Cohort Study

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# Outcomes and complications of percutaneous nephrolithotomy as primary versus secondary procedure for kidney stones: a prospective cohort study

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**Introduction:** Currently, percutaneous nephrolithotomy (PCNL) is the gold standard of treatment for large renal stones. The high prevalence of urolithiasis is associated with a high recurrence rate increasing the risk of re-intervention. This study aimed to compare the effectiveness and complications of PCNL among patients with previous therapeutic interventions for renal stones.

**Methods:** Between August 2018 and September 2023, 245 patients were prospectively enrolled in this study and who underwent PCNL for renal stones at our institution. We compared patients who had no previous renal surgery (group 1: $n=171$) with those who had a history of open renal surgery (group 2: $n=45$) or previous PCNL on the ipsilateral kidney (group 3: $n=31$). All patients underwent surgery in the Galdakao-modified Valdivia position. Data on stone characteristics and perioperative and postoperative parameters were collected. Technical features, success rates and morbidity were analyzed and compared between the groups.

**Results:** The fluoroscopy time was significantly longer in the group of patients with previous open surgery than in groups 1 and 3 (161.47 ± 52.44, 223.05 ± 33.29, 172.27 ± 30.51 sec, $P<0.001$). Similarly, the operative time was longer in group 2 (138.20 ± 38.86 min, $P<0.001$). The immediate stone-free rates in groups 1, 2, and 3 were 74.8%, 72.1%, and 77.4%, respectively ($P=0.945$). At 1-month, these rates increased to 98.8%, 96.2% and 96.8%, respectively ($P=0.857$). No difference was detected between the groups in terms of complication rate. The average Hb variation was 1.08 ± 0.82, 1.34 ± 1.01 and 0.94 ± 0.69 g/dl for groups 1, 2 and 3, respectively($P=0.082$). Hospital stay was longer in group 2 than in groups 1 and 3 (2.17 ± 1.03, 2.53 ± 1.22, 1.88 ± 1.00 days, $P=0.07$), respectively.

**Conclusion:** PCNL in patients with a history of renal surgery was associated with longer fluoroscopy and operative time. However, the success and morbidity rates as a secondary procedure were similar to those of PCNL in patients with no previous intervention.

**Keywords:** bleeding, complications, kidney stones, minimally invasive surgery, percutaneous nephrolithotomy

## Introduction

Urolithiasis is a common condition, with a prevalence ranging from 1 to 20%. The management of urolithiasis has evolved in recent decades from open pyelotomy and nephrolithotomy to minimally invasive surgery and endourology. The recurrence rate of urolithiasis is more than 50%, which increases the need for re-intervention[1,2]. Therefore, many patients in the era of open stone surgery present with recurrent stones.

### HIGHLIGHTS

- PCNL in patients who underwent previous open surgery for kidney stones is challenging due to retroperitoneal scars and perinephric fibrosis.
- The distortion of the pelvicalyceal system leads to a longer fluoroscopy time.
- Difficulties encountered when dilating the tract leads to a longer operative time.
- The success and morbidity rates of PCNL as a secondary procedure were similar to those of primary PCNL.
- In such situations, expertise in PCNL is needed to ensure optimal outcomes.

Currently, percutaneous nephrolithotomy (PCNL) is the gold-standard treatment for large kidney stones. This procedure has shown good efficacy and safety for stones greater than 2 cm and staghorn calculi. Since its first description in 1976 by Fernström[3], PCNL has undergone several modifications, such as patient position, dilation techniques and fragmentation devices. It seems that in cases of previous open kidney surgery leading to perinephric fibrosis and retroperitoneal adherences, PCNL may be more challenging and

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the outcomes in terms of success rate and morbidity may be impaired.

This study aimed to compare the efficacy and complications of PCNL in patients with or without previous surgery for renal stones.

## Methods

We conducted a prospective cohort study including 245 patients who underwent PCNL for kidney stones in a single tertiary care center between August 2018 and December 2023. This study has been reported in line with the STROCSS 2021 criteria[4].

Patients aged younger than 18 years, bilateral PCNL, multitract PCNL and patients with coagulation and hematologic disorders were excluded from this study.

The patients were divided into 3 groups:

Group 1 ($n = 171$): Patients who underwent first-time procedure.

Group 2 ($n = 43$): Patients who underwent previous open surgery on the ipsilateral kidney, including pyelotomy with or without nephrotomy.

