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Original Research Article

COMPARATIVE EVALUATION OF POSTOPERATIVE OUTCOMES FOLLOWING TUBELESS VERSUS STANDARD PERCUTANEOUS NEPHROLITHOTOMY: A PROSPECTIVE STUDY

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ABSTRACT

Background: Percutaneous nephrolithotomy (PCNL) is the standard treatment for large and complex renal calculi. Conventional PCNL involves nephrostomy tube placement, which may contribute to postoperative pain, prolonged hospital stay, and delayed recovery. Tubeless PCNL has emerged as a modified technique aimed at reducing postoperative morbidity while maintaining surgical efficacy. Objectives: To compare postoperative outcomes between tubeless and standard PCNL, with emphasis on pain, perioperative parameters, recovery outcomes, and complication rates.

Materials and Methods: This prospective comparative study included 54 patients undergoing PCNL, divided into two equal groups: standard PCNL (n=27) and tubeless PCNL (n=27). Demographic, operative, perioperative, and postoperative parameters were recorded. Outcomes assessed included operative duration, postoperative pain (VAS score), analgesic requirement, hemoglobin drop, hospital stay, complications, return to normal activity, and need for ancillary procedures. Statistical analysis was performed using appropriate parametric and non-parametric tests, with a p-value <0.05 considered statistically significant.

Results: The tubeless PCNL group demonstrated significantly shorter operative time (67.41 ± 18.75 vs 87.70 ± 16.09 minutes; $p<0.01$), reduced hospital stay (3.54 ± 1.44 vs 5.40 ± 1.56 days; $p<0.01$), lower postoperative pain scores (4.26 ± 1.43 vs 6.22 ± 1.09; $p<0.01$), and decreased analgesic requirement (85.19 ± 58.53 mg vs 122.22 ± 34.90 mg; $p<0.01$). Time to return to normal activity was also significantly shorter in the tubeless group (4.82 ± 1.27 vs 7.44 ± 2.24 days; $p<0.01$). Perioperative hemoglobin drop, blood transfusion requirement, postoperative fever, bleeding, urinary leakage, and ancillary procedure rates were comparable between the two groups.

Conclusion: Tubeless PCNL offers significant advantages in postoperative recovery and patient comfort without increasing complication rates. It represents a safe and effective alternative to standard PCNL in selected uncomplicated renal stone cases.

Keywords: Percutaneous nephrolithotomy (PCNL). Tubeless PCNL. Postoperative outcomes.

INTRODUCTION

Urolithiasis is a common urological disorder with increasing global prevalence and significant socioeconomic burden. Percutaneous nephrolithotomy (PCNL) has emerged as the gold standard surgical treatment for large renal calculi (>20 mm) and complex stones owing to its high stone-free rates and acceptable morbidity profile. Conventionally, standard PCNL involves placement of a nephrostomy tube at the end of the procedure to facilitate urinary drainage, tamponade bleeding, and provide access for second-look procedures. However, note that nephrostomy tubes are associated with postoperative discomfort, prolonged hospital stay, increased analgesic requirement, and delayed return to daily activities.[1]

In recent years, tubeless PCNL has gained attention as a modification of the conventional technique. In this approach, nephrostomy tube placement is omitted and renal drainage is maintained using an internal ureteral stent or catheter. Several studies have demonstrated that tubeless PCNL may reduce postoperative pain, shorten hospitalization, decrease urinary leakage, and allow faster convalescence without compromising stone clearance or patient safety. Bellman et al. were among the first to establish the feasibility and safety of tubeless PCNL, reporting reduced morbidity and improved postoperative recovery compared to standard PCNL. Subsequent randomized controlled trials and meta-analyses have supported these findings, highlighting comparable complication rates and stone-free outcomes between the two approaches.[2,3]

Despite promising results, tubeless PCNL has not yet become universal practice. Concerns persist regarding postoperative urine leakage, bleeding risk, need for secondary interventions, and appropriate patient selection. Tubeless PCNL is generally recommended in carefully selected patients with uncomplicated stones, minimal intraoperative bleeding, intact pelvicalyceal systems, and complete stone clearance. Therefore, systematic comparison between standard and tubeless PCNL remains important to establish evidence-based clinical protocols.[4]

AIM

To compare postoperative outcomes between tubeless and standard percutaneous nephrolithotomy in patients undergoing PCNL.

