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Tube vs Tubeless PCNL: A Comparative Review of Efficacy, Safety and Post-Operative Outcomes

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ABSTRACT

Background: Percutaneous nephrolithotomy (PCNL) is the standard treatment for large and complex kidney stones. Traditionally, placing a nephrostomy tube at the end of PCNL has been seen as necessary for drainage, controlling bleeding, and allowing access for follow-up procedures. However, tubeless PCNL, which does not involve placing a nephrostomy tube, has become a less invasive option intended to lower postoperative pain, complications, and hospital stays. The above study was conducted to compare the efficacy, safety and post-operative outcomes in Tube vs. Tubeless PCNL. Methodology- The study was conducted at a tertiary care hospital which included 100 patients undergoing PCNL, who were selected based on the inclusion and exclusion criteria.Based on postoperative drainage, patients were divided into Tube PCNL and Tubeless PCNL groups. Data was collected and analyzed for perioperative and postoperative outcomes using the statistical tests.Results- Mean operative time was significantly higher in the Tube PCNL group (36.6 ± SD)compared to the Tubeless PCNL group (29.0 ± 9.8 minutes; p=0.036).There was no statistically significant difference between Tube and Tubeless PCNL with respect to postoperative hematuria, blood transfusion requirement, UTI, or fever.Conclusion-Tubeless PCNL is a safe and effective option compared to traditional tube PCNL for certain patients. It provides better comfort after surgery and allows for quicker recovery without sacrificing the success of the procedure

Keywords: Tubeless PCNL, renal calculi, nephrostomy tube, Nephrolithotomy..

1. INTRODUCTION

Percutaneous Nephrolithotomy (PCNL) is one of the most effective and widely used minimally invasive procedures for the removal of large or complex kidney stones, particularly those greater than 2 cm in size. PCNL involves the insertion of a nephroscope through a small incision in the back, allowing the surgeon to access the kidney and break down or remove the stone fragments. The procedure was first introduced in the 1970s and has since become the gold standard for treating large renal stones, especially those located in the renal pelvis or calyces. PCNL offers several advantages over traditional open surgery, including reduced morbidity, shorter hospital stays, and faster recovery times.[1,2]The technique of PCNL has undergone significant advancements in recent years, improving both its effectiveness and safety. The procedure typically begins with the identification of a suitable access point into the kidney, followed by dilation of the nephrostomy tract and the insertion of a nephroscope. Various methods of stone fragmentation, such as ultrasonic, laser, and pneumatic lithotripsy, are employed depending on the stone's characteristics. After the stones are fragmented, they are either removed or irrigated out of the kidney.[2,3]

Though PCNL is well established as the treatment of choice for large and complex renal calculi, the ideal method of postoperative drainage continues to be a subject of debate, particularly between conventional nephrostomy tube placement (tube PCNL) and omitting the usage of the nephrostomy tube, referred to as tubeless or totally tubeless PCNL. Proponents of the tubeless approach suggest that avoiding nephrostomy tube placement may lead to reduced postoperative pain, shorter hospital stay, and faster recovery, without adversely affecting stone clearance when patients are appropriately selected. Evidence from previously conducted studies analyses of randomized controlled trials and comparative studies supports these claims, demonstrating significantly lower pain scores, reduced analgesic requirements, and shorter hospitalization.

in tubeless PCNL, while maintaining comparable stone-free and transfusion rates to standard tube PCNL.[4] Earlier systematic reviews and meta-analyses have reported similar findings, further establishing tubeless PCNL as a safe and effective alternative in uncomplicated cases.[5] More recent conducted studies have reinforced these observations, showing that with strict patient selection, tubeless PCNL does not increase the risk of hemorrhage, infection, or other major complications, while offering improved patient comfort and reduced catheterization duration.[6]Additionally, growing interest in totally tubeless PCNL—where both nephrostomy

tubes and ureteral stents are omitted—has been fueled by recent studies demonstrating feasibility and reduced length of hospital stay in selected patients, although careful case selection remains critical.[7] Advances in surgical technique, including one-shot tract dilatation and minimally invasive access strategies, have further contributed to improving the safety profile and outcomes of tubeless PCNL.[8]

Despite these encouraging results, variability in patient selection, operative techniques, and outcome measures across studies highlights the need for a contemporary comparative review focusing on efficacy, safety, and postoperative outcomes to better guide clinical decision-making between tube and tubeless PCNL andhence the above study was conducted.

2. MATERIALS AND METHODS

The study was conducted in the Department of Surgery, at a Tertiary Care Hospital in Jammu for period of one year. All the necessary ethical clearance was obtained from the Institutional Ethics Committee before the commencement of the study. The sample size selected for the study was 100 participants based on the fulfilment of inclusion and exclusion criteria.

