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Tubeless versus Standard Percutaneous Nephrolithotomy for Renal Calculi: A Prospective Comparative Study of Postoperative Outcomes and Complications

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استئصال حصى الكلية عبر الجلد بدون أنبوب مقارنةً بالطريقة القياسية في علاج حصى الكلية: دراسة مقارنة استباقية للنتائج والمضاعفات بعد العلمية

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Abstract:
Placement of a nephrostomy tube after percutaneous nephrolithotomy (PCNL) provides tamponade and drainage but contributes to postoperative pain and prolonged hospitalisation. This prospective comparative study evaluated tubeless and standard PCNL in 120 adults with renal calculi treated at the Department of Surgery, College of Medicine, University of Wasit. After an uncomplicated procedure, patients were managed either without a nephrostomy tube (tubeless, n = 60) or with a nephrostomy tube (standard, n = 60). The primary endpoint was pain on the visual analogue scale (VAS) 6 hours after surgery; secondary endpoints included VAS scores to 48 hours, rescue analgesic consumption, haemoglobin reduction, hospital stay, stone-free status on computed tomography at 4 weeks and 30-day complications graded by the Clavien–Dindo system. Baseline and stone characteristics were comparable between groups. The tubeless group had lower VAS scores at 6 hours (3.8 ± 1.2 vs 5.2 ± 1.4; $p < 0.001$) and at every later time point, lower rescue tramadol consumption (74.2 ± 42.6 vs 121.7 ± 55.3 mg; $p < 0.001$) and a shorter hospital stay (1.7 ± 0.7 vs 2.8 ± 1.0 days; $p < 0.001$). Operative time, haemoglobin reduction and stone-free rates (90.0% vs 86.7%; $p = 0.570$) did not differ. Overall complications occurred in 15.0% and 23.3% of patients, respectively ($p = 0.247$), and most were Clavien–Dindo grade I–II. In selected patients with an uncomplicated procedure, tubeless PCNL improves early recovery without compromising stone clearance or safety; the decision to omit the nephrostomy tube should rest on intraoperative assessment.

Keywords: Percutaneous nephrolithotomy, Tubeless, Nephrostomy, Renal calculi, Postoperative pain, Clavien–Dindo.

الملخص
يوفر أنبوب فغر الكلية بعد عملية استئصال حصى الكلية عبر الجلد إرقاءً لمسار الدخول وتصريفًا للبول، لكنه يزيد الألم بعد العملية ويطيل مدة البقاء في المستشفى. هدفت هذه الدراسة الاستباقية المقارنة إلى تقييم الطريقة بدون أنبوب مقارنةً بالطريقة القياسية لدى 120 مريضًا بالغًا في فرع الجراحة، كلية الطب، جامعة واسط، إذ عولج 60 مريضًا دون أنبوب فغر الكلية و60 مريضًا مع الأنبوب بعد عملية غير مختلطة. كان المؤشر الرئيس شدة الألم على المقياس التناظري البصري بعد 6 ساعات من العملية، وشملت المؤشرات الثانوية الألم حتى 48 ساعة، واستهلاك المسكنات، وانخفاض الهيموغلوبين، ومدة البقاء في المستشفى،

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ونسبة الخلو من الحصى بالتصوير المقطعي بعد 4 أسابيع، والمضاعفات خلال 30 يومًا وفق تصنيف Clavien–Dindo. كانت المجموعتان متماثلتين في الخصائص الأساسية وخصائص الحصى. سجلت مجموعة بدون أنبوب ألمًا أقل بعد 6 ساعات (3.8 مقابل 5.2) وفي جميع الأوقات اللاحقة، واستهلاكًا أقل للترامادول، ومدة بقاء أقصر (1.7 مقابل 2.8 يوم)، مع نسبة خلو من الحصى متقاربة (90.0% مقابل 86.7%) ومعدل مضاعفات غير مختلف إحصائيًا (15.0% مقابل 23.3%). تشير النتائج إلى أن الطريقة بدون أنبوب تحسن التعافي المبكر لدى المرضى المختارين دون التأثير في إزالة الحصى أو السلامة.

الكلمات المفتاحية: استئصال حصى الكلية عبر الجلد، بدون أنبوب، فغر الكلية، حصى الكلية، الألم بعد العملية.

Introduction

Percutaneous nephrolithotomy (PCNL) is the reference treatment for large, staghorn and complex renal calculi, offering high stone-free rates with acceptable morbidity [1–4]. Since its introduction, refinements in access, tract dilatation, intracorporeal lithotripsy and exit strategy have aimed to maximise clearance while reducing complications [5,6].

