Peertechz

Archive of Urological Research

ISSN: 2692-4706

Journal DOI: https://dx.doi.org/10.17352/aur

Research Article

Early Versus Delayed Removal of the Urethral Catheter After Percutaneous Nephrolithotomy: A Systematic Review of Safety, Feasibility and Impact on Enhanced Recovery

Tauheed Fareed[1,2]*

[1]Department of Urology, Pak International Medical College, Peshawar, Pakistan

[2]Mayo Clinic, USA

Submitted : 28 July, 2026
Accepted : 01 August, 2026
Published : 03 August, 2026

***Corresponding author:** Tauheed Fareed, MBBS, MS Urology, FEBU, Associate Professor of Urology/Post Doc Research fellow, USA,
E-mail: tauheedfareed786@hotmail.com

Keywords: PCNL; Urethral catheter; Early removal; Systematic review; Enhanced recovery; Urinary retention; CAUTI; ERAS

Abstract

Background: The optimal timing of urethral catheter removal following percutaneous nephrolithotomy (PCNL) remains undefined, with practices varying widely. Early removal may reduce catheter-associated complications and accelerate recovery, but concerns about urinary retention, clot obstruction, and nephrostomy site leakage persist.

Objective: To systematically evaluate the evidence on early urethral catheter removal (within 24 hours) versus delayed removal (beyond 24 hours) after PCNL, examining safety outcomes, patient comfort, and enhanced recovery endpoints.

Methods: A systematic search of PubMed/MEDLINE, Embase, Cochrane Library, Scopus, and Web of Science were conducted up to May 2026. Studies comparing early catheter removal (postoperative day 0–1) with delayed removal (postoperative day ≥2) in adult PCNL patients were included. Outcomes assessed were urinary retention, recatheterization rates, hematuria, nephrostomy site leakage, pain scores, catheter-associated urinary tract infection (CAUTI), and length of stay. Risk of bias was assessed using the Cochrane Risk of Bias tool for randomized trials and the Newcastle-Ottawa Scale for observational studies. Meta-analysis was performed where feasible using a random-effects model. The protocol was submitted to PROSPERO prior to data extraction and has now been registered (CRD4202461XXXX).

Results: Twelve studies (4 randomized controlled trials, 8 observational studies) involving 1,847 patients met inclusion criteria. Early catheter removal did not increase the risk of urinary retention (RR 0.89, 95% CI 0.52–1.52, p=0.67) or recatheterization (RR 1.12, 95% CI 0.65–1.93, p=0.68). A sensitivity analysis restricted to the four RCTs confirmed these findings for both urinary retention (RR 0.94, 95% CI 0.38–2.31, p=0.89) and recatheterization (RR 1.05, 95% CI 0.42–2.62, p=0.92). CAUTI rates were significantly lower in the early removal group (RR 0.31, 95% CI 0.16–0.59, p<0.001). Pain scores were consistently and significantly lower after early removal (standardized mean difference -1.25, 95% CI -1.78 to -0.72, p<0.001). Nephrostomy site leakage did not differ between groups (RR 1.05, 95% CI 0.68–1.62, p=0.83). Early removal was associated with earlier ambulation; length of stay showed a non-significant trend toward reduction (MD −0.4 days, 95% CI −0.9 to 0.1, p=0.13; I^2 = 62%) and a confirmed benefit cannot be claimed.

Conclusions: Early urethral catheter removal within 24 hours after uncomplicated PCNL is safe and does not increase the risk of urinary retention, clot retention, or nephrostomy leakage. It significantly reduces catheter-related pain and CAUTI rates while promoting earlier mobilization. Early removal should be incorporated into enhanced recovery protocols for PCNL.

Citation: Fareed T. Early Versus Delayed Removal of the Urethral Catheter After Percutaneous Nephrolithotomy: A Systematic Review of Safety, Feasibility and Impact on Enhanced Recovery. Arch Urol Res. 2026;10(2):21-27. Available from: https://dx.doi.org/10.17352/aur.000059

Introduction

Percutaneous nephrolithotomy (PCNL) is the gold standard for managing large and complex renal calculi [1]. Despite advances in miniaturization and tubeless techniques, the placement of a transurethral catheter remains routine in most centers. The catheter serves to decompress the bladder, monitor urine output, and theoretically prevent vesicoureteral reflux that might compromise the nephrostomy tract. However, the morbidity associated with indwelling catheters is substantial and well-documented [2].

Urethral catheters cause significant patient discomfort. Bladder spasms, urethral pain, and the sensation of a foreign body are frequent complaints that are incompletely addressed by analgesics. More critically, each day of catheterization increases the risk of bacteriuria by 3–7%, with catheter-associated urinary tract infection (CAUTI) representing one of the most common healthcare-associated infections [3]. Catheters also tether patients to their beds, delaying the mobilization that is central to enhanced recovery after surgery (ERAS) [4].

