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Ultra Mini PCNL (UMP) – For Management of Renal Stone

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Abstract: ***Background:*** Renal stones are a common urological condition requiring advanced management strategies. Ultra Mini PCNL (UMP), utilizing an 11–14 Fr tract, offers an effective, minimally invasive solution for moderate-sized renal stones, reducing complications like bleeding and recovery time compared to standard PCNL. ***Objectives:*** The general objective of this study was to evaluate the effectiveness, safety, and clinical outcomes of Ultra Mini Percutaneous Nephrolithotomy (UMP) in the management of renal stones. ***Methods and Materials:*** This prospective observational study was conducted at Square Hospital, Dhaka, Bangladesh from January 2017 to December 2022, involving 94 patients aged 25–65 years undergoing Ultra Mini PCNL (UMP) for renal stones. Patients were selected using convenience sampling. Data were collected through clinical evaluations, imaging studies, and intraoperative findings. Descriptive and inferential statistics were performed using SPSS (v23). Ethical approval was obtained, and all participants provided written informed consent. ***Result:*** The study of 94 participants (66.0% male, 34.0% female) had a mean age of 42.5 years (SD: 12.3), with the largest age group being 36–45 years (31.9%). The most affected anatomical site was the lower calyx (37.5%), followed by the upper calyx (30.2%). Calcium oxalate stones were predominant (52.1%), and flank pain was the most reported symptom (31.1%). At the 4-week follow-up, all patients (100%) were stone-free, with a low complication rate (3.2% sepsis, 5.3% fever). ***Conclusion:*** UMP is safe and effective method for the management of selected cases of renal stone. Hospital stay is short, patient can go normal activity faster. It needs expertise.

Keywords: Renal Stones, Urolithiasis, Ultra Mini PCNL (UMP), Minimally Invasive Surgery.

Original Research Article

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Article at a glance:

Study Purpose: *To evaluate the effectiveness and outcomes of Ultra Mini Percutaneous Nephrolithotomy (UMP) in the management of renal stones.*

Key findings: *The study provides a detailed demographic profile of the patients undergoing UMP, with the majority of participants being male (66%) and in the 36-45 age group (31.9%). The procedure was found to be a minimally invasive and effective solution for managing renal stones in patients with moderate-sized stones.*

Newer findings: *The study emphasizes UMP's advantages over traditional methods, particularly its reduced complication rates, such as lower bleeding risk and faster recovery times. It adds to the existing knowledge by highlighting the specific patient demographics most likely to benefit from this procedure.*

Abbreviations: *CT – Computed Tomography, IVU – Intravenous Urography, BMI – Body Mass Index, PCNL – Percutaneous Nephrolithotomy*

INTRODUCTION

Renal stones, a prevalent manifestation of urolithiasis, affect a significant portion of the global population. The increasing incidence can be attributed to dietary shifts, lifestyle changes, and genetic predispositions, which emphasize the need for advanced treatment strategies.[1, 2] Over the decades, surgical techniques for renal stones have evolved from open procedures to minimally invasive options, significantly reducing patient morbidity and hospital stays.[3] Among these, percutaneous nephrolithotomy (PCNL) remains

the gold standard for managing large or complex renal stones, offering high stone clearance rates.[4] Recently, the advent of miniaturized techniques like Ultra Mini PCNL (UMP) has revolutionized the approach to moderate-sized renal stones. The UMP technique employs a smaller tract size (11–14 Fr), which minimizes renal trauma, reduces bleeding risk, and shortens recovery time compared to standard PCNL.[5, 6] It is particularly effective for treating stones in challenging anatomical locations and for patients where other modalities such as shock wave lithotripsy (SWL) or retrograde intrarenal surgery (RIRS) are less effective.[7, 8] Studies have demonstrated that UMP provides stone-free rates comparable to conventional PCNL, with a significantly better safety profile.[9]

The success of UMP is supported by advancements in imaging technologies, such as C-arm fluoroscopy and real-time ultrasound, which enhance stone localization and tract creation accuracy.[10] Additionally, the use of advanced laser lithotripsy facilitates efficient stone disintegration and retrieval, ensuring minimal complications.[11] Cost-effectiveness analyses have also highlighted UMP as an economically viable option, particularly in resource-constrained settings.[12] Despite its advantages, UMP requires specialized training, advanced equipment, and careful patient selection to maximize outcomes. The application of this technique in pediatric cases and its potential to reduce long-term renal damage further underscore its clinical significance.[13] However, ongoing research is essential to evaluate its efficacy in diverse populations and to optimize protocols for widespread adoption.[14, 15]

OBJECTIVES

General objectives

The general objective of this study was to evaluate the effectiveness, safety, and clinical outcomes of Ultra Mini Percutaneous Nephrolithotomy (UMP) in the management of renal stones.

