



ORIGINAL ARTICLE: NEPHROLOGY

Comparison of Standard Percutaneous Nephrolithotomy with Mini-Percutaneous Nephrolithotomy for Removal of Renal Stones in Adults

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Abstract

Renal stones are the third most common problem affecting about 10% of global population. The management of nephrolithiasis has undergone a complete transformation since the 1980s. Percutaneous nephrolithotomy (PCNL) has established itself an effective and safe technique that delivers high stone-free rate as well as overall shorter treatment time. We aim to compare the outcome of mini-PCNL with standard-PCNL in patients presenting with renal stones. In all, 90 patients fulfilled the selection criteria and randomized into two groups. Group A underwent mini-PCNL whereas Group B underwent standard-PCNL. Pre-operative hemoglobin level was recorded. Duration of procedure as well as drop in hemoglobin level was also recorded. A kidney, ureter, and bladder (KUB) X-ray was performed to confirm the presence of stone and stone-free status. The mean age of patients in mini-PCNL group was 43.11 years and in standard-PCNL group, it was 36.91 years. The mean stone size in patients of mini-PCNL group was 29.53 mm and 31.58 mm in standard-PCNL group. The mean duration of renal stone in mini-PCNL group was 1.91 years and that in standard-PCNL group 1.80 years. The mean operative time in mini-PCNL group was 59.56 min and 61.22 min in standard-PCNL group. The mean fall in hemoglobin in mini-PCNL group was 0.38 g/dL and that in standard-PCNL group 0.51 g/dL. In mini-PCNL group, stone clearance was observed in 42 (93.3%) patients, while in standard-PCNL group, it was observed in 45 (100%) patients. This difference was insignificant ($P > 0.05$). Mini-PCNL and standard-PCNL have no significant differences in terms of outcome, operative time, and stone clearance, although fall in hemoglobin level was less in mini-PCNL group, which showed less blood loss in this group, thereby making it a more appropriate method for renal stone removal.

Keywords: hemoglobin; mini-percutaneous nephrolithotomy; operative time; renal stone; standard procedure; stone removal;

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Introduction

Renal stones are a common pathology with annual prevalence of 2–3% in the general population. Pakistan is located in the global stone belt and has one of the highest prevalence of renal stones in the world (1). Renal stones are the third most common problem affecting about 10% of the global population. The lifetime risk for nephrolithiasis has exceeded by 6–12% in the general population, and the prevalence of kidney stones has been projected to escalate (2).

Following the introduction of extracorporeal shock wave lithotripsy (ESWL) and endourologic procedures such as percutaneous nephrolithotomy (PCNL), uretero renoscopy, and retrograde intrarenal surgery in the 1980s, management of nephrolithiasis has undergone a complete transformation (3–5). Open surgery for removal of urinary stones became rare due to success of these minimally invasive therapies. However, the choice of appropriate treatment among these minimally invasive options continuous to remain a debatable issues (3,5,6).

PCNL has established itself as an effective and safe technique that delivers high stone-free success rate as well as overall shorter treatment time (5,7). One of the most important differences between various PCNL techniques is the size of renal access, which contributes to a wide range of complications and outcomes (7). Standard-PCNL is an ideal procedure adopted for treating renal and upper ureteric stones using a 28–30-Fr nephroscope (8,9). Helal et al. introduced the mini-percutaneous (mini-PCNL) procedure, using a 10–22-Fr nephroscope (8,10). Haghighi et al. (8) found that there was no significant difference between the outcomes of mini-PCNL and standard-PCNL with respect to operative time: 48 ± 4.3 min and 51 ± 5.6 min, respectively, and stone clearance: 93.58% and 94.60%, respectively ($P > 0.05$), but hemoglobin drop was significantly low in mini-PCNL group (1.65 ± 1.20 g/dL) compared with Standard-PCNL group (3.13 ± 1.06 g/dL) ($P < 0.05$). Zeng also found that there was no difference between mini-PCNL and Standard-PCNL regarding operative time: 42.1 ± 24.3 min and 41.2 ± 21.3 min, respectively, and stone clearance: 79.3% and 78.1%, respectively ($P > 0.05$) (11).

Objective of this study was to compare the outcome of mini-PCNL with that of S-PCNL in patients presenting with renal stones.

Material and Methods

This study was conducted in the department of Urology, KRL Hospital, Islamabad, Pakistan, for a period of 6 months from May 27, 2019 to November 27, 2019.

Inclusion criteria

Adult patients in the age group of 18–70 years of both genders presenting with renal calculi were included in our study.

