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Comparative Study Between Percutaneous Nephrolithotomy in Patients with and without History of Open Renal Stone Surgery

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Abstract **Original Research Article**

Background: Percutaneous nephrolithotomy (PCNL) is an established method for renal stone removal. Due to the high recurrence rate of renal stones, patients previously treated with open renal stone surgery often require re-intervention. Open surgeries can result in scar tissue and anatomical changes that may affect subsequent PCNL procedures. ***Objective:*** The study aimed to compare the outcomes of PCNL in patients with and without a history of open renal stone surgery. ***Method:*** This prospective study was conducted at Dhaka Medical College Hospital and Dhaka Central International Medical College Hospital from October 2019 to September 2020. Sixty patients with renal stone disease scheduled for PCNL were selected based on inclusion and exclusion criteria. They were divided into two groups: Group A (n=30) comprised patients without a history of open renal stone surgery. At the same time, Group B (n=30) included those with a history of open renal stone surgery. ***Results:*** No significant differences were found between the groups regarding age, sex, number, size, or location of stones. Group B required more puncture attempts to access the collecting system (3.63 ± 1.06 vs. 1.56 ± 0.71, $p < 0.001$). Although the operation time was longer in Group B (106.83 ± 21.63 vs. 102.33 ± 24.76 minutes), it was not statistically significant (p=0.49). Blood transfusion was more frequently required in Group B (26.66% vs. 13.33%, p=0.02). No significant differences were observed in the number of tracts (p=1.00), perioperative complications, postoperative fever (p=0.64), or hospital stay (p=0.48). Stone clearance rates were 90.0% in Group B and 93.33% in Group A (p=0.64). ***Conclusion:*** PCNL in patients with a history of open renal stone surgery requires more puncture attempts and blood transfusions than in those without such a history. However, stone clearance rates are comparable between the two groups.

Keywords: PCNL, renal stones, open renal stone surgery.

INTRODUCTION

Kidney stone disease has been a part of human history since the earliest records of civilization, with Hippocrates being among the first to describe renal stones as a disease of the kidney [1]. Urolithiasis has long plagued human populations, and managing patients with urinary tract calculi remains a significant healthcare challenge due to its prevalence and recurrence [2]. The lifetime risk of kidney stone formation is approximately 11% for men and 7% for women, potentially increasing due to changes in diet and climate. Nephrolithiasis is particularly common, with peak incidence occurring in the third and fourth decades of life [3]. Moreover, untreated renal stone disease has a high tendency to recur, with reported recurrence rates of 50% at five years and 80-90% at ten years.

The treatment of renal stones has significantly evolved from open surgery to minimally invasive procedures since the first report of renal stone removal via nephrostomy by Rupel and Brown in 1941 [4]. There have been substantial advancements in techniques, instruments, and experience. Currently, four minimally invasive treatment modalities are available for kidney stones: Extracorporeal Shock Wave Lithotripsy (ESWL), Percutaneous Nephrolithotomy (PCNL), Retrograde Intrarenal Surgery (RIRS), and laparoscopic stone surgery.

Fernstrom and Johannson first reported Percutaneous Nephrolithotomy (PCNL) 1976 [1]. Alken further developed the technique by introducing the renal endoscope and ultrasonic lithotripsy [5]. Today, PCNL is the preferred management for stones larger than 2 cm or staghorn calculi. PCNL has largely replaced open renal stone surgeries for large and multiple stones in developed countries. However, open renal stone surgery and its consequences have not been eliminated. Due to the high recurrence rate of urolithiasis, some patients who have undergone open nephrolithotomy in the past may require re-intervention. Additionally, open surgery still holds importance in specific medical scenarios where minimally invasive interventions may not be suitable. Open surgery remains a critical option in many peripheral regions of developing countries, where PCNL is not readily available [6].

In Bangladesh, PCNL was not available until 2013 [7]. Percutaneous methods treat most uncomplicated and complicated renal stones as a routine procedure in Western setups. However, the technique still evolves in many developing countries, including Bangladesh. Patients with previous open renal surgery often present with retroperitoneal scar tissue around the kidney and distortion of the pelvicalyceal anatomy. Generally, performing surgery in an anatomical region previously operated on poses technical challenges that may be associated with longer operating times, higher complication rates, and lower success rates [8]. A similar study reported longer operation times and more attempts to access the collecting system, though similar stone clearance rates, in patients with recurrent stones and a history of open renal stone surgery. Conversely, no significant differences in outcomes between PCNL in patients with and without a history of open renal stone surgery.