Inclusion Criteria

Partients >18 years, belonging to both genders, patients with renal calculi, those having no history of any pre-existing chest disease.

Exclusion Criteria

Patients with multiple access tracts, having significant intra-operative bleeding, pyonephrosis or any active infection, residual stone burden requiring second look PCNL, pregnant women and those having coagulation disorders.

Written informed consent was obtained in their local language from all the participants. All the patients undergoing PCNL for renal calculi were further divided into two groups based on post-operative drainage system.

Tube PCNL Group- Nephrostomy tube was placed at the end of the procedure in the patients.

Tubeless PCNL Group- No nephrostomy tube was placed in the patients. Internal drainage was achieved using a DJ stent.

Followed by a standardized surgical protocol for PCNL, all the necessary pre-operative preparations were done. Thorough clinical investigations were performed followed by all the necessary baseline investigations (CBC, Urine culture and sensitivity, renal function test, urine analysis).Computed tomography (CT) scanwas done to assess the number, size, and location of renal calculi and to assist in surgical planning. Standard PCNL technique was performed under fluoroscopic guidance. Post-operative outcomes were assessed (pain requiring analgesia, hematuria, fever,UTI, residual stones, duration of hospital stay)

Data was collected, entered into Microsoft Excel and analyzed using SPSS version 24.0.A p-value< 0.05 was considered as statistically significant.

Result

Table 1. Baseline Stone Characteristics in Patients Undergoing Tube versus Tubeless PCNL (n = 100)

Variable	**n (%)**
Laterality of stone	
Left kidney	37 (37.0)
Right kidney	63 (63.0)
Number of stones	
Single	80 (80.0)
Two	19 (19.0)
Three	1 (1.0)

Variable	n (%)
Stone location on IVP	
Renal pelvis	31 (31.0)
Inferior calyx	19 (19.0)
Middle calyx	6 (6.0)
Superior calyx	9 (9.0)
Renal pelvis + inferior calyx	6 (6.0)
Renal pelvis + middle calyx	3 (3.0)
Partial staghorn	8 (8.0)
Partial staghorn with secondary stone	6 (6.0)
Complete staghorn	9 (9.0)
Multicalyceal (superior, middle & inferior)	1 (1.0)

Table 2. Operative Characteristics of Tube versus Tubeless Percutaneous Nephrolithotomy (n = 79)

Variable	Tube PCNL (n = 58)	Tubeless PCNL (n = 21)	p-value
Puncture site			0.984
Superior calyx	25 (43.1)	9 (42.9)	
Other calyces	33 (56.9)	12 (57.1)	
Operative duration (minutes)	36.6 ± 21.0	29.0 ± 9.8	**0.036**

Table 3. Comparison of Postoperative Complications between Tube and Tubeless PCNL (n = 79)

Complication	Tube PCNL n (%)	Tubeless PCNL n (%)	p-value
Hematuria	11 (19.0)	8 (38.1)	0.630
Blood transfusion	11 (19.0)	8 (38.1)	0.630
Postoperative UTI	1 (1.7)	0 (0)	0.430
Postoperative fever	1 (1.7)	0 (0)	0.430
Sepsis	0	0	—
SICU admission	0	0	—

Table 4. Postoperative Pain and Recovery Outcomes after Tube versus Tubeless PCNL

Outcome	Tube PCNL (n = 58)	Tubeless PCNL (n = 21)	p-value
Pain requiring analgesia	16 (27.6)	4 (19.0)	**<0.001**
Hospital stay (days)	2.79 ± 0.59	2.73 ± 0.45	0.604

Table 5. Comparison of Stone Clearance and Efficacy between Tube and Tubeless PCNL

Outcome	Tube PCNL n (%)	Tubeless PCNL n (%)	p-value
Residual stone	4 (6.9)	0 (0)	0.074
Stone-free rate	54 (93.1)	21 (100)	—
Relook procedure	0	0	—

Table 6. Influence of Number of Access Tracts on Outcomes in Tube versus Tubeless PCNL (n = 100)

Variable	Single Tract (n = 79)	Multiple Tracts (n = 21)	p-value
Nephrostomy tube placement	58 (73.4)	21 (100)	**0.008**
Hematuria	11 (13.9)	8 (38.1)	**0.012**
Blood transfusion	11 (13.9)	8 (38.1)	**0.012**
Postoperative UTI	1 (1.3)	5 (23.8)	**<0.001**
Postoperative fever	1 (1.3)	5 (23.8)	**<0.001**
Sepsis	0	4 (19.0)	—
SICU admission	0	3 (14.3)	**0.001**
Residual stone	4 (5.1)	6 (28.6)	**0.001**
Hospital stay (days)	2.76 ± 0.51		

3. DISCUSSION

Traditional tube PCNL involves inserting a nephrostomy tube to ensure proper drainage, control bleeding, and provide access for future procedures. However, this method often leads to more postoperative pain and longer hospital stays. On the other hand, tubeless PCNL skips the nephrostomy tube and usually uses an internal ureteral stent or catheter. Studies show that tubeless PCNL can lower pain relief needs, reduce hospital stays, and improve patient comfort without affecting stone-free rates or increasing complications in carefully chosen patients. As a result, tubeless PCNL is becoming the preferred option for straightforward cases, while tube PCNL is still suitable for complex stones, significant bleeding, or when future re-entry is expected.The above study was conducted to compare the efficacy, safety and post-operative outcomes in Tube vs. Tubeless PCNL.