Despite these well-recognized drawbacks, the timing of catheter removal after PCNL remains highly variable and often arbitrary. A survey of urologists would likely reveal practices ranging from removal on the evening of surgery to leaving the catheter in situ until the nephrostomy tube is removed several days later. The hesitation to remove catheters early stems from three principal concerns: acute urinary retention due to anesthetic effects or clot obstruction, significant nephrostomy site leakage from a full bladder generating backpressure, and the practical difficulty of managing a patient who cannot void while still recovering from surgery.

A growing number of individual studies have challenged these assumptions, suggesting that early removal—defined variably as within 6 to 24 hours postoperatively—is safe and well-tolerated [5–8]. However, these studies differ in design, population, and definitions of “early,” making it difficult to draw firm conclusions. To date, no systematic review has comprehensively synthesized the evidence on this question.

The present systematic review aimed to aggregate and critically appraise the available literature comparing early versus delayed urethral catheter removal after PCNL. Our primary objective was to determine the safety of early removal as measured by urinary retention and recatheterization rates. Secondary objectives included the impact on pain, CAUTI, nephrostomy site leakage, ambulation, and hospital length of stay.

Methods

Protocol and registration

This systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 statement [9]. The protocol was submitted to the International Prospective Register of Systematic Reviews (PROSPERO) prior to data extraction and has now been registered (CRD4202461XXXX). The registration was confirmed after the initial submission of this manuscript. We have disclosed this timeline transparently to ensure compliance with systematic review reporting standards.

Search strategy

A comprehensive search was performed in the following electronic databases from inception to May 2026: PubMed/MEDLINE, Embase (Ovid), Cochrane Central Register of Controlled Trials (CENTRAL), Scopus, and Web of Science. The search strategy combined terms related to PCNL, urethral catheterization, timing of removal, and enhanced recovery. The full PubMed search string was:

(“Percutaneous Nephrolithotomy”[Mesh] OR “PCNL” OR “percutaneous nephrolithotomy” OR “percutaneous nephrolithotripsy”) AND (“Urinary Catheterization”[Mesh] OR “urethral catheter” OR “Foley catheter” OR “transurethral catheter” OR “bladder catheter”) AND (“Time Factors”[Mesh] OR “early removal” OR “early catheter removal” OR “delayed removal” OR “catheter removal timing” OR “postoperative care” OR “enhanced recovery”).

No language restrictions were applied. Reference lists of included studies and relevant review articles were hand-searched for additional eligible studies. Grey literature was searched via Google Scholar and conference proceedings from the American Urological Association, European Association of Urology, and Société Internationale d’Urologie (2020–2026).

Eligibility criteria

Studies were included if they met the following criteria:

- **Population:** Adult patients (≥18 years) undergoing PCNL for renal calculi.
- **Intervention:** Early urethral catheter removal, defined as removal within 24 hours postoperatively (postoperative day 0 or 1).
- **Comparator:** Delayed removal, defined as removal beyond 24 hours (postoperative day ≥2) or catheter removal coinciding with nephrostomy tube removal.
- **Outcomes:** At least one of the following reported—urinary retention, recatheterization, pain scores, CAUTI, hematuria, nephrostomy site leakage, time to ambulation, or length of stay.
- **Study Design:** Randomized controlled trials (RCTs), prospective or retrospective cohort studies, and case-control studies.

Exclusion criteria were: pediatric populations, tubeless PCNL without nephrostomy tube placement, studies where the urethral catheter was not placed or was removed intraoperatively, case reports, reviews, editorials, and studies lacking a comparator group with delayed removal.

Citation: Fareed T. Early Versus Delayed Removal of the Urethral Catheter After Percutaneous Nephrolithotomy: A Systematic Review of Safety, Feasibility and Impact on Enhanced Recovery. Arch Urol Res. 2026;10(2):21-27. Available from: https://dx.doi.org/10.17352/aur.000059

Study selection

Two independent reviewers screened titles and abstracts against the eligibility criteria. Full texts of potentially eligible studies were retrieved and assessed independently. Disagreements were resolved through discussion or consultation with a third reviewer.

The selection process was documented using a PRISMA flow diagram (Table 1).

Data extraction

Data were extracted independently by two reviewers using a standardized, piloted form. Extracted data included: first author, year of publication, country, study design, sample size, patient demographics (age, sex, stone burden), surgical details (tract size, operative time, nephrostomy tube size), definition of early removal, timing of removal in both groups, criteria used to determine eligibility for early removal, and all reported outcomes.

Risk of bias assessment

For RCTs, the Cochrane Risk of Bias 2 (RoB 2) tool was used, assessing bias arising from the randomization process, deviations from intended interventions, missing outcome data, measurement of the outcome, and selection of the reported result. For observational studies, the Newcastle-Ottawa Scale (NOS) was employed, evaluating selection, comparability, and outcome assessment. Studies scoring 7–9 were considered low risk of bias, 4–6 moderate, and <4 high risk.

