

Efficacy and Safety of Percutaneous Nephrolithotomy in Patients with and without Previous Renal Stone Surgery

Jamal Mustafa Khan, Agha Mohammad Zubair, Najeebullah, Syed Rafiuddin Shah, Sayyad Sarwar, Muhammad Arsalan Saleem

Abstract

Objective: To determine the efficacy and Safety of Percutaneous Nephrolithotomy in Patients with and without Previous Renal Stone Surgery

Study design and setting: This descriptive comparative study was carried out at the Department of Urology, Sindh Institute of Urology & Transplantation (SIUT) in Karachi, Pakistan from April 2023 to October 2023.

Methodology: In the current study we included 151 patients in the age group of 18-65 years of either gender who underwent a PCNL in a prone position for renal stone of size ranging from 2-3 cm. Sample size was determined by the WHO sample size calculator at 95% confidence interval and a 5% margin of error. PCNL was done with general anaesthesia using universal techniques. Follow-up arrived at four weeks postoperatively. All the data was analyzed by using SPSS version 24.

Results: Participants were 45.1±9.3 years old, with males being dominant (69.5%). In 91.4% of cases, concrete stones were cleared. These were reducing in hemoglobin 19.2%, pneumothorax 6.0%, colon injury 3.3%, and postoperative fever 12.6%. Renal patients with no previous history of renal surgery also had significantly higher stone clearance rates of 77.5% & 13.9% (p=0.005) and lower complications rates p < 0.001.

Conclusion: Our study concludes that PCNL is a very efficient technique for the stone clearance with an efficiency rate of over 90%. But when patients have a previous history of renal surgery, they have lower clearance rates of stones and higher complication rates.

Keywords: PCNL, kidney stones, stone removal, complications, urology

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INTRODUCTION

Urolithiasis is a common disorder affecting the global population; Pakistan has ranked eighth among the overall renal diseases causing an estimated 20,000 deaths.^{1,2} Surgical pathology, the most common within the present discussion, is renal stone disease. Urinary calculi management has greatly advanced from open surgeries to minimally invasive approaches, including PCNL, which became conventional for large and intricate renal calculi after its development in the 1980s.^{3,4}

They include staghorn calculi, large renal calculi and some upper ureteral stones for which PCNL has high stone clearance coefficients and relatively low complications.⁵ Success in performing PCNL degrees depends upon the proper positioning of the percutaneous tract in the way that gives direct access in manipulating the stone. In addition, PCNL, like any other surgical technique, is not free from risk factors, particularly in malrotated, ectopic or previously operated kidney patients, since they are likely to develop complications.⁶

The rate of recurrence of renal stones means that there will be multiple procedures on the same renal unit; however,

repeat PCNL is performed rarely because of hypothetical higher complication rates.⁶ Previous renal surgery and failure have been found by prior research to have an inconsistent effect on patient outcomes during PCNL. Of the few studies that were done regarding this matter, some found no significant difference between the complication rates and stone clearance efficacy of patients with previous renal surgery and those without^{5, 7} while the rest indicated that patients with previous renal surgery have higher complication rates and slightly less effective in terms of stone clearance.⁸⁻¹²

With advancements in contemporary urology, the therapeutic approach to renal stone disease has undergone substantial transformation. The scope of percutaneous nephrolithotomy (PCNL) has broadened significantly due to the development of miniaturized nephroscopes and a wide range of intracorporeal lithotripsy devices.^{7,8} PCNL is now widely recognized as the primary treatment modality for renal calculi exceeding 2 cm in size, as well as for complex stone conditions such as staghorn calculi, multiple renal stones, and stones associated with anomalous renal anatomy.⁹ Furthermore, PCNL serves as an effective alternative for the management of moderate-sized stones that are unsuitable for clearance using less invasive interventions.¹⁰

The European Association of Urology guidelines recommend PCNL as the preferred treatment for renal stones larger than 20 mm, whereas extracorporeal shock wave lithotripsy (ESWL) is advised for stones measuring less than 10 mm. For renal calculi within the 10–20 mm size range, ESWL, retrograde intrarenal surgery (RIRS), and PCNL are all considered acceptable and effective treatment options. The selection of an appropriate minimally invasive technique for renal stone management is influenced by multiple factors, which can be categorized into four major groups.¹¹ These include: Stone-related factors, such as stone size, anatomical location, number of stones, and their chemical composition. Renal anatomical factors, including conditions like renal fusion or ectopia, lower pole calculi, calyceal diverticula, ureteropelvic junction obstruction, urinary stasis, and hydronephrosis. Patient-related clinical factors, including bleeding disorders, active infections, obesity, musculoskeletal deformities, hypertension, and impaired renal function. Technical and procedural considerations, encompassing the availability of advanced equipment, surgeon expertise, patient expectations, physician preference, success rates of procedures, potential complications, and overall cost-effectiveness.¹² Therefore, the current study seeks to fill this gap by making a comparison of the outcome of PCNL, in terms of its efficiency and safety in newly diagnosed renal units, with that of renal units that previously underwent renal stone surgery at SIUT, Karachi. The information that will be established will be useful for clinicians, especially when discharging individuals after the PCNL surgical procedure as well as when correcting patients' expectations

in regard to the surgery.

