



Postoperative Pain and Recovery Outcomes Following Tubeless versus Standard PCNL

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Abstract

Background: Urinary stones are a common urological condition that can impair renal function and pose a significant public health concern, with prevalence rates ranging from 1% to 20% and higher rates (>10%) in developed countries. The purpose of this study is to compare postoperative pain and recovery outcomes between tubeless and standard percutaneous nephrolithotomy in our patient population, addressing a critical gap in current clinical evidence.

Methods: This prospective RCT at the Department of Urology, Bangladesh Medical University Hospital, Dhaka, enrolled 100 adults with large renal stones (>2 cm) to compare Tubeless and Standard PCNL. Outcomes included postoperative pain, hospital stay, 30-day complications, stone-free status at 3 months, and recurrence at 12 months. Data were collected by blinded assistants, analyzed using appropriate statistical tests ($p < 0.05$).

Results: In 100 patients, baseline characteristics were comparable. Tubeless PCNL showed lower postoperative pain (VAS 3.9–1.8 vs 5.8–3.1, 6–48 h), shorter hospital stay (1.6 ± 0.8 vs 3.2 ± 1.1 days, $p < 0.001$), and fewer overall complications (14.0% vs 44.0%, $p = 0.002$), with significantly less urinary leakage (2.0% vs 14.0%, $p = 0.03$).

Conclusion: Tubeless PCNL provides faster recovery, less postoperative pain, and fewer complications than standard PCNL.

Keywords: Postoperative Pain; Recovery Outcomes; Percutaneous Nephrolithotomy.

Introduction

Urinary stones are a prevalent urological condition, with occurrence rates ranging from 1% to 20%. In nations with higher living standards, such as Canada and the United States, the prevalence of renal calculi is particularly elevated, exceeding 10%. These stones can impair renal function and pose a significant public health concern [1]. Since its introduction, percutaneous nephrolithotomy (PCNL) has revolutionized the management of large and complex kidney stones [2, 3]. Traditionally, nephrostomy tubes are placed after PCNL to facilitate drainage, control bleeding, and allow access for any necessary subsequent procedures. However, the use of nephrostomy tubes has been associated with increased postoperative discomfort, urine leakage, and prolonged hospitalization. To address these issues, the concept of “tubeless PCNL” was introduced in the late 1990s, wherein a ureteral stent is used

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for drainage instead of a nephrostomy tube. This approach maintains safety and effective stone clearance while potentially reducing morbidity [4]. In conventional PCNL, nephrostomy tubes are routinely inserted after stone removal [5], but this practice can lead to postoperative pain, urinary leakage, and extended hospital stay [6]. Evidence suggests that tubeless PCNL is associated with lower postoperative pain, quicker recovery [7, 8], and overall improved patient comfort, while demonstrating comparable outcomes to standard PCNL in terms of hemorrhagic and other postoperative complications [9]. Although tubeless PCNL has gained increasing attention, the existing evidence remains limited, as the number and quality of randomized controlled trials (RCTs) are still insufficient to draw definitive conclusions. Well-designed RCTs are needed to strengthen the evidence supporting this technique [10]. In this context, our study aims to compare conventional PCNL and tubeless PCNL with respect to operative time, postoperative pain, analgesic requirements, hospital stay, complications, and stone clearance. Specifically, we focus on assessing postoperative pain and recovery outcomes within our patient population, addressing an important gap in the current literature.

Objective

- To compare postoperative pain and recovery outcomes between tubeless and standard percutaneous nephrolithotomy.

Methodology & Materials

This prospective, randomized controlled trial was conducted at the Department of Urology, Bangladesh Medical University Hospital, Dhaka, Bangladesh, over a 12-month period following ethical approval. A total of 100 adult patients aged 18–65 years with large renal stones (>2 cm) scheduled for Percutaneous Nephrolithotomy (PCNL) were enrolled to compare postoperative pain and recovery outcomes between Tubeless and Standard PCNL.

Inclusion Criteria

- Adults aged 18–65 years.
- Large renal stones (>2 cm) confirmed by preoperative imaging (CT scan or ultrasound).

No active urinary tract infection or other surgical contraindications.

Provided written informed consent.

Exclusion Criteria

- Solitary kidney or severe renal impairment.
- Coagulopathies or other blood disorders.
- Pregnancy.
- Contraindications to general anesthesia.
- Anatomical abnormalities precluding successful PCNL.

