

Comparative Outcomes of Flexible Ureterorenoscopy (FURS) versus Mini Percutaneous Nephrolithotomy (Mini PCNL) for Management of Large Proximal Ureteric Stones

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Abstract: Large proximal ureteric stones present a considerable management challenge, particularly in regions with high urolithiasis prevalence, such as Pakistan. With advancements in endourological techniques, both Flexible Ureterorenoscopy (FURS) and Mini Percutaneous Nephrolithotomy (Mini PCNL) have emerged as standard minimally invasive modalities; however, comparative evidence within the local population remains limited. **Objective:** To compare the stone-free rate, operative duration, hospital stay, and postoperative complications between Mini PCNL and FURS in the management of large proximal ureteric stones. **Methods:** A randomized controlled trial was conducted at the Department of Urology, National Institute of Kidney Diseases, Shaikh Zayed Medical Complex, Lahore, from June 2025 to September 2025. A total of 110 patients aged 18–65 years with large proximal ureteric stones (>1.5 cm) were enrolled through consecutive sampling and randomized into two equal groups: Mini PCNL ($n = 55$) and FURS ($n = 55$). All procedures were performed under general anesthesia by experienced consultants following standardized surgical protocols. Patients were followed for 4 weeks postoperatively, and stone-free status was assessed using CT KUB. Secondary outcomes included operative time, hospital stay, and complications based on the Clavien Dindo classification. Data were analyzed using SPSS 26.0, applying chi-square and independent t tests with significance set at $p < 0.05$. **Results:** The Mini PCNL group achieved a significantly higher stone-free rate (90.9%) compared to the FURS group (76.4%; $p = 0.041$). Mean operative time was shorter with Mini PCNL (49.6 ± 8.5 minutes) than with FURS (72.4 ± 11.3 minutes; $p < 0.001$). Conversely, hospital stay was significantly longer in the Mini PCNL group (3.4 ± 0.9 days) versus the FURS group (1.8 ± 0.6 days; $p < 0.001$). Postoperative complications were comparable between groups, with 16.4% in each group, and no statistically significant difference was observed ($p = 1.000$). **Conclusion:** Mini PCNL demonstrates superior stone-free rates and shorter operative times compared to FURS for large proximal ureteric stones, although it requires longer hospitalization. Both procedures exhibit comparable safety profiles. Mini PCNL may therefore be considered the more effective option in appropriately selected patients within the Pakistani population.

Keywords: Mini-PCNL, Flexible Ureterorenoscopy, Proximal ureteric stones, Stone-free rate, Urolithiasis, Minimally invasive urology

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Introduction

The management of large proximal ureteric stones poses significant challenges due to anatomical complexities and the high likelihood of complications. Factors such as stone size, degree of impaction, and patient-specific characteristics inform decision-making regarding optimal management techniques. Traditional interventions such as open surgery have largely been supplanted by various minimally invasive approaches, including flexible ureterorenoscopy (FURS) and mini percutaneous nephrolithotomy (Mini-PCNL). Recent literature indicates the efficacy, safety, and patient outcomes associated with these techniques, providing a basis for comparative analysis in clinical practice.

FURS employs a flexible ureteroscope to visualize and fragment stones using laser technology. This approach is particularly beneficial for stones in difficult anatomical regions. Multiple studies have reported high stone-free rates (SFRs) with minimal complications (1, 2). However, FURS may be limited by factors such as stone size and burden, leading to variability in outcomes, especially for larger calculi (3, 4). Additionally, advancements in ureteroscope design have improved operational efficiency, although issues such as prolonged procedure times and potential ureteral injuries persist (5, 6).

In contrast, Mini-PCNL is designed to enable effective stone removal through small access tracts, thereby reducing recovery times and complication rates compared to conventional percutaneous

nephrolithotomy. Recent evidence suggests that Mini-PCNL may offer superior outcomes for larger stones when compared to FURS, achieving favorable SFRs with lower overall morbidity (7,8). Importantly, Mini-PCNL facilitates efficient clearance of larger debris while enhancing visualization of the renal calyces, potentially leading to fewer residual fragments post-operation (9).

Comparative studies have evaluated the efficacy of FURS versus Mini-PCNL for large proximal ureteral stones. A systematic review indicated that while both techniques yield acceptable outcomes, Mini-PCNL may be preferred for rocks larger than 2 cm due to its higher SFR and lower complication rates (10, 11). However, FURS remains essential in cases where ureteral access is difficult or when stones are located in challenging anatomical positions (12, 13).

In the Pakistani population, investigating these technologies is critical given the increasing incidence of urolithiasis. Access to quality healthcare and advanced surgical techniques can vary significantly between urban and rural settings, necessitating a better understanding of the performance of both FURS and Mini-PCNL (14).

As lifestyle and dietary patterns evolve, so does the burden of urinary stones, making evidence-based guidelines critical for clinicians. The outcomes from this comparative analysis can help align treatment protocols with global best practices, ultimately enhancing patient management in Pakistan.



Methodology

This randomized controlled trial was conducted at the Department of Urology, National Institute of Kidney Diseases, Shaikh Zayed Medical Complex, Lahore, over a period of six months from June 2025 to September 2025, following formal approval by the institutional ethical review board and the Research and Training Monitoring Cell of the College of Physicians and Surgeons Pakistan (CPSP). The study aimed to compare the outcomes of Mini Percutaneous Nephrolithotomy (Mini-PCNL) and Flexible Ureterorenoscopy (Flexible URS) for the management of large proximal ureteric stones. A total of 110 patients meeting the eligibility criteria were enrolled through non-probability consecutive sampling. The sample size was calculated using the CPSP-approved sample size calculator, with parameters set at a 5% level of significance and 90% power, assuming expected stone-free rates of 90.8% for Mini-PCNL and 71.3% for Flexible URS, based on prior published studies. All participants were between 18 and 65 years of age and were diagnosed with large proximal ureteric stones—defined operationally as stones greater than 1.5 cm located between the ureteropelvic junction and the lower border of the L4 vertebral body on CT urography.

Patients were excluded if they had an ASA classification greater than III, BMI over 35 kg/m², multiple ureteric stones, concomitant renal or bladder calculi, deranged renal function tests, anatomical abnormalities such as PUJ obstruction or ectopic kidney, a history of ipsilateral open renal surgery, retro-renal colon, untreated urinary tract infections, bleeding disorders, were on anticoagulant therapy, or were pregnant females. After detailed counseling, informed written consent was obtained from all eligible participants. Demographic and baseline clinical data, including age, sex, BMI, stone laterality, and stone size, were recorded using a structured proforma developed by the principal investigator. Patients were then randomized into two equal groups using a computer-generated random number sequence, with the allocation concealed in sealed, opaque envelopes. Group A underwent Mini-PCNL while Group B underwent Flexible URS.

All procedures were performed under general anesthesia by consultant urologists with more than five years of post-fellowship experience. In Group A, Mini-PCNL was performed in either the supine or prone position, depending on the patient's anatomy and the surgeon's preference. A 6 Fr ureteric catheter was introduced via cystoscopy just distal to the stone under fluoroscopic guidance, followed by retrograde pyelography. Percutaneous access was achieved through the upper or middle calyx using fluoroscopic guidance, and tract dilation was performed with Amplatz dilators to accommodate an 18 Fr sheath. A 15 Fr nephroscope was then inserted to visualize the stone in the proximal ureter. Lithotripsy was performed using a holmium laser with energy settings between 1.5 and 2.0 Joules and a frequency of 10 Hz. Stone fragments were extracted, and a 6 Fr double-J stent was inserted at the end of the procedure.

In Group B, patients were placed in the dorsal lithotomy position for Flexible URS. A 7.5 Fr flexible ureteroscope was introduced over a hydrophilic-tipped guidewire, and a ureteral access sheath was placed to facilitate navigation. Upon locating the stone, holmium laser lithotripsy was performed with lower energy settings of 0.8–1.0 Joules and frequency between 6–10 Hz. A 6 Fr double-J stent was placed following complete fragmentation of the stone. Patients in whom the ureter was too narrow to proceed with ureteroscopy were stented and scheduled for delayed URS after two weeks.

Postoperative care was standardized across both groups and followed institutional protocols. Patients were monitored for perioperative complications and followed up at four weeks with a CT KUB to assess

stone clearance. The primary outcome was stone-free rate, defined as the absence of residual fragments >3 mm. Secondary outcomes included duration of surgery, duration of hospital stay, and occurrence of postoperative complications categorized using the Clavien-Dindo classification system. Data were entered and analyzed using SPSS version 26.0. Continuous variables such as age, operative time, and hospital stay were presented as mean and standard deviation or median with interquartile range, depending on normality. Categorical variables, such as stone-free and complication rates, were reported as frequencies and percentages. The chi-square test was used for categorical comparisons, and the independent t-test was applied for continuous variables. A p-value < 0.05 was considered statistically significant.