This study aimed to compare the outcomes of PCNL in patients with and without a history of open renal stone surgery, aiming to improve confidence in the management of recurrent renal stones. Evaluating factors such as operation time, puncture attempts, complication rates, and stone clearance, this study provides a comprehensive understanding of the challenges and efficacy of PCNL in patients with different surgical histories. The findings could inform clinical practices and potentially enhance the surgical management strategies for renal stone disease, particularly in regions where both open and minimally invasive procedures are utilized.

OBJECTIVES

General objective

- To compare the outcome of Percutaneous Nephrolithotomy (PCNL) in patients with and without a history of open renal stone surgery

Specific objectives

- To count & record the number of punctures attempts to access the collecting system & document the number of tracts & compare between PCNL in patients with and without a history of open renal stone surgery group
- To determine operation time & compare PCNL in patients with and without a history of open renal stone surgery group
- To detect per-operative complications (pneumothorax, haemothorax, colon injury & compare PCNL in patients with and without a history of open renal stone surgery group
- To know the number of blood transfusion requirements & compare PCNL in patients with and without a history of open renal stone surgery group.
- To assess stone clearance & compare PCNL in patients with and without a history of open renal stone surgery group
- To document postoperative fever & postoperative hospital stay & compare PCNL in patients with and without a history of open renal stone surgery group.

MATERIAL AND METHODS

Study Design

This quasi-experimental study was conducted to compare the outcomes of Percutaneous Nephrolithotomy (PCNL) in patients with and without a history of open renal stone surgery. The study was conducted in the Department of Urology at Dhaka Medical College Hospital and Dhaka Central International Medical College Hospital from October 2019 to September 2020. A total of 60 patients with renal stone disease scheduled for PCNL were selected through purposive sampling and divided into two groups: 30 patients without prior open surgery (Group A) and 30 patients with prior open surgery (Group B). Data on puncture attempts, operation time, perioperative complications, blood transfusions, stone clearance, and postoperative outcomes were collected and analysed.

Inclusion criteria

- Age 18-70 years
- Renal stone 2-4 cm in the pelvis or any calyx or pelvicalyceal system

Exclusion criteria

- Anatomical abnormalities of kidney (ectopic kidney, horseshoe kidney, transplanted kidney)
- History of open renal stone surgery more than one time in the ipsilateral side
- Patients having serum creatinine > 2 mg/dl
- Radiolucent renal stone

Data Collection

Data were collected from 60 patients with renal stone disease undergoing PCNL, divided into two

groups: 30 without prior open surgery (Group A) and 30 with prior open surgery (Group B). The number of puncture attempts and tracts used were recorded. Operation time was measured from start to finish. Perioperative complications (pneumothorax, haemothorax, colon injury) were documented. Blood transfusion requirements were noted. Stone clearance was assessed using postoperative imaging. Postoperative outcomes were also recorded, including fever incidence and length of hospital stay. Data were analysed to compare outcomes between the two groups using appropriate statistical methods.

Data Analysis

Data were analyzed using SPSS version 26. Descriptive statistics were used to summarize the data. Continuous variables, such as operation time and number of puncture attempts, were compared between groups using independent t-tests. Categorical variables were compared using chi-square tests, including perioperative complications, blood transfusion requirements, stone clearance rates, and postoperative outcomes. A p-value of <0.05 was considered statistically significant. The results were presented in tables and charts to highlight the differences between patients with and without a history of open renal stone surgery undergoing PCNL.

Ethical Considerations

The study was conducted following the ethical guidelines of the Declaration of Helsinki. Approval was obtained from the Institutional Review Board (IRB) of Dhaka Medical College Hospital and Dhaka Central International Medical College Hospital. Informed consent was obtained from all participants before inclusion in the study. Confidentiality of patient information was maintained throughout the research process, ensuring that personal data were anonymized and securely stored. Participants were assured of their right to withdraw from the study at any time.

RESULTS

Table 1: Distribution of Patients According to Age (N=60)

Groups	Age (years) (Mean ± SD)	p-value
Group A	42.3 ± 15.22	
Group B	46.16 ± 7.30	0.463

The mean age of patients in Group A was 42.3 ± 15.22 years, while in Group B, it was 46.16 ± 7.30 years. The age difference between the two groups was not statistically significant (p = 0.463).