METHODOLOGY

From April 2023 to October 2023, a descriptive study was carried out at the Department of Urology, Sindh Institute of Urology & Transplantation (SIUT) in Karachi, Pakistan. Using the WHO sample size calculator with the following parameters: Confidence Interval: 95%

Margin of Error: 5% Proportion of post-operative fever in patients undergoing PCNL: 11.03%⁷

From the following formula, the required sample size was calculated as 151 patients. A non-probability consecutive sampling method was used in order to gather all the qualified patients across the research period. These criteria focus on the eligibility of study participants, which include inclusion and exclusion. The inclusion criteria was Age between 18 to 65 years, Kidney stone of 2-3 cm size diagnosed on the CT scan, Planned for prone PCNL, Both genders and ASA class I-II while the exclusion criteria was Systemic illnesses, which affect major organs (for example diabetics, hypertensives, bleeding disorders), BMI > 30 kg/m², Such as in the case of multi-renal organs such as a solitary functioning kidney or with renal abnormalities such as an ectopic kidney or a horseshoe kidney, Stones in >2 calyces and Split renal function <20%. The patients who met the inclusion criteria during the study were recruited after obtaining their consent. They include hemoglobin level, X-ray KUB and ultrasonography. PCNL was done with general anaesthesia using universal techniques. Follow-up arrived at four weeks postoperatively. to evaluate the clearance of stone using computed CT KUB and detect complications. Details collected were made anonymous and recorded on a pro forma prepared for this study. Renal Stone was defined as Hyperdense opacity < 3 cm on CT at presentation. Stone Clearance was defined as No more stone or fragment size > 3.5 mm on postoperative CT KUB done at the end of the 6th week. Previous Renal Stone Surgery was defined as Subjects with a confirmed prior renal stone disease and who underwent PCNL surgery as the treatment modality. The different complications were defined as: Drop in Hemoglobin: of 0.5 gm/dL from baseline on at least 50 % of study days in at least one hemoglobin measurement or red blood cell count. Pneumothorax: Complication which has symptoms witnessed through chest x-ray includes presence of air in the plural cavity. Damage to Colon: Symptoms suggestive of peritonitis or fecal presence. Postoperative Fever: Temperature above normal for 48 hours after the procedure was performed > 37.8°C. Descriptive statistics analysis and t-tests were computed using the Statistical Package for Social Science (SPSS) version 24. Mean, standard deviation and frequencies were calculated on the continuous and categorical variables, respectively. In the paired groups, we used the chi-square/Fisher test for the categorical and then the t-test/Mann-Whitney for the continuous parameters. Statistical

significance was determined when $p < 0.05$.

RESULTS

A total of 151 patients were included in the study to evaluate and compare stone clearance, complications, and outcomes in patients undergoing PCNL with and without a history of previous renal stone surgery. Table 1 presents the descriptive statistics for continuous variables, demonstrating normal distribution across all parameters ($p > 0.05$). Table 2 compares stone clearance rates based on previous renal surgery, showing significantly higher clearance in patients without prior surgery (77.5% vs. 13.9%, $p=0.005$).

The Stone Clearance was achieved in 138 (91.4%) patients. The different complications observed were drop in hemoglobin in 29 (19.2%) patients, Pneumothorax 9 (6.0%), damage to colon was 5 (3.3%), postoperative fever was observed in 19 (12.6%) patients while no complications was observed in 89 (58.9%) patients. Table 3 illustrates the comparison of complications, revealing higher complication rates in patients with previous renal surgery ($p=0.0001$). Duration of Procedure was Longer in patients without stone clearance (79.30±12.19 mins vs. 74.57±7.81 mins, $p=0.049$) and in hospital Stay no significant difference (4.51±0.96 days vs. 4.20±1.47 days, $p=0.292$) was observed.