In all, 90 patients fulfilled the selection criteria; they were randomized into two groups with 45 patients in each group. Sample size was calculated with 5% significance level, 80% power of study, and mean operative time of 48 ± 4.3 min for mini-PCNL and 51 ± 5.6 min for standard-PCNL for renal stone removal. Non-probability, consecutive sampling technique was used.

Exclusion criteria

Following patients were excluded from the study: patients with solitary functioning kidney (on medical record), uncorrected coagulopathy ProThrombin Time (PT > 15 s), active urinary tract infection (clinical examination), morbid obesity (body mass index [BMI] > 35 kg/m²), undergone renal transplant or urinary diversion, having congenital abnormalities, pregnancy, malignancy, failed Extracorporeal shock wave lithotripsy (ESWL), previous renal surgery, or patients with musculoskeletal deformity.

Approval was taken from the ethical committee of KRL Hospital, Islamabad (KRL-HI-ERC/May21/10). Informed, written consent was taken from each patient. Demographics such as name, age, gender, duration of stone, and size of stone were acquired. Patients were randomized into two groups by lottery method. Group A underwent mini-PCNL by minimally invasive procedure to remove kidney stones by creating a small puncture wound through the skin by using 10–22-Fr nephroscope. Group B underwent Standard-PCNL by minimally invasive procedure to remove stones from the kidney by a small puncture wound through the skin by using 28–30-Fr nephroscope. Pre-operative hemoglobin levels were recorded. Duration of both procedures was recorded, and patients underwent PCNL by a single surgical team under general anesthesia. Hemoglobin levels were assessed after 24 h of surgery and drop in hemoglobin levels was noted. Meanwhile, all patients underwent a kidney, ureter, and bladder (KUB) X-ray for confirmation of stone and stone-free status.

All data were entered and analyzed using SPSS version 21.0. Continuous variables such as age, size of stone, duration of renal stone, operative time, and drop in hemoglobin level were calculated as mean value \pm standard deviation (SD). Post-stratified, Independent Samples t-test was used to compare mean operative time and hemoglobin levels. Chi-square test was applied to compare stone clearance in both groups. $P \leq 0.05$ was considered significant. Data were stratified for age, gender, and size and duration of renal stone.

Results

The mean age of patients in mini-PCNL group was 43.11 ± 13.79 years whereas in standard-PCNL group it was 36.91 ± 11.07 years. The selected sample had 62 (68.9%) males and 28 (31.1%) females, and male-to-female ratio

Table 1: Descriptive statistics of stone size and duration of renal stone.

		Study group	
		Mini-PCNL	Standard-PCNL
Stone size (mm)	N	45	45
	Mean	29.53	31.58
	SD	3.94	3.13
	Minimum	22	26
	Maximum	36	36
Duration (years)	Mean	1.91	1.80
	SD	0.76	0.69
	Minimum	1.0	1.0
	Maximum	3.0	3.0

was 2.2:1. Mini-PCNL group had 37 (82.2%) males and 8 (17.8%) females whereas standard-PCNL group had 25 (55.6%) males and 20 (44.4%) females.

As shown in Table 1, the mean stone size in mini-PCNL group was 29.53±3.94 mm whereas it was 31.58±3.13 mm in standard-PCNL group. The mean duration of renal stone in mini-PCNL group was 1.91±0.76 years whereas it was 1.80±0.69 years in standard-PCNL group.

Data were stratified for stone size. For stone size 20–30 mm, mean operative time was 58.60±2.00 min in mini-PCNL group and 59.37±7.58 min in standard-PCNL group, although the difference was insignificant ($P > 0.05$). For stone size of 31–40 mm, mean operative time was 60.75±2.31 min in mini-PCNL group and 62.58±1.75 min in standard-PCNL group, and the difference was significant ($P < 0.05$).

In renal stone duration of 1 year, mean operative time was 57.93±2.25 min in mini-PCNL group and 60.75±1.53 min in standard-PCNL group, and the difference was significant ($P < 0.05$). In renal stone duration of 2 years, mean operative time was 60.00±1.97 min in mini-PCNL group and 60.68±7.25 min in standard-PCNL group, and this difference was insignificant ($P > 0.05$). In renal stone duration of 3 years, mean operative time was 61.00±2.05 min in mini-PCNL group and 64.00 ± 1.92 min in standard-PCNL group, and this difference in operative time was significant.

Table 2 shows the mean operative time of 59.56 ± 2.38 min in mini-PCNL group and 61.22 ± 5.27 min in standard-PCNL group; the difference was insignificant ($P > 0.05$). Independent Samples t-test = 1.932, and operative time $P = 0.057$ (insignificant).