All procedures were performed under standardized protocols for preoperative preparation, anesthesia, and surgical technique, with Tubeless PCNL omitting nephrostomy tube placement and Standard PCNL including routine tube placement. Primary outcomes were postoperative pain (assessed by Visual Analogue Scale [VAS] 0–10 at 6, 12, 24, and 48 hours), hospital stay (days from surgery to discharge), and 30-day complications (graded by Clavien-Dindo), while secondary outcomes included stone-free status at 3 months and recurrence at 12 months. Data were collected by trained, blinded research assistants using standardized forms, hospital records, and imaging, with quality control maintained through regular audits and secure database management. Potential confounders such as age, sex, comorbidities, stone characteristics, and surgeon experience were considered, and randomization, assessor blinding, and standardized care minimized bias. Continuous variables were summarized as mean \pm SD and compared using independent t-tests, while categorical variables were presented as frequencies and percentages and compared using Chi-square or Fisher's exact tests, with $p < 0.05$ considered statistically significant (SPSS software). Ethical approval was obtained from the Institutional Review Board, written informed consent was secured from all participants, data were anonymized, and patient safety was closely monitored throughout the study.

Results

Table 1 summarizes the baseline characteristics of patients in the Tubeless and Standard PCNL groups, demonstrating no significant differences between the groups across demographic, clinical, and stone-related variables.

Table 1: Baseline Characteristics of the Study Participants (n = 100)

Category	Variable	Tubeless PCNL (n = 50)	Standard PCNL (n = 50)	p-value
Demographic	Age (years), mean \pm SD	42.6 \pm 10.8	44.1 \pm 11.2	0.480
	Male sex, n (%)	31 (62.0%)	29 (58.0%)	0.680
Clinical	BMI (kg/m ²), mean \pm SD	24.9 \pm 2.8	25.3 \pm 3.1	0.470
	Diabetes mellitus, n (%)	7 (14.0%)	9 (18.0%)	0.610
	Hypertension, n (%)	10 (20.0%)	11 (22.0%)	0.820
Stone-related	Stone size (cm), mean \pm SD	2.7 \pm 0.5	2.8 \pm 0.6	0.390

Table 2: Postoperative Pain Score Comparison (VAS 0–10) Between Tubeless and Standard PCNL at Different Time Points

Time Point	Tubeless PCNL	Standard PCNL	p-value
6 hours	3.9 ± 1.1	5.8 ± 1.4	<0.001
12 hours	3.2 ± 1.0	5.1 ± 1.3	<0.001
24 hours	2.6 ± 0.9	4.2 ± 1.1	<0.001
48 hours	1.8 ± 0.7	3.1 ± 1.0	<0.001

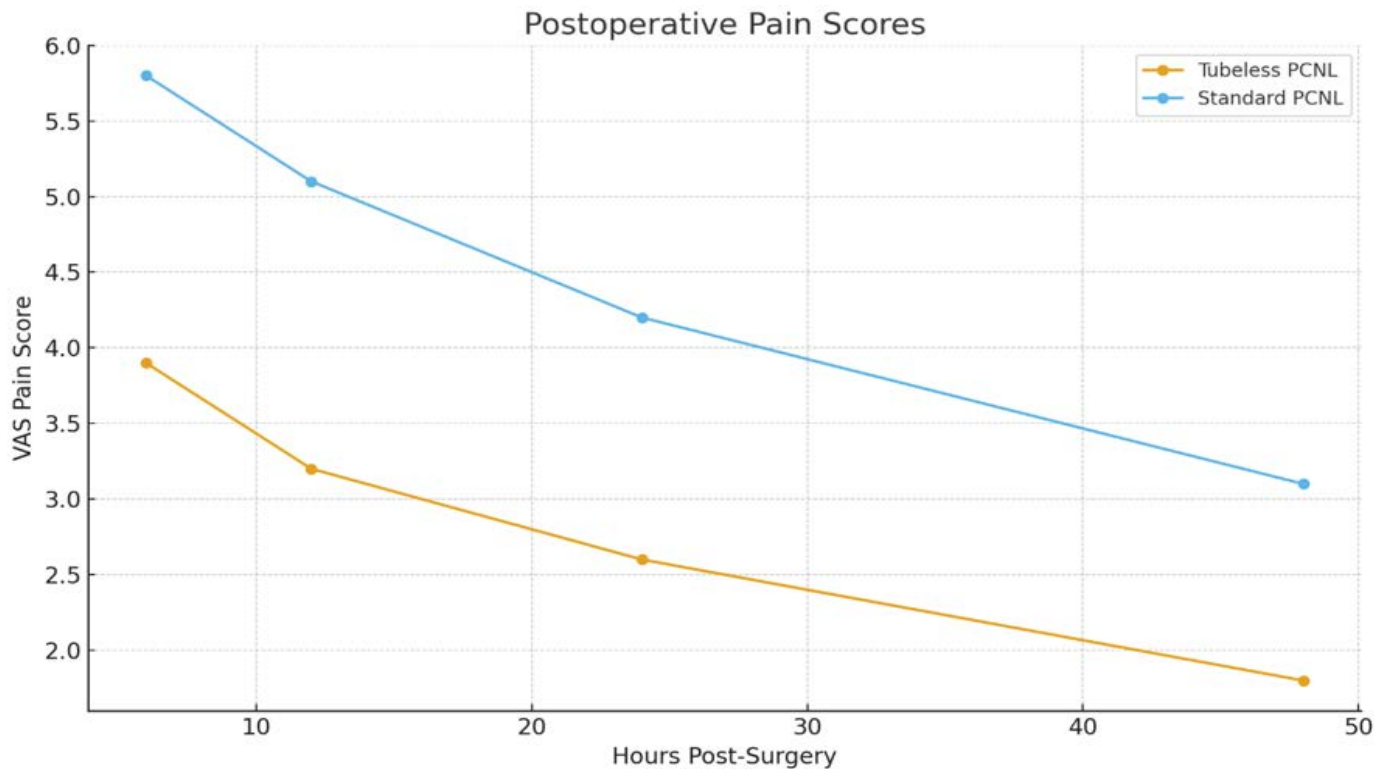


Figure 1: Postoperative Pain Score Trends in Tubeless and Standard PCNL

Table 2 presents postoperative VAS pain scores measured at 6, 12, 24, and 48 hours following surgery. At each time point, the Tubeless PCNL group reported significantly lower pain scores compared to the Standard PCNL group, with all differences reaching statistical significance ($p < 0.001$).

The Tubeless PCNL group consistently demonstrated lower VAS scores at all time intervals.

Table 3 summarizes the mean duration of hospital stay for patients undergoing Tubeless and Standard PCNL. The Tubeless PCNL group had a significantly shorter hospital

stay (1.6 ± 0.8 days) compared to the Standard PCNL group (3.2 ± 1.1 days, $p < 0.001$).

Table 4 summarizes the incidence of postoperative complications within 30 days in the Tubeless and Standard PCNL groups. The Tubeless PCNL group experienced fewer overall complications (14.0%) compared to the Standard PCNL group (44.0%, $p = 0.002$). Specifically, rates of urinary leakage were significantly lower in the tubeless group (2.0% vs 14.0%, $p = 0.03$), while differences in bleeding requiring transfusion and fever/UTI did not reach statistical significance.

Table 3: Comparison of Postoperative Hospital Stay Between Tubeless and Standard PCNL

Group	Hospital Stay (days, mean ± SD)	p-value
Recovery	Tubeless PCNL	1.6 ± 0.8
	Standard PCNL	3.2 ± 1.1
		<0.001

Table 4: Comparison of 30-Day Postoperative Complications Between Tubeless and Standard PCNL

Complication	Tubeless PCNL (n = 50)	Standard PCNL (n = 50)	p-value
Bleeding requiring transfusion	2 (4.0%)	6 (12.0%)	0.140
Fever / UTI	4 (8.0%)	9 (18.0%)	0.140
Urinary leakage	1 (2.0%)	7 (14.0%)	0.030
Overall complication rate	7 (14.0%)	22 (44.0%)	0.002