DISCUSSION

With advances in modern medical practice, the management strategies for renal calculi have evolved considerably. The indications for percutaneous nephrolithotomy (PCNL) have expanded following the development of miniaturized nephroscopes and a variety of intracorporeal lithotripsy

technologies. PCNL is now regarded as the treatment of choice for renal stones larger than 2 cm, as well as for complex calculi such as staghorn stones, multiple renal stones, and stones associated with abnormal renal anatomy. In addition, PCNL remains an effective therapeutic option for medium-sized stones that cannot be successfully treated using less invasive modalities.¹⁰

According to the European Association of Urology guidelines, PCNL is recommended for renal stones exceeding 20 mm in diameter, while extracorporeal shock wave lithotripsy (ESWL) is preferred for stones smaller than 10 mm. For stones measuring between 10 and 20 mm, ESWL, retrograde intrarenal surgery, and PCNL are all considered suitable treatment approaches. The selection of an appropriate minimally invasive technique for renal stone management is influenced by multiple factors, which can be categorized

Table 1: Descriptive Statistics for Continuous Variables (n=151)

Variable	Mean ± SD	P-Value
Age (years)	45.1 ± 9.3	0.211
Weight (kg)	68.6 ± 12.2	0.601
Height (cm)	162.8 ± 15.3	0.078
BMI (kg/m ²)	26.5 ± 6.2	0.119
Number of Stones	2.7 ± 1.2	0.278
Stone Size (cm)	2.4 ± 1.3	0.224
Duration of Procedure (min)	74.9 ± 13.3	0.526
Preoperative Hemoglobin (gm/dL)	14.2 ± 3.3	0.414
Postoperative Hemoglobin (gm/dL)	12.3 ± 2.9	0.329
Hospital Stay (days)	4.5 ± 1.9	0.665

Table 2: Comparison of Stone Clearance with and without History of Renal Surgery (n=151)

Stone Clearance	History of Renal Surgery	P-Value
Yes	21 (13.9%)	0.005
Yes	117 (77.5%)	
No	6 (4.0%)	
No	7 (4.6%)	

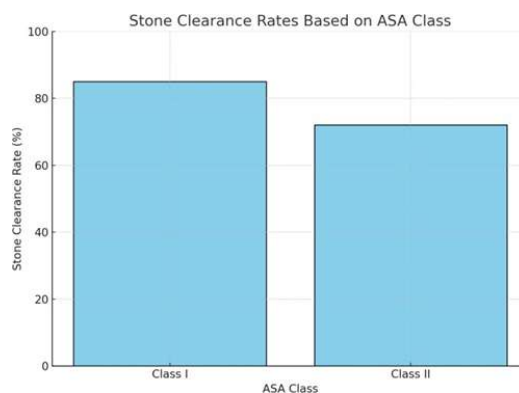
Table 3: Comparison of Complications with and without History of Renal Surgery (n=151)

Complication	History of Renal Surgery	P-Value
Drop in Hemoglobin	11 (7.3%)	0.0001
Drop in Hemoglobin	18 (11.9%)	
Pneumothorax	3 (2.0%)	
Pneumothorax	6 (4.0%)	
Damage to Colon	2 (1.3%)	
Damage to Colon	3 (2.0%)	
Postoperative Fever	6 (4.0%)	
Postoperative Fever	13 (8.6%)	
No Complications	5 (3.3%)	
No Complications	84 (55.6%)	

Table 4: Comparison of Outcomes (Duration of Procedure and Hospital Stay) Based on Stone Clearance (n=151)

Outcome	Stone Clearance	P-Value
Duration of Procedure (mins)	Yes: 74.57±7.81	0.049
	No: 79.30±12.19	
Hospital Stay (days)	Yes: 4.51±0.96	0.292
	No: 4.20±1.47	

Figure 1: Stone Clearance Rates Based on ASA Class



into four main groups.¹¹ Stone-related factors, including stone size, location, number, and chemical composition. Renal anatomical factors, such as renal fusion or ectopia, lower pole calculi, calyceal diverticula, ureteropelvic junction stenosis, urinary obstruction or stasis, and hydronephrosis. Clinical factors, including coagulopathies, active infections, obesity, skeletal deformities, hypertension, and renal insufficiency. Technical considerations, encompassing the availability of advanced equipment, surgeon expertise, patient expectations, physician preference, procedural success rates, potential complications, and treatment cost.¹² During PCNL, patients are most commonly positioned in the prone posture. This position offers several advantages, including a wider area for puncture site selection—particularly for upper calyceal access—greater maneuverability of the nephroscope and lithotripter, and a reduced risk of injury to surrounding visceral organs.¹³ However, the conventional prone position is also associated with certain drawbacks, such as patient discomfort, prolonged operative time due to repositioning, and anesthetic challenges including hemodynamic instability, respiratory compromise, limited airway access, increased sympathetic stimulation, and the risk of cervical spine or peripheral nerve injuries.¹⁴

In a previous study involving 1,028 patients, only 6% underwent PCNL in the supine position, whereas the vast majority were treated in the prone position.¹⁵ In the present study, all procedures were performed with the patient in the prone position, and percutaneous renal access was achieved under fluoroscopic guidance by a urologist. Access was obtained through the lower calyx in 12 patients (85.7%), the middle calyx in 1 patient (7.14%), and the upper calyx in 1 patient (7.14%).

Upper calyceal access, typically performed through the 11th or 12th intercostal spaces, is associated with a higher risk of complications due to its close proximity to the lungs. Consequently, this approach carries an increased risk of pneumothorax, pleural effusion, and calico-pleural fistula formation, with pulmonary complications reported in nearly 25% of patients undergoing intercostal access.¹⁷ In the present study, the supracostal approach was used in only one patient, and no postoperative complications were observed.

Similar to other minimally invasive procedures, PCNL continues to evolve and improve. One of the most critical steps in PCNL is dilation of the percutaneous renal tract to facilitate intrarenal access. Since the first nephrostomy was performed in 1955, continuous advancements in technique have significantly improved the outcomes of percutaneous nephrolithotomy.^{18–20}

A study conducted in 1994 evaluated the impact of balloon dilators and Alken coaxial metal dilators on intraoperative blood loss and found no significant difference between the two methods.²¹ Another comparative study assessed Amplatz

dilators, balloon dilators, and Alken coaxial metal dilators, reporting reduced blood loss with the use of Amplatz dilators; however, the difference was not statistically significant.²²

Urolithiasis is one of the most common complaints seen in clinical practice and is characterized by a high rate of relapse. PCNL has changed the approach to the treatment of renal stone disease by proposing a less invasive procedure of high efficiency for large and complex renal stones.^{3–5} This work supports previous studies, as the stone clearance rate of 91.4% was obtained in this study, and according to literature, clearance rates range from 80–94%.^{7, 13, 14} The rate of 19.2% for complications is reasonable, and a prior expectation of such a rate was given; thus, the postoperative drop in hemoglobin was the most frequently reported complication, with postoperative fever and pneumothorax after them.

One of the impressive findings of this work is the difference in stone clearance and complication rates in patients who had no history of previous renal surgery. This indicates and supports previous surgeries that cause scarring and change in the renal anatomy that makes subsequent PCNL to be technically difficult.^{15–18} On the other hand, other research has found no significant difference in the results of groups treated with quinine compared with placebo.^{6–7} These differences may be due to differences in the operation techniques, the patients' characteristics, and the experience of the operator.

The overall duration of the procedure was significantly longer in patients without stone clearance, which could be attributed to difficult anatomical areas or intraoperative complications of the procedure. Yet, the length of hospital stay remained unaffected, arguing that postoperative convalescence did not vary with stone clearance.

Breaking down stratification, it appeared that patients aged 18–40 years and patients with BMI 18–24 kg/m² cleared stones effectively. Furthermore, while comparing Class I and Class II patients, the former reported a higher clearance rate than the latter, which pointed towards the condition of ASA on surgeries. The literature review demonstrated the multivariate analysis of previous renal surgery on the outcome of PCNL, which reveals conflicting outcomes. For example, Hossain et al. stated that HBP had comparable stone clearance rates for patients who had had prior surgery and those that had not¹⁹, whereas another study noted that the former group incurred higher complications.²⁰ This research brings into context previous renal surgeries as a possible predictor of poor PCNL outcomes, therefore requiring optimal planning and shared decision-making with the patient.^{21–23}

Some of the weaknesses of this work are that it was descriptive in design, conducted in only one hospital, and had a fairly small sample size, which may limit the generalization of the results.

The results of this present study should be further investigated in studies with higher sample sizes. multi-center studies to

confirm these findings and to investigate way to reduce complications in patients with a history of renal surgeries.

CONCLUSION

The findings of this work show that PCNL is a very efficient technique for the stone clearance with an efficiency rate of over 90%. But when patients have a previous history of renal surgery, they have lower clearance rates of stones and higher complication rates. This study underlines the necessity of correct selection of patients and proper planning of the surgery in such groups to get the best possible results. However, previous renal surgery increases the risk of complications with good results of PCNL, which further emphasizes the trends in the development of surgical methods and the improvement of the operators skills. Prospective and controlled future research is now relevant to confirm these discoveries and enhance the protocols to increase the safety and effectiveness of PCNL treatment.

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Authors Contribution:

Jamal Mustafa khan: Substantial contribution to study design, acquisition of data. Manuscript drafting or reviewing it critical for important intellectual content.

Agha Mohammad Zubair: Substantial contribution to study design, acquisition of data. Manuscript drafting or reviewing it critical for important intellectual content.

Najeebullah: Manuscript drafting or reviewing it critical for important intellectual content. Has given final approval of the version to be published

Syed Rafiuddin Shah: Substantial contribution to study design, acquisition of data. Manuscript drafting or reviewing it critical for important intellectual content. Critical review

Sayyad Sarwar: Substantial contribution to study design, acquisition of data. Manuscript drafting or reviewing it critical for important intellectual content.

Muhammad Arsalan Saleem: Critical review Proof reading

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