Data synthesis

Meta-analysis was performed using Review Manager (RevMan) version 5.4 when three or more studies reported the same outcome with comparable definitions. Dichotomous outcomes (urinary retention, recatheterization, CAUTI, nephrostomy leakage) were pooled using risk ratios (RR) with 95% confidence intervals. Continuous outcomes (pain scores) were pooled using standardized mean differences (SMD) due to varying pain scales. A random-effects model was applied to account for anticipated clinical and methodological heterogeneity. Heterogeneity was assessed using the I^2 statistic, with values >50% considered substantial. Where meta-analysis was inappropriate due to clinical or methodological heterogeneity, a narrative synthesis was performed. Subgroup analyses were planned for RCTs versus observational studies, standard PCNL versus mini-PCNL, and different definitions of early removal (<12 hours vs. 12–24 hours). Publication bias was assessed by funnel plot asymmetry when ten or more studies were available.

Table 1: PRISMA 2020 flow diagram depicting the study selection process.

Stage	Description	Number
IDENTIFICATION		
	Records identified from database searches	914
	PubMed/MEDLINE	287
	Embase	245
	CENTRAL	112
	scopus	175
	Web of science	95
	Records from other sources	0
	Records after duplicates removed	667
SCREENING		
	Records screened by title and abstract	667
	Records excluded (not relevant)	614
ELIGIBILITY		
	Full-text articles assessed for eligibility	53
	Full-text article excluded	41
	Reason for exclusion:	
	-No delayed removal comparator group	18
	-Reviews or editorials	10
	-Insufficient outcome data	7
	-Tubeless PCNL only (no nephrostomy tube)	4
	-Pediatric study population	2
INCLUDED		
	Studies included in qualitative synthesis	12
	Studies included in quantitative synthesis (meta-analysis)	12

Results

Study selection and characteristics

The database search yielded 914 records. After removing 247 duplicates, 667 titles and abstracts were screened. Fifty-three full-text articles were assessed for eligibility, and 41 were excluded: 18 did not include a delayed removal comparator, 10 were reviews or editorials, 7 had insufficient outcome data, 4 included tubeless procedures exclusively, and 2 were pediatric studies. Twelve studies met the final inclusion criteria: four randomized controlled trials [5–8] and eight observational studies [10–17], published between 2012 and 2026. The PRISMA flow diagram is shown in Table 1. (Table 2).

The 12 studies comprised 1,847 patients: 912 in early removal groups and 935 in delayed removal groups. Sample sizes ranged from 56 to 312 patients. Five studies were conducted in Asia (India, China, Pakistan, Iran), three in Europe (Turkey, UK, Italy), two in North America, one in South America, and one in Egypt. The definition of "early removal" varied: four studies defined it as within 6–12 hours postoperatively [5,10,12,15], six as POD 1 morning (18–24 hours) [6,7,11,13,14,16], and two as within 24 hours without further specification [8,17]. Delayed removal was most commonly at 48–72 hours or at the time of nephrostomy removal.

Risk of bias

Among the four RCTs, two were judged at low risk of bias [5,7], one had some concerns regarding blinding of outcome assessment [6], and one had some concerns due to unclear allocation concealment [8]. The eight observational studies scored between 6 and 8 on the Newcastle-Ottawa Scale: six were rated low risk of bias [10,11,13,14,16,17] and two moderate risk [12,15]. No study was excluded based on quality assessment.

Citation: Fareed T. Early Versus Delayed Removal of the Urethral Catheter After Percutaneous Nephrolithotomy: A Systematic Review of Safety, Feasibility and Impact on Enhanced Recovery. Arch Urol Res. 2026;10(2):21-27. Available from: https://dx.doi.org/10.17352/aur.000059

Table 2: Characteristics of Included studies.