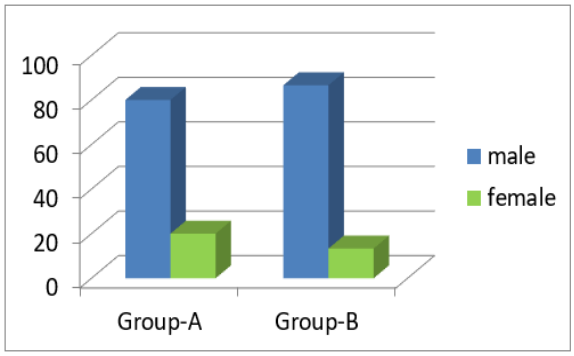

Figure 1: Distribution of Patients According to Sex in Group A & Group B

There were 24 males (80%) and 6 females (20%) in Group A. In Group B, there were 26 males (86.66%) and 4 females (13.33%). The sex distribution difference between the two groups was insignificant (p = 0.48).

Table 2: Distribution of Patients by Size and Number of Stones in Two Groups

Variables	Group A (n = 30)	Group B (n = 30)	p-value
Size of stone (cm)	2.81 ± 0.76	2.73 ± 0.73	0.49
Number of stones			
Single	22 (73.33%)	23 (76.66%)	
Multiple	8 (26.66%)	7 (23.3%)	0.766

The mean stone size was 2.81 ± 0.76 cm in Group A and 2.73 ± 0.73 cm in Group B. The difference in stone size between the two groups was not statistically significant (p = 0.49). In Group A, 22 patients (73.33%) had a single stone, and 8 (26.66%) had multiple stones. In Group B, 23 patients (76.66%) had a single stone, and 7 (23.3%) had multiple stones. There was no statistically significant difference between the two groups regarding the number of stones (p = 0.766).

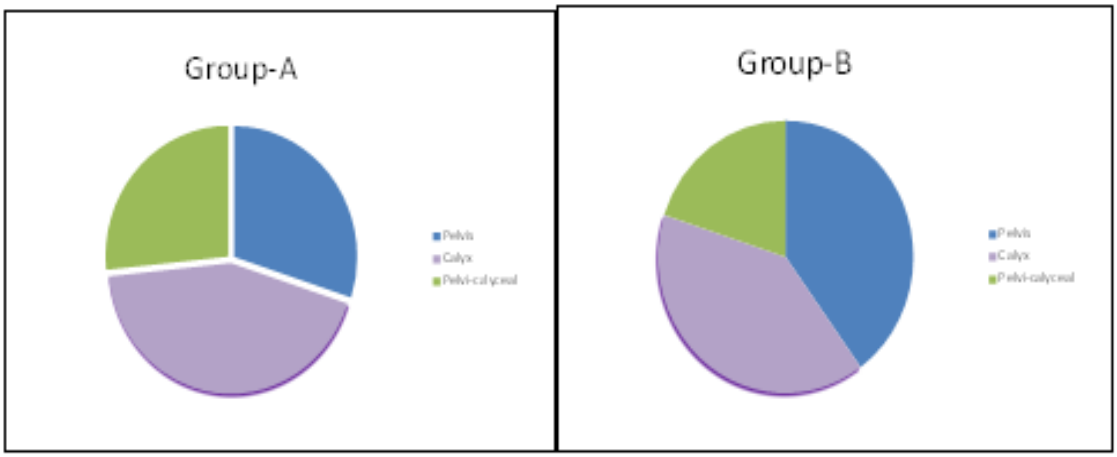

Figure 2: Distribution of Patients According to Location of Stones in Group A and Group B

In Group A, stones were located in the pelvis in 9 patients (30.0%), in the calyx in 13 patients (43.3%), and in the pelvicalyceal system in 8 patients (26.6%). In Group B, stones were located in the pelvis in 12 patients (40%), in the calyx, and in the pelvicalyceal system in 6 patients (20%). There was no significant difference between the two groups regarding stone location (p = 0.75).

