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ORIGINAL ARTICLE

Outcome of tract dilation techniques in mini PCNL: Saldinger Technique vs. Single-Step Dilator 18 Fr.

Imran Qadir[1], Firasat Majid[2], Naseem Javed[3], Muhammad Irfan Munir[4], Aamir Imtiaz Khan[5], Tahir Shahzad Nawaz Babar[6]

ABSTRACT… Objective: To compare the outcomes of Mini PCNL performed using Saldinger technique versus single-step dilator 18 Fr in terms of procedure time, per-operative blood loss, hospital stay, postoperative pain, and postoperative hematuria. **Study Design:** Prospective Analytic Research. **Setting:** Children Hospital, Faisalabad. **Period:** January 2023 to the December 2024. **Methods:** Total of 80 patients were randomly assigned to two groups: The Group A (Saldinger technique) and The Group B (single-step dilator 18 Fr). Outcomes were assessed and analyzed. **Results:** Total of 80 patients were equally divided into the "Saldinger" and "Single-Step dilation" groups. Mean age was similar between groups (Saldinger: 9.24 ± 2.09 years; Single-step: 9.27 ± 1.73 years). Gender distribution showed no significant difference ($p = 0.361$). The mean operative time was noted significantly longer in the Saldinger group (67.89 ± 9.82 min) compared to the Single-Step group (44.65 ± 4.75 min, $p < 0.001$). Conversely, mean preoperative blood loss was significantly lