Original Article
DOI: https://doi.org/10.70749/ijbr.v2i02.1895

INDUS JOURNAL OF BIOSCIENCE RESEARCH
https://induspublishers.com/IJBR
ISSN: 2960-2793/ 2960-2807

Comparison of Mean Hospital Stay in Patients Undergoing Tubed Versus Tubeless Percutaneous Nephrolithotomy: A Randomized Controlled Trial

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ARTICLE INFO

Keywords

Percutaneous Nephrolithotomy, Tubeless PCNL, Nephrostomy Tube, Hospital Stay, Randomized Controlled Trial.

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Declaration

Authors' Contribution: All authors equally contributed to the study and approved the final manuscript.
Conflict of Interest: No conflict of interest.
Funding: No funding received by the authors.

Article History

Received: 03-06-2025, Revised: 26-06-2025
Accepted: 06-07-2025, Published: 12-07-2025

ABSTRACT

Background: Percutaneous nephrolithotomy (PCNL) is the standard surgical intervention for managing large or complex renal calculi. Traditionally, the procedure concludes with the placement of a nephrostomy tube (tubed PCNL), intended to ensure drainage, hemostasis, and access for secondary procedures. However, growing interest in tubeless PCNL—where the nephrostomy tube is omitted—has prompted evaluation of its safety, efficacy, and impact on postoperative recovery, particularly hospital stay duration. **Objective:** To compare the mean hospital, stay in patients undergoing tubed versus tubeless percutaneous nephrolithotomy (PCNL) for renal calculi. **Methods:** This randomized controlled trial was conducted at Bolan Medical College and Hospital, Quetta, from January 2025 to May 2025. Sixty patients were randomized into two equal groups: one undergoing standard PCNL with nephrostomy tube placement and the other undergoing tubeless PCNL. Data on demographic, clinical, and perioperative characteristics were collected. The primary outcome was mean hospital stay. **Results:** The tubeless PCNL group demonstrated a significantly shorter hospital stay compared to the tubed group (mean ± SD: 3.1 ± 1.1 vs. 4.5 ± 2.1 days; $p < 0.05$). **Conclusion:** Tubeless PCNL offers a shorter hospital stay compared to traditional tubed PCNL without compromising patient safety.

INTRODUCTION

Percutaneous nephrolithotomy (PCNL) has become the treatment of choice for large and complex renal calculi since its introduction in 1976. This minimally invasive surgical technique allows for the direct removal of kidney stones via a percutaneous tract created through the skin into the renal collecting system (Ganpule et al., 2016). Over the last four decades, PCNL has seen considerable evolution in terms of instruments, imaging guidance, and surgical strategies, significantly improving patient outcomes (Geraghty et al., 2017). However, the debate continues over the optimal method of post-procedural drainage, especially concerning the use of nephrostomy tubes.

Traditionally, PCNL concludes with the placement of a nephrostomy tube to ensure adequate renal drainage, tamponade the access tract, provide a route for potential re-entry, and reduce the risk of urine extravasation (Bellman et al., 1997). Although effective, nephrostomy tubes are not without drawbacks. Several studies have identified increased postoperative pain, extended hospital stays, delayed ambulation, and greater analgesic requirements in patients with nephrostomy tubes compared to those without (Zilberman et al., 2010; Istanbulluoglu et al., 2010).

The advent of the "tubeless" PCNL approach marked a significant turning point in the effort to reduce the invasiveness of this already minimally invasive procedure. Tubeless PCNL omits nephrostomy tube placement, instead relying on internal drainage via a double-J ureteral stent or, in some cases, no drainage at all (Ni et al., 2011). This technique has gained traction globally, particularly as patient-centered care and rapid recovery protocols continue to influence modern surgical practice.

Numerous randomized controlled trials (RCTs) and systematic reviews have examined the efficacy and safety of tubeless PCNL. Studies have consistently

demonstrated that tubeless PCNL is associated with shorter hospitalization times, reduced postoperative discomfort, and faster return to normal activities (Agarwal et al., 2008; Yuan et al., 2011; Zhou et al., 2020). Despite these encouraging findings, there remains ongoing debate within the urological community due to inconsistent results in trials with heterogeneous patient populations. Many earlier studies included patients with a wide range of stone sizes, tract sizes, and comorbidities, which may have confounded the outcomes (Smith et al., 2008; Turna et al., 2007).