In mini-PCNL group, stone clearance was observed in 42 (93.3%) patients, while (6.7%) patients had stone residuals.

Table 2: Comparison of operative time and stone clearance in both groups.

		Study group	
		Mini-PCNL	Standard-PCNL
Operative time (min)	N	45	45
	Mean	59.56	61.22
	SD	2.38	5.27
	Minimum	56	29
	Maximum	66	66
Stone clearance	Yes	42	45
		93.3%	100%
	No	3	0
		6.7%	0.0%

In standard-PCNL group, stone clearance was observed in all 45 (100%) patients. Overall, in the sample, stone clearance was observed in 87 (96.7%) patients, while 3 (3.3%) patients had stone residuals. The difference was insignificant ($P > 0.05$); Chi-square test = 3.103, and stone clearance $P = 0.078$ (insignificant).

In the stone size of 20–30 mm, stone clearance occurred in 25 patients (100%) in mini-PCNL group and 19 patients (100%) in standard-PCNL group. In the stone size of 31–40 mm, stone clearance occurred in 17 patients (85%) in mini-PCNL group and 26 patients (100%) in standard-PCNL group; the difference was significant ($P < 0.05$).

In the stone duration of 1 year, stone clearance occurred in 14 patients (93.3%) in mini-PCNL group and 16 patients (100%) in standard-PCNL group; the difference was insignificant ($P > 0.05$). In the stone duration of 2 years, stone clearance occurred in 17 patients (89.5%) in mini-PCNL group and 22 patients (100%) in standard-PCNL group; the difference was insignificant ($P > 0.05$). In the stone duration of 3 years, stone clearance occurred in 11 patients (100%) in mini-PCNL group and only 7 patients (100%) in standard-PCNL group.

Considering operative time in patients aged 20–40 years, the mean operative time was 60.09 ± 2.20 min in mini-PCNL group and 60.94 ± 6.03 min in standard-PCNL group; the difference was insignificant ($P > 0.05$). In patients aged 41–60 years, the mean operative time was 59.18 ± 2.65 min in mini-PCNL group and 61.75 ± 1.28 min in standard-PCNL group; the difference was significant ($P < 0.05$). In patients aged >60 years, the mean operative time was 58.67 ± 2.07 min in mini-PCNL group and 63.00 ± 0.00 min in standard-PCNL group; the difference was significant ($P < 0.05$).

Table 3: Comparison of hemoglobin level at baseline, post-operative, and fall in hemoglobin in both groups.

		Study group	
		Mini-PCNL	Standard-PCNL
Baseline hemoglobin (g/dL)	N	45	45
	Mean	14.33	14.39
	SD	0.88	0.64
	Minimum	12.9	13.3
	Maximum	16.3	15.3
Postoperative hemoglobin (g/dL)	Mean	13.95	13.89
	SD	0.92	0.69
	Minimum	12.4	12.8
	Maximum	16.0	15.0
Fall in hemoglobin (g/dL)	Mean	0.38	0.51
	SD	0.11	0.20
	Minimum	0.2	0.2
	Maximum	0.7	1.0

In patients aged 20–40 years, stone clearance occurred in 19 patients (86.4%) in mini-PCNL group and 34 patients (100%) in standard-PCNL group; this difference was significant ($P < 0.05$). In patients aged 41–60 years, stone clearance occurred in 17 patients (100%) in mini-PCNL group and 8 patients (100%) in standard-PCNL group. In patients aged >60 years, stone clearance occurred in 6 patients (100%) in mini-PCNL group and only 3 patients (100%) in standard-PCNL group.

In males, mean operative time was 59.19 ± 2.28 min in mini-PCNL group and 60.60 ± 6.81 min in standard-PCNL group; this difference was insignificant ($P > 0.05$). In females, mean operative time was 61.25 ± 2.19 min in mini-PCNL group and 62.00 ± 2.15 min in standard-PCNL group; the difference was insignificant ($P > 0.05$). In males, stone clearance occurred in 37 patients (100%) in mini-PCNL group and 25 patients (100%) in standard-PCNL group. In females, stone clearance occurred in 5 patients (62.5%) in mini-PCNL group and 20 patients (100%) in standard-PCNL group; this difference was significant ($P < 0.05$).

The mean hemoglobin at baseline in mini-PCNL group was 14.33 ± 0.88 g/dL and that in standard-PCNL group was 14.39 ± 0.64 g/dL; the difference was insignificant ($P > 0.05$). Independent Samples t-test = 0.396, and $P = 0.693$ for hemoglobin at baseline (insignificant).

The mean postoperative hemoglobin in mini-PCNL group was 13.95 ± 0.92 g/dL and that in standard-PCNL group was 13.89 ± 0.69 g/dL; the difference was insignificant ($P > 0.05$). Independent Samples t-test = 0.351, and $P = 0.727$ for post-operative hemoglobin (insignificant) (Table 3).

The mean fall in hemoglobin in mini-PCNL group was 0.38 ± 0.11 g/dL and that in standard-PCNL group was 0.51 ± 0.20 g/dL; the difference was significant ($P < 0.05$). Independent Samples t-test = 3.713, and $P = 0.000$ for fall in hemoglobin (significant).

In the stone duration of 1 year, mean fall in hemoglobin level was 0.35 ± 0.11 g/dL in mini-PCNL group and 0.41 ± 0.15 g/dL in standard-PCNL group; the difference was insignificant ($P > 0.05$). In the stone duration of 2 years, mean fall in hemoglobin level was 0.36 ± 0.09 g/dL in mini-PCNL group and 0.54 ± 0.23 g/dL in standard-PCNL group; this difference was significant ($P < 0.05$). In the stone duration of 3 years, mean fall in hemoglobin level was 0.44 ± 0.13 g/dL in mini-PCNL group and 0.63 ± 0.14 g/dL in standard-PCNL group; the difference was significant ($P < 0.05$).

This study demonstrated that in patients aged 20–40 years, mean fall in hemoglobin level was 0.42 ± 0.12 g/dL in mini-PCNL group and 0.48 ± 0.21 g/dL in standard-PCNL group; the difference was insignificant ($P > 0.05$). In patients aged 41–60 years, mean fall in hemoglobin level was 0.33 ± 0.08 g/dL in mini-PCNL group and 0.63 ± 0.15 g/dL in standard-PCNL group; this difference was significant ($P < 0.05$). In patients aged >60 years, mean fall in hemoglobin level was 0.37 ± 0.10 g/dL in mini-PCNL group and 0.53 ± 0.12 g/dL in standard-PCNL group; the difference was insignificant ($P > 0.05$).

In males, mean fall in hemoglobin level was 0.37 ± 0.11 g/dL in mini-PCNL group and 0.51 ± 0.24 g/dL in standard-PCNL group; this difference was significant ($P < 0.05$). In females, mean fall in hemoglobin level was 0.41 ± 0.10 g/dL in mini-PCNL group and 0.50 ± 0.17 g/dL in standard-PCNL group; the difference was insignificant ($P > 0.05$).

In the stone size of 20–30 mm, mean fall in hemoglobin level was 0.36 ± 0.13 g/dL in mini-PCNL group and 0.41 ± 0.16 g/dL in standard-PCNL group; the difference was insignificant ($P > 0.05$). In the stone size of 31–40 mm, mean fall in hemoglobin level was 0.41 ± 0.08 g/dL in mini-PCNL group and 0.58 ± 0.20 g/dL in standard-PCNL group.

Discussion

Percutaneous nephrolithotomy is a surgical standard for treating large and complex renal stones. Since its inception, this technique has undergone many modifications (12). Precise needle puncture of renal collecting system is an essential but challenging step for a successful PCNL procedure (13).

The stone-free rate (SFR) following PCNL is 78–95%. However, PCNL can still be associated with significant complications, such as uncontrolled hemorrhage, injury to

collecting system and surrounding viscera, urinary leakage, sepsis, loss of the kidney, and even death (14). Therefore, PCNL poses a significant risk, especially in case of patients having solitary kidney. Meanwhile, the standard size tract (26–30 F) may be too large for pediatric kidneys and some undilated adult kidneys. To decrease morbidity, especially uncontrolled hemorrhage, some urologists have modified the technique of standard-PCNL by performing it with a miniature endoscope by way of a small size tract (12–20 F), and called it MPCNL (15–17).

Although MPCNL has presented advantages with respect to hemorrhage, injury to the renal parenchyma, postoperative pain, and shortened hospitalization time, its disadvantages include need of specialized equipment and relatively low efficiency in case of fragmented large stones than standard-PCNL. This has limited MPCNL's indications (15,18).

In the present trial, the mean age of patients in mini-PCNL group was 43.11 ± 13.79 years and 36.91 ± 11.07 years in standard-PCNL group. In mini-PCNL group, there were 37 (82.2%) males and 8 (17.8%) females. In standard-PCNL group, there were 25 (55.6%) males and 20 (44.4%) females. The mean size of stone in mini-PCNL group was 29.53 ± 3.94 mm and that in standard-PCNL group 31.58 ± 3.13 mm. The mean duration of renal stone in mini-PCNL group was 1.91 ± 0.76 years and that in standard-PCNL group 1.80 ± 0.69 years.

In this study, the mean operative time was 59.56 ± 2.38 min in mini-PCNL group and 61.22 ± 5.27 min in standard-PCNL group; the difference was insignificant ($P > 0.05$). Haghighi et al. found that there is no difference in outcomes of mini-PCNL and standard-PCNL in case of operative time, that is, 48 ± 4.3 min and 51 ± 5.6 min, respectively, and stone clearance, that is, 93.58% and 94.60% ($P > 0.05$), respectively, but drop in hemoglobin was significantly low in mini-PCNL, that is, 1.65 ± 1.20 g/dL but 3.13 ± 1.06 g/dL in standard-PCNL ($P < 0.05$) (8). Zeng (11) also found no difference in operative time of 42.1 ± 24.3 min in mini-PCNL versus 41.2 ± 21.3 min in standard-PCNL, and stone clearance, that is, 79.3% in mini-PCNL versus 78.1% in standard-PCNL ($P > 0.05$).

Sebaey et al., found that the mean operative time was longer in standard-PCNL group (46.9 ± 18.6 min) than in mini-PCNL group (40.6 ± 11.9 min), but this difference was statistically insignificant (19). In the conducted study, no statistically significant difference in operative time between standard-PCNL and mini-PCNL groups was found by Salem et al. (20), while Ni et al. reported that tubeless PCNL had a reduced operative time versus standard-PCNL (21).

The mean fall in hemoglobin was 0.38 ± 0.11 g/dL in mini-PCNL group and 0.51 ± 0.20 g/dL in standard-PCNL group; this difference was significant ($P < 0.05$). In mini-PCNL group, stone clearance was observed in 42 (93.3%) patients whereas in 45 (100%) patients in standard-PCNL group; the difference was insignificant ($P > 0.05$).

In the study conducted by Sebey et al., insignificant difference was observed for mean postoperative drop in hemoglobin between the two groups: 0.82 ± 0.3 g/dL in standard-PCNL versus 0.85 ± 0.4 g/dL in mini-PCNL (19). Kara et al. in their study observed no significant difference in the hematocrit values of both groups in case of elderly patients: 3.9% in mini-PCNL versus 3.2% in standard-PCNL (22). In the study conducted by Salem et al. (20), no blood transfusion was required due to blood loss or low hemoglobin and haematocrit levels during surgery or postoperatively.

In the study conducted by Shoma et al. (23), placement of nephrostomy tube had no effect on postoperative drop in hemoglobin, development of perinephric hematoma, and postoperative hematuria, because, according to authors, hemostasis after PCNL was related to the characteristic of hemostatic power of human body, rather than placement of nephrostomy tube, unless there was significant trauma or coagulopathy. Ni et al. reported no significant differences between tubeless PCNL and standard-PCNL (21). Salem et al. (20) reported that all their patients were free from renal stone except one patient in the standard-PCNL group, and in the study conducted by Bilen et al., the SFR was 91.6% in the mini-PCNL group and 78.5% in the standard-PCNL group (24).

Elsheemy et al. (25) conducted a trial to compare the outcome for renal stones in mini-PCNL with that in standard-PCNL group. They presented the following conflicting results: Mini-PCNL had longer operative time (68.6 ± 29.09 min) in comparison to operative time of 60.49 ± 11.38 min in standard-PCNL group ($P = 0.434$); and significantly shorter hospital stay (2.43 ± 1.46 days) in mini-PCNL versus 4.29 ± 1.28 days in standard-PCNL group; and significantly higher rate of tubeless-PCNL (75.1% vs. 4.6%). Complications in standard-PCNL were significantly higher (20.5%) than in mini-PCNL (7.9%; $P < 0.001$). SFR was significantly lower in Mini-PCNL (89.9%) than in standard-PCNL group (96%; $P = 0.022$). This significant difference was also found between multiple stones and single stone (> 2 cm²) burden, but the SFR was comparable between both groups with single stone and multiple stones burden (≤ 2 cm²). Finally, the researchers concluded that mini-PCNL had significantly lower SFR than in standard-PCNL, with markedly reduced postoperative complications and hospital stay (25).

Conclusion

Mini-PCNL and standard-PCNL had no significant differences in outcome in terms of operative time and stone clearance, although fall in hemoglobin level was less in mini-PCNL, which showed less blood loss, making this procedure more appropriate for removal of renal stones. Thus, the results of the present study would help to improve our practice and update local guidelines for the procedures used for removal of renal stones.

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