Group 3 ($n = 31$): Patients who previously underwent PCNL on the ipsilateral kidney.

All patients underwent a Uro-CT scan before surgery to characterize the anatomy of the pelvicalyceal system and stone topography and to rule out a retrorenal bowel. Preoperative laboratory analysis included complete blood count, serum creatinine level, bleeding and coagulation profiles, and urine culture.

The baseline patient characteristics were recorded. Data on stone characteristics and perioperative and postoperative parameters were also collected.

Technical features, success and morbidity rates were recorded and analyzed. Ethical approval was obtained from the Institutional Review Board of our Hospital. All patients provided their written consent in accordance with the Declaration of Helsinki.

### *Surgical technique*

All procedures were performed under general anesthesia in the Galdakao-modified Valdivia position. Cefazolin (1g) was administered to all patients as antibioprophylaxis at the time of induction. After performing cystoscopy, a 6 Fr ureteric catheter was inserted into the pelvicalyceal system and filled with contrast agent. Then, puncture was performed under fluoroscopic guidance by choosing the calyx providing access to the maximal stone burden, mainly at the lower posterior calyx. A hydrophilic guidewire was placed in the collecting system, preferably in the ureter or the superior calyx. Dilation was ensured using an Alken telescopic dilator and the tract was established by inserting a 30Fr access sheath. A 24Fr nephroscope and a pneumatic lithotripter were used for navigation and stone fragmentation. Fragment extraction was performed by using a bipod grasper. The procedure was completed with the insertion of a 16 Fr nephrostomy tube and a double-J stent as and when needed. The nephrostomy tube was clamped 24 h postoperative and removed on the same day if there were no leakage and no pain or kept for a 2nd look PCNL. The double-J stent was removed after 2–4 weeks.

Blood loss was assessed by the postoperative decrease in the hemoglobin level (a blood count was done the day before the surgery and a second at 4 h postoperatively), and blood transfusion requirement. The total perioperative fluid intake was limited to 0.5 l of saline serum to minimize hematocrit variation and to better reflect the hemoglobin decrease.

Complications were graded according to the Clavien–Dindo classification system.

The stone-free rate was defined as the absence of fragments or the persistence of a residual fragment less than 4 mm based on a CT scan performed one month postoperatively.

### *Data analysis*

Statistical analysis was performed with IBM SPSS version 26.0, using ANOVA, Mann–Whitney U and Kruskal–Wallis H tests. Statistical significance was set at $P$ less than 0.05.

## Results

The present study included 245 patients of whom171 patients (69.7%) presented for a first-time PCNL (group 1), 43 patients (17.5%) had undergone previous open surgery on the ipsilateral kidney, including pyelotomy with or without nephrotomy (group 2) and 31 patients had a history of PCNL in the ipsilateral kidney (group 3).

The mean patient age was $49.4 \pm 15.85$ years in group 1, $53.63 \pm 11.55$ years in group 2, and $50.79 \pm 16.98$ years in group 3 ($P = 0.2$). There were no differences among the three groups in terms of diabetes mellitus, chronic kidney dysfunction, hypertension, solitary kidney, or ASA score. In the group of patients who underwent primary PCNL, the mean BMI was lower than that in groups 2 and 3 ($25.51 \pm 4.03$; $28.26 \pm 5.36$; $28.5 \pm 3.3$ kg/m$^2$, $P = 0.001$), respectively. As shown in Table 1, the mean stone burden and density were comparable between the groups ($P = 0.880$ and $P = 0.974$, respectively). However, we found a significant difference in stone location ($P = 0.018$).

Regarding perioperative and postoperative outcomes, the fluoroscopic time was significantly longer in the group with previous open surgery than in groups 1 and 3 ($161.47 \pm 52.44$, $223.05 \pm 33.29$, $172.27 \pm 30.51$ sec, $P < 0.001$). Similarly, the operative time was longer in group 2 ($138.20 \pm 38.86$ min, $P < 0.001$). The immediate stone-free rates were 74.8%, 72.1% and 77.4% in Groups 1, 2 and 3, respectively ($P = 0.945$). After one month, these rates increased to 98.8%, 96.2%, and 96.8%, respectively ($P = 0.857$).

As illustrated in Table 2, no difference was detected between the groups in terms of the complication rate. Most of the complications were grade 1 or 2. However, there was one case of bowel perforation in group 2 and one case of persistent postoperative bleeding requiring radioembolization. The average Hb variation was $1.08 \pm 0.82$, $1.34 \pm 1.01$ and $0.94 \pm 0.69$ g/dl for groups 1, 2 and 3, respectively ($P = 0.082$). Only five patients (2.9%) in group 1 and two patients in group 2 (4.6%) required blood transfusions ($P = 0.061$). We observed longer hospital stay in group 2 than in groups 1 and 3 ($2.17 \pm 1.03$, $2.53 \pm 1.22$, $1.88 \pm 1.00$, $P = 0.07$), respectively. However, this difference was not statistically significant.

## Discussion

Currently, PCNL is the gold-standard treatment for renal stones greater than 2 cm. In the last two decades, PCNL has gained popularity among urologists owing to its high success and low morbidity rates. Since the recurrence rate of stone formation is

**Table 1**

**Demographic data and stone characteristics**

| | Group 1 (no previous intervention) $n=171$ | Group 2 (previous open surgery) $n=43$ | Group 3 (previous PCNL) $n=31$ | $P$ |
|---|---|---|---|---|
| Age (years), mean ± SD | 49.4 ± 15.85 | 53.63 ± 11.55 | 50.79 ± 16.98 | 0.20[a] |
| Sex ratio (M/F) | 1.67 | 1.68 | 1.91 | 0.577[b] |
| BMI (kg/m²), mean ± SD | 25.51 ± 4.03 | 28.26 ± 5.36 | 28.5 ± 3.3 | 0.001[a] |
| Medical history | | | | |
| Diabetes mellitus, *n* (%) | 23 (13.4) | 8 (20.9) | 5 (16.1) | 0.097[a] |
| Hypertension, *n* (%) | 38 (22.2) | 15 (34.9) | 7 (22.5) | 0.224[a] |
| Kidney failure, *n* (%) | 7 (4.1) | 1 (2.3) | 2 (6.4) | 0.555[a] |
| ASA score, *n* (%) | | | | |
| I | 123 (71.9) | 20 (46.5) | 18 (58.1) | |
| II | 32 (18.7) | 15 (34.9) | 13 (41.9) | 0.082[a] |
| III | 16 (9.4) | 8 (18.6) | 0 (0) | |
| Solitary kidney, *n* (%) | 6 (3.5) | 2 (4.6) | 1 (3.8) | 0.088[a] |
| Laterality right:left | 77:93 | 18:24 | 15:13 | 0.847[b] |
| Stone location, *n* (%) | | | | |
| Pelvic | 45 (26.3) | 6 (13.9) | 5 (16.1) | |
| One calyx | 15 (8.8) | 5 (11.6) | 7 (22.5) | |
| Pelvic + calyx | 84 (49.1) | 20 (46.5) | 9 (29) | 0.018[c] |
| Multiple calyx | 10 (5.9) | 7 (16.4) | 4 (13) | |
| Staghorn | 17 (9.9) | 5 (11.6) | 6 (19.4) | |
| Stone size mm (mean ± SD) | 33.80 ± 11.64 | 35.72 ± 12.11 | 34.53 ± 11.61 | 0.880[a] |
| Density HU (mean ± SD) | 883.65 ± 324.6 | 941.74 ± 367.1 | 902.14 ± 331.21 | 0.974[a] |
| RT:RO, *n* (%) | 47:124 (37.9) | 15:28 (53.5) | 10:21 (47.6) | 0.061[b] |

ASA Score, American Society of Anesthesiologists Score; F, female; HU, Hounsfield Unit; M, male; PCNL, percutaneous nephrolithotomy; RO, radio-opaque; RT, radiotransparent.
Mean ± SD = Data presented as mean (standard deviation).
[a]*P* values based on the one-way ANOVA. Statistical significance at $P<0.05$.
[b]*P* values based on the Mann–Whitney U-test. Statistical significance at $P<0.05$.
[c]*P* values based on the Kruskal–Wallis H-test. Statistical significance at $P<0.05$.

greater than 50%, urologists are more likely to treat patients previously treated for renal calculi with open surgery. In such cases, PCNL outcomes may be impaired.