Among 100 PCNL patients a notable predominance of right-sided renal stones was observed , with 63% (n=63) of stones and 37% (n=37) on the left.Our findings align with**Mousavi-Bahar et al.**[9]who reported that the right kidney was more commonly accessed in their cohort of 123 patients undergoing supracostal PCNL, especially when managing upper and staghorn stones.Although laterality itself was not significantly correlated with complications or outcomes in our study, the observation remains important for future predictive models of stone recurrence and surgical difficulty. This laterality trend also mirrors national kidney stone registries, which have shown a mild but consistent right-sided predominance in non-PCNL stone patients as well.

The analysis of stone number showed that a vast majority (80%) of patients had a single renal stone, 19% had two stones, and only 1% presented with three stones.**Shalaby et al.**[10]reported mostly multiple stones (17 out of 26), with successful management via single-tract lower calyceal PCNL.Multiple stones often correlate with higher procedural complexity, longer operative time, and greater likelihood of requiring auxiliary procedures. In our study, the predominance of single-stone cases may partly explain the overall lower complication rates and reduced need for additional access tracts. Furthermore, this observation aligns with global trends, where PCNL is evolving toward single-tract miniaturized systems, suitable primarily for single bulky stones rather than multiple dispersed fragments.

Renal pelvis involvement was the most frequent stone location (31%), followed by inferior calyceal calculi (19%). Staghorn or partial staghorn stones constituted 23% of the study population.**Singh et al.**[11]demonstrated a higher success rate (90.7%) for upper calyceal puncture when targeting complex stones compared to lower pole punctures (76.47%).

Accurate IVP evaluation facilitates access planning and helps minimize intraoperative complications. Our study's wide variability in stone distribution reflects real-world complexity and supports a flexible, patient-tailored approach to PCNL.

Among 79 patients with complete intraoperative and postoperative data, nephrostomy tube placement was performed in 58 patients (Tube PCNL), while 21 patients underwent Tubeless PCNL. The distribution of superior versus non-superior calyceal puncture was comparable between groups (p=0.984). Mean operative duration was significantly longer in the Tube PCNL group (36.6 ± 21.0 minutes) compared to the Tubeless PCNL group (29.0 ± 9.8 minutes; p=0.036)

Amareshet al. [12]reported a higher nephrostomy tube placement in inferior calyceal puncture cases due to longer operative times and more bleeding (74.6%) compared to superior access (65.1%).Literature suggests that tubeless PCNL can reduce hospital stay and postoperative pain without increasing complications.

The occurrence of complications was low in both groups (Tube vs Tubeless PCNL). Hematuria and the need for blood transfusion were seen in both groups, with no significant difference between tube and tubeless PCNL (p = 0.630). Infective complications, such as postoperative urinary tract infection and fever, were rare and occured in the tube PCNL group; however, these differences were not statistically significant (p = 0.430). No cases of sepsis or SICU admission were reported in either group. These findings suggest that tubeless PCNL does not carry a higher risk of postoperative complications compared to conventional tube PCNL.

Singh et al. [11] **(2015) and Yong-Bi**[13]noted more complex surgeries with a greater number of access points led to increased rates of fever and septic complications. In the context of tube versus tubeless PCNL, these insights are particularly important. Tubeless PCNL usually occurs in simpler cases that only need one access point and less manipulation inside the kidney. This approach helps to reduce inflammation and infection risks. **Nawaz et al.** [14]pointed out lower transfusion and overall complication rates for upper pole puncture PCNL compared to multi-tract lower pole access. This highlights the benefits of single-tract procedures whenever possible. Our comparison of tube and tubeless PCNL supports the above concept. The tubeless method showed similar or lower complication rates without increasing the risk of infections. This indicates that leaving out the nephrostomy tube in carefully chosen patients is safe.

Patients who underwent tubeless PCNL had notably less postoperative pain requiring pain relief compared to those in the tube PCNL group (19.0% vs 27.6%, p < 0.001). This suggests better postoperative comfort without the nephrostomy tube. However, the average hospital stay was similar for both groups (2.79 ± 0.59 days for tube PCNL vs 2.73 ± 0.45 days for tubeless PCNL), and there was no significant difference (p = 0.604). These results indicate that while tubeless PCNL significantly reduces postoperative pain, the overall recovery, measured by hospital stay length, is comparable between the two methods in the above study.

