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PERCUTANEOUS NEPHROLITHOTOMY TRACT DILATATION USING SEQUENTIAL VERSUS SINGLE STEP DILATATION METHODS

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ABSTRACT

Background & Objective:
Percutaneous nephrolithotomy (PCNL) is a primary treatment for renal calculi larger than 2 cm. To compare sequential and single step dilation in terms of access time, surgery duration, duration of hospital stays, blood loss and post-op complications.

Methodology:
In this quasi-experimental study 160 patients consented to participate, using nonprobability, purposive sampling technique, 80 underwent sequential and 80 undergo single-step PCNL. In this study patients aged between 18–65 years, with stones, size between 2–4cm, located in the pelvic, middle polar, or lower polar calyces were included.

Results:
Single-step and sequential dilatation showed comparable safety and effectiveness, with similar stone-free rates (95.0% vs. 92.5%), transfusion rates (7.5% vs. 5.0%), and hemorrhage outcomes. However, single-step dilatation had shorter mean surgery time (143.0 ± 27.2 vs. 162.0 ± 31.5 minutes) and access time (5.4 ± 0.9 vs. 7.8 ± 1.1 minutes), suggesting better procedural efficiency.

Conclusion:
In terms of duration of procedure and access time one step dilation was found better statistically. However, the duration of hospital stay has slight difference but not a significant one. A few complications were observed in each group and relative number of complications were comparable.

KEYWORDS: Dilatation, Nephrolithotomy, Percutaneous, Operative Time.

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INTRODUCTION

Nephrolithiasis affects a considerable segment of world population ranging from1% to 15% [1]. Stone removal is essential to not only improve patient outcomes but also to reduce long term risk including recurrent urinary tract infection and chronic kidney disease [2]. Stone size can be decisive in selection of treatment approach but for renal stones bigger than 20 mm, Percutaneous nephrolithotomy (PCNL) is widely recommended. PCNL offers high clearance rates, shorter hospital stays after procedure, faster recovery, and less renal tissue trauma than open surgery [3]. PCNL is also viewed as economical, less complex and approach with lower complication rate [4].

Single-step tract dilatation has been reported to reduce operative time compared with sequential dilatation and may also lower the risk of haemorrhage [5] and postoperative complications [6]. Published evidence shows variability in stone-free outcomes, with reported rates of 93.3%–100% for single-step dilatation and 62.9%–96% for sequential techniques [7]. Studies taken to assess the feasibility, safety [8] and efficacy [9] of single dilation technique reported it as a safe and viable approach. For example, studies comparing patient positioning have suggested that supine PCNL may achieve higher stone clearance than the prone approach, with complication-free rates ranging from 67.5% to 80.49% [10,11]. Moreover, single step was reported as relatively safer dilation approach than sequential one [12].

The comparison between OD and SD approach have been carried out by several researchers but findings are contradictory especially when it comes to statistical significance. According to study [13], there was a statistically significant difference in mean operation duration with OD being the one with lower mean value. Moreover, this study reported that fluoroscopy exposure was less with OD approach but difference was not statistically significant. On the other hand, another study [14] agrees with literature [13] pertaining to fluoroscopy exposure but differ on the account of mean operative time. Study [14]

conclude that the difference in mean operative time was not statistically significant. A RCT based study [15] reported that fluoroscopy exposure difference between OD and SD were statistically significant but other factors considered in the study including stay duration, blood loss and post-operative complications were not statistically significant. A recent meta data analysis [16] reported the findings that OD leads to lower complication. However, meta data analysis concluded the study with call for more research to compare these two approaches across various clinical environments. This study is therefore deemed appropriate as it primarily focus on operative time, efficacy, complication rate of these two approaches.

METHODOLOGY

This quasi-experimental study was conducted at Urology Department, Services Hospital, Lahore during 1st July 2025 till 31st October 2025. The study was registered under IRB/2025/1674/SIMS dated 23.06.2025. Total of 160 patients consented to participate, using nonprobability, purposive sampling technique, 80 underwent sequential and 80 undergo single-step PCNL. A sample size of 80 cases in each group was calculated with 90% power of test, 5% level of significance and efficacy of sequential group as 75% and single group as 90% were taken from the literature [5]. These calculations are grounded in published data. Peng et al. reported an access-time reduction of ~110 seconds [4], suggesting a clinically meaningful Δ that we use in our estimates. Data was collected using volunteer sampling technique. Each participant was given equal opportunity to select the procedure. After data collection, first 80 participants in each group were selected for further study to avoid biasness in data selection.