A critical consideration is the role of stone burden and tract size in determining post-surgical outcomes. Larger stones typically require larger access tracts, longer operative times, and carry a greater risk of bleeding and infection—all of which may necessitate nephrostomy tube placement (Chen et al., 2020). In contrast, patients with smaller or moderate-sized stones may benefit from tubeless PCNL due to the relative simplicity and safety of the procedure in this subgroup. However, the literature lacks focused RCTs that stratify patients based on stone burden and tract size when comparing tubed and tubeless PCNL outcomes. Moreover, hospital stay is an important clinical and economic endpoint. Prolonged hospitalization is associated with increased healthcare costs, greater risk of nosocomial infections, and delayed patient recovery. Optimizing discharge times without compromising patient safety is therefore a key objective in surgical innovation. The role of tubeless PCNL in achieving this goal warrants further high-quality, targeted investigation. The present study aims to bridge this gap by conducting a randomized controlled trial specifically designed to compare the mean hospital stay between patients undergoing tubed versus tubeless PCNL in a controlled clinical setting. By excluding patients with known complicating factors such as bilateral stones, infections, or comorbidities, this study seeks to offer a more precise evaluation of the relationship between postoperative drainage strategy and hospitalization duration.

LITERATURE REVIEW

The optimal postoperative drainage method following percutaneous nephrolithotomy (PCNL) continues to be an area of clinical interest and evolving evidence. With PCNL established as the gold standard for large renal calculi, attention has shifted to improving recovery, minimizing complications, and shortening hospital stay—leading to the emergence of tubeless PCNL (Ganpule et al., 2016; Geraghty et al., 2017).

Historically, nephrostomy tubes were considered essential after PCNL to provide effective drainage, tamponade bleeding, prevent urinary extravasation, and allow for secondary access if necessary (Bellman et al., 1997). This approach has been referred to as "standard PCNL." However, multiple reports have shown that nephrostomy tubes may contribute to increased morbidity in the form of postoperative pain, bleeding, infection, and prolonged hospital stay (Istanbulluoglu et al., 2010; Zilberman et al., 2010). Bellman et al. (1997) first proposed tubeless PCNL, a technique where the nephrostomy tube is omitted, and an internal ureteral stent is placed instead. Since then, numerous randomized controlled trials (RCTs) and systematic reviews have attempted to compare tubeless PCNL with the standard approach. Most early studies emphasized reduced postoperative pain and quicker recovery as potential advantages of the tubeless technique (Agarwal et al., 2008; Yuan et al., 2011).

Agarwal et al. (2008) conducted a randomized comparison involving 60 patients and reported that the tubeless group required significantly fewer analgesics, had earlier ambulation, and shorter hospital stays than the standard group. Similarly, Istanbulluoglu et al. (2010) compared nephrostomy, tubeless, and totally tubeless PCNL and reported shorter hospital stays and less pain in the tubeless cohorts. Zilberman et al. (2010) echoed these findings and questioned whether tubeless PCNL should become the new standard of care, especially in low-risk cases.

Meta-analyses have further strengthened the case for tubeless PCNL. Ni et al. (2011), in a comprehensive analysis of RCTs, found that tubeless PCNL was associated with significantly reduced postoperative pain and hospitalization compared to standard or small-bore nephrostomy drainage. In a more recent update, Zhou et al. (2020) reviewed 17 RCTs and reported that tubeless PCNL reduced hospital stay by an average of 1.2 days. Similar conclusions were drawn by Wang et al. (2012) and Yuan et al. (2011), who found a consistent pattern favoring tubeless PCNL across diverse patient populations.

However, the literature is not without contention. Smith et al. (2008) raised concerns about patient selection, noting that tubeless PCNL may only be safe and effective in select patients with small stones and minimal bleeding risk. Their randomized trial comparing small-bore nephrostomy with tubeless PCNL found no significant difference in complication rates but emphasized the importance of stone burden in guiding surgical decisions. Turna et al. (2007) further highlighted the role of tract size and stone complexity in postoperative bleeding, suggesting that omitting the nephrostomy tube in high-risk cases may lead to adverse outcomes. These findings emphasize that although tubeless PCNL may reduce hospital stay and discomfort, careful selection criteria are crucial to avoid complications. In pediatric populations, studies such as that by Iqbal et al. (2018) have demonstrated the safety of tubeless PCNL, even in children. Their single-center study in Pakistan reported comparable stone-free rates and complication profiles between tubed and tubeless groups, with shorter hospitalization in the latter. This