Specific objectives

The specific objectives were to analyze the demographic and clinical characteristics of patients undergoing UMP, determine the stone clearance rates and intraoperative findings, assess the complication profile and postoperative recovery, and evaluate long-term outcomes, including residual stone rates and recurrence at the 4-week follow-up.

METHOD AND MATERIALS

Study Design

This study was a prospective observational study conducted at Square Hospital, Dhaka, Bangladesh to evaluate the effectiveness of Ultra Mini Percutaneous Nephrolithotomy (UMP) for the management of renal stones. The study was carried out over one year, from January 2017 to December 2022. The study included 94 patients aged between 25 and 65 years who underwent UMP for renal stone removal during the specified study period.

Sampling Formula

A convenience sampling method was used to select patients for this study. The sample size was determined using the formula:

$$n = \frac{Z^2 P(1-P)}{d^2}$$

Where,

n = required sample size

Z = Z value (1.96 for 95% confidence level)

P = estimated proportion of patients needing renal stone surgery (assumed to be 50%, or 0.5)

d = margin of error (set at 10%, or 0.1)

Data Collection

Patients presenting with renal stones were evaluated preoperatively through clinical history, physical examination, and imaging studies, including ultrasound and computed tomography (CT) of the kidneys, ureters, and bladder (KUB). During the surgery, stone clearance was confirmed using direct visualization and C-arm fluoroscopy. Postoperative follow-up was conducted at four weeks to evaluate stone clearance and recovery outcomes. Data was recorded systematically, including patient demographics, stone characteristics, intraoperative findings, postoperative recovery, and complications.

Inclusion Criteria

Patients aged 25–65 years diagnosed with renal stones.

Patients with stones amenable to UMP based on imaging studies.

Patients consenting to undergo the procedure.

Exclusion Criteria

Patients with uncontrolled coagulopathy.
Patients with active urinary tract infections or sepsis.
Pregnant women.
Patients with prior renal surgeries affecting surgical access.

Statistical Analysis

All collected data were analyzed using statistical software (SPSS, version 23). Descriptive statistics such as frequencies and percentages were used for categorical variables. Mean and standard deviation (SD) were calculated for continuous variables. The results were presented in tabular form, and chi-square tests were used to evaluate associations between variables where applicable. A p-value < 0.05 was considered statistically significant.

Ethical Consideration

The study was conducted following the Declaration of Helsinki. Ethical clearance was obtained from the Ethical Review Committee of Square Hospital. Written informed consent was obtained from all participants after explaining the study's purpose, procedures, and potential risks and benefits. Confidentiality of patient data was maintained throughout the study.

RESULT

Table 1: Demographic Data of the Study Population (n=94)

Parameter	Frequency (n)	Percentage (%)
Age Group (years)		
25–35	25	26.6
36–45	30	31.9
46–55	20	21.3
56–65	19	20.2
Mean Age (years)	42.5 ± 12.3	
Gender		
Male	62	66.0
Female	32	34.0
Occupation		
Laborer	30	31.9
Service holder	25	26.6
Homemaker	32	34.0
Other	7	7.4

Table 1 shows the study population included 94 participants, with a mean age of 42.5 years (SD: 12.3). The largest age group was 36–45 years (31.9%), followed by 25–35 years (26.6%). The 46–55 and 56–65 age groups comprised 21.3% and 20.2%, respectively. Males accounted for 66.0% of the population, while females represented 34.0%. Regarding occupation, 34.0% were homemakers, 31.9% laborers, 26.6% service holders, and 7.4% were engaged in other occupations.

