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COMPARATIVE STUDY BETWEEN PERCUTANEOUS NEPHROLITHOTOMY AND URETEROSCOPIC LITHOTRIPSY IN THE MANAGEMENT OF LARGE UPPER URETERIC STONES

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ABSTRACT

Background:Large upper ureteric stones (>10 mm) present a therapeutic challenge, with both Percutaneous Nephrolithotomy (PCNL) and Ureteroscopic Lithotripsy (URSL) being viable minimally invasive options. While PCNL is more invasive, it offers higher stone clearance rates. URSL, on the other hand, is less invasive, with faster recovery. This study aims to compare the efficacy and safety of PCNL and URSL in managing large upper ureteric stones.

Method: This prospective randomized study was conducted on 160 patients from July 2023 to December 2024. Patients were randomly assigned to two groups: Group A (PCNL, n=80) and Group B (URSL, n=80). Inclusion criteria were patients aged 21–70 with single upper ureteric stone >10 mm. Parameters assessed included operative time, pain scores (VAS), residual fragments, hospital stay, complications, and stone-free status at 1, 4, and 12 weeks.

Result: PCNL had significantly longer operative time (82.5 vs 65.8 min, p=0.03) and hospital stay (3.9 vs 2.1 days, p<0.001), and higher pain scores. However, it resulted in fewer residual fragments (7.5% vs 22.5%, p=0.01) and higher stone-free rates at 1, 4, and 12 weeks (p<0.05). URSL had fewer postoperative discomforts but showed a trend toward more complications, though not statistically significant (21.25% vs 12.5%, p=0.12).

Conclusion: Both PCNL and URSL are effective for managing large upper ureteric stones. PCNL offers superior stone clearance, while URSL provides faster recovery with less pain. Selection should be individualized based on patient condition, equipment availability, and surgeon expertise.

INTRODUCTION

Urolithiasis is a common urological condition with an increasing global prevalence, significantly affecting quality of life and healthcare systems. Upper ureteric stones, especially those larger than 1 cm, often pose a therapeutic challenge due to their potential for obstruction, infection, and renal impairment if not treated promptly and effectively. The management of such stones has evolved over The years with the advent of minimally invasive techniques such as Percutaneous Nephrolithotomy (PCNL) and Ureteroscopic Lithotripsy (URSL)[1]. PCNL, traditionally considered the gold standard for large renal calculi (>2 cm), is now being increasingly used for upper ureteric stones as well. It offers high stone clearance rates, particularly for large, impacted, or hard stones, albeit at the cost of being more invasive, with increased risk of bleeding, longer hospital stay, and higher need for general anesthesia [2]. It was first introduced in 1976 by Fernström and Johansson in Sweden as an alternative to open

surgery for large renal calculi [3]. This technique allowed direct access to the renal collecting system via a small flank incision, dramatically improving stone clearance rates and reducing morbidity compared to open nephrolithotomy. On the other hand, URSL has gained popularity due to its less invasive nature, shorter operative time, and quicker recovery. Technological advancements such as flexible ureteroscopes and laser lithotripsy have improved its efficacy in stone clearance even for large upper ureteric stones [4]. This emerged in the 1980s with the advent of semi-rigid ureteroscopes, later evolving with the development of flexible ureteroscopes and the introduction of holmium:YAG laser lithotripsy. This enabled the retrograde approach to ureteral and even renal stones, with reduced need for percutaneous or open access [5]. The selection between PCNL and URSL for large upper ureteric stones remains controversial, primarily due to variability in patient anatomy, stone characteristics, and surgeon expertise. Large upper ureteric stones typically refer to ureteral calculi located between the pelviureteric junction (PUJ) and the upper border of the sacroiliac joint that measure greater than 1 cm in diameter (≥10 mm)**.** While PCNL is more invasive, it typically provides higher stone-free rates in a single session, especially in large, impacted stones. URSL offers the advantage of being less invasive with quicker recovery, but may require multiple sessions for complete clearance and carries a risk of ureteral injury or stricture [6]. There remains ongoing debate regarding the optimal treatment modality for large upper ureteric stones. Both the American Urological Association (AUA) and European Association of Urology (EAU) guidelines recommend either approach based on stone size, location, and patient-specific factors, highlighting the importance of individualized care [7]. This study aims to compare PCNL and URSL in the management of large upper ureteric stones.

MATERIALS AND METHODS: Study Design and Source of Data: This was a prospective, randomized comparative study conducted in the Department of Urology at a Rural Hospital in South Indiabetween July 2023 to December 2024 over a period of 18 months, after obtaining ethical clearance from the institutional review board. Patients were evaluated and enrolled after informed consent.

Sample Size and Grouping:A total of **160 patients** with large upper ureteric stones were included. They were randomized into two equal groups using a computer-generated random number table:

Group A (n = 80): Treated with Percutaneous Nephrolithotomy (PCNL)

Group B (n = 80): Treated with Ureteroscopic Lithotripsy (URSL)

Inclusion Criteria:

Age between 21 and 70 years

Single upper ureteric stone >10 mm confirmed by non-contrast CT KUB

Normal contralateral kidney

Fit for GeneralAnesthesia

Exclusion Criteria: Pregnancy

Active urinary tract infection or urosepsis Bleeding diathesis or uncorrected coagulopathy Anatomical abnormalities (e.g., horseshoe kidney, PUJ obstruction) Surgery Procedure details: All surgeries were performed by the same Surgeon to prevent bias. Group A – PCNL performed under Spinal Anaesthesia in prone position. Fluoroscopic-guided puncture of the renal calyx was done, tract was dilated to 24–30 Fr using Amplatz dilators, Nephroscope was inserted, stone was visualized and fragmented using pneumatic or ultrasonic lithotripsy, fragments were evacuated and nephrostomy tube was placed.

Group B - URSL performed under SpinalAnaesthesia in lithotomy position, semi-rigid ureteroscope was advanced to the stone under fluoroscopic guidance, stone was fragmented using Holmium:YAG laser, stone fragments were extracted using forceps or allowed to pass spontaneously and a Double-J stent was placed. All patients underwent thorough preoperative evaluation, including demographic details (age and gender), stone characteristics such as size (measured in millimeters using non-contrast CT KUB), laterality (right or left), and precise anatomical location within the upper ureter. Associated hydronephrosis was assessed via ultrasound or CT and graded accordingly. Baseline renal function was evaluated using serum creatinine levels. Urine routine examination and culture were performed in all patients to detect any pre-existing urinary tract infection, which was treated appropriately prior to surgery. Intra-

operative assessment included measurement of operative time (in minutes) from initial scope

Group	Mean Duration (min) ± SD	p-value
PCNL	82.5 ± 8.2	0.03
URSL	65.8 ± 10.1	

insertion to placement of drainage or stent. Post-operative stone-free status was evaluated at one week and again at one month post-procedure using ultrasound and, if required, non-contrast CT KUB. Any residual fragments >4 mm were considered clinically significant. Complications were monitored and documented, including hematuria, fever, sepsis, ureteric injury or need for blood transfusion. Pain levels were assessed using the Visual Analog Scale (VAS) during the first 24 hours. Duration of hospital stay (in days) and requirement for any auxiliary procedures such as repeat URSL, ESWL, or second-look PCNL were also recorded. These parameters were compared between both groups to evaluate and compare the overall efficacy, safety, and clinical outcomes of PCNL versus URSL. **Statistical Analysis:** Data were analyzed using **SPSS software version 26**. Quantitative variables were expressed as mean ± standard deviation and analyzed using **unpaired Student's t-test**. Categorical variables were compared using the **Chi-square test or Fisher's exact test**. A p-value of **<0.05** was considered statistically significant. As seen in Table 1, the number of males were 101 (63%) and number of females were 79 (37%).

As seen in Table 2, the patients in age group of 41-50 had the highest involvement (42/160). The age distribution was statistically similar (p = 0.98), indicating proper randomization and comparability between groups.