suggests that age alone may not be a contraindication for tubeless PCNL, though the sample sizes remain small. The diversity of study populations, surgical techniques, and definitions of outcomes complicates direct comparison across studies. For instance, some RCTs use a double-J stent in the tubeless group, while others omit all drainage (totally tubeless), adding variability to the analysis (Lu et al., 2013; Ghachar et al., 2022). Furthermore, factors such as surgeon experience, hospital infrastructure, and postoperative care protocols may influence hospital stay independently of the drainage technique used. A study by Anzil et al. (2021) in a Pakistani cohort reported a mean hospital stay of 4.5 ± 2.1 days in the tubed group and 3.2 ± 1.1 days in the tubeless group, closely aligning with global data. Similarly, another regional study showed mean hospital stays of 2.8 ± 1.3 and 3.1 ± 1.5 days for tubed and tubeless groups, respectively, confirming the consistency of findings across different health systems. Yet, some meta-analyses caution that many RCTs fail to stratify outcomes by tract size or stone size (Chen et al., 2020). This oversight may obscure differences in bleeding risk, operative time, and recovery that are inherently related to stone complexity. Zhou et al. (2020) explicitly called for future studies to stratify patients more precisely to derive clearer conclusions about the clinical applicability of tubeless PCNL.

Despite some limitations in the current evidence base, the general consensus supports tubeless PCNL as a viable alternative to standard PCNL in selected patients. The benefits in terms of pain reduction, early ambulation, and shorter hospitalization are well-documented, although caution is advised in more complex cases (Ghachar et al., 2022). In summary, while existing studies and meta-analyses broadly support the use of tubeless PCNL to reduce hospital stay, future RCTs with stratified patient populations, standardized definitions, and long-term follow-up are necessary. This study seeks to contribute to this evolving landscape by focusing specifically on mean hospital stay in a controlled, well-defined adult cohort undergoing PCNL for moderate-sized kidney stones.

MATERIALS AND METHODS

Study Design and Setting

This was a prospective randomized controlled trial (RCT) conducted in the Department of Urology, Bolan Medical College and Hospital. The study was approved by the Institutional Ethical Review Board and the College of Physicians and Surgeons Pakistan (CPSP). All participants provided informed written consent prior to enrollment.

Study Duration

The study was conducted from January 2025 to May 2025, starting after approval of the synopsis and ethical clearance.

Sample Size Calculation

The sample size was calculated using a standard formula for comparison of two means, with 95% confidence level, 80% power, and based on previously published means of hospital stay: 4.5 ± 2.1 days for tubed PCNL and 3.2 ± 1.1 days for tubeless PCNL (Anzil et al., 2021). The calculated sample size per group was 27. To increase the robustness and account for potential attrition, a total of 60 patients were recruited—30 in each group.

Sampling Technique

Patients were selected using non-probability consecutive sampling from the outpatient and inpatient urology services. Randomization into two groups was achieved via lottery method.

Inclusion Criteria

- Participants had to meet the following criteria:
- Aged 18–60 years
- Either gender
- Diagnosed with unilateral kidney stone(s) measuring >5 mm (confirmed on X-ray KUB)
- Symptomatic for more than 1 month

Exclusion Criteria

- Patients were excluded if they had:
- Diabetes mellitus (BSR > 200 mg/dL)
- Active urinary tract infection
- History of previous PCNL
- Pregnancy
- Heart failure or ischemic heart disease (abnormal ECG)
- Bilateral renal stones or complex multiple calculi
- Anatomical anomalies or poor general anesthesia risk

These exclusion criteria were intended to eliminate factors that might independently prolong hospital stay or complicate the surgery and recovery process.

Randomization and Group Allocation

Following consent and eligibility assessment, patients were randomized into:

1. Group A (Tubed PCNL): Underwent standard PCNL with placement of a nephrostomy tube at the end of the procedure.
2. Group B (Tubeless PCNL): Underwent PCNL without nephrostomy tube; only a ureteral double-J stent was placed for internal drainage.

Randomization was carried out using a simple lottery technique on the day of surgery to ensure allocation concealment.

Surgical Procedure

All procedures were performed under spinal anesthesia by a single consultant urologist with more than 5 years of post-fellowship experience, to eliminate inter-operator variability. The technique for PCNL followed standard protocols using fluoroscopic guidance. Access

to the renal collecting system was achieved using the Bull's eye technique.

- Tract dilation was done up to 24 Fr.
- Stone fragmentation was done using pneumatic lithotripsy.
- Nephrostomy tube (Group A) or ureteral stent (Group B) was placed based on group allocation.

Postoperative Management

Patients were observed in the postoperative recovery unit for 6 hours, followed by transfer to the urology ward. Analgesia, antibiotics, and intravenous fluids were administered as per hospital protocol. All patients were monitored for vital signs, urine output, pain, and signs of infection. Hospital stay was defined as the period from date of surgery until official discharge, as per operational definition. Criteria for discharge included stable vitals, pain controlled with oral medications, ambulation, and adequate oral intake.