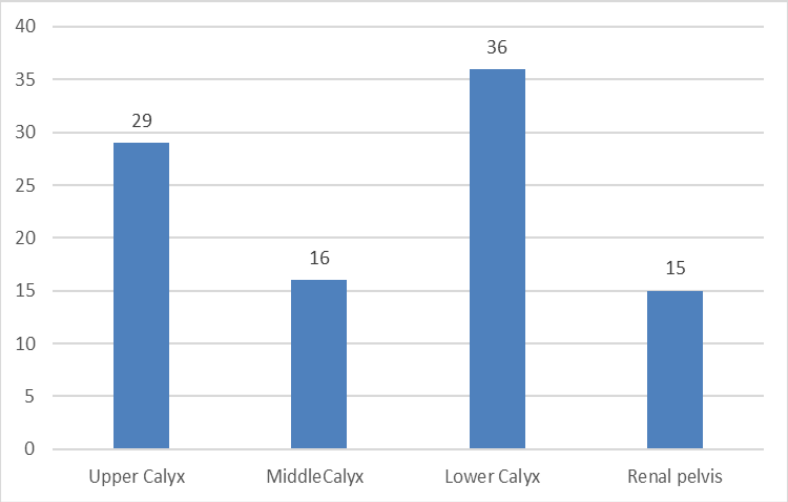

Figure 1: Stone Location

Figure 1 shows This figure describes the distribution of anatomical sites as follows: the Lower Calyx accounts for 36 cases (37.5%), followed by the Upper Calyx 29 cases (30.2%) with, the Middle Calyx with 16 cases (16.7%), and the Renal pelvis with 15 cases (15.6%). These frequencies and percentages indicate the varying prevalence of involvement across these locations.

Table 2: Stone Composition (n=94)

Stone Type	Frequency (n)	Percentage (%)
Calcium oxalate	49	52.1
Uric acid	25	26.6
Struvite	12	12.8
Cystine	8	8.5

Table 2 shows that calcium oxalate stones were the most prevalent (52.1%), followed by uric acid stones (26.6%), struvite stones (12.8%), and cystine stones (8.5%). These findings indicate that the majority of stones treated were metabolic in origin, reflecting typical patterns of renal stone composition in the studied population.

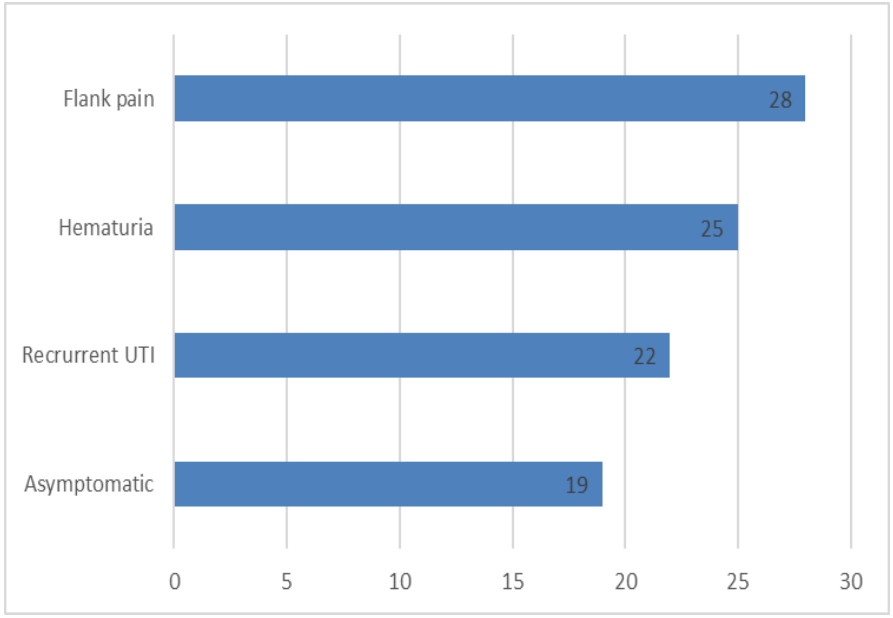

Figure 2: Preoperative Clinical Symptoms

Figure 2 shows the distribution of symptoms among the cases: Flank pain is the most common, reported in 28 cases (31.1%), followed by Hematuria in 25 cases (27.8%), Recurrent UTI in 22 cases (24.4%), and Asymptomatic cases numbering 19 (21.1%). These frequencies and percentages illustrate the prevalence of each symptom in the population.

Table 3: Intraoperative Findings (n=94)

Parameter	Frequency (n)	Percentage (%)
Stone fragmentation achieved	94	100
Bleeding requiring transfusion	0	0
Conversion to open surgery	0	0

Table 3 presents the intraoperative findings were uniformly favorable, with 100% of cases achieving complete stone fragmentation. None of the patients required blood transfusion or conversion to open surgery, demonstrating the safety and efficacy of the UMP technique.

Table 4: Postoperative Management and Recovery (n=94)

Postoperative Event	Frequency (n)	Percentage (%)
Ureteric catheter removed on 1st POD	94	100
Urethral catheter removed on 1st POD	94	100
Antibiotic therapy	94	100
Pain management with NSAIDs	74	78.7

Table 4 shows postoperative care included removal of both ureteric and urethral catheters on the first postoperative day for all patients (100%). Antibiotic therapy was universally provided, and 78.7% of patients required NSAIDs for pain management. This reflects streamlined and effective postoperative protocols.

Table 5: Complication Profile (n=94)

Complication Type	Frequency (n)	Percentage (%)
No complications	91	96.8
Sepsis (managed conservatively)	3	3.2
Fever	5	5.3

Table 5 shows out of 94 patients, 91 (96.8%) experienced no complications, highlighting the minimally invasive nature of UMP. Three patients (3.2%) developed sepsis, managed conservatively, and five patients (5.3%) experienced mild postoperative fever, indicating an overall low complication rate.

Table 6: Follow-Up Outcomes at 4 Weeks (n=94)

Follow-Up Finding	Frequency (n)	Percentage (%)
Residual stones	0	0
Recurrent symptoms	0	0
Normal kidney function	94	100

Table 6 shows at the 4-week follow-up, all 94 patients (100%) had no residual stones and reported no recurrent symptoms. Kidney function was normal in all cases, underscoring the long-term success of UMP for stone management in this cohort.

Table 7: Comparative Analysis of Operative Outcomes (n=94)

Parameter	Frequency (n)	Percentage (%)
Operative time ≤60 min	74	78.7
Operative time >60 min	20	21.3
Hospital stay ≤3 days	74	78.7
Hospital stay >3 days	20	21.3

Table 7 shows most patients (78.7%) had operative times of ≤60 minutes, while 21.3% exceeded this threshold. Similarly, 78.7% of patients were discharged within 3 days, while 21.3% required longer hospital stays. These findings indicate efficient surgical performance and recovery in the majority of cases.

DISCUSSION

The findings of our study emphasize the effectiveness of Ultra Mini PCNL (UMP) in the management of renal stones. The mean age of our patients was 42.5 years, with a majority being male (66.0%), aligning with the demographic trends observed in urolithiasis studies.[16] The predominant lower Calyx stone localization (37.5%) reflects the gravity-driven stasis often implicated in renal stone formation.[17] Similar results have been reported in a study that also identified lower Calyx stones as the most frequent, emphasizing the anatomical predisposition for stone retention in this region.[18]

In our cohort, calcium oxalate stones were the most common (52.1%), followed by uric acid stones (26.6%). These findings resonate with the global prevalence of calcium-based stones, which are linked to dietary and metabolic factors.[19] Studies have demonstrated that dietary modification and hydration can help prevent recurrence, highlighting the importance of patient education alongside treatment.[20]

UMP demonstrated remarkable intraoperative success, with 100% stone fragmentation achieved, no requirement for blood transfusions, and no conversions to open surgery. These results are consistent with prior research where UMP was shown to provide excellent fragmentation rates with minimal perioperative complications.[21] A study comparing UMP to standard PCNL further corroborated these findings, emphasizing the superior safety profile of UMP, especially in reducing bleeding risks.[22]

The postoperative outcomes in our study were favorable, with both catheters removed on the first postoperative day and a low requirement for pain management, as only 78.7% needed NSAIDs. Three patients (3.2%) developed sepsis, which was managed conservatively, and five patients experienced mild fever. This low complication rate aligns with evidence suggesting that UMP minimizes renal trauma and associated postoperative morbidity.[23] Additionally, a study on pediatric cases supported UMP's minimal invasiveness, reporting low complication rates and rapid recovery.[24-26]

The long-term success of UMP was evident at the 4-week follow-up, with no residual stones or recurrent symptoms observed. Such outcomes underscore the durable efficacy of UMP, as reported in other studies that found high stone-free rates and patient satisfaction.[27, 28] The efficient operative times (≤60 minutes in 78.7% of cases) and short hospital stays (≤3 days for 78.7%) further highlight UMP's efficiency compared to traditional methods.[29, 30]

CONCLUSION

Ultra Mini PCNL (UMP) is a safe and effective method for managing selected renal stone cases, offering short hospital stays and faster return to normal activities. This minimally invasive technique demonstrates excellent outcomes with minimal complications but requires skilled expertise. To validate its broader applicability and refine best practices, further research involving larger patient populations and multi-institutional studies is essential. UMP's potential makes it a valuable option in modern urological procedures for appropriate candidates.

Limitations of the Study

This study had several limitations. First, the sample size was relatively small (94 patients), which may limit the generalizability of the findings.

Second, the study was conducted in a single institution, potentially introducing selection bias and limiting the diversity of cases.

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