Our study showed that the operative time may be longer in patients who underwent previous open surgery or secondary PCNL. Margel *et al.*[5] compared 21 patients with previous open surgery versus 146 patients without open surgery and concluded that PCNL may take a longer time and lead to a greater percentage of auxiliary procedures. This longer operative time may be explained by perinephric fibrosis and adherences. In the case of PCNL in a previously operated kidney, scarring may occur within the collecting system. Accordingly, puncture and dilation are more challenging and lead to longer operative time. Razvan and colleagues reported that the number of attempts to access the pelvicalyceal system was significantly higher in patients who had previously undergone open surgery[6]. In our study, this conjuncture was linked to a longer fluoroscopy time. Similarly, in a large series of 565 patients, Memik *et al.*[7] reported that the total fluoroscopy time was longer in the arm of patients with previous open surgery (107.14 ± 47.8, 90.69 ± 40.7 min, $P=0.003$). Singh and colleagues concluded that the operative time and the tract dilation time were longer in patients with previous kidney surgery, respectively (62.75 ± 12.1, 73.86 ± 18.5 min, $P=0.002$) (10.31 ± 3.4 13.94 ± 3.6 min, $P<0.05$)[8]. However, some studies have not demonstrated significant differences in operative time[9,10]. This conjuncture is due to advancements in instrument development and increasing surgical experience. This difficulty can now be resolved in most situations.

Compared with open surgery, PCNL has lower morbidity and postoperative pain and a shorter recovery period. It seems that supine PCNL has the same complication rate as prone PCNL. Severe complications such as severe bleeding, sepsis, and organ perforation may occur. The supine position has the advantage of a shorter operative time with less fever and blood transfusion[11]. In addition, the supine position showed an increasing trend when performing endoscopic combined intrarenal surgery or in patients with respiratory diseases. In our study, the mean decrease in hemoglobin levels was higher in patients who previously underwent open surgery. In the same group, major bleeding requiring blood transfusion was observed in two patients (4.6%), but the difference was not significant. Qohaf *et al.*[12] reported blood transfusion rates of 5% for primary cases and 10% for recurrent cases, but the variation was not statistically significant. Furthermore, Reddy *et al.*[13] reported transfusion rates of 4.7% and 7% in patients with and without previous open surgery on the kidney, respectively. In a meta-analysis of 17 studies, Hu *et al.*[14] demonstrated that patients with previous open surgery were at greater risk of a decrease of hemoglobin level (1.78 g/l; 95% CI: 1.09–2.47, $P<0.05$) and arterial embolization (RR, 3.73; 95% CI 1.36–10.21; $P=0.01$). The risk of bleeding increases with a history of previous open interventions and is related to retroperitoneal fibrosis and adherence. The sequelae of open renal surgery, such as incisional hernia and bowel displacement, increase the complication rates[5,15]. In such situations, more attempts are usually required to puncture the pelvicalyceal system and dilation can be more difficult, sometimes leading to pelvic injuries and severe bleeding. Dilation with fascial

**Table 2**

**Perioperative and postoperative outcomes.**

| | Group 1 (no previous intervention) $n = 171$ | Group 2 (previous open surgery) $n = 43$ | Group 3 (previous PCNL) $n = 31$ | P |
|---|---|---|---|---|
| Fluoroscopy time (sec), mean ± SD | 161.47 ± 52.44 | 223.05 ± 33.29 | 172.27 ± 30.51 | < 0,001[a] |
| Operative time (min), mean ± SD | 101.86 ± 36.06 | 138.20 ± 38.86 | 115.2 ± 44.06 | < 0,001[a] |
| Hemoglobin drop (g/dl), mean ± SD | 1.08 ± 0.82 | 1.34 ± 1.01 | 0.84 ± 0.69 | 0.042[b] |
| Hematocrit drop (%), mean ± SD | 2.35 ± 1.1 | 2.85 ± 1.8 | 2.41 ± 1.6 | 0.269[b] |
| Blood transfusion, *n* (%) | 5 (2.9) | 2 (4.6) | 0 (0) | 0.061[a] |
| Postoperative fever, *n* (%) | 23 (13.4) | 5 (11.6) | 5 (16.1) | 0.072[a] |
| Complications, *n* (%) | | | | |
| Grade 1 | 44 (25.7) | 11 (25.5) | 9 (29) | |
| Grade 2 | 21 (12.2) | 5 (11.6) | 1 (3.2) | 0.091[c] |
| Grade 3 | 0 | 1 (2.3) | 1 (3.2) | |
| Initial SFR (%) | 74.8 | 72.1 | 77.4 | 0.945[a] |
| SFR 1-month (%) | 81.9 | 79.1 | 83.9 | 0.857[a] |
| Auxiliary procedure, *n* (%) | 23 (13.4) | 5 (11.6) | 3 (9.7) | 0.445[a] |
| Hospital stay (days) | 2.17 ± 1.03 | 2.53 ± 1.22 | 1.88 ± 1.00 | 0.072[b] |

Mean ± SD = Data presented as mean (standard deviation).