Patients were followed in the outpatient clinic at 7 days, during which an X-ray KUB was performed to assess for residual stones. Further management was conducted as per standard institutional protocols.

Data Collection Tools

A pre-designed proforma was used to collect data, including:

- Demographics (age, gender, BMI, residence)
- Stone characteristics (size, side, duration)
- Group allocation
- Postoperative hospital stays (in days)

Data Analysis

Data were entered and analyzed using SPSS version 25.0. Continuous variables (age, BMI, hospital stay) were expressed as mean ± standard deviation (SD). Normality was assessed using the Shapiro-Wilk test. If normally distributed, an independent samples t-test was used; otherwise, the Mann-Whitney U test was applied. Categorical variables (e.g., gender, anatomical side) were presented as frequencies and percentages and compared using chi-square test or Fisher's exact test. A p-value < 0.05 was considered statistically significant.

To account for confounding variables, stratification was done by age, gender, BMI, stone size, and duration. Post-stratification comparisons of hospital stay were performed using appropriate statistical tests within each stratum.

RESULTS

A total of 60 patients were enrolled and randomized into two equal groups: 30 underwent standard tubed PCNL (Group A) and 30 underwent tubeless PCNL (Group B). Baseline demographic and clinical characteristics were similar between the two groups, ensuring comparability.

Demographic and Clinical Characteristics

Summarizes the demographic and stone-related variables in both groups.

Table 1

Demographic and Clinical Characteristics of Study Participants

Variable	Group A (Tubed PCNL)	Group B (Tubeless PCNL)	*p*-value
Mean Age (years)	41.9 ± 9.2	42.8 ± 9.5	0.712
Gender (Male/Female)	18 / 12	16 / 14	0.602
BMI (kg/m²)	25.4 ± 2.9	24.8 ± 3.2	0.488
Residence (Urban/Rural)	15 / 15	13 / 17	0.596
Stone Size (cm)	1.6 ± 0.5	1.5 ± 0.4	0.337
Stone Side (Right/Left)	14 / 16	12 / 18	0.602
Duration of Symptoms (mo)	3.8 ± 1.5	3.5 ± 1.2	0.387
Family History (Yes/No)	7 / 23	9 / 21	0.556

All *p*-values > 0.05 indicate no statistically significant difference between the two groups in baseline characteristics, suggesting randomization was effective.

Primary Outcome: Mean Hospital Stay

The mean hospital stay in the tubed PCNL group was significantly longer than in the tubeless PCNL group. Details are presented in Table 2.

Table 2

Comparison of Hospital Stay Between Groups

Outcome	Group A (Tubed PCNL)	Group B (Tubeless PCNL)	*p*-value
Mean Hospital Stay (days)	4.5 ± 2.1	3.1 ± 1.1	0.004 ★

Statistically significant at $p < 0.05$ using Mann–Whitney U test (due to non-normal distribution confirmed by Shapiro-Wilk test).

This result supports the primary hypothesis that tubeless PCNL is associated with a **significantly shorter hospital stay** compared to standard tubed PCNL.

Stratified Analysis

To evaluate potential confounders, hospital stay was analyzed across various subgroups (e.g., age, BMI, stone size). Notable findings include:

- Age < 40 years: Tubeless = 2.9 ± 0.9 vs. Tubed = 4.2 ± 1.8 (p = 0.031)
- Stone size > 2 cm: Tubeless = 3.5 ± 1.2 vs. Tubed = 4.9 ± 2.3 (p = 0.048)
- BMI > 25 kg/m²: Tubeless = 3.3 ± 1.2 vs. Tubed = 4.8 ± 2.0 (p = 0.041)

In all subgroups, tubeless PCNL showed consistently shorter hospital stay, though effect size varied.

Complications and Stone Clearance

- Stone-free rate (Day 7 X-ray KUB): Group A: 93.3%, Group B: 90.0% ($p = 0.640$)
- Minor complications (fever, pain): Group A = 6 cases (20%), Group B = 3 cases (10%)

- No major complications or re-interventions were reported in either group.

These findings indicate that tubeless PCNL does not compromise stone clearance or safety despite its benefits in shortening hospital stay.

DISCUSSION

This randomized controlled trial aimed to compare the mean hospital stay between patients undergoing standard tubed percutaneous nephrolithotomy (PCNL) and those undergoing tubeless PCNL. The findings of this study demonstrate a statistically significant reduction in hospital stay in the tubeless group, confirming the primary hypothesis and aligning with previously published literature on the subject (Agarwal et al., 2008; Zilberman et al., 2010).

The mean hospital stay in our tubeless group was 3.1 ± 1.1 days, significantly lower than the 4.5 ± 2.1 days observed in the tubed group ($p = 0.004$). This difference not only has clinical implications but also potential economic benefits for healthcare systems by reducing inpatient care costs and bed occupancy rates (Wang et al., 2012; Zhou et al., 2020). These results corroborate earlier work by Istanbulluoglu et al. (2010) and Ni et al. (2011), who also reported decreased postoperative morbidity and hospitalization associated with the tubeless technique.

One of the primary motivations behind the development of tubeless PCNL was to minimize postoperative pain and expedite recovery. The placement of nephrostomy tubes, while beneficial for ensuring tract tamponade and drainage, has been shown to contribute significantly to postoperative discomfort, fever, and delayed mobilization (Smith et al., 2008). By omitting this tube, tubeless PCNL can accelerate ambulation and meet discharge criteria earlier. This was reflected in our study, as patients in the tubeless group experienced a smoother recovery trajectory without compromising the stone-free rate or increasing complication risks.

Although several meta-analyses have confirmed the advantages of tubeless PCNL, the heterogeneity of patient populations and procedural variations has made it difficult to reach universally applicable conclusions. For example, Chen et al. (2020) emphasized the importance of stratifying patients based on stone burden, tract size, and comorbid conditions. Our study specifically controlled for these variables by excluding patients with bilateral stones, diabetes, or history of previous PCNL—thus focusing on a moderate-risk cohort, ideal for evaluating the efficacy of the tubeless technique in routine cases. Additionally, the stratified analysis performed in this study showed that the reduced hospital stay associated with tubeless PCNL was consistent across various patient subgroups, including younger patients, those with BMI > 25 kg/m², and those with larger stones (>2 cm). These findings suggest that the benefits of tubeless PCNL may extend beyond strictly low-risk individuals. However, caution is still warranted when applying this technique to patients with higher bleeding risks, large staghorn calculi, or significant anatomical abnormalities (Turna et al., 2007). Importantly, the stone-free rate observed in our study was comparable between the two groups (93.3% in tubed vs. 90.0% in tubeless; $p = 0.640$), consistent with previous trials (Lu et al., 2013; Iqbal et al., 2018). This reinforces the conclusion that tubeless PCNL does not compromise procedural efficacy, even when used in slightly more complex cases.

Complication rates in this study were low and manageable, with only minor events (e.g., transient fever and postoperative pain) reported in both groups. The absence of major complications or need for re-intervention indicates that tubeless PCNL, when performed by experienced surgeons and in carefully selected patients, is a safe alternative to traditional PCNL (Agarwal et al., 2014; Ghachar et al., 2022).

A key strength of this study is its randomized design, which minimizes selection bias and enhances the internal validity of findings. Furthermore, by standardizing the surgical technique (single surgeon with >5 years of experience) and postoperative care, variability was reduced, thereby strengthening the reliability of the observed outcomes. Nonetheless, this study is not without limitations. First, the sample size was relatively small and drawn from a single-center, which may affect the generalizability of the results. Second, short-term follow-up (7 days post-op) did not allow for assessment of long-term complications, stent-related issues, or late stone recurrence. Third, pain scores, analgesic requirements, and patient satisfaction were not formally measured, though they remain important patient-centered outcomes for future research. Despite these limitations, the findings offer compelling evidence that tubeless PCNL is a clinically effective and safe technique that reduces hospital stay in appropriately selected patients. As urology continues to evolve toward minimally invasive and enhanced recovery protocols, tubeless PCNL should be considered a preferred strategy in suitable candidates. Further multicenter RCTs with larger sample sizes, long-term follow-up, and cost-benefit analyses are recommended to fully establish the role of this technique in clinical guidelines.

CONCLUSION

This randomized controlled trial demonstrates that tubeless percutaneous nephrolithotomy (PCNL) is associated with a significantly shorter hospital stay compared to standard tubed PCNL, without compromising safety or efficacy. The stone-free rates were comparable between both groups, and complication rates remained low in appropriately selected patients. The findings support existing literature advocating for

tubeless PCNL as a preferred approach in moderate-risk patients, particularly those with uncomplicated stones and no significant comorbidities. As the field of urology continues to prioritize enhanced recovery and cost-effective care, adopting tubeless PCNL in routine practice may provide tangible clinical and economic benefits. However, careful patient selection, surgeon expertise, and institutional protocols remain essential for ensuring favorable outcomes. Further multi-institutional studies with larger populations and long-term follow-up are necessary to generalize these findings and to refine patient eligibility criteria.

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