OBSERVATIONS AND RESULTS

Table 1 - Gender Distribution

Gender	PCNL	URSL	p-value
Male	52 (65%)	49 (61.25%)	0.63
Female	28 (35%)	31 (38.75%)	

Table 2 - Age distribution between groups

Age Group (years)	PCNL	URSL
21–30	14 (17.5%)	16 (20%)
31–40	20 (25%)	19 (23.75%)
41–50	22 (27.5%)	20 (25%)
51–60	16 (20%)	17 (21.25%)
>60	8 (10%)	8 (10%)

Table 3 - Distribution based on mean operative time between groups

As seen in Table 3, PCNL had a significantly longer mean operative time (82.5 ± 8.2 minutes) compared to URSL (65.8 ± 10.1 minutes), with asignificant p-value (0.03). This suggests procedural efficiency in URSL for large upper ureteric stones.

Table 4 - Residual Fragments after surgery between groups

Residual Fragments	PCNL	URSL	p-value
Present	6 (7.5%)	18 (22.5%)	0.01
Absent	74 (92.5%)	62 (77.5%)	

As seen in Table 4, the presence of residual stone fragments (>4 mm) postoperatively was significantly lower in the PCNL group (7.5%) compared to the URSL group (22.5%), with a p-value of 0.01, indicating better primary stone clearance with PCNL.

Table 5 - Pain Scores as per VAS in the first 3 days post surgery between groups

Day	PCNL (Mean ± SD)	URSL (Mean ± SD)	p-value
1	4.6 ± 1.1	3.2 ± 1.0	<0.001
2	3.2 ± 0.9	2.1 ± 0.8	<0.001
3	2.0 ± 0.7	1.4 ± 0.6	<0.001

As seen in Table 5, pain scores assessed using the Visual Analog Scale (VAS) on postoperative days 1, 2, and 3 were significantly lower in the URSL group across all days ($p < 0.001$). This confirms that URSL is associated with less postoperative pain compared to PCNL.

Table 6 - Duration of stay at Hospital between groups

Group	Mean ± SD	p-value
PCNL	3.9 ± 1.2 days	<0.001
URSL	2.1 ± 0.8 days	

As noted in Table 6, the duration of hospital stay was significantly longer in the PCNL group (3.9 ± 1.2 days) compared to the URSL group (2.1 ± 0.8 days), with a p-value <0.001. This reflects the more invasive nature of PCNL. As seen in Table 7, complications like fever, hematuria, sepsis, and ureteric injury were more common in the URSL group but the overall difference was not statistically significant (p = 0.12). Thus, both these

procedures were relatively safe with acceptable complication rates. As seen in Table 8, at all follow-up intervals (1 week, 4 weeks, and 12 weeks), PCNL showed significantly higher stone-free rates than URSL, with p-values of 0.02, 0.01, and 0.01 respectively. This confirms PCNL's superior efficacy in complete stone clearance for large upper ureteric stones.

Table 7 - Complications noted between groups

Complication	PCNL	URSL	p-value
Fever	6 (7.5%)	10 (12.5%)	0.29
Hematuria	3 (3.75%)	2 (2.5%)	0.65
Sepsis	1 (1.25%)	3 (3.75%)	0.31
Ureteric Injury	0 (0%)	2 (2.5%)	0.15
Total complications	10 (12.5%)	17 (21.25%)	0.12

Table 8 - Stone free status on follow-up between groups

Time Point	PCNL	URSL	p-value
1 Week	72 (90%)	61 (76.25%)	0.02
4 Weeks	77 (96.25%)	67 (83.75%)	0.01
12 Weeks	78 (97.5%)	69 (86.25%)	0.01