PCNL, percutaneous nephrolithotomy; SFR, stone-free rate.

[a]*P* values based on the Mann–Whitney U-test. Statistical significance at $P < 0.05$.

[b]*P* values based on the Kruskal–Wallis H-test. Statistical significance at $P < 0.05$.

[c]*P* values based on the $\chi^2$ test. Statistical significance at $P < 0.05$.

or serial metallic dilators is more effective and safer in patients with a history of renal surgery. Therefore, urologists who have adopted serial metallic dilation have not reported technical difficulties in several studies[16]. The efficiency of serial metallic dilators is attributed to the small diameter of the distal tip, which can easily penetrate fibrous scarred tissues[17,18].

Histologic variation in retroperitoneal and perinephric tissues depends on several factors, including struvite stones, long-standing calculi pyelonephritis, operative complications (bleeding and urine leakage) and the modality of postoperative urine drainage[19]. In this study, the bleeding risk in the group of patients who underwent previous kidney surgery might be explained by the high proportion of patients with diabetes mellitus found in several studies as a predictor of bleeding during PCNL[11,20].

This study showed that the success rate was similar to that of patients with no previous open surgery or secondary PCNL. Bsairi and colleagues concluded that previous open surgery had no impact on the final SFR or the need for an auxiliary procedure after the first PCNL. In this study, the high proportion of single stones in the group of patients with a history of open renal surgery could act as a confounding bias[21]. The results of the study by Gupta and colleagues were comparable to our findings, with no difference in the SFR between the groups. The fact that the procedures were performed by the same surgeon and the comparable baseline characteristics between the groups made the results more valuable[22]. Hu and colleagues concluded that the initial SFR is lower in patients with a history of open surgery, which is associated with more need for an auxiliary procedure. However, this difference was not statistically significant (RR = 0.96), which may be explained by the heterogeneity of SFR definitions[14]. Onal *et al.*[23] reported that the SFR was lower in pediatric female patients who had previously undergone open nephrolithotomy (65.4% vs. 81.4%, $P = 0.79$). In such situations, special attention must be given to detecting a retrorenal colon, which has a high incidence in pediatric female patients with a history of previous renal surgery[24].

We are aware of the limitations of our study. First, most of the procedures were performed by three main surgeons with different levels of expertise. Regarding the patients and stones' baseline characteristics, there were significant differences between the groups in terms of BMI and stone location, which may have impacted the success and morbidity of the procedure. Finally, the number of tubeless operations was very limited. This may be explained by the trend at the beginning of our experience of leaving a double-J stent and nephrostomy tube, especially when the intervention was performed by residents. Further prospective randomized studies with a single experienced surgeon and more tubeless procedures are needed.

## Conclusion

PCNL in patients with a history of open renal surgery may be challenging when dilating the tract because of retroperitoneal fibrosis, leading to higher fluoroscopy consumption and longer operative time. However, the success and morbidity rates of PCNL as a secondary procedure were similar to those of primary PCNL. Expertise is required to ensure optimal outcomes under such conditions.

## Ethics approval

This study was approved by the Ethics Committee of Tahar Sfar University Hospital.

## Consent

Written informed consent was obtained from the patient for publication and any accompanying images. A copy of the written consent is available for review by the Editor-in-Chief of this journal on request.

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Not applicable.

## Author contribution

All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by A.S., S.K., A.T. and E.D. The manuscript was written by A.S. and S.K. and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

## Conflicts of interest disclosure

The authors declare no conflicts of interest.

## Research registration unique identifying number (UIN)

Our work is registered in the Pan African Clinical Trials Registry 'PACTR' ID: PACTR202408311109457, pactr.samrc.ac.za.

## Guarantor

Aymen Sakly.

## Data availability statement

Data will be available at the request to the corresponding author.

## Provenance and peer review

Not commissioned, externally peer-reviewed.

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