Discussion

Percutaneous nephrolithotomy (PCNL) is a well-established surgical intervention for the management of large and complex renal stones, offering effective stone clearance with lower morbidity compared to open surgery. However, the placement of nephrostomy tubes in standard PCNL has been associated with increased postoperative pain, urinary leakage, and prolonged hospital stay, which can impact patient recovery and overall healthcare burden. The findings of this study demonstrate that Tubeless PCNL, which omits nephrostomy tube placement, is associated with significantly lower postoperative pain scores, shorter hospital stays, and reduced overall complication rates compared to Standard PCNL. These results highlight the clinical benefit of Tubeless PCNL in improving postoperative recovery and patient comfort while maintaining procedural safety and efficacy. The baseline characteristics in the present study demonstrated no statistically significant differences between the Tubeless PCNL and Standard PCNL groups across demographic, clinical, and stone-related variables, including age, sex distribution, BMI, diabetes, hypertension, and stone size. This balanced distribution aligns closely with the observations of Ichaoui et al.[11], who similarly reported no significant variation in age, sex, or comorbidities such as diabetes and hypertension between the two PCNL approaches in their comparative analysis of 125 procedures. Likewise, the findings are consistent with the propensity-score-matched cohort reported by Hao et al.[12], where both groups showed comparable preoperative characteristics, including BMI, gender, stone burden, and other stone-related parameters. Such concordance across studies reinforces the methodological robustness of achieving baseline equivalence, ensuring that subsequent differences in postoperative outcomes can be more reliably attributed to the surgical technique rather than underlying patient or disease-related variability.

The present study demonstrated consistently lower postoperative VAS pain scores in the Tubeless PCNL group across all assessed time points—from 6 hours through 48 hours—when compared with the Standard PCNL group, with all differences reaching high statistical significance. These findings closely mirror the results of Kamalakshi et al.[13], who similarly reported substantially reduced postoperative pain in the tubeless group (approximately 3.6 vs 6.0 on

VAS) along with decreased analgesic requirements and shorter hospitalization. The pattern observed in our study is further reinforced by the meta-analysis conducted by Chen et al.[14], which pooled data from multiple randomized trials and confirmed that tubeless PCNL is consistently associated with lower pain scores, reduced need for analgesia, shorter hospital stay, and fewer postoperative issues such as urinary leakage. Collectively, the concordance between our results and existing literature highlights the clear postoperative comfort advantage of the tubeless technique and supports its value as a less painful and more recovery-friendly alternative to standard PCNL. The present study demonstrated a significantly shorter postoperative hospital stay in the Tubeless PCNL group (1.6 ± 0.8 days) compared to the Standard PCNL group (3.2 ± 1.1 days, $p < 0.001$), reflecting faster recovery and earlier discharge associated with the tubeless technique. These findings are in concordance with Choi et al.[15], who reported a mean hospital stay of 1.72 ± 0.58 days for tubeless PCNL versus 4.10 ± 1.88 days for standard PCNL, and with El et al.[16], who also observed a significantly reduced stay in the tubeless group (mean 3.2 days) compared to the standard PCNL group (mean 4.5 days). Collectively, these consistent observations across different studies reinforce the advantage of the tubeless approach in promoting quicker postoperative recovery and minimizing hospitalization.

In the present study, the Tubeless PCNL group demonstrated a lower overall 30-day complication rate (14.0%) compared to the Standard PCNL group (44.0%, $p = 0.002$), with a notably reduced incidence of urinary leakage (2.0% vs 14.0%, $p = 0.030$). Although rates of bleeding requiring transfusion and postoperative fever/UTI were lower in the tubeless group, these differences did not reach statistical significance. These findings are largely consistent with the retrospective cohort reported by Hill et al.[17], in which no significant difference in major complications (Clavien ≥ 2 or ≥ 3) was observed between tubeless and standard PCNL, although the tubeless group exhibited higher transfusion rates (6.4% vs 0.9%). The concordance between studies underscores the safety profile of the tubeless approach, while also highlighting that variations in bleeding risk or transfusion requirements may occur depending on patient selection, surgical technique, and institutional practices. Overall, the results support the advantage of tubeless PCNL

in reducing postoperative morbidity, particularly urinary leakage, without increasing major complication risk.

Limitations of the study

The study had a few limitations:

- Single-center study, which may limit generalizability to other healthcare settings.
- Sample size may be insufficient to detect subtle differences in stone recurrence or long-term complications.
- Follow-up limited to 12 months, preventing assessment of long-term durability of outcomes.

Further multicenter studies with larger cohorts are needed to validate findings.

Conclusion

Tubeless PCNL is associated with significantly lower postoperative pain, shorter hospital stay, and reduced overall 30-day complication rates, particularly urinary leakage, compared to standard PCNL, while baseline demographic, clinical, and stone-related characteristics were comparable between groups. These findings suggest that the tubeless approach offers superior postoperative recovery and enhanced patient comfort without increasing major complications.

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