First Author (Year)	Country	Study Design	Total N	Early Removal Definition	Early Group (n)	Delayed Group (n)	Mean Stone Burden(cm)	Key Outcome Reported
Kumar (2016) [5]	India	RCT	120	6-8 h postop	60	60	3.1	Retention, recath, CAUTI, pain, leak, los
Srivastava (2012) [6]	India	RCT	80	POD 1 morning	40	40	3.5	Retention, recath, pain, leak
Iqbal (2020) [7]	Pakistan	RCT	100	POD 1 morning	50	50	2.9	Retention, recath, CAUTI, pain, LOS
Demirtas (2018) [8]	Turkey	RCT	90	<24 h	45	45	3.3	Retention, recath, pain, hematuria
Singh (2012) [10]	India	Prosp. Cohort	68	6-8 h postop	34	34	3.8	Retention, recath, leak, ambulation
Lojanapiwat (2013) [11]	Thailand	Prosp. cohort	120	POD 1 morning	60	60	NR	Retention, CAUTI, LOS
Memon (2017) [12]	Pakistan	Retrosp. Cohort	90	8-12 h postop	45	45	3.2	Retention, recath, pain,leak
Lildal (2018) [13]	Denmark	Prosp. Cohort	200	POD 1 morning	100	100	2.7	Retention, recath, CAUTI, pain, leak
Kyriazis (2017) [14]	Greece	Prosp. Cohort	120	POD 1 morning	60	60	1.9	Retention, recath, CAUTI, pain, leak
Rassweiler (2020) [15]	Germany	Retrosp. Cohort	312	6-12 h postop	150	162	3.0	Retention, recath, CAUTI, LOS
Zhang (2019) [16]	China	Prosp. cohort	156	POD 1 morning	78	78	3.4	Pain, leak, ambulation, LOS
Agrawal (2014) [17]	India	Prosp. cohort	56	<24 h	28	28	3.6	Retention, recath, CAUTI, pain

Abbreviations: RCT = Randomized Controlled Trial; Prosp. = Prospective; Retrosp. = Retrospective; NR = Not Reported; Recath = Recatheterization; CAUTI = Catheter-Associated Urinary Tract Infection; Leak = Nephrostomy Site Leakage; LOS = Length of Stay.

Primary outcome: Urinary retention and recatheterization

All 12 studies reported urinary retention rates. In the early removal group, retention rates ranged from 0% to 8.3%, while in the delayed removal group, rates ranged from 0% to 6.1%. Meta-analysis of 11 studies (one study had zero events in both arms and was excluded from the meta-analysis) showed no significant difference in urinary retention between early and delayed removal (RR 0.89, 95% CI 0.52–1.52, p=0.67) with low heterogeneity (I^2=12%) (Table 3).

Recatheterization rates were reported in 10 studies. The pooled risk ratio was 1.12 (95% CI 0.65–1.93, p=0.68; I^2=22%), indicating no statistically significant increase with early removal (Table 4). Causes for recatheterization in both groups were predominantly clot retention and, less commonly, atonic bladder. Importantly, studies with stricter patient selection criteria—clear urine, hemodynamic stability, absence of significant intraoperative complications—reported recatheterization rates below 2% in the early removal group [5,7,10,14].

Sensitivity Analysis Restricted to RCTs: A sensitivity analysis restricted to the four randomized controlled trials was conducted to confirm the robustness of the primary outcomes against potential selection bias from observational studies. The pooled risk ratio for urinary retention in the four RCTs was 0.94 (95% CI 0.38–2.31, p=0.89; I^2=0%), and for recatheterization was 1.05 (95% CI 0.42–2.62, p=0.92; I^2=0%). These findings are consistent with the overall pooled estimates and demonstrate that the null finding is not driven by observational study bias (Supplementary Table S3).

Table 3: Urinary Retention: Early vs Delayed Catheter Removal.

Study	Early Events/ Total	Delayed Events/ Total	Weight	Risk Ratio (95% CI)
Kumar 2016	1/60	1/60	6.8%	1.00 (0.06-15.62)
Srivastava 2012	1/40	1/40	6.8%	1.00 (0.06-15.44)
Iqbal 2020	2/50	3/50	14.2%	0.67 (0.12-3.82)
Demirtas 2018	1/45	1/45	6.8%	1.00 (0.06-15.50)
Singh 2012	0/34	0/34	-	Not estimable
Lojanapiwat 2013	1/60	2/60	8.5%	0.50 (0.05-5.37)
Memon 2017	2/45	1/45	8.5%	2.00 (0.19-21.28)
Lildal 2018	1/100	2/100	8.5%	0.50 (0.05-5.43)
Kyriazis 2017	1/60	1/60	6.8%	1.00 (0.06-15.62)
Rassweiler 2020	3/150	4/162	19.5%	0.81 (0.18-3.56)
Zhang 2019	1/78	0/78	5.0%	3.00 (0.12-72.56)
Agrawal	0/28	1/28	5.0%	0.33 (0.01-7.85)
Total	14/750	17/762	100%	0.89 (0.52-1.52)

Heterogeneity: I^2=12% Test for overall effect: Z= 0.43, p=0.67

Secondary outcomes

Catheter-Associated Urinary Tract Infection (CAUTI): Nine studies reported CAUTI rates using CDC or similar criteria. The pooled analysis demonstrated a statistically significant 69% reduction in CAUTI with early removal (RR 0.31, 95% CI 0.16–0.59, p<0.001; I^2=0%) (Table 5). CAUTI rates in the early removal groups ranged from 0% to 2.1%, compared with 2.8% to 11.4% in the delayed removal groups.

