle calyx under fluoroscopic guidance. Tract dilation was done using a 17 Fr metal dilator, and a 12 Fr miniature nephoscope was used for stone visualization. Stone fragmentation was achieved using a pneumatic lithoclast, and fragments were

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ISSN: (e) 3007-1607 (p) 3007-1593

retrieved. A nephrostomy tube and double J (DJ) stent were placed post-procedure, with stent removal planned for six weeks. A postoperative X-ray KUB was obtained on day one. All data were documented on a structured proforma.

Data Analysis

Data was analyzed using SPSS version 22.0. Mean ± SD was calculated for continuous variables (age, operative time, hospital stay), while frequencies and percentages were reported for categorical variables (gender, stone clearance, residual stones). Effectiveness was assessed as per operational definition. Stratification by age, gender, operative time, and hospital stay was performed to evaluate effect modification. Post-stratification, the Chi-square test was applied with a significance level set at $p \leq 0.05$.

Results

Demographic Profile of Study Participants

A total of 139 participants were enrolled in the study. The age distribution showed that the largest proportion of participants, 54 individuals (38.8%), were between 41 and 55 years of age. This was followed closely by the 15 to 30 years age group, comprising 53 individuals (38.1%), while the 31 to 40 years group had the lowest representation with 32 participants (23.0%). In terms of gender, 81 participants (58.3%) were male and 58 (41.7%) were female, indicating a higher prevalence of male patients in the study population. This demographic profile suggests a relatively even distribution across younger and older adult age groups, with a moderate male predominance.

Table 1: Demographic Distribution of Study Participants (n = 139)

Variable	Category	Frequency	Percent (%)
Age (Years)	15–30	53	38.1
	31–40	32	23.0
	41–55	54	38.8
Gender	Male	81	58.3
	Female	58	41.7
	Total	139	100.0

Postoperative Stone Status

Out of the 139 patients included in the study, postoperative evaluation revealed that 32 patients (23.0%) had residual stones, while 107 patients (77.0%) were free of residual stones following the procedure. In terms of overall treatment success, stone clearance was achieved in 123 patients (88.5%), whereas 16 patients (11.5%) did not achieve complete stone clearance. The overall details are shown in the table 2.

Table 2: Postoperative Stone Status of Study Participants (n = 139)

Variable	Category	Frequency	Percent (%)
Residual Stones	Yes	32	23.0
	No	107	77.0
	Total	139	100.0
Stone Clearance	Achieved	123	88.5
	Not Achieved	16	11.5
	Total	139	100.0

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

Association of Stone Clearance Rate with Clinical and Demographic Variables

Age Distribution

The data were divided into three age groups: 15 to 30 years, 31 to 40 years, and 41 to 55 years. For patients aged 15 to 30 years, 48 patients (accounting for 39.0% of those with clearance) achieved stone clearance while 5 patients (31.2% of those without clearance) did not. In the 31 to 40 years group, 27 patients (22.0%) reached stone clearance with 5 (31.2%) not clearing the stones. Similarly, among patients aged 41 to 55 years, 48 (39.0%) had stone clearance compared to 6 (37.5%) who did not. The overall distribution across age groups did not show a statistically significant difference in stone clearance rates, as indicated by a p-value of 0.68.

Gender Stratification

When looking at the patient's gender, males were found to have a stone clearance rate of 56.9% (70 patients) versus 68.8% (11 patients) without clearance, based on an overall male total of 81 patients. For females, 53 patients achieved clearance (43.1%) while 5 did not (31.2%) out of 58 total females. The differences in stone clearance between genders were not statistically significant, with the p-value reported as 0.36.

Presence of Residual Stones

The analysis further stratified the data based on whether any residual stones were present after treatment. Among the patients with any residual stones, only 16 (13.0%) achieved stone clearance, while an equal number (16, representing 100% of the non-clearance group for this variable) did not clear the stones. In contrast, for those with no residual stones, 107 patients (87.0%) had successful stone clearance, and none were in the non-clearance group. The distinction in stone clearance rates based on the presence of residual stones was highly significant, as demonstrated by a p-value of 0.0001.

Operative Time

The study also reviewed the role of operative time by dividing cases into two categories: 60 to 95 minutes and greater than 95 minutes. In the 60 to 95 minutes group, 68 patients (55.3%) achieved stone clearance compared to 10 patients (62.5%) who did not, out of a subtotal of 78 patients. Meanwhile, for operations lasting longer than 95 minutes, 55 patients (44.7%) had clearance versus 6 patients (37.5%) who did not, out of 61 patients. The differences observed in stone clearance relative to operative time were not statistically significant ($p = 0.58$).

Hospital Stay

Lastly, the effect of hospital stay duration was assessed by categorizing patients into those staying 1 to 3 days and those with hospital stays greater than 3 days. For hospital stays between 1 and 3 days, 66 patients (53.7%) achieved stone clearance compared to 9 patients (56.2%) without clearance, among 75 patients. For stays longer than 3 days, 57 patients (46.3%) achieved clearance while 7 (43.8%) did not, among a total of 64 patients. The clearance rate differences in relation to hospital stay duration were not statistically significant, with a p-value of 0.84.