Objectives

1. To evaluate postoperative pain and analgesic requirement in tubeless versus standard PCNL.
2. To compare perioperative outcomes including hemoglobin drop, complications, and hospital stay.
3. To assess recovery parameters including return to normal activities and need for ancillary procedures.

MATERIALS AND METHODS

Source of Data: Data were collected from patients diagnosed with renal calculi who underwent percutaneous nephrolithotomy at the Department of General Surgery of a tertiary care teaching hospital.

Study Design: This was a hospital-based prospective comparative study.

Study Location: The study was conducted in the Department of General Surgery at a tertiary care hospital.

Study Duration: The study was conducted over a period of two years.

Sample Size: A total of 54 patients were included in the study. Patients were randomly allocated into two equal groups:

- Standard PCNL group: 27 patients
- Tubeless PCNL group: 27 patients

Inclusion Criteria

- Patients with renal and/or upper ureteric calculi >2 cm
- Lower calyceal stones >1.5 cm suitable for PCNL
- Patients providing informed written consent

Exclusion Criteria

- Significant intraoperative bleeding
- Multiple puncture tracts
- Pelvicalyceal system injury
- Residual stone fragments requiring second-look procedure
- Age less than 18 years
- Coagulopathies or active urinary tract infection
- Solitary kidney or congenital renal anomalies
- Simultaneous bilateral PCNL

Procedure and Methodology: After obtaining informed consent, all patients underwent detailed clinical evaluation including history, physical examination, and laboratory investigations such as complete blood count, renal function tests, coagulation profile, and urine culture. Radiological assessment included X-ray KUB, ultrasonography, and intravenous urography or CT urography to determine stone burden and renal anatomy.

Patients were randomized into standard PCNL or tubeless PCNL groups. Procedures were performed under standard aseptic conditions following institutional protocols. In the standard PCNL group, nephrostomy tubes were placed postoperatively and removed on postoperative day one. In the tubeless PCNL group, nephrostomy tubes were omitted and internal drainage was maintained using DJ stents. DJ stents were removed after three weeks in both groups. Follow-up imaging was performed on postoperative day 7 and day 21 to assess stone clearance and complications.

Sample Processing: Blood samples were collected preoperatively and postoperatively for hemoglobin estimation. Urine samples were processed for culture and sensitivity testing. Radiological images were evaluated by experienced radiologists for stone clearance and complications.

Statistical Methods: Data were entered into a predesigned proforma and analyzed using statistical software. Qualitative variables were expressed as frequencies and percentages. Quantitative variables were expressed as mean ± standard deviation. Chi-square test and Fisher's exact test were used for categorical variables. Independent t-test or Mann–Whitney U test was applied for continuous variables depending on data distribution. A p-value less than 0.05 was considered statistically significant.

Data Collection: Data were collected prospectively using structured case record forms. Parameters assessed included demographic variables, operative details, postoperative pain scores, analgesic requirement, hemoglobin drop, complications, hospital stay, and time to return to normal activities.

RESULTS

[Table 1] compares the postoperative outcomes between patients undergoing standard PCNL and tubeless PCNL. The mean duration of surgery was significantly shorter in the tubeless PCNL group (67.41 ± 18.75 minutes) compared to the standard PCNL group (87.70 ± 16.09 minutes), with a mean difference of −20.29 minutes (95% CI: −29.83 to −10.75), which was statistically significant ($p < 0.01$). Similarly, the mean hospital stay was significantly reduced in the tubeless PCNL group (3.54 ± 1.44 days) compared to the standard PCNL group (5.40 ± 1.56 days), with a mean difference of −1.86 days (95% CI: −2.68 to −1.04; $p < 0.01$).

Postoperative urinary leak was observed in 11.1% of patients in the standard PCNL group, whereas no cases were reported in the tubeless PCNL group; however, this difference did not reach statistical significance ($p = 0.075$). The incidence of postoperative fever was slightly higher in the standard PCNL group (18.5%) compared to the tubeless PCNL group (11.1%), but this difference was not statistically significant ($p = 0.70$). Similarly, postoperative bleeding was more frequent in the standard PCNL group (14.8%) than in the tubeless PCNL group (3.7%), although the difference was not statistically significant ($p = 0.35$).

Table 1: Postoperative outcomes

Postoperative outcome	Standard PCNL (n=27) Mean±SD / n(%)	Tubeless PCNL (n=27) Mean±SD / n(%)	Test of significance	Effect size (95% CI)	p-value
Duration of surgery (min)	87.70 ± 16.09	67.41 ± 18.75	Unpaired t-test	Mean diff (T−S)= −20.29 (−29.83 to −10.75)	<0.01
Hospital stay (days)	5.40 ± 1.56	3.54 ± 1.44	Unpaired t-test	Mean diff (T−S)= −1.86 (−2.68 to −1.04)	<0.01
Urinary leak (Yes)	3 (11.1%)	0 (0.0%)	Fisher's exact	RR (T vs S)= 0.14 (0.01 to 2.64)	0.075
Fever (Yes)	5 (18.5%)	3 (11.1%)	Chi-square/Fisher	RR (T vs S)= 0.60 (0.16 to 2.26)	0.70
Bleeding (Yes)	4 (14.8%)	1 (3.7%)	Chi-square/Fisher	RR (T vs S)= 0.25 (0.03 to 2.09)	0.35

Table 2: Postoperative pain and analgesic requirement

Pain outcome	Standard PCNL (n=27) Mean±SD	Tubeless PCNL (n=27) Mean±SD	Test of significance	Mean diff (T−S) (95% CI)	p-value
VAS score at discharge	6.22 ± 1.09	4.26 ± 1.43	Unpaired t-test	−1.96 (−2.65 to −1.27)	<0.01
Analgesic requirement (mg)	122.22 ± 34.90	85.19 ± 58.53	Unpaired t-test	−37.03 (−63.35 to −10.71)	<0.01

[Table 2] highlights the comparison of postoperative pain scores and analgesic requirements between the two study groups. The mean VAS score at discharge was significantly lower in the tubeless PCNL group (4.26 ± 1.43) compared to the standard PCNL group (6.22 ± 1.09), with a mean difference of −1.96 (95% CI: −2.65 to −1.27; $p < 0.01$). This finding indicates better postoperative pain control in patients undergoing tubeless PCNL. In addition, the mean postoperative analgesic requirement was significantly reduced in the tubeless PCNL group (85.19 ± 58.53 mg) compared to the standard PCNL group (122.22 ± 34.90 mg), with a mean difference of −37.03 mg (95% CI: −63.35 to −10.71; $p < 0.01$).

Table 3: Perioperative outcomes (Hb drop, complications, hospital stay)

Perioperative outcome	Standard PCNL (n=27) Mean±SD / n(%)	Tubeless PCNL (n=27) Mean±SD / n(%)	Test of significance	Effect size (95% CI)	p-value
Baseline Hb (g/dL)	12.39 ± 1.86	12.56 ± 2.11	Unpaired t-test	Mean diff (T−S)= +0.17 (−0.92 to +1.26)	0.82
Post-op Hb (g/dL)	11.59 ± 1.81	11.89 ± 1.12	Unpaired t-test	Mean diff (T−S)= +0.30 (−0.52 to +1.12)	0.57
Hb drop (g/dL)	1.57 ± 0.19	1.14 ± 0.18	Unpaired t-test	Mean diff (T−S)= −0.43 (−0.53 to −0.33)	0.64
Blood transfusion (Yes)	2 (7.4%)	1 (3.7%)	Fisher's exact	RR (T vs S)= 0.50 (0.05 to 5.19)	1.0

Hospital stay (days)	5.40 ± 1.56	3.54 ± 1.44	Unpaired t-test	Mean diff (T−S)= −1.86 (−2.68 to −1.04)	<0.01
Fever (Yes)	5 (18.5%)	3 (11.1%)	Chi-square/Fisher	RR (T vs S)= 0.60 (0.16 to 2.26)	0.70
Bleeding (Yes)	4 (14.8%)	1 (3.7%)	Chi-square/Fisher	RR (T vs S)= 0.25 (0.03 to 2.09)	0.35

[Table 3] compares perioperative parameters between the two groups. Baseline hemoglobin levels were comparable between the standard PCNL group (12.39 ± 1.86 g/dL) and the tubeless PCNL group (12.56 ± 2.11 g/dL), with no statistically significant difference (p = 0.82). Similarly, postoperative hemoglobin levels did not differ significantly between the two groups (11.59 ± 1.81 g/dL vs. 11.89 ± 1.12 g/dL; p = 0.57). The mean hemoglobin drop was slightly lower in the tubeless PCNL group (1.14 ± 0.18 g/dL) compared to the standard PCNL group (1.57 ± 0.19 g/dL); however, this difference was not statistically significant (p = 0.64).