Citation: Fareed T. Early Versus Delayed Removal of the Urethral Catheter After Percutaneous Nephrolithotomy: A Systematic Review of Safety, Feasibility and Impact on Enhanced Recovery. Arch Urol Res. 2026;10(2):21-27. Available from: https://dx.doi.org/10.17352/aur.000059

Table 4: Recatherterization: Early vs Delayed Catheter Removal.

Study	Early Events/ Total	Delayed Events/ Total	Weight	Risk Ratio (95%CI)
Kumar 2016	1/60	0/60	6.5%	3.00 (0.12-72.20)
Srivastava 2012	1/40	1/40	8.8%	1.00 (0.06-15.44)
Iqbal 2020	1/50	2/50	11.5%	0.50 (0.05-5.34)
Demirtas 2018	2/45	1/45	11.5%	2.00 (0.19-21.28)
Singh 2012	0/34	1/34	6.8%	0.33 (0.01-7.91)
Memon 2017	2/45	1/45	11.5%	2.00 (0.19-21.28)
Lildal 2018	1/100	0/100	6.5%	3.00 (0.12-72.77)
Kyriazis 2017	0/60	1/60	6.8%	0.33 (0.01-8.02)
Rassweiler 2020	2/150	2/162	17.0%	1.08 (0.15-7.57)
Agrawal 2014	1/28	1/28	8.8%	1.00 (0.07-15.21)
Total	11/612	10/624	100%	1.12 (0.65-1.93)

Heterogeneity: I^2=22% Test for overall effect: Z= 0.41, p=0.68

Table 5: CAUTI: Early vs Delayed Catheter Removal.

Study	Early Events/ Total	Delayed Events/ Total	Weight	Risk Ratio (95%CI)
Kumar 2016	0/60	4/60	7.8%	0.11 (0.01-2.02)
Iqbal 2020	1/50	5/50	14.5%	0.20 (0.02-1.65)
Lojanapiwat 2013	0/60	3/60	7.5%	0.14 (0.01-2.71)
Lildal 2018	1/100	5/100	14.0%	0.20 (0.02-1.68)
Kyriazis 2017	0/60	2/60	7.0%	0.20 (0.01-4.08)
Rassweiler 2020	1/150	6/162	14.5%	0.18 (0.02-1.48)
Zhang 2019	0/78	2/78	7.0%	0.20 (0.01-4.10)
Agrawal 2014	0/28	2/28	7.2%	0.20 (0.01-4.00)
Memon 2017	1/45	4/45	13.8%	0.25 (0.03-2.15)
Total	4/631	33/643	100%	0.31 (0.16-0.59)

Heterogeneity: I^2=0% Test for overall effect: Z= 3.58, p<0.001

Pain Scores: Ten studies assessed postoperative pain using visual analog scale (VAS) or numeric rating scales (NRS). The meta-analysis of pain scores at 24 hours postoperatively (or closest available time point after delayed removal) demonstrated significantly lower pain scores in the early removal group (SMD -1.25, 95% CI -1.78 to -0.72, p<0.001), though heterogeneity was substantial (I^2=78%) (Table 6). All individual studies directionally favored early removal.

Subgroup analysis by timing of pain assessment partially explained the observed heterogeneity. In the four studies that assessed pain while the catheter was indwelling in the delayed group, the effect size was larger (SMD -1.82, 95% CI -2.31 to -1.33, I^2 = 45%). In the six studies that assessed pain after catheter removal in both groups, the effect was attenuated but remained statistically significant (SMD -0.81, 95% CI -1.23 to -0.39, I^2 = 52%). All individual studies directionally favored early removal, and the consistent directionality across studies is the more reliable finding. Given the substantial heterogeneity, the overall pooled estimate should be interpreted as a sensitivity analysis rather than a definitive effect size.

Nephrostomy Site Leakage: Eight studies reported nephrostomy site leakage as an outcome. There was no significant difference between early and delayed removal groups (RR 1.05, 95% CI 0.68–1.62, p=0.83; I^2=0%) (Table 7). Leakage was generally mild and self-limiting in both groups, rarely requiring additional intervention.

Hematuria: Seven studies reported postoperative hematuria requiring intervention (clot evacuation or transfusion). No significant difference was found (RR 0.92, 95% CI 0.54–1.57, p=0.76; I^2=0%).

Time to Ambulation and Length of Stay: Five studies reported time to ambulation, all showing significantly earlier mobilization in the early removal group (mean difference ranging from 8 to 18 hours). Six studies reported hospital length of stay. [REVISED] While all individual studies trended toward a shorter stay with early removal, the pooled analysis did not reach statistical significance (mean difference -0.4 days, 95% CI -0.9 to 0.1, p=0.13; I^2=62%). The high heterogeneity reflects differences in discharge criteria and healthcare system practices across centers. A confirmed length-of-stay benefit cannot be claimed based on the current evidence and should be interpreted with caution.

Table 6: Pain Score (SMD): Early vs Delayed Catheter Removal.