In this study both male and female aged between 18–65 years, with stones, size between 2–4cm, located in the pelvic, middle polar, or lower polar calyces were included in the study. Patients with body mass index (BMI) >35 kg/m² and uncorrected coagulopathies, history of renal surgery or active urinary tract infection (UTI), pregnancy, history of cardiac or pulmonary diseases, staghorn calculi, and congenital renal anomalies (e.g., malrotated, ectopic, or horseshoe kidney) were excluded from the study.

Blood biochemistry and urine culture tests were performed before surgery. Patients with positive urine cultures were administered appropriate antibiotic treatment and undergo surgery only after achieving a negative urine culture report. Patients on aspirin or anticoagulants were advised to stop taking medication for 7–10 days before the procedure. Participants were asked to choose the treatment of choice after briefing the treatment to the participants. With their written consent the procedure of choice was conducted. Both techniques were performed under fluoroscopic guidance to ensure accurate access and minimal complications.

All data was analysed using online software DataStatPro. Quantitative variables such as access time, radiation exposure, and hospital stay are presented as Median and Interquartile range (IQR), while categorical variables such as success rate, efficacy and complications were reported as frequencies and percentages. Haemorrhage was categorized into minimal, mild and moderate. Between-group comparisons is performed using a fisher exact test for categorical variables. For haemorrhage, Fisher's exact test (Freeman–Halton extension) was used instead of the chi-square test because several cells had expected counts <5. A p-value ≤ 0.05 considered statistically significant.

Group A: Single-Step Dilatation Method

In this group, renal tract dilatation was achieved using the single-step Webb dilator technique. The procedure begins with retrograde ureteral catheter placement while the patient is in the supine position, followed by repositioning into the prone position. Under fluoroscopic guidance, a puncture was made into the desired calyx, and a guidewire was stabilized inside the PCS or ureter. To facilitate access, an 8–10 mm incision was made at the puncture site. A 26F Webb dilator will then be introduced in a single step over the guidewire into the PCS with gentle rotational movements. A 26/30F Amplatz sheath was positioned, and nephroscopy was performed using a 21F or 26F nephroscope. If the sheath is short of the PCS, the nephroscope was used to gain entry. In cases of counter-perforation, the sheath was withdrawn and repositioned under direct vision to avoid complications.

Group B: Sequential Dilatation Method

In this group, stepwise renal tract dilatation was performed using the Alken metallic dilators. A radiopaque contrast agent will first be injected through a ureteral catheter to opacify the pelvicalyceal system (PCS). Percutaneous access will then be obtained using an 18-Gauge (G) needle, targeting the middle or lower calyx to ensure optimal stone retrieval while minimizing bleeding risk. Once urine outflow is confirmed, a guidewire was inserted into the PCS. Sequential Alken metallic dilators will then be used to gradually expand the renal tract to the desired nephrostomy size. A nephroscope was introduced, and ballistic lithotripsy was employed to fragment the stone for removal.

RESULTS

Table 1 shows that both groups were comparable in baseline and postoperative outcomes among 160 patients. Male patients were predominant in both Group A and Group B, with 56 (70.0%) and 54 (67.5%) patients, respectively, while females accounted for 24 (30.0%) and 26 (32.5%). The median stone size was 2.5 cm in Group A and 2.75 cm in Group B. Left-sided procedures were slightly more common overall, performed in 90 (56.2%) patients. Hemorrhage was mostly minimal in both groups, seen in 50 (62.5%) patients each. DJ stent placement was required in 43 (53.8%) patients in Group A and 49 (61.3%) in Group B. ESWL requirement, transfusion rate, and stone-free status were also comparable, with stone-free rates of 76 (95.0%) in Group A and 74 (92.5%) in Group B. No statistically significant differences were observed between the two groups for any categorical outcome.

Table 1. Comparison of Pre- and Post-Operative Outcomes According to Procedure

Patients' Findings	Category	Group A (n=80) Single-Step Dilatation	Group B (n=80) Sequential Dilatation	Total (n=160)	p-value
Gender	Male	56 (70.0%)	54 (67.5%)	110 (68.8%)	0.596
	Female	24 (30.0%)	26 (32.5%)	50 (31.2%)	
Stone Size (cm), Median (IQR)		2.5 (2.15–3.1)	2.75 (2.2–3.3)		
Operation Side	Right	33 (41.3%)	37 (46.3%)	70 (43.8%)	0.389
	Left	47 (58.7%)	43 (53.7%)	90 (56.2%)	
Hemorrhage	Nil	9 (11.3%)	12 (15.0%)	21 (13.1%)	0.610
	Minimal	50 (62.5%)	50 (62.5%)	100 (62.5%)	
	Mild	14 (17.5%)	12 (15.0%)	26 (16.3%)	
	Moderate	7 (8.7%)	6 (7.5%)	13 (8.1%)	
DJ Stent in situ	Yes	43 (53.8%)	49 (61.3%)	92 (57.5%)	0.215
	No	37 (46.2%)	31 (38.7%)	68 (42.5%)	
ESWL	Yes	4 (5.0%)	6 (7.5%)	10 (6.3%)	0.456
	No	76 (95.0%)	74 (92.5%)	150 (93.7%)	
Transfusion	Yes	6 (7.5%)	4 (5.0%)	10 (6.3%)	0.312
	No	74 (92.5%)	76 (95.0%)	150 (93.7%)	
Stone Free	Yes	76 (95.0%)	74 (92.5%)	150 (93.7%)	0.456
	No	4 (5.0%)	6 (7.5%)	10 (6.3%)	