The requirement for blood transfusion was low in both groups, with 7.4% of patients in the standard PCNL group and 3.7% in the tubeless PCNL group requiring transfusion, showing no statistically significant difference (p = 1.0). Postoperative fever and bleeding complications were also comparable between the two groups and did not show statistically significant differences. However, hospital stay remained significantly shorter in the tubeless PCNL group (3.54 ± 1.44 days) compared to the standard PCNL group (5.40 ± 1.56 days), with a mean difference of −1.86 days (p < 0.01).

Table 4: Recovery parameters and ancillary procedures

Recovery parameter	Standard PCNL (n=27) Mean±SD / n(%)	Tubeless PCNL (n=27) Mean±SD / n(%)	Test of significance	Effect size (95% CI)	p-value
Return to normal activity (days)	7.44 ± 2.24	4.82 ± 1.27	Unpaired t-test	Mean diff (T−S)= −2.62 (−3.61 to −1.63)	<0.01
Ancillary procedure ESWL (Yes)	2 (7.4%)	2 (7.4%)	Fisher's exact	RR (T vs S)= 1.00 (0.15 to 6.59)	1.0
Urinary leak (Yes)	3 (11.1%)	0 (0.0%)	Fisher's exact	RR (T vs S)= 0.14 (0.01 to 2.64)	0.075

[Table 4] evaluates recovery outcomes and the need for ancillary procedures in both groups. The mean time to return to normal activities was significantly shorter in the tubeless PCNL group (4.82 ± 1.27 days) compared to the standard PCNL group (7.44 ± 2.24 days), with a mean difference of −2.62 days (95% CI: −3.61 to −1.63; p < 0.01). This finding indicates faster postoperative recovery in patients undergoing tubeless PCNL.

The requirement for ancillary procedures such as ESWL was identical in both groups (7.4%), with no statistically significant difference observed (p = 1.0). Urinary leak was noted in 11.1% of patients in the standard PCNL group, whereas no cases were observed in the tubeless PCNL group; however, this difference did not achieve statistical significance (p = 0.075).

DISCUSSION

[Table 1] (postoperative outcomes) showed a significantly shorter duration of surgery in the tubeless group (67.41 ± 18.75 min) compared with standard PCNL (87.70 ± 16.09 min) (p<0.01). Similar reductions in operative time and improved perioperative efficiency have been reported in comparative studies evaluating modified drainage strategies after PCNL, where omission of nephrostomy tube reduced time spent on tube placement and postoperative tube-related management Kamble VB et al.(2024).[2] Your finding of a significantly shorter hospital stay in tubeless PCNL (3.54 ± 1.44 vs 5.40 ± 1.56 days; p<0.01) strongly aligns with the foundational work by Wan C et al.(2022),[3] and subsequent prospective comparisons showing earlier discharge in tubeless cohorts due to reduced discomfort and fewer tube-related issues. Similar reductions in hospitalization have also been reinforced by systematic evidence, where tubeless PCNL was consistently associated with shorter hospital stay compared with standard nephrostomy drainage Chen ZJ et al.(2020).[4] With respect to complications, urinary leak was lower in tubeless PCNL (0%) vs standard (11.1%), though not statistically significant (p=0.075). Prior reports note that urine leakage may occur after PCNL but tends to be less problematic when the tract is not externally drained and when internal drainage is adequate Deng S et al (2024).[5] Fever and bleeding were numerically lower in tubeless PCNL but non-significant, consistent with literature showing overall comparable complication rates when tubeless PCNL is applied in properly selected uncomplicated cases Hyder I et al (2024).[6]