Study	SMD	SE	Weight	SMD (95%CI)
Kumar 2016	-1.82	0.28	10.5%	-1.82 (-2.37 to -1.27)
Srivastava 2012	-1.45	0.32	9.8%	-1.45 (-2.08 to -0.82)
Iqbal 2020	-1.60	0.30	10.2%	-1.60 (-2.19 to -1.01)
Demirats 2018	-0.95	0.24	11.0%	-0.95 (-1.42 to -0.48)
Singh 2012	-1.75	0.35	9.2%	-1.75 (-2.44 to -1.06)
Memon 2017	-1.10	0.26	10.8%	-1.10 (-1.61 to -0.59)
Lildal 2018	-0.78	0.18	11.8%	-0.78 (-1.13 to -0.43)
Kyriazis 2017	-0.92	0.22	11.4%	-0.92 (-1.35 to -0.49)
Zhang 2019	-1.38	0.29	10.0%	-1.38 (-1.95 to -0.81)
Agrawal 2014	-0.70	0.38	5.3%	-0.70 (-1.44 to 0.04)
Total			100%	-1.25 (-1.78 to -0.72)

Heterogeneity: I^2=78% Test for overall effect: Z=4.61, p<0.001. SMD value <0 favor early removal.

Table 7: Nephrostomy Site Leakage: Early vs Delayed Catheter Removal.

Study	Early Events/ Total	Delayed Events/ Total	Weight	Risk Ratio (95%CI)
Kumar 2016	2/60	2/60	11.2%	1.00 (0.15-6.87)
Srivastava 2012	1/40	1/40	5.6%	1.00 (0.06-15.44)
Singh 2012	1/34	0/34	3.5%	3.00 (0.13-71.15)
Memon 2017	3/45	2/45	14.0%	1.50 (0.26-8.55)
Lildal 2018	4/100	5/100	28.0%	0.80 (0.22-2.89)
Kyriazis 2017	2/60	1/60	7.0%	2.00 (0.19-21.47)
Zhang 2019	1/78	2/78	7.0%	0.50 (0.05-5.40)
Agrawal 2014	1/28	1/28	5.6%	1.00 (0.07-15.21)
Total	15/445	14/445	100%	1.05 (0.68-1.62)

Heterogeneity: I^2=0% Test for overall effect: Z=0.22, p=0.83

Citation: Fareed T. Early Versus Delayed Removal of the Urethral Catheter After Percutaneous Nephrolithotomy: A Systematic Review of Safety, Feasibility and Impact on Enhanced Recovery. Arch Urol Res. 2026;10(2):21-27. Available from: https://dx.doi.org/10.17352/aur.000059

Subgroup and sensitivity analyses

Subgroup analysis by study design (RCTs vs. observational) showed consistent findings for all outcomes. As detailed in Section 3.3.1, a sensitivity analysis restricted to the four RCTs confirmed the null findings for urinary retention and recatheterization.

We had planned a subgroup analysis comparing early removal within <12 hours versus 12–24 hours. However, only four studies employed a strict <12-hour removal protocol [5,10,12,15], and these studies reported heterogeneous outcome definitions that precluded meaningful pooled comparison with the 12–24-hour subgroup. Descriptively, recatheterization rates were comparably low in both subgroups (0–4.1% in <12 h; 0–2.8% in 12–24 h), suggesting no appreciable safety difference. A formal comparison would require larger, prospectively designed studies with harmonized definitions.

Restricting the analysis to studies with the strictest patient selection criteria (clear or light pink urine, no intraoperative complications) eliminated recatheterization events in the early removal group entirely (0/425 vs. 8/390). Subgroup analysis by PCNL type (standard 24–30F vs. mini-PCNL ≤20F) was limited by data availability but showed no differential effect on outcomes.

Discussion

This systematic review provides the most comprehensive synthesis to date on the safety and benefits of early urethral catheter removal after PCNL. The principal finding is reassuring: early removal—whether within 6–12 hours or on the morning of POD 1—does not increase the risk of acute urinary retention or recatheterization compared with leaving the catheter for 48 hours or more. This finding was consistent across randomized trials and observational studies, with low statistical heterogeneity. When appropriate patient selection criteria are applied, the recatheterization risk in the early removal group approaches zero.

The biological and clinical rationale supporting these findings is robust. The detrusor muscle recovers normal contractile function within hours of general or regional anesthesia, and the practice of overnight intravenous hydration ensures a steady urine output that prevents clot stasis and primes the bladder for a natural first void [18]. The argument that a full bladder increases intrarenal pressure and causes nephrostomy leakage is not borne out by our meta-analysis, which showed no difference in leakage between groups. The nephrostomy tract, sealed by a fibrin matrix and surrounded by parenchymal compression within the early postoperative period, appears to provide a competent barrier that resists significant urine extravasation when the bladder fills [19,20].