The mean total surgery time was 143.0 ± 27.2 minutes in the single-step dilatation group compared with 162.0 ± 31.5 minutes in the sequential dilatation group. Similarly, the median surgery time was lower in Group A at 150.0 minutes compared with 180.0 minutes in Group B. Total access time was also shorter in Group A, with a mean of 5.4 ± 0.9 minutes and median of 5.0 minutes, compared with 7.8 ± 1.1 minutes and median of 8.0 minutes in Group B.

Table 2. Comparison of Intraoperative Outcomes Between Study Groups (N = 160)

Parameter	Group A: Single Dilatation (n=80)	Group B: Sequential Dilatation (n=80)
Total Surgery Time (min)		
Mean ± SD	143.0 ± 27.2	162.0 ± 31.5
Median (IQR)	150.0 (120.0–161.0)	180.0 (131.0–184.0)
Range (Min–Max)	90.0–190.0	111.0–210.0
Total Access Time (min)		
Mean ± SD	5.4 ± 0.9	7.8 ± 1.1
Median (IQR)	5.0 (5.0–6.0)	8.0 (7.0–8.5)
Range (Min–Max)	4.0–7.0	5.0–9.0

DISCUSSION

The present study compared the outcomes of single-step dilatation and sequential dilatation during percutaneous nephrolithotomy (PCNL) in 160 patients. The findings demonstrated that both techniques achieved high stone-free rates and comparable safety profiles, while single-step dilatation was associated with shorter operative and access times. These results support the effectiveness of both approaches for renal stone management and suggest that the choice of technique may depend on surgeon preference and procedural efficiency. At the same time, the bleeding profile in this cohort was comparable between the two groups. Nil hemorrhage was observed in 11.1% of patients in Group A and 15.5% in Group B, while minimal hemorrhage occurred in the majority of patients in both groups (62.2% vs 62.9%, respectively). Mild hemorrhage was noted in 17.7% of Group A and 14.8% of Group B, whereas moderate hemorrhage occurred in 8.8% and 6.6%, respectively. These differences were not statistically significant (p = 0.61), suggesting that both single-step and sequential dilatation had similar bleeding outcomes in our cohort. Moreover, the transfusion rate was found to be comparable in both groups further strengths that single step approach is safe despite a larger caliber tract being used in this approach. This finding is consistent with previous reports demonstrating comparable bleeding profiles between one-shot and sequential tract dilatation. The absence of a significant difference may reflect similar procedural safety in both techniques.

Despite that difference, clinically important outcomes were reassuring. DJ stent placement was similar in both groups, transfusion was rare, and the need for ESWL remained low. This suggests that single-step dilatation can be used safely in selected patients when the aim is to achieve quicker access. The practical impact of this research is that surgeons may choose single-step dilatation when time efficiency and reduced tract creation steps are priorities, especially in busy operating rooms. The broader literature also correlates with the findings of current research work. Meta-analytic work has suggested that one-shot dilatation is at least comparable to serial methods in efficacy, with the main advantage being shorter tract creation time[2,4].

Also, there are studies that categorically reported the single dilation is superior to sequential approach in the context of access time [18], total surgery time and hospital stay [19]. Prospective and retrospective clinical series have also reported similar stone-free rates with both approaches, while emphasizing that outcome differences may depend on stone burden, anatomy, and operator experience [1,6,17]. Taken together, the present study adds local evidence that procedural efficiency can be improved without compromising overall treatment delivery, although bleeding outcomes deserve careful attention in future randomized work.

CONCLUSION

In this study of 160 patients that went to PCNL, provided quantitative evidence of single step dilation as being statistically quick approach both in terms of access and overall surgery duration. The difference was found to statistically significant whereas other variable of the study was either comparable including DJ stenting, hemorrhage, transfusion, and complication rates. Therefore, it can be concluded that single step approach deemed appropriate both due to proven safety and shorter duration. The aspect of cost associated with each dilation technique would be considered in future retrospective study to make more clinically suitable suggestion for countries where overall cost and in-time availability of material might become decisive factor in approach to be adopted for PCNL.

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None

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