Results

A total of 110 patients with large proximal ureteric stones were enrolled and randomized into two equal groups: 55 underwent Mini Percutaneous Nephrolithotomy (Mini-PCNL), and 55 underwent Flexible Ureterorenoscopy (Flexible URS). The mean age of the overall cohort was 42.7 ± 9.6 years, with a range of 18 to 65 years. The Mini-PCNL group had a mean age of 42.4 ± 10.1 years, while the Flexible URS group had a mean age of 43.0 ± 9.1 years. There was a male predominance in both groups, with 40 males in the Mini-PCNL group and 39 males in the Flexible URS group, representing 71.8% of the entire study population. Right-sided stones were slightly more common (53.6%), and the average stone size was comparable in both groups, with a mean of 1.95 ± 0.35 cm. Obesity (BMI > 30) was observed in 12.7% of patients, more frequently in the Mini-PCNL group (14.5%) than in the Flexible URS group (10.9%) (Table 1).

Evaluation of the primary outcome revealed that 90.9% of patients in the Mini-PCNL group were stone-free at four-week follow-up, compared with 76.4% in the Flexible URS group. Stone-free status was defined as the absence of any residual stone greater than 3 mm on CT KUB. The difference in stone clearance was statistically significant ($p = 0.041$), indicating a superior efficacy of Mini-PCNL in the management of large proximal ureteric stones (Table 2).

The mean operative procedure duration was significantly shorter in the Mini-PCNL group than in the Flexible URS group. Specifically, patients undergoing Mini-PCNL had a mean operative time of 49.6 ± 8.5 minutes, whereas those in the Flexible URS group had a longer mean duration of 72.4 ± 11.3 minutes. This difference was highly significant ($p < 0.001$), favoring Mini-PCNL as a more time-efficient procedure (Table 3).

In terms of hospitalization, the Flexible URS group had a shorter mean hospital stay of 1.8 ± 0.6 days, whereas the Mini-PCNL group required a significantly longer hospital stay of 3.4 ± 0.9 days. The difference was statistically significant ($p < 0.001$), reflecting the more invasive nature of the Mini-PCNL procedure and its associated postoperative care requirements (Table 4).

Postoperative complications were minimal in both groups and were assessed using the Clavien-Dindo classification. The most common complication observed was fever, affecting 10.9% of patients in the Mini-PCNL group and 5.5% in the Flexible URS group. Hematuria occurred in 3.6% of patients in the Mini-PCNL group and in 7.3% of patients in the Flexible URS group. A small number of patients in each group required additional procedures. Overall, 16.4% of patients in each group experienced at least one postoperative complication. There was no statistically significant difference in complication rates between the two groups ($p = 1.000$), indicating comparable safety profiles (Table 5).

Table 1: Baseline Demographics of Study Participants (n = 110)

Variable	Mini-PCNL (n = 55)	Flexible URS (n = 55)	Total (n = 110)
Mean Age (years)	42.4 ± 10.1	43.0 ± 9.1	42.7 ± 9.6
Gender (Male / Female)	40 / 15	39 / 16	79 / 31
BMI > 30 (%)	8 (14.5%)	6 (10.9%)	14 (12.7%)
Right Side Stones (%)	29 (52.7%)	30 (54.5%)	59 (53.6%)

Stone Size (cm)	1.9 ± 0.3	2.0 ± 0.4	1.95 ± 0.35
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Table 2: Comparison of Stone-Free Rates between Groups

Group	Stone-Free (n)	Not Stone-Free (n)	Percentage	p-value
Mini-PCNL	50	5	90.9%	0.041*
Flexible URS	42	13	76.4%	

*Chi-square test, $p < 0.05$ indicates significance

Table 3: Comparison of Operative Duration

Group	Mean Duration (min)	SD	p-value
Mini-PCNL	49.6	8.5	<0.001†
Flexible URS	72.4	11.3	

†Independent t-test

Table 4: Comparison of Hospital Stay Duration

Group	Mean Stay (days)	SD	p-value
Mini-PCNL	3.4	0.9	<0.001†
Flexible URS	1.8	0.6	

Table 5: Postoperative Complications

Complication	Mini-PCNL (n = 55)	Flexible URS (n = 55)	p-value
Fever (Grade I)	6 (10.9%)	3 (5.5%)	0.298
Hematuria (Grade I)	2 (3.6%)	4 (7.3%)	0.401
Additional Procedure Needed	1 (1.8%)	2 (3.6%)	0.558
Overall Complications	9 (16.4%)	9 (16.4%)	1.000

No statistically significant difference in overall complication rates was found between the groups ($p = 1.000$).