A nephrostomy tube has traditionally been left at the end of PCNL to tamponade the tract, drain the collecting system, preserve access for a second-look procedure and manage selected complications [7,8]. These benefits come at a cost: the tube traverses the renal parenchyma and flank muscles and is a recognised source of postoperative pain, analgesic requirement, urinary leakage and prolonged hospitalisation [9–11].

Tubeless PCNL omits the nephrostomy tube and relies on internal drainage with a ureteral stent or catheter when needed, whereas totally tubeless PCNL avoids any drainage device [7,12–14]. Randomised trials and subsequent meta-analyses have shown that tubeless PCNL reduces postoperative pain, analgesic consumption and hospital stay without lowering stone-free rates or increasing transfusion [15–20], and some authors have proposed it as the new standard of care for suitable patients [21]. The 2026 European Association of Urology (EAU) guidelines accordingly support tubeless or totally tubeless PCNL in uncomplicated cases [1].

Because the tubeless approach depends on careful case selection, prospective data that describe recovery outcomes together with systematically graded complications remain useful, particularly from centres where the technique is being adopted. This study therefore compared postoperative recovery, stone clearance and 30-day complications between tubeless and standard PCNL, and identified independent predictors of postoperative morbidity.

Materials and methods

Study design and setting

This prospective comparative study was conducted in the Department of Surgery, College of Medicine, University of Wasit, Wasit, Iraq, between August 2025 and July 2026. The protocol was approved by the Ethics Committee of the University of Wasit (approval no. 234 WU, dated 15 August 2025), and written informed consent was obtained from all participants. Allocation was not randomised. Among patients whose procedure fulfilled the intraoperative criteria for tubeless management (described below), the decision to omit or place a nephrostomy tube was left to the judgement of the operating surgeon, taking into account the overall intraoperative course, the number of tracts and the anticipated need for postoperative drainage.

Participants

Adults aged 18 years or older with renal calculi suitable for PCNL were eligible. Preoperative exclusion criteria were pregnancy, uncorrected coagulopathy, untreated urinary tract infection and a planned second-look procedure. Patients were also excluded if a major collecting-system perforation or uncontrolled bleeding occurred during surgery, so that both groups represented uncomplicated procedures.

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Preoperative assessment

All patients underwent clinical evaluation, complete blood count, serum creatinine, coagulation profile, urinalysis and urine culture. Non-contrast computed tomography (CT) of the urinary tract was used to determine stone burden, location and attenuation (Hounsfield units, HU), the degree of hydronephrosis and collecting-system anatomy, and to plan access.

Surgical technique

All procedures were performed under general anaesthesia with fluoroscopic and/or ultrasound-guided access, tract dilatation and intracorporeal lithotripsy. After stone extraction, the collecting system was inspected for residual stones, bleeding and perforation. In the standard group, a nephrostomy tube was placed at the end of the procedure. In the tubeless group, no nephrostomy tube was placed, and a ureteral stent or catheter was left when clinically indicated. Tubeless management was applied only when the procedure was uncomplicated, with satisfactory clearance, no clinically significant collecting-system injury and no significant bleeding.

Outcomes and follow-up

The primary endpoint was pain on the visual analogue scale (VAS, 0–10) 6 hours after surgery. Secondary endpoints were VAS scores at 12, 24 and 48 hours, rescue analgesic consumption, perioperative haemoglobin reduction, operative time, hospital stay, stone-free status and complications within 30 days (fever, transfusion, prolonged urinary leakage, urinary tract infection requiring treatment, secondary intervention and readmission). All patients received intravenous paracetamol 1 g every 6 hours (maximum 4 g/day), with intravenous tramadol 50 mg up to every 8 hours for breakthrough pain (VAS ≥ 4); analgesic consumption was recorded as the cumulative tramadol dose over the first 48 hours. Complications were graded according to the Clavien–Dindo classification [22,23]. Stone-free status was assessed by low-dose non-contrast CT at 4 weeks and defined as no residual calculus or clinically insignificant fragments smaller than 4 mm.

Sample size and statistical analysis

Assuming a mean 6-hour VAS score of 5.0 in the standard group and 4.2 in the tubeless group with a common standard deviation of 1.4 (effect size 0.57), 49 patients per group were required to detect this difference with 80% power at a two-sided α of 0.05. To allow for approximately 18% attrition, the target was set at 60 patients per group. Continuous variables are presented as mean ± standard deviation (SD) and compared with Student's t test or the Mann–Whitney U test; categorical variables are presented as numbers and percentages and compared with the χ^2 test, or Fisher's exact test when any expected cell count was below 5. Multivariable logistic regression was used to identify independent predictors of any 30-day complication, with results expressed as adjusted odds ratios (OR) and 95% confidence intervals (CI). A two-sided p value below 0.05 was considered significant. Analyses were performed with IBM SPSS Statistics version 29.0 (IBM Corp., Armonk, NY, USA).

Results

Participants and baseline characteristics

Of 146 patients assessed for eligibility, 26 were excluded (15 did not meet the eligibility criteria, 6 declined and 5 for other reasons), and 120 were included: 60 in the tubeless group and 60 in the standard group. All patients completed the 30-day follow-up (Figure 1). The groups were comparable in demographic characteristics (Table 1) and stone characteristics (Table 2).

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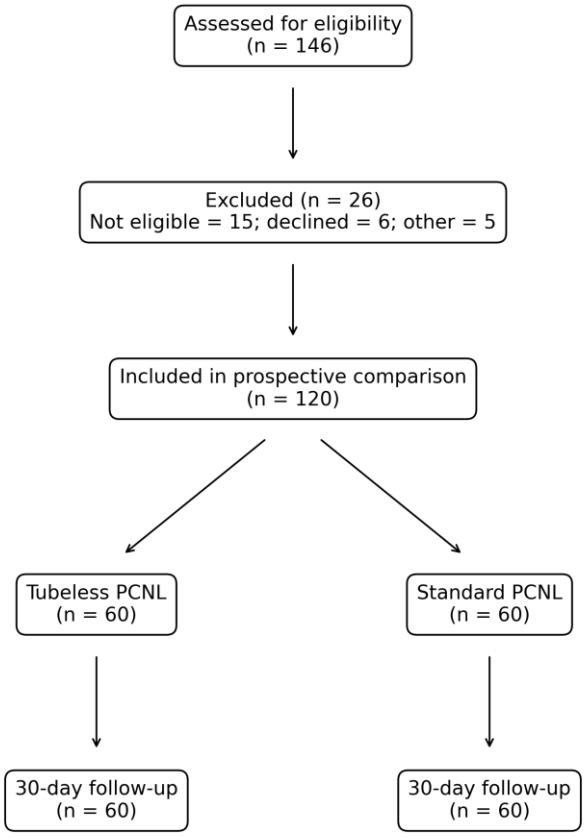


Figure 1. Flow diagram of patient enrolment and follow-up.

Table 1 Baseline demographic characteristics of the study groups

Variable	Tubeless (n = 60)	Standard (n = 60)	p value
Age, years	43.8 ± 12.1	45.1 ± 11.7	0.551
Male sex, n (%)	37 (61.7)	39 (65.0)	0.705
Body mass index, kg/m²	27.1 ± 3.8	27.6 ± 4.1	0.489
Diabetes mellitus, n (%)	9 (15.0)	11 (18.3)	0.624
Hypertension, n (%)	13 (21.7)	15 (25.0)	0.668

Values are mean ± SD unless otherwise indicated.

Table 2 Stone characteristics of the study groups

Variable	Tubeless (n = 60)	Standard (n = 60)	p value
Maximum stone diameter, mm	27.6 ± 7.4	28.3 ± 7.8	0.615
Stone density, HU	1048 ± 267	1081 ± 281	0.511
Multiple stones, n (%)	22 (36.7)	24 (40.0)	0.708
Partial staghorn stone, n (%)	9 (15.0)	10 (16.7)	0.803
Hydronephrosis, n (%)	31 (51.7)	34 (56.7)	0.583

HU: Hounsfield units. Values are mean ± SD unless otherwise indicated.

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Operative and recovery outcomes

Operative time and haemoglobin reduction did not differ between groups (Table 3). The tubeless group had significantly lower VAS scores at 6 hours (3.8 ± 1.2 vs 5.2 ± 1.4; $p < 0.001$) and at 12, 24 and 48 hours (all $p < 0.001$; Figure 2); these differences remained significant after Bonferroni correction for the four time points. Cumulative tramadol consumption over 48 hours was lower in the tubeless group (74.2 ± 42.6 vs 121.7 ± 55.3 mg; $p < 0.001$), and hospital stay was shorter by a mean of 1.1 days (1.7 ± 0.7 vs 2.8 ± 1.0 days; $p < 0.001$).