Table 3: Comparison According to Number of Attempts to Access the Collecting System and Operation Time

Variables	Group A (Mean ± SD)	Group B (Mean ± SD)	p-value
Attempts to access the collecting system (number)	1.56 ± 0.71	3.63 ± 1.06	<0.001
Operation time (minutes)	102.33 ± 24.76	106.83 ± 21.63	0.49

The mean number of puncture attempts to access the collecting system was significantly higher in Group B (3.63 ± 1.06) compared to Group A (1.56 ± 0.71) (p < 0.001). The mean operation time was 102.33 ± 24.76 minutes in Group A and 106.83 ± 21.63 minutes in Group B, with no statistically significant difference between the two groups (p = 0.495).

Table 4: Comparison by Number of Tracts Between Two Groups (N=60)

Tract Number	Group A (n = 30)	Group B (n = 30)	p-value
Single	28 (93.33%)	28 (93.33%)	
Multiple	2 (6.66%)	2 (6.66%)	1.00

In both groups, single tracts were used in 28 patients (93.33%), and multiple tracts were used in 2 patients (6.66%). The two groups had no statistically significant difference (p = 1.00).

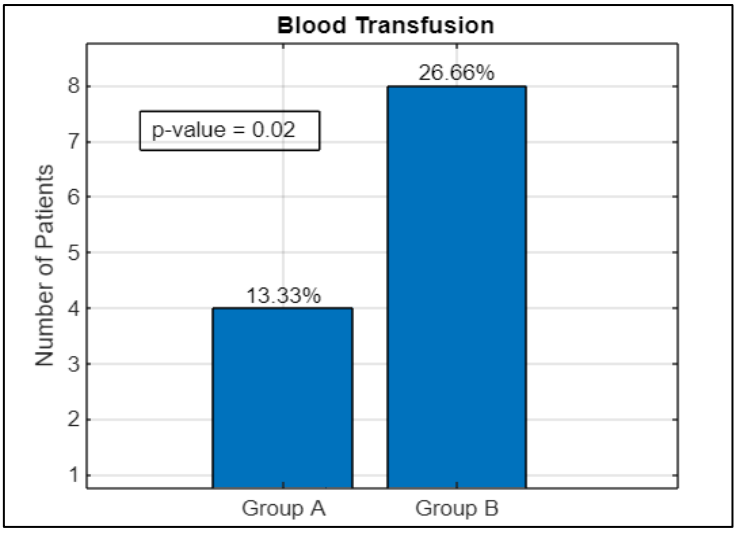

Figure 3: Comparison of Blood Transfusion Requirements Between Two Groups

There were no perioperative occurrences of pneumothorax, hemothorax, or colon injury in either group, indicating no significant difference between the groups (p > 0.05). Blood transfusions were required in 4 patients (13.33%) in Group A and 8 patients (26.66%) in Group B, with a significantly higher requirement in Group B (p = 0.02).

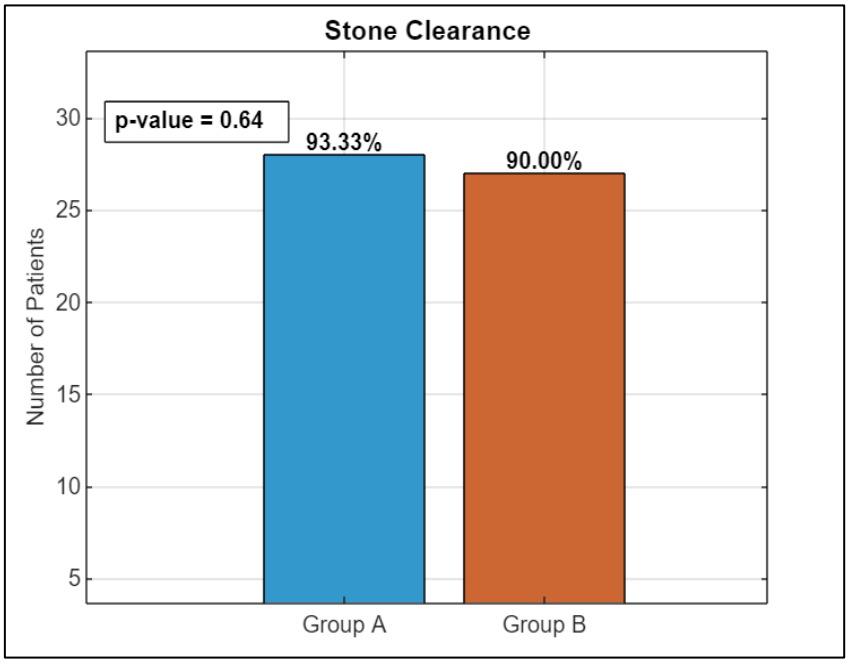

Figure 4: Comparison by Stone Clearance Between Two Groups

Complete stone clearance was achieved in 28 patients (93.33%) in Group A and 27 (90%) in Group B. There was no statistically significant difference between the two groups regarding stone clearance (p = 0.64).

Table 5: Comparison of Postoperative Fever and Hospital Stay Between Two Groups (N=60)

Variables	Group A	Group B	p-value
Postoperative fever	2 (6.66%)	3 (10%)	0.64
Postoperative hospital stay (days)	3.5 ± 1.28	3.43 ± 1.45	0.49

Postoperative fever was observed in 2 patients (6.66%) in Group A and in 3 patients (10%) in Group B. The mean postoperative hospital stay was 3.5 ± 1.28 days in Group A and 3.43 ± 1.45 days in Group B. The differences in postoperative fever and hospital stay between the two groups were not statistically significant (p = 0.64 for fever and p = 0.49 for hospital stay).

DISCUSSION

The surgical management of renal stone disease has evolved significantly with the advent of minimally invasive techniques such as Percutaneous Nephrolithotomy (PCNL). Given the high recurrence rate of renal stones, patients previously treated with open surgical techniques often require re-intervention. Highlighted those anatomical changes post-open stone surgery, including infundibulum stenosis, perinephric fibrosis, bowel displacement, and incisional hernia, can reduce PCNL success rates and increase complications [9]. This study aimed to compare the outcomes of PCNL in patients with and without a history of previous open renal stone surgery. The age of patients in this study ranged from 18 to 65 years. Stone formation is uncommon before age 20, with the peak incidence in the fourth to sixth decades of life. This study found an age distribution of 42.3 ± 15.22 years for Group A and 46.16 ± 7.30 years for Group B, similar to the findings (42.5 ± 12.25 vs 45.7 ± 17.27 years) and (43.5 vs 45.7 years) [10]. However, the age distribution differed from Reddy *et al.*, who reported a higher mean age in patients with a history of open renal stone surgery (25.54 ± 5.55 vs 45.67 ± 13.21 years) [2].

Sex distribution in this study was consistent between the two groups, aligning with the findings; the lower incidence of stone disease in women compared with men is attributed to the protective effect of estrogen against stone formation in premenopausal women, enhancing renal calcium absorption and reducing bone resorption [11]. This study found a higher prevalence of patients with single stones (73.33% vs 76.66%), consistent with (76.3% vs 77.9%) [2]. However, there is a higher incidence of multiple stones (70% vs 73.3%). The stone size in this study was 2.81 ± 0.757 cm for Group A and 2.73 ± 0.730 cm for Group B, similar (3.03 ± 0.67 cm vs 2.98 ± 0.65 cm) [11]. Larger stone sizes

were reported (3.81 ± 1.85 vs 3.86 ± 1.63 cm) and (4.76 ± 1.39 vs 4.92 ± 11.9 cm [12].

The location of stones in the kidney significantly impacts PCNL outcomes. This study found that calyceal stones were most common (43.3% vs 40%), whereas Hossain *et al.* reported predominantly pelvicalyceal stones [11]. During the COVID-19 pandemic, four patients from Group A and two from Group B were initially selected but could not undergo surgery due to pandemic-related disruptions. They were discharged and advised to return later but did not do so within the study period. As a result, four more patients were included in Group A and two in Group B.

The mean number of punctures attempts to access the collecting system was significantly higher in Group B (1.56 ± 0.71 vs 3.63 ± 1.06). This finding is similar to studies by Reddy *et al.* (1.82 ± 0.49 vs 3.71 ± 0.56), (1.5 ± 0.9 vs 2.5 ± 0.5), and (1.2 ± 1.1 vs 2.3 ± 1.9). However, found no significant difference (1.59 ± 0.76 vs 1.58 ± 0.77) [2]. The increased number of puncture attempts in Group B may be due to distorted calyceal anatomy from previous open surgery and subsequent scarring. Different approaches to puncture, such as supra-costal or lower calyceal, are used to minimize complications. Suggested supra-costal puncture to avoid colonic injury in scarred regions, while Marga *et al*. noted that scar tissue alone does not indicate upper pole access. Perinephric scar tissue was identified as the main obstacle, influenced by calculous pyelonephritis, prolonged urine leakage, and the severity of endogenous patient reactions[13].

In this study, the calyx that provided access to the maximum stone burden was chosen for the primary puncture, preferably away from incision scars in patients with a history of open renal stone surgery. Also, dilatation away from scars is recommended to reduce guide wire kinking and access failure. Nephrostomy tract creation is a crucial step in PCNL. In this study, multiple tracts were created in 6.66% of cases in both groups, consistent with (8.5% vs 10.2%) and (12.8% vs 15%). Various methods for tract formation include balloon dilators, fascial dilatation, and amplatz dilatation [14,15]. This study used multi-step fascial dilators, am Platz sheaths, or serial co-axial metallic dilators for tract dilatation.

Hemorrhage is the most frequent complication in PCNL. This study found higher blood transfusion requirements in Group B (13.33% vs 26.66%), similar (4.7% vs 7.0%), (5% vs. 5.4%), (12.4% vs. 18.2%), and (30% vs. 40%) [11]. None of these studies showed significant differences between groups. A greater mean hemoglobin drop (1.82 vs 2.46 gm/dl) in the previous open surgery group. Excessive bleeding can occur during needle passage, tract dilatation, and nephrostomy. This study controlled per-operative bleeding by increasing irrigation fluid flow and repositioning or advancing the am Platz sheath. No patients required angioembolization or nephrectomy for hemorrhage control. Injury to surrounding organs, such as the lung and pleura, resulting in pneumothorax or hemothorax, is a risk during PCNL. This study did not encounter such complications. Pneumothorax (2.6% vs. 4.7%), and hydrothorax (3.9% vs. 2.8%), with 50% requiring intercostal chest drainage [12].

Operation time in this study was 102.33 ± 24.76 vs 106.83 ± 21.63 minutes. Though not statistically significant, a mean operation time of 88.4 vs. 80.2 minutes and a reported 2.2 vs. 2.3 hours show longer operation times for patients with a history of open renal stone surgery. Shorter operation times in the open surgery group (1.52 ± 0.33 vs 1.50 ± 0.46 hours), but this was also not significant, (116 ± 24 vs. 128 ± 14) and (78.24 ± 19.47 vs 83.67 ± 19.83 minutes) found longer operation times in patients with previous open surgery [16,17]. Factors contributing to prolonged PCNL include increased needle access attempts, difficulties in tract dilatation and stone fragment removal, and cautious kidney fixation in the retroperitoneum.

Complete stone clearance was achieved in 93.33% vs 90% of patients, similar to Reddy *et al.* (94% vs. 93%), (63% vs. 59%), (82.6% vs. 80.3%), (93.3% vs. 96.7%), and Margel *et al.* (93% vs. 95%) [2,9]. None of these studies showed significant differences between groups. Postoperative fever occurred in 6.66% vs 10% of patients, likely due to pyelonephritis or urosepsis. Affected patients were treated with antipyretics and broad-spectrum injectable antibiotics and later switched to oral therapy [18,19. This finding aligns with (10.8% vs. 15.2%) and (24% vs 22.5%), but neither is statistically significant. Postoperative hospital stay was 3.5 ± 1.28 vs 3.43 ± 1.45 days. Comparable studies include (3.16 ± 0.90 vs. 3.14 ± 0.83 days), (3.93 ± 1.47 vs 3.90 ± 1.47 days), and (3.67 ± 0.60 vs. 3.87 ± 1.13 days), all showing no significant differences between groups [20-22]. This study demonstrates that while PCNL in patients with a history of open renal stone surgery requires more puncture attempts and blood transfusions, the overall stone clearance rate and other outcomes are comparable to those without such a history. These findings suggest that PCNL can be effectively performed in patients regardless of their surgical history with careful technique and planning.

CONCLUSIONS

Percutaneous Nephrolithotomy (PCNL) in patients with a history of open renal stone surgery requires more puncture attempts to access the collecting system & blood transfusion than PCNL in patients without a history of open renal stone surgery. Still, the two groups have no significant difference regarding stone clearance rate.

Recommendations

Percutaneous nephrolithotomy (PCNL) with a history of open renal stone surgery needs more puncture attempts to enter into the renal collecting system & requires more blood transfusion due to anatomical modification & scar tissue. A large sample & multi-center-based study is needed.

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