Discussion

In this discussion, we will compare the results from our study, which evaluated the effectiveness of Mini Percutaneous Nephrolithotomy (Mini-PCNL) and Flexible Ureterorenoscopy (Flexible URS) for managing large proximal ureteric stones, against findings from recent literature. The results reported will focus on stone-free status, operative time, length of hospital stay, and postoperative complications, as discussed in the context of relevant peer-reviewed studies.

Our study achieved a stone-free status of 90.9% in the Mini-PCNL group compared to 76.4% in the Flexible URS group, indicating a statistically significant difference ($p = 0.041$). Consistent with our findings, a study by Lu et al. demonstrated similarly high stone-free rates following Mini-PCNL for impacted proximal ureteral stones, reinforcing the notion that Mini-PCNL may be more effective for larger stones (15). Furthermore, Kargı et al. indicated that Mini-PCNL is particularly advantageous for stones larger than 15 mm, which is within the size range in our study (16). The higher efficacy observed with Mini-PCNL may be attributable to its direct access to the renal pelvis and lower pole regions, which can be challenging for endoscopic techniques.

The mean operative time was significantly shorter in the Mini-PCNL group (49.6 ± 8.5 minutes) compared to the Flexible URS group (72.4 ± 11.3 minutes), with a p-value of <0.001 . This is corroborated by findings from a meta-analysis by Wei, which reported reduced operative times for procedures using minimally invasive techniques such as Mini-PCNL compared to traditional approaches (17). Our results align with the literature, emphasizing that Mini-PCNL yields efficient outcomes that also translate into benefits for workflow and resource allocation in surgical settings.

Patients in the Flexible URS group had a shorter mean hospital stay (1.8 ± 0.6 days) than those in the Mini-PCNL group (3.4 ± 0.9 days), highlighting the more invasive nature of Mini-PCNL ($p < 0.001$). This finding is supported by recent studies, including one by Mosquera et al., which found that less invasive procedures, such as Flexible URS, typically lead to shorter hospitalization times, thereby improving the overall patient experience (18). The longer hospitalization following Mini-PCNL in our study reflects its invasiveness and the need for

enhanced postoperative care, a common characteristic in the literature on PCNL recovery protocols.

The overall complication rate was similar between the two groups, with 16.4% experiencing complications. This aligns with findings from Jafar et al., which indicated that, despite the higher effectiveness of Mini-PCNL, complication rates were not significantly different from those observed with Flexible URS (19). While our study noted fever and hematuria as common complications, the rates varied among studies; for instance, other studies have cited higher rates of febrile complications, suggesting that while risks are present, both methods offer a safe approach to stone management without substantial differences in overall complication rates.

Thus, our findings corroborate current literature suggesting that Mini-PCNL offers superior stone-free rates and is more time-efficient, albeit at the cost of increased hospitalization compared to Flexible URS. As emerging studies continue to refine these techniques, our results underline the importance of individualized patient treatment profiles in achieving optimal outcomes in urolithiasis management.

Conclusion

This study demonstrates that Mini-PCNL offers significantly higher stone-free rates and shorter operative times than Flexible Ureterorenoscopy in the treatment of large proximal ureteric stones, albeit at the cost of a longer hospital stay. Both procedures were found to be safe, with comparable complication rates. Given its superior efficacy and procedural efficiency, Mini PCNL represents a more effective option for managing large proximal ureteric stones in the Pakistani population, supporting its wider adoption in clinical practice.

Declarations

Data Availability statement

All data generated or analysed during the study are included in the manuscript.

Ethics approval and consent to participate

Approved by the department concerned. (IRBEC-25)

Consent for publication

Approved

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Conflict of interest

The authors declared no conflict of interest.

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All authors reviewed the results and approved the final version of the manuscript. They are also accountable for the study's integrity.

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