Table 3 Operative and early recovery outcomes

Outcome	Tubeless (n = 60)	Standard (n = 60)	p value
Operative time, min	69.4 ± 16.8	72.8 ± 17.5	0.280
Haemoglobin reduction, g/dL	1.12 ± 0.61	1.28 ± 0.69	0.181
VAS at 6 h	3.8 ± 1.2	5.2 ± 1.4	< 0.001
VAS at 12 h	3.0 ± 1.1	4.5 ± 1.3	< 0.001
VAS at 24 h	2.3 ± 1.0	3.7 ± 1.2	< 0.001
VAS at 48 h	1.4 ± 0.8	2.3 ± 1.0	< 0.001
Rescue tramadol, mg/48 h	74.2 ± 42.6	121.7 ± 55.3	< 0.001
Hospital stay, days	1.7 ± 0.7	2.8 ± 1.0	< 0.001

VAS: visual analogue scale (0–10). Values are mean ± SD.

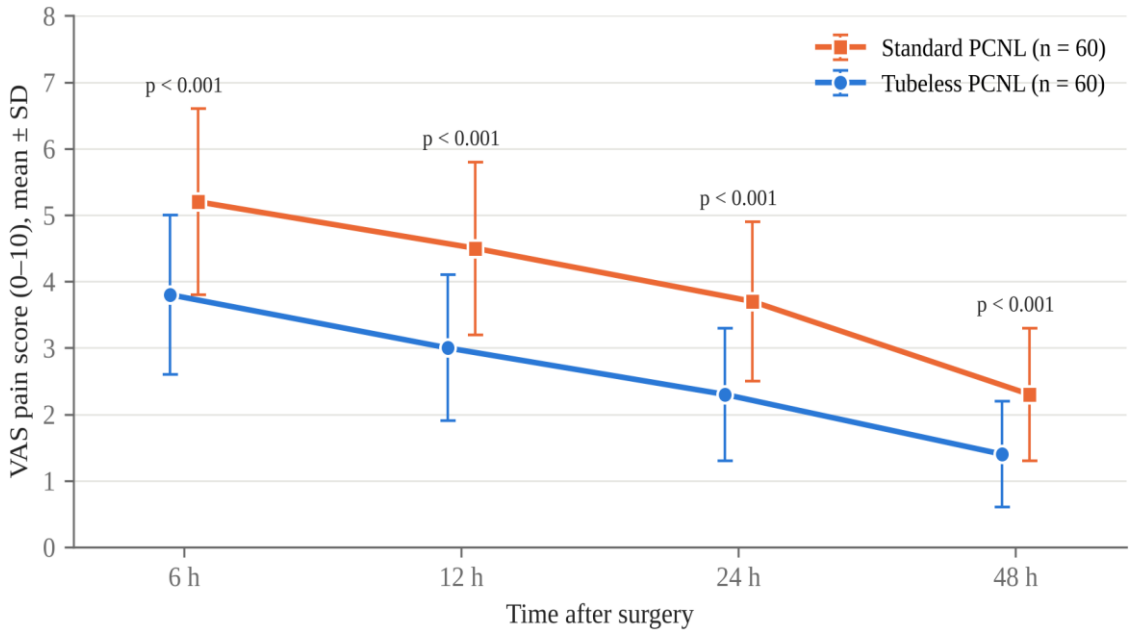


Figure 2. Postoperative pain scores (VAS, mean ± SD) after tubeless and standard PCNL.

Stone clearance and complications

Stone-free rates were similar (90.0% vs 86.7%; $p = 0.570$), as was the need for a secondary procedure (5.0% vs 8.3%; $p = 0.717$) (Table 4). Individual complications were numerically less frequent after tubeless PCNL, but none of the differences was significant (Table 5). The overall complication rate was 15.0% in the tubeless group and 23.3% in the standard group ($p = 0.247$), and most events were Clavien–Dindo grade I or II (Table 6).

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Table 4 Stone clearance and secondary procedures

Outcome	Tubeless (n = 60)	Standard (n = 60)	p value
Stone-free, n (%)	54 (90.0)	52 (86.7)	0.570
Residual fragments, n (%)	6 (10.0)	8 (13.3)	0.570
Secondary procedure, n (%)	3 (5.0)	5 (8.3)	0.717[a]

[a] Fisher's exact test. Secondary procedures were planned auxiliary treatments for residual fragments and were not graded as complications.