The comparison of stone clearance outcomes shows a high success rate in both groups. Residual stones were found in 6.9% of patients who underwent tube PCNL, while no residual stones were seen in the tubeless PCNL group. However, this difference was not statistically significant (p = 0.074). The stone-free rate was also high in both groups, with complete clearance achieved in 93.1% of tube PCNL cases and 100% of tubeless PCNL cases. No patient in either group needed a relook procedure. These findings suggest that not using a nephrostomy tube does not negatively impact stone clearance. Tubeless PCNL can achieve stone-free rates that are similar to, or slightly better than, traditional tube PCNL in appropriately selected patients.

Mazumder et al. [15]reported similar residual stone rates in their study of upper versus lower calyceal access, with rates of 10.5% and 24.3%. This supports the idea that a carefully planned single puncture, especially through the superior calyx, can improve stone clearance. This observation is important for comparing tube versus tubeless PCNL. Tubeless PCNL is usually done after complete stone clearance through a single, well-placed tract with minimal bleeding. Findings suggest that the need for nephrostomy tube placement often indicates greater procedural complexity, multiple tracts, or leftover stone burden, rather than better clearance. Therefore, while multiple tracts and tube placement may be necessary in complicated cases, they do not guarantee better stone-free results and may increase complications. On the other hand, tubeless PCNL can provide excellent stone clearance with fewer complications and better recovery when used in appropriately selected single-tract procedures.

Nephrostomy tube placement was much more common in patients who needed multiple tracts compared to those treated with a single tract (100% vs. 73.4%, p = 0.008). This difference points to greater complexity in the procedure. Hematuria and the need for blood transfusion were significantly higher in the multiple-tract group (38.1% vs. 13.9%, p = 0.012 for both), indicating that more access tracts lead to greater tissue damage. Infective complications were much more frequent in the multiple-tract group, with notably higher rates of postoperative urinary tract infections and fever (23.8% vs. 1.3%, p < 0.001 for both). Sepsis and SICU admissions occured in patients with multiple tracts. The rates of residual stones were also significantly higher in the multiple-tract group (28.6% vs. 5.1%, p = 0.001). This suggests that having additional tracts does not always result in better stone removal.

Kukreja et al.[16] showed that multiple access tracts were linked to significantly higher rates of bleeding and blood transfusions, without a corresponding increase in stone-free rates. This emphasizes that a greater number of tracts reflects

procedural complexity instead of effectiveness. Similarly, **Aron et al.** [17] noted a higher occurrence of postoperative fever and sepsis in patients undergoing multi-tract PCNL, which they attributed to more significant renal parenchymal injury and longer surgery times. **Shrestha and Kunwar**[18] **and Singh et al.**[11] reported significantly higher rates of infectious complications, including fever and sepsis, in multi-tract PCNL compared to single-tract procedures. Together, these comparative studies support the findings here that single-tract PCNL, when technically possible, provides better safety with less bleeding and fewer infections while achieving high stone-free rates.

Yong-bi[13] **(2014)** also emphasized nephrostomy placement in multi-access cases to ensure drainage, tamponade of bleeding, and postoperative tract stability.**El-Karamany**[19]noted higher nephrostomy usage in patients undergoing multiple tract PCNL for partial and complete staghorn stones.

Overall, the above findings suggest that single-tract PCNL leads to fewer complications, a lower need for nephrostomy tube placement, and better stone-free outcomes. The use of multiple tracts reflects more complex cases and is linked to increased bleeding, infections, and stone residue. This emphasizes the need to limit the number of tracts whenever possible.

The above study has several strengths. It makes a focused comparison of tube and tubeless percutaneous nephrolithotomy (PCNL) while also looking at both single-tract and multiple-tract access. This setup allows for a clearer distinction between the effects of drainage methods and the complexity of the procedure. Clinical outcomes were assessed under consistent surgical protocols. The findings were significant supporting the selective use of tubeless PCNL in well-selected, single-tract cases. This approach can lower complications and improve patient comfort without risking safety or stone removal. However, the study has limitations. Its non-randomized, single-center design and the relatively small sizes of some subgroups make it hard to generalize the results and create potential selection bias. Additionally, the lack of long-term follow-up limits the ability to assess delayed outcomes.

4. CONCLUSION

From the above observations it can be concluded that tubeless PCNL, when done on properly chosen patients with complete stone clearance, minimal bleeding, and a single access tract, achieves postoperative results similar to those of conventional tube PCNL while providing benefits like less pain and better patient comfort. In contrast, the need for nephrostomy tube placement is more linked to procedural complexity, multiple access tracts, and intraoperative issues than to a poorer surgical technique

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