Table 3: Stratification of Stone Clearance Rate with Different Variables

Variable	Subgroup	Stone Clearance (Yes)	% age	Stone Clearance (No)	% age	Total	% age	P-Value
Age (Years)	15–30	48	39.0%	5	31.2%	53	38.1%	0.68
	31–40	27	22.0%	5	31.2%	32	23.0%	
	41–55	48	39.0%	6	37.5%	54	38.8%	
Gender	Male	70	56.9%	11	68.8%	81	58.3%	0.36
	Female	53	43.1%	5	31.2%	58	41.7%	
Any Residual Stones	Yes	16	13.0%	16	100.0%	32	23.0%	0.0001
	No	107	87.0%	0	0.0%	107	77.0%	
Operative Time (Minutes)	60–95	68	55.3%	10	62.5%	78	56.1%	0.58
	>95	55	44.7%	6	37.5%	61	43.9%	

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ISSN: (e) 3007-1607 (p) 3007-1593

Hospital Stay (Days)	1–3	66	53.7%	9	56.2%	75	54.0%	0.84
	>3	57	46.3%	7	43.8%	64	46.0%	

Discussion

Mini-percutaneous nephrolithotomy (Mini-PCNL) has gained prominence as an effective and minimally invasive technique for the management of large impacted upper ureteric stones, particularly when accessed via the middle calyx approach. Its growing adoption can be attributed to the balance it offers between high stone clearance rates and reduced procedural morbidity, making it an increasingly preferred option in urological practice. Reported clearance rates ranging from 80% to 95% underscore its clinical efficacy and support its use as a reliable intervention in such cases. One of the key advantages of Mini-PCNL lies in its use of a smaller tract size compared to conventional percutaneous nephrolithotomy, which contributes to lower complication rates while maintaining comparable treatment outcomes. The middle calyx approach provides superior access to upper ureteric stones, facilitating optimal visualization and efficient stone manipulation. This targeted access minimizes the need for multiple renal punctures, thereby reducing the risk of complications and preserving renal parenchyma [9].

A critical measure of the success of Mini-percutaneous nephrolithotomy (Mini-PCNL) is its high stone clearance rate, which has been consistently reported in the range of 80% to 95% [10]. This high level of efficacy is attributable to several key factors. The use of the middle calyx approach enables direct and efficient access to impacted upper ureteric stones, allowing for accurate stone fragmentation and removal. Technological advancements, particularly the development of miniaturized nephroscopes and improvements in laser lithotripsy, have significantly enhanced the effectiveness of this procedure. Notably, the reduction in tract size does not compromise the ability to fragment and evacuate stones, reflecting the considerable progress made in endourological instrumentation [11]. Furthermore, careful patient selection contributes to the success of Mini-PCNL. Ideal candidates are those with large, impacted upper ureteric stones that are unsuitable for extracorporeal shock wave lithotripsy (ESWL) or retrograde intrarenal surgery (RIRS), often due to the stone's density or challenging anatomical location. In such scenarios, where conventional methods may be ineffective, Mini-PCNL offers a precise and controlled approach for stone removal, thereby improving outcomes in complex cases [12].

In terms of safety, Mini-percutaneous nephrolithotomy (Mini-PCNL) has demonstrated a more favorable complication profile compared to conventional PCNL. The incidence of postoperative complications such as bleeding, sepsis, and renal injury is significantly lower, largely due to the use of smaller tract sizes and refined surgical techniques. The adoption of the middle calyx approach further enhances safety by offering a stable and direct access point, thereby minimizing the risk of injury to surrounding renal structures [13]. These safety advantages translate into shorter hospital stays, quicker recovery times, and reduced postoperative discomfort, factors that collectively contribute to the overall success and patient satisfaction associated with the procedure. In addition to its immediate efficacy, Mini-PCNL also shows promising long-term outcomes. The high rate of complete stone clearance, particularly when using the middle calyx approach, is associated with lower recurrence rates. Importantly, the minimally invasive nature of the procedure does not compromise renal function, ensuring that patients not only remain stone-free but also maintain favorable renal health over time. These results are particularly evident in single-center studies, where consistent protocols and experienced surgical teams contribute to the reproducibility and reliability of outcomes [14].

Despite its advantages, Mini-PCNL is not without limitations. The technique requires a steep learning curve and a high level of technical proficiency, especially when utilizing the middle calyx approach. Additionally, it demands access to specialized instruments such as miniaturized nephoscopes and advanced lithotripters. However, in well-equipped centers with trained personnel, the benefits of Mini-PCNL far outweigh these challenges, reinforcing its value as a standard approach in the treatment of large impacted upper ureteric stones [15]. The

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

effectiveness of Mini-percutaneous nephrolithotomy (Mini-PCNL) in managing large impacted upper ureteric stones, particularly through the middle calyx approach, is well-established, with stone clearance rates consistently ranging from 80% to 95%. This technique offers an optimal balance between therapeutic efficacy and procedural safety, making it a preferred modality for treating complex stone cases. Its high success rates and low complication profile highlight its significance in modern urological practice, especially for patients in whom other modalities such as extracorporeal shock wave lithotripsy (ESWL) or retrograde intrarenal surgery (RIRS) are ineffective. Evidence from single-center studies further supports the clinical utility of Mini-PCNL, reinforcing its role as a reliable and reproducible procedure. These findings provide a strong rationale for its broader implementation and continued evolution within the domain of minimally invasive urological interventions.

Conclusion

Mini-percutaneous nephrolithotomy (Mini-PCNL) utilizing the middle calyx approach demonstrates high efficacy in the management of impacted upper ureteric stones, with a stone clearance rate of 88.5% observed in this study. The approach offers a safe, minimally invasive alternative to conventional techniques, providing optimal access to the upper ureter while minimizing renal parenchymal trauma. The favorable outcomes across a broad patient demographic support the utility of this technique as a reliable and effective intervention. Further prospective, multicenter studies are warranted to validate these findings and to establish standardized protocols for its broader clinical application.

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