[Table 2] (pain and analgesic requirement) demonstrated a clinically and statistically meaningful benefit: lower VAS at discharge in tubeless PCNL (4.26 ± 1.43 vs 6.22 ± 1.09; p<0.01) and reduced analgesic requirement (85.19 ± 58.53 mg vs 122.22 ± 34.90 mg; p<0.01). This is one of the most consistently reproduced advantages of tubeless PCNL in the literature. Both early feasibility and subsequent prospective studies have repeatedly shown that nephrostomy tubes contribute substantially to postoperative pain and analgesic consumption, and their omission improves patient

comfort Gauhar V et al (2022).[1] These observations are supported by randomized and comparative experiences where tubeless or totally tubeless techniques significantly reduced pain scores and analgesic needs without compromising outcomes Minami T et al (2020).[7] Meta-analytic evidence also supports "less postoperative analgesia" and better pain outcomes for tubeless PCNL compared with standard PCNL Guru N et al (2025).[8]

[Table 3] (perioperative outcomes including hemoglobin drop, complications, and hospital stay) indicates that both groups were comparable in baseline Hb and postoperative Hb, and although the Hb drop appeared numerically lower in tubeless PCNL (1.14 ± 0.18 vs 1.57 ± 0.19 g/dL), it was not statistically significant in your dataset. This pattern—similar hematologic change and transfusion rates between groups—has been widely noted, suggesting that nephrostomy tube omission does not inherently increase bleeding risk when hemostasis is secured intraoperatively Li Q et al (2020).[9] Your low transfusion rates and non-significant differences are concordant with earlier comparative trials and feasibility series, which generally report comparable bleeding outcomes between tubeless and standard drainage approaches in selected patients. The shorter hospital stay in tubeless PCNL again mirrors consistent published experience across multiple cohorts and comparative designs Rakib MA et al (2021).[10]

[Table 4] (recovery parameters and ancillary procedures) further strengthens the clinical relevance of tubeless PCNL, showing significantly faster return to normal activity (4.82 ± 1.27 vs 7.44 ± 2.24 days; $p<0.01$). This endpoint is particularly patient-centered and has been repeatedly shown to favor tubeless strategies, likely due to reduced pain, earlier mobility, and earlier discharge Yogesh K. (2022).[11] Importantly, the need for ancillary procedures (ESWL) was identical (7.4% in both groups; $p=1.0$), indicating that tubeless PCNL did not compromise effectiveness or necessitate additional interventions—consistent with comparative studies reporting similar stone clearance/secondary procedure needs when selection criteria are appropriate Gupta K et al (2025).[12]

CONCLUSION

This prospective comparative study demonstrates that tubeless percutaneous nephrolithotomy is a safe and effective alternative to standard PCNL in appropriately selected patients. The tubeless technique was associated with significantly shorter operative duration, reduced postoperative pain scores, lower analgesic requirement, shorter hospital stay, and earlier return to normal daily activities when compared with the standard nephrostomy-based approach. Importantly, perioperative outcomes such as hemoglobin drop, need for blood transfusion, postoperative fever, bleeding complications, and requirement for ancillary procedures were comparable between the two groups, indicating that omission of nephrostomy tube did not compromise patient safety or procedural efficacy.

These findings highlight the clinical advantages of tubeless PCNL in improving postoperative recovery and patient comfort while maintaining similar complication rates and effectiveness. Therefore, tubeless PCNL can be considered a preferable option in uncomplicated renal stone cases with complete stone clearance and minimal intraoperative bleeding. Wider adoption of this technique may contribute to enhanced patient satisfaction, reduced hospital resource utilization, and faster postoperative rehabilitation.

Limitations of the Study

1. The study was conducted at a single tertiary care center, which may limit the generalizability of the findings to other institutions with different patient populations and surgical expertise.
2. The sample size was relatively small, which may have reduced the statistical power to detect differences in less frequent postoperative complications such as bleeding and urinary leakage.
3. Randomization was limited to patient allocation, and surgeon-related factors such as operative experience and technique variation were not fully controlled.
4. Long-term outcomes such as stone recurrence, late complications, and long-term renal function were not evaluated due to limited follow-up duration.
5. The study included only selected uncomplicated cases suitable for tubeless PCNL; therefore, the results may not be applicable to complex stones, multiple access tracts, or patients with significant comorbidities.

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