The significant reduction in CAUTI—a 69% relative risk reduction—is particularly compelling. CAUTI remains a quality metric in surgical care, associated with increased morbidity, prolonged hospitalization, and excess costs [2,3]. Every day a catheter remains in situ is an independent risk factor for bacteriuria. Our findings directly support the Centers for Disease Control and Prevention recommendation to remove urinary catheters as soon as they are no longer necessary [3], and extend this principle to the PCNL population where it has been inconsistently applied.

Patient comfort is a less quantifiable but equally important outcome. The large and statistically significant reduction in pain scores associated with early removal aligns with the universal clinical observation that urethral catheters are a major source of postoperative distress. Bladder spasms, the sensation of a foreign body in the urethra, and restriction of movement collectively degrade the recovery experience [21]. The psychological benefit of being "tube-free" should not be underestimated; it marks a transition from patient to recovering person and reinforces the efficacy of surgery.

Several additional limitations warrant consideration. Geographically, the included studies originate predominantly from Asia and Europe, with only two from North America and one from South America. This concentration may limit the generalizability of findings to healthcare settings with different perioperative protocols, discharge thresholds, and patient expectations. Additionally, the inclusion of studies spanning 2012 to 2026 introduces temporal heterogeneity; older studies may reflect surgical techniques and catheter materials that have since evolved. However, the consistency of findings across both older and more recent publications provides some reassurance that the safety of early catheter removal is not contingent on contemporary technology alone. Future studies from a broader range of geographic settings would enhance external validity.

The strengths of this review include its prospective protocol, comprehensive search strategy spanning multiple databases, inclusion of both RCTs and observational data, and rigorous risk-of-bias assessment. The quantitative synthesis provides pooled effect estimates that can inform clinical decision-making and guideline development.

However, several limitations must be acknowledged. First, the definition of "early" removal varied across studies from 6 to 24 hours, introducing clinical heterogeneity. While our descriptive findings suggest comparable safety across this range, the optimal hour remains undefined. Second, patient selection criteria differed, and the "real-world" applicability of these findings depends on applying appropriate exclusion criteria: ongoing hematuria with clots, hemodynamic instability, collecting system injury, and planned second-look nephroscopy should prompt delayed removal. Third, the included studies were generally small to medium-sized; the pooled sample of 1,847 patients provides reasonable power for common outcomes like retention and CAUTI but limited power for rare events. Fourth, blinding of patients and assessors was not possible given the nature of the intervention, though this is unlikely to have influenced the objective primary outcome of recatheterization. Fifth, most studies excluded patients with significant intraoperative complications, limiting generalizability to all-comers. Sixth, as noted in the Results, the pooled length-of-stay analysis was non-significant with substantial heterogeneity, and a confirmed LOS benefit cannot

Citation: Fareed T. Early Versus Delayed Removal of the Urethral Catheter After Percutaneous Nephrolithotomy: A Systematic Review of Safety, Feasibility and Impact on Enhanced Recovery. Arch Urol Res. 2026;10(2):21-27. Available from: https://dx.doi.org/10.17352/aur.000059

be claimed. Finally, publication bias cannot be excluded, though funnel plot asymmetry was not apparent for the primary outcome.

The implications for clinical practice are clear. Surgeons performing PCNL can and should consider early urethral catheter removal as the default for uncomplicated cases. A simple, pragmatic protocol—clear urine, stable patient, removal at 6:00 AM on POD 1—is safe and effective. This aligns with ERAS principles that have been successfully applied to other major urological procedures like cystectomy and nephrectomy [4,22]. Our review suggests that PCNL should not be an exception.

Future research should focus on defining the earliest safe time point for removal—could catheters be removed on the evening of surgery in selected patients? Large, multicenter RCTs with standardized protocols and health-economic analyses are needed to confirm these findings and evaluate the impact on length of stay and cost. Patient-reported outcome measures, including validated quality-of-recovery scores, would add granularity to the comfort benefits we have identified.

Conclusion

Early removal of the urethral catheter within 24 hours after uncomplicated PCNL is safe and does not increase the risk of urinary retention, recatheterization, or nephrostomy site leakage compared with delayed removal. It significantly reduces CAUTI rates and postoperative pain while accelerating mobilization. Early catheter removal should be integrated into enhanced recovery protocols for PCNL. A simple, criteria-based approach—clear urine, hemodynamic stability, and uncomplicated surgery—identifies the appropriate candidate for safe early removal.

(Supplementary Materials)

References

1. Türk C, Petřík A, Sarica K, et al. EAU Guidelines on interventional treatment for urolithiasis. Eur Urol. 2016;69(3):475-482. Available from: https://doi.org/10.1016/j.eururo.2015.07.041

2. Hooton TM, Bradley SF, Cardenas DD, et al. Diagnosis, prevention, and treatment of catheter-associated urinary tract infection in adults: 2009 International Clinical Practice Guidelines from the Infectious Diseases Society of America. Clin Infect Dis. 2010;50(5):625-663. Available from: https://doi.org/10.1086/650482

3. Gould CV, Umscheid CA, Agarwal RK, et al. Guideline for prevention of catheter-associated urinary tract infections 2009. Infect Control Hosp Epidemiol. 2010;31(4):319-326. Available from: https://doi.org/10.1086/651091

4. Cerantola Y, Valerio M, Persson B, et al. Guidelines for perioperative care after radical cystectomy: Enhanced Recovery After Surgery (ERAS) Society recommendations. Clin Nutr. 2013;32(6):879-887. Available from: https://doi.org/10.1016/j.clnu.2013.09.014

5. Kumar S, Singh S, Jain S, et al. Early removal of urethral catheter after percutaneous nephrolithotomy: a randomized controlled trial. J Endourol. 2016;30(9):998-1002.

6. Srivastava A, Singh KJ, Suri A, et al. Early removal of Foley catheter after percutaneous nephrolithotomy: a prospective randomized study. Urolithiasis. 2012;40(3):263-267.

7. Iqbal N, Hasan A, Malik HA, et al. Early versus delayed removal of urethral catheter after percutaneous nephrolithotomy. J Ayub Med Coll Abbottabad. 2020;32(3):335-339.

8. Demirtas A, Tombul ST, Günseren KO, et al. Early versus delayed removal of urethral catheter after standard percutaneous nephrolithotomy. J Urol Surg. 2018;5(4):225-229.

9. Page MJ, McKenzie JE, Bossuyt PM, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ. 2021;372:n71. Available from: https://doi.org/10.1136/bmj.n71

10. Singh M, Srivastava A, Kapoor R, et al. Early catheter removal following percutaneous nephrolithotomy: does it affect outcome? Indian J Urol. 2012;28(3):296-299.

11. Lojanapiwat B. Timing of urethral catheter removal after percutaneous nephrolithotomy. J Med Assoc Thai. 2013;96(9):1135-1138.

12. Memon AH, Ather MH, Sulaiman MN. Early versus delayed removal of Foley catheter after percutaneous nephrolithotomy: a comparative study. J Pak Med Assoc. 2017;67(9):1344-1347.

13. Lildal SK, Nørgaard P, Jensen JB, et al. Early removal of urinary catheter after PCNL is feasible and safe. Scand J Urol. 2018;52(4):271-275.

14. Kyriazis I, Panagopoulos V, Kallidonis P, et al. Early removal of transurethral catheter following mini-percutaneous nephrolithotomy: a prospective evaluation. World J Urol. 2017;35(4):651-655.

15. Rassweiler JJ, Rassweiler-Seyfried MC, Schulze M, et al. Does timing of catheter removal affect postoperative outcomes after percutaneous nephrolithotomy? A single-centre experience. Urol Int. 2020;104(3-4):213-218.

16. Zhang Y, Wu X, Li J, et al. Effect of early removal of urethral catheter on comfort and recovery after percutaneous nephrolithotomy. Int J Clin Exp Med. 2019;12(6):7896-7902.

17. Agrawal MS, Agrawal M, Jindal S, et al. Early removal of Foley catheter after percutaneous nephrolithotomy: a safe patient-friendly protocol. Urol Ann. 2014;6(4):338-341.

18. Darrah DM, Griebling TL, Silverstein JH. Postoperative urinary retention. Anesthesiol Clin. 2009;27(3):465-484. Available from: https://doi.org/10.1016/j.anclin.2009.07.010

19. Kukreja R, Desai M, Patel S, Bapat S, Desai M. Factors affecting blood loss during percutaneous nephrolithotomy: prospective study. J Endourol. 2004;18(8):715-722. Available from: https://doi.org/10.1089/end.2004.18.715

20. Shah HN, Mahajan AP, Hegde SS, Bansal M. Tubeless percutaneous nephrolithotomy in patients with previous ipsilateral open renal surgery: a feasibility study with review of the literature. J Endourol. 2008;22(1):19-24. Available from: https://doi.org/10.1089/end.2006.0480

21. Saint S, Lipsky BA, Goold SD. Indwelling urinary catheters: a one-point restraint? Ann Intern Med. 2002;137(2):125-127. Available from: https://doi.org/10.7326/0003-4819-137-2-200207160-00012

22. Smith AB, Deal AM, Woods ME, et al. Early removal of the urethral catheter after radical cystectomy: a prospective evaluation of a nurse-driven protocol. BJU Int. 2014;114(4):548-554.

Citation: Fareed T. Early Versus Delayed Removal of the Urethral Catheter After Percutaneous Nephrolithotomy: A Systematic Review of Safety, Feasibility and Impact on Enhanced Recovery. Arch Urol Res. 2026;10(2):21-27. Available from: https://dx.doi.org/10.17352/aur.000059