DISCUSSION

The comparison between URSL and PCNL for large ureteric stones had been a topic of research for a long time now with various evidences in literature supporting one over the other. In this study, the majority of patients were male (63.1%) and between 31–50 years of age. This aligns with the epidemiological trend observed globally as reported by Romero et al in 2010 [8], where males are more prone to urolithiasis due to higher muscle mass and dietary habits leading to increased urinary oxalate and calcium excretion. This finding is also supported by evidence from Scales et al in 2012 [9] wherein they found the prevalence of stones was 10.6% (95% CI, 9.4-11.9), in men compared with 7.1% (95% CI, 6.4-7.8) among women. A meta analysis done in 2017 by Wang et al [10] included 837 patients from various studies. They found that URSL was associated with much shorter duration of surgery as compared to PCNL. Hospital stay was also shorter in the URSL group. The amount of complications noted were higher in the URSL group. All these parameters had a positive correlation to this study indicating similar surgical methods and expertise. Patients in the PCNL group in this study had a longer average hospital stay (3.9 ± 1.2 days) compared to URSL (2.1 ± 0.8 days, $p < 0.001$). This difference is clinically relevant in terms of cost, patient comfort and resource utilization. A study done in 2020 by Zhao et al [11] reported a 73.3% success rate in the URSL group and 96.6% in the PCNL group. This correlated well with this study too indicating that the practices of surgery have been properly understood all over the World and the documentation of the same has been incorporated well in all literature. They also reported a longer duration of stay in the PCNL group indicating a more invasive procedure thus taking longer to heal as compared to URSL. The incidence of residual fragments (>4 mm) was significantly lower in the PCNL group (7.5%) than in the URSL group (22.5%) ($p = 0.01$). At 1, 4, and 12 weeks, PCNL consistently achieved higher stone-free rates (90%, 96.25%, and 97.5%, respectively) compared to URSL (76.25%, 83.75%, and 86.25%), with all comparisons showing statistical significance. These results echo the findings of Singh et al in 2011, who reported stone-free rates of 95.8% in PCNL versus 79.1% in URSL for large proximal ureteric stones[12]. This superiority is attributed to the ability of PCNL to directly access and clear larger stone burdens without being limited by ureteral angulation or mucosal edema. A recent study performed in 2025 by Jiang et al [13] stated that the PCNL group had significantly higher intraoperative blood loss and longer postoperative hospital stay compared with the URSL group. The stone clearance and lithotripsy success rates were considerably higher in the PCNL group than in the URSL group, and the complication rates were significantly lower ($P<0.05$). After treatment, the levels of renal function indicators, including serum creatinine (Scr), blood urea

nitrogen (BUN), and cystatin C (CysC), decreased significantly in both groups, with the PCNL group showing more pronounced decrease compared to the URSL group ($P<0.05$), approaching normal levels. These findings correlate well with this study. In a study by Paneque et al in 2023 [14], it was reported that PCNL causes pain and discomfort after surgery. The primary causes of immediate postoperative pain after PCNL are visceral pain from the ureters and kidneys, and body surface discomfort from incisions. Acute, untreated pain has the potential to develop into chronic pain, which remains a considerable burden for the rehabilitation of patients. Similarly, it was clearly found that the pain as per the VAS was higher in the PCNL group in this study. On day 1, PCNL patients reported a mean VAS of 4.6 ± 1.1 compared to 3.2 ± 1.0 in the URSL group ($p < 0.001$). URSL's less invasive nature and absence of renal puncture explains the reduced postoperative discomfort. Although the overall complication rate was higher in the URSL group (21.25%) compared to PCNL (12.5%), this was not statistically significant ($p = 0.12$). Fever and sepsis were slightly more frequent in URSL, potentially due to ureteric manipulation and irrigation pressure leading to pyelovenous backflow.

CONCLUSION

It can be concluded that both PCNL and URSL are excellent procedures in the management of Large Upper Ureteric Stones. Both the procedures are well tolerated and pose minimal to no risks. URSL is faster, less invasive and has a storter stay at Hospital. PCNL has a better clearance rate and lesser residual rate. The decision of which procedure to be performed can be taken on a case-to-case basis based on the equipment available and Surgeon experience.

LIMITATIONS

Stone-free rates were assessed only up to 12 weeks post-procedure. Longer follow-up would be necessary to evaluate stone recurrence, long-term complications, and renal function outcomes. Economic factors such as the cost of instruments, hospitalization, and repeat procedures were not analyzed. A cost-effectiveness comparison could provide more comprehensive guidance for resource-limited settings.

Conflict of interest: The authors report no Conflict of Interest of any kind.

Declaration: The study protocol for medical research involving human subjects was approved by the local ethics committee under the latest Declaration of Helsinki. This article does not contain any studies with animals performed by any of the authors.

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