Table 5 Postoperative complications within 30 days

Complication	Tubeless (n = 60)	Standard (n = 60)	p value
Fever, n (%)	4 (6.7)	7 (11.7)	0.343
Blood transfusion, n (%)	2 (3.3)	3 (5.0)	1.000[a]
Prolonged urinary leakage, n (%)	1 (1.7)	4 (6.7)	0.364[a]
UTI requiring treatment, n (%)	3 (5.0)	5 (8.3)	0.717[a]
Readmission, n (%)	2 (3.3)	4 (6.7)	0.679[a]

UTI: urinary tract infection. [a] Fisher's exact test (expected cell count < 5); other comparisons by χ^2 test.

Table 6 Complications graded by the Clavien–Dindo classification

Clavien–Dindo grade	Tubeless (n = 60)	Standard (n = 60)	p value
No complication	51 (85.0)	46 (76.7)	–
Grade I	4 (6.7)	6 (10.0)	–
Grade II	4 (6.7)	6 (10.0)	–
Grade III	1 (1.7)	2 (3.3)	–
Any complication	9 (15.0)	14 (23.3)	0.247

Values are n (%). Each patient is classified by the highest grade experienced. Grade-specific data are descriptive.

Predictors of complications

In multivariable analysis (Table 7), the exit strategy was not independently associated with complications (adjusted OR for tubeless vs standard 0.58, 95% CI 0.23–1.47; p = 0.252). Stone size of 30 mm or larger (OR 2.31), operative time of 90 minutes or longer (OR 2.84) and a positive preoperative urine culture (OR 3.12) were independently associated with a higher risk of complications.

Table 7 Multivariable logistic regression for predictors of postoperative complications (23 events)

Predictor	Adjusted OR	95% CI	p value
Tubeless vs standard	0.58	0.23–1.47	0.252
Stone size ≥ 30 mm	2.31	1.01–5.30	0.048
Multiple stones	1.71	0.72–4.07	0.225
Operative time ≥ 90 min	2.84	1.12–7.18	0.028
Diabetes mellitus	2.19	0.77–6.22	0.141
Positive preoperative urine culture	3.12	1.08–9.02	0.036

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OR: odds ratio; CI: confidence interval. All variables shown were entered simultaneously.

Discussion

In this prospective comparison, omitting the nephrostomy tube after uncomplicated PCNL was associated with less postoperative pain at every time point, lower rescue analgesic consumption and a hospital stay that was about one day shorter, while operative time, blood loss, stone clearance and complication rates were similar. These findings agree with randomised trials and meta-analyses comparing tubeless and standard PCNL [15–18,20]. In the meta-analysis by Zhong et al., for example, total tubeless PCNL shortened hospital stay by about 1.1 days and reduced analgesic requirement [19], an effect of similar size to that observed here.

The mechanism is plausible. A nephrostomy tube passes through the renal capsule, parenchyma and flank musculature, causing pain, splinting and reduced mobility [9–11]. The largest difference in VAS scores in our series occurred in the first 24 hours, when the tube is in place, and the groups converged by 48 hours. The historical concern that loss of tract tamponade would increase bleeding [7,24,25] was not supported: haemoglobin reduction and transfusion rates were comparable. Most complications were low grade, in line with contemporary series and the CROES Global Study [4,26].

Larger stones, longer operative time and a positive preoperative urine culture, rather than the exit strategy, were associated with complications. These factors reflect stone complexity and infection risk, and they support individualised decisions on drainage. Significant bleeding, residual stones that may require a second look, collecting-system injury, obstruction and infection-related concerns remain valid indications for a nephrostomy tube [8,27], and the EAU guidelines restrict tubeless PCNL to uncomplicated cases [1]. Our results apply within this context.

This study has limitations. First, allocation was not randomised but left to surgeon judgement among patients with an uncomplicated procedure; selection bias may therefore have favoured the tubeless group, even though baseline and stone characteristics were balanced. Second, stone complexity was not graded with a validated score such as the Guy's stone score or the CROES nephrolithometric nomogram [28,29], and tract size and surgeon experience were not analysed. Third, VAS assessment and hospital discharge were not blinded to the exit strategy. Fourth, the multivariable model included six predictors for 23 complications, fewer than the ten events per variable usually recommended, so the estimates may be unstable and should be regarded as exploratory. Finally, this was a single-centre, single-surgeon study, which may limit generalisability.

Conclusion

After an uncomplicated PCNL, omitting the nephrostomy tube reduced early postoperative pain, analgesic requirement and hospital stay without compromising stone clearance or safety. Tubeless PCNL is a reasonable option for selected patients, with the final decision based on intraoperative assessment of bleeding, residual stone burden and collecting-system integrity. A randomised trial with validated complexity scoring would strengthen these conclusions.

Conflict of interest

The author declares no conflict of interest.

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Data availability

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

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