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ORIGINAL PAPER

Safety and outcomes of second-look percutaneous nephrolithotomy for complex renal stones: A retrospective study

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Summary

***Introduction:** Residual stones after percutaneous nephrolithotomy (PCNL) remain a major clinical challenge, particularly in patients with large or complex calculi. Second-look PCNL offers a minimally invasive option for achieving complete stone clearance; however, real-world data on outcomes, timing, and predictive factors are limited.*

***Materials and methods:** We retrospectively analyzed 72 patients who underwent second-look mini-PCNL at a high-volume tertiary center. Perioperative parameters were compared between procedures and between stone-free and residual stone groups. Stone-free status was defined as the absence of residual fragments ≥ 4 mm on non-contrast computed tomography. Outcomes of early (same admission) versus delayed second-look PCNL were evaluated.*

***Results:** Most patients had high stone complexity, with 79.17% classified as Guy's Stone Score grade 4. The overall stone-free rate after second-look PCNL was 55.56%. Multivariate analysis identified the presence of more than five stones as the only independent predictor of residual fragments (OR 6.49, 95% CI 1.65-25.52; p = 0.007). Operative time and complication rates were comparable between procedures, while early re-intervention significantly reduced hospitalization duration and antibiotic use (both p < 0.01).*

***Conclusions:** Despite a modest SFR, second-look PCNL is a safe and effective strategy for managing residual stones. Early re-intervention during the same admission improves recovery and optimizes resource utilization.*

KEY WORDS: *Percutaneous nephrolithotomy; Second-look PCNL; Residual stones; Early re-intervention.*

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INTRODUCTION

Urolithiasis is the third most common urologic condition after urinary tract infections and benign prostatic hyperplasia, and *percutaneous nephrolithotomy* (PCNL) is the gold-standard treatment for large and complex renal stones (1-4). Nevertheless, a significant proportion of patients have residual stone fragments following PCNL, particularly those with complex stones. Intraoperative challenges such as bleeding, infection, prolonged operative time, or suboptimal access planning can also lead to incomplete clearance (5-7). These residual stones not only increase the risk of recurrence, infection, and ultimately compromise long-term outcomes if not adequately managed (8-10).

Salvage strategies include extracorporeal *shock wave lithotripsy* (SWL) or *retrograde intrarenal surgery* (RIRS); however, these are often unsuitable for large fragments (6, 7, 11). In contrast, second-look PCNL via an existing nephrostomy tract provides a direct and minimally invasive approach to complete clearance, potentially avoiding the need for re-puncture and reducing morbidity. Encouragingly, recent studies suggest that this approach is safe and improves *stone-free rate* (SFR) (5-7, 12, 13).

Despite these potential benefits, real-world data on the characteristics of PCNL failures and outcomes of second-look procedures remain limited. Therefore, this study aims to identify the reasons for initial PCNL failure and evaluate the efficacy and safety of second-look PCNL in a high-complexity cohort.

METHODS

Between September 2021 and September 2023, we retrospectively reviewed patients who underwent mini-PCNL at a high-volume tertiary center. A total of 72 patients who initially underwent prone mini-PCNL but had residual stones and subsequently required an additional intervention were included in this study. The study protocol was approved by the *Institutional Review Board and Ethics Committee* (Approval No. 386/HĐĐĐ-ĐHYD).

Demographic and clinical characteristics were recorded. Preoperative evaluation consisted of routine blood tests, urinalysis, urine culture, and non-contrast *computed tomography* (CT). Severe hydronephrosis was defined as grade 3-4 on CT, and obesity as *body mass index* (BMI) ≥ 25 kg/m² according to Asian criteria. Stone burden was calculated as the stone surface area using the formula Length × Width × π × 0.25 (π = 3.14159) (14). Staghorn calculi were defined as branched stones occupying a large portion of the collecting system (13).

All procedures were performed under general anesthesia with 16 Fr mini-PCNL sheaths under fluoroscopic guidance. Intraoperative data included whether a ureteral catheter was placed before renal puncture, the number of access tracts, operative time, placement of nephrostomy tubes or *double-J* (DJ) stents, and postoperative outcomes such as transfusion requirements and complications. Procedures were terminated at the discretion of the operating surgeon in cases of excessive bleeding, risk of sepsis, or prolonged operative time when complete clearance could not be achieved in a single session, with significant residual stone burden detected intraoperatively by nephroscopy or fluoroscopy. "*Same admission*" referred to patients who remained hospitalized after the initial procedure, whereas "*readmission*" referred to those discharged and readmitted for the second procedure. The old nephrostomy was reused whenever feasible; otherwise, an additional tract was created at the surgeon's decision. Complications were classified according to the Clavien-Dindo system (15).

Stone-free status was defined as the absence of residual fragments ≥ 4 mm on non-contrast CT one month after the second procedure (12, 16). Statistical analyses were performed using Stata software (*version 17.0; StataCorp LLC, USA*). Categorical variables were reported as frequencies and percentages, while continuous variables were expressed as mean ± standard deviation (SD). Chi-square or Fisher's exact tests were applied for categorical comparisons, while Student's t-test was used for continuous variables. Univariate logistic regression was performed for each variable, and factors with $p < 0.2$ were entered into a multivariate logistic regression model. A $p < 0.05$ was considered statistically significant.

Results

A total of 72 patients who underwent a second-look mini-PCNL were analyzed. The demographic and stone-related data are presented in Table 1. Overall, the cohort demonstrated substantial stone complexity, as 79.17% of patients were classified as *Guy's Stone Score* (GSS) grade 4. Most stones were located in the middle and lower poles, with a mean of 4.7 ± 2.4 calyces involved. The mean stone diameter and surface area indicated a large stone burden, consistent with the high proportion of multiple stones.

The overall SFR after the second-look PCNL was 55.56%, and no patient required a third intervention. Failures after the first session were mostly due to limited operative time or intraoperative bleeding, whereas in the second procedure, residual stones were predominantly caused by anatomical challenges – particularly inaccessible calyces (Figure 1).

Most residual fragments after the second-look procedure were small, clinically insignificant, located in inaccessible calyces, and were man-

Table 1.
Demographic and preoperative stone data of patients (n = 72).

Variables	
Age (Mean ± SD)	58.03 ± 10.63
Gender (N, %)	
o Male	41 (56.94)
o Female	31 (43.06)
History of prior ipsilateral renal stone surgery (N, %)	
o PCNL	2 (2.78)
o Open surgery	11 (15.28)
Obesity (N, %)	13 (18.06)
Intervention side (N, %)	
o Right	31 (43.06)
o Left	41 (56.94)
Maximum stone diameter (mm, mean ± SD)	44.63 ± 15.11
Number of stones (N, %)	
o One stone	42 (58.33)
o Two-five stones	9 (12.50)
o More than five stones	21 (29.17)
Stone burden (mm^2, mean ± SD)	897.20 ± 665.22
Number of involved calyces (mean ± SD)	4.72 ± 2.37
Stone location	
o Upper pole involvement	50 (69.44)
o Middle pole involvement	65 (90.28)
o Lower pole involvement	56 (77.78)
GSS (N, %)	
o Grade 1	3 (4.17)
o Grade 2	6 (8.33)
o Grade 3	6 (8.33)
o Grade 4	57 (79.17)
Stone density (HU, mean ± SD)	1043.74 ± 234.52
Preoperative hydronephrosis (N, %)	
o None	3 (4.17)
o Grade 1	31 (43.06)
o Grade 2	24 (33.33)
o Grade 3	13 (18.06)
o Grade 4	1 (1.39)
Positive urine culture (N, %)	4 (5.56)

HU: Hounsfield unit.

Figure 1.
Reasons for residual stone after first and second-look PCNL.

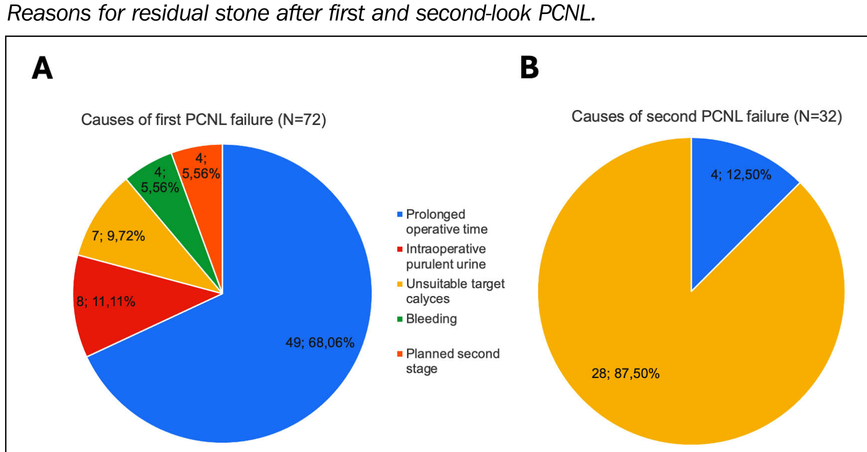

Table 2.
Comparison between first and second-look PCNL procedures.

Variables	First PCNL	Second-look PCNL	P
Ureteral catheterization (N, %)	22 (30.56)	6 (8.33)	0.0016^
Number of tracts (N, %)			0.018^
o Single	71 (98.61)	62 (86.11)	
o Two	1 (1.39)	9 (12.50)	
o Three	0 (0)	1 (1.39)	
Targeted calyces (N, %)			
o Upper pole	1 (1.39)	5 (6.94)†	
o Middle pole	2 (2.78)	2 (2.78) †	
o Lower pole	70 (97.22)	3 (4.17) †	
o Old tract only	NA	62 (86.11) ‡	
Exit (N, %)			
o DJ stent placement	21 (29.17)	37 (51.39)*	0.011^
o Nephrostomy placement	72 (100)	72 (100)	1^
Mean operative time (mean ± SD)	87.29 ± 24.99	84.03 ± 27.34	0.47#
Postoperative fever (N, %)	12 (16.67)	7 (9.72)	0.32^
Blood transfusion (N, %)	4 (5.56)	0 (0)	0.12^
Clavien-Dindo grade (N, %)	0.53^		
o 0	52 (72.22)	58 (80.56)	
o 1	7 (9.72)	7 (9.72)	
o 2	10 (13.89)	5 (6.94)	
o 3a	3 (4.17)	2 (2.78)	

† New addition tracts. ‡ One of them was upper pole tract, the rest were lower pole tracts.
** New double J placement. ^ Chi square/Fisher test. # t-test. NA: not available.*

Table 4.
The logistic regression of residual stones after the second-look procedure.

Variables	Univariate analysis			Multivariate analysis		
	OR	95% CI	p	OR	95% CI	p
Age	1.01	0.97-1.06	0.59			
Sex (Male/female)	1.20	0.47-3.06	0.71			
History of PCNL	1.26	0.08-20.93	0.87			
History of open surgery	1.05	0.29-3.81	0.94			
Obesity	1.09	0.33-3.63	0.89			
Maximum stone diameter (mm)	1.01	0.98-1.04	0.53			
More than five stones	3.67	1.35-10.73	0.018	6.49	1.65-25.52	0.007
Stone burden (mm^2)	1.00	0.99-1.01	0.51			
Number of involved calyces	1.25	1.00-1.56	0.04	1.16	0.88-1.54	0.30
Staghorn stone	2.66	0.76-9.33	0.13	3.54	0.52-23.99	0.20
Stone location						
o Upper pole	0.94	0.34-2.58	0.91			
o Middle pole	2.14	0.39-11.86	0.38			
o Lower pole	2.04	0.63-6.67	0.23			
Stone density (HU)	1.00	0.99-1.00	0.82			
Severe hydronephrosis	1.89	0.58-6.15	0.29			
Second-look PCNL new tract	0.81	0.21-3.16	0.76			
Readmission	1.05	0.41-2.68	0.92			

CI: confidence interval; OR: odds ratio.

Table 3.
Comparison between early (same admission) vs delayed second-look PCNL (N = 72).

Variables (days, mean ± SD)	Total	Same admission (N = 32)	Readmission (N = 40)	P
Interval between sessions	19.91 ± 14.06	8.69 ± 3.42	28.90 ± 12.82	< 0.01#
Hospitalization	18.38 ± 6.03	16.31 ± 4.86	20.03 ± 6.42	< 0.01#
Antibiotic course	17.46 ± 6.08	15.44 ± 4.60	19.08 ± 6.67	< 0.01#

 # t-test.

aged conservatively. Table 2 demonstrates that the second-look procedure involved a greater use of multi-tract access compared with the first PCNL ($p = 0.018$). Despite this, operative time and complication rates were comparable between sessions (both $p > 0.05$). Postoperative morbidity, including fever, transfusion, and complication grade remained low and showed no significant difference between sessions. When comparing patients who underwent early second-look PCNL during the same admission with those requiring readmission (Table 3), the delayed group had a significantly longer hospitalization and course of antibiotics (all $p < 0.01$).

Appendix Table 1 provides a comparative overview of the parameters observed between patients with residual stones and those achieving stone-free status after the second-look PCNL. In univariate analysis, several factors were associated with residual stones after second-look PCNL, including more than five stones ($p = 0.018$) and the number of involved calyces ($p = 0.04$). In the multivariate logistic regression, having more than five stones was the only independent predictor of residual fragments (OR 6.49, 95% CI 1.65-25.52, $p = 0.007$) (Table 4).

Appendix Table 1.
Comparison of patient characteristics, stone parameters, and perioperative factors between residual stone and stone-free groups after second-look PCNL.

Parameter	Residual stone group (N = 32)	Stone-free group (N = 40)	P
Age	58.78 ± 9.10	57.42 ± 11.56	0.58#
Male (N, %)	19 (59.37)	22 (55)	0.89^
Obesity (N, %)	6 (18.75)	7 (17.5)	1^
History of open surgery (N, %)	5 (15.63)	6 (15)	1^
History of PCNL (N, %)	1 (3.13)	1 (2.5)	1^
Severe hydronephrosis (N, %)	8 (32)	6 (40)	0.29^
Staghorn stone (N, %)	28 (87.5)	29 (72.5)	0.15^
Number of stones (N, %)			
o One stone	12 (37.5)	30 (75)	0.003^
o Two-five stones	6 (18.75)	3 (7.5)	0.17^
o More than five stones	14 (43.75)	7 (17.5)	0.03^
Stone location (N, %)			
o Upper pole	22 (68.75)	28 (70)	1^
o Middle pole	30 (93.75)	35 (87.5)	0.45^
o Lower pole	27 (84.37)	29 (72.5)	0.36^
Number of involved calyces	5.38 ± 1.95	4.20 ± 2.52	0.015#
Stone density	1050.59 ± 214.96	1038.25 ± 246.15	0.82#
Stone burden	954.70 ± 737.68	851.20 ± 587.67	0.63#
New tract puncture (N, %)	4 (12.5)	6 (15)	1^
Readmission (N, %)	18 (56.25)	22 (55)	1^

^ Chi square/Fisher test. # t-test.

Discussion

The primary aim of modern stone management is to achieve maximal stone clearance while minimizing renal injury (17, 18). PCNL remains the standard for large or complex renal stones, balancing efficacy and renal preservation (2-4). However, residual fragments are a frequent challenge, often necessitating repeat procedures. In our cohort, over 79% of patients had GSS grade 4, reflecting high stone complexity. Similarly, *Borofsky et al.* identified stone burden and limited access as key contributors to initial PCNL failure (7). *Kumar et al.* reported second-look PCNL in 8.5% of cases, associated with high GSS, staghorn stones, bleeding, perforation, and infection (5). *Moeen et al.* also observed a 10.3% re-intervention rate, typically due to significant residual stones or intraoperative complications or suboptimal access (6). In our study, prolonged lithotripsy, infection risk, and unsuitable target calyces were leading causes of incomplete clearance. Thus, second-look PCNL is often required due to combined stone complexity, anatomical challenges, and intraoperative factors.

Managing residual fragments after PCNL remains a significant challenge and reported SFRs after second-look procedures vary. *Dai et al.* achieved 60.7% SFR using flexible nephroscopy, while *Kumar and Moeen* reported higher rates of 86.1% and 94.9%, respectively, especially with adjunctive procedures (5, 6, 19). *Borofsky et al.* reached 97% SFR, though 65.5% required additional treatments (7). In the randomized trial by *Gücük et al.*, routine flexible nephroscopy improved SFR from 70% to 92.5%, and *Giannakopoulos et al.* reported a 93.3% SFR after early second-look flexible nephroscopy (20, 21). In contrast, our SFR was 55.56%, likely reflecting greater anatomical and stone complexity, characterized by large and multiple calculi. Notably, many patients requiring a second-look procedure initially underwent single-tract PCNL despite high stone complexity, which may have limited complete clearance at the first session. During the second procedure, restricted use of additional access tracts and reliance on existing tracts – while reducing procedural risk – often limited access to certain calyces and contributed to residual stones. Although operative times were comparable, surgical strategies varied according to surgeon judgment. In contrast to studies using flexible nephroscopy or *endoscopic combined intrarenal surgery* (ECIRS), our tract-based approach reflects practice in resource-limited settings. Importantly, most residual fragments were clinically insignificant, located in inaccessible calyces, and managed conservatively after substantial stone burden reduction.

Timing of re-intervention is also crucial. *Kumar et al.* noted that over half of their second-look procedures occurred during the same admission, and *Moeen et al.* advocated for early re-intervention within the same hospital stay to optimize outcomes (5, 6). *Giannakopoulos et al.* demonstrated that performing second-look flexible nephroscopy within 2-4 days achieved high SFRs and was well tolerated (21). In contrast, *Borofsky et al.* reported a median 48-day delay between procedures (7), while *Dai et al.* did not specify the interval (19). Consistent with prior reports, early second-look PCNL significantly reduced hospitalization and antibiotic duration. Early re-intervention shortens nephrostomy indwelling time, reduces tract fibrosis, thereby lowering infection risk, bacterial colonization, and the need for prolonged antibiotic use, while also improving patient comfort and reducing unplanned readmissions. Consequently, early second-look PCNL facilitates faster recovery and minimizes overall morbidity (5, 7).

Regarding safety, *Borofsky et al.* found no increase in complication rates despite high re-intervention frequency (7), while Kumar and Moeen demonstrated comparable or even lower complication rates between first and second sessions (5, 6). Similarly, in our series, transfusion, fever, and Clavien-Dindo complication rates were not significantly different between procedures, reinforcing the safety profile of second-look PCNL. *Giannakopoulos et al.* also supported its favorable tolerance and low morbidity (21). Second-look PCNL through established tracts is safe, while individualized planning and selective use of additional access or adjunctive techniques, such as flexible nephroscopy, may further enhance SFR.

Strengths of our study include a relatively large cohort of second-look PCNL patients and its focus on a high-complexity population. This offers valuable real-world insight into outcomes in challenging cases. Importantly, our analysis directly compared early versus delayed second-look interventions.

Finally, our multivariate analysis identified independent predictors of residual fragments, enabling more accurate preoperative risk stratification and personalized surgical

Declarations

Ethical approval and consent for participate: *The study protocol was reviewed and approved by the Institutional Review Board and Ethics Committee of the University of Medicine and Pharmacy at Ho Chi Minh City (Approval No. 386/HĐĐĐ-ĐHYD). Given the retrospective nature of the study, the requirement for written informed consent was waived by the Institutional Review Board. All patient data were anonymized prior to analysis, and the study was conducted in accordance with the principles of the Declaration of Helsinki.*

Availability of data and material: *The data supporting the findings of this study are available from the corresponding author upon reasonable request.*

Competing interests: *The authors declare no conflicts of interest.*

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Authors' contributions: *Anh Toan Do: Conceptualization, Methodology, Supervision, Data interpretation, Writing – review & editing. Ngoc Thai Nguyen: Conceptualization, Methodology, Investigation, Data curation, Data interpretation, Writing – original draft. Shinnosuke Kuroda: Methodology, Data interpretation, Writing – review & editing, Critical revision of the manuscript for important intellectual content. Phan Nhat Duy Le: Investigation, Data curation, Formal analysis, Writing – original draft. Dao Thuan Nguyen: Methodology, Investigation, Data curation, Writing – review & editing. Huynh Dang Khoa Nguyen: Investigation, Data collection, Data curation, Formal analysis, Writing – original draft, Writing – review & editing. Xuan Thai Ngo: Methodology, Investigation, Data curation, Writing – review & editing. All authors reviewed the manuscript, approved the final manuscript for submission, agreed to take public responsibility for its content, and agreed to provide the underlying data upon reasonable request by the Editorial Office.*

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planning. This retrospective study has inherent limitations, including potential selection bias, non-standardized timing and surgical strategies, and the absence of repeat non-contrast CT before re-intervention, as residual stones were identified intraoperatively using fluoroscopy or nephroscopy. Long-term outcomes and the impact of adjunctive treatments were not evaluated, and techniques such as ECIRS or flexible nephroscopy were not employed.

Conclusions

In conclusion, second-look PCNL is a safe and feasible option for managing residual stones after initial PCNL failure, particularly in complex cases. Early re-intervention during the same admission improves recovery and resource utilization, while careful preoperative assessment and individualized surgical planning are essential to optimize stone-free outcomes. Despite a modest SFR, results were acceptable given the high stone complexity, with more than five stones identified as an independent predictor of residual fragments. The selective use of multiple access tracts and adjunctive modalities such as flexible nephroscopy or ECIRS may further enhance outcomes, warranting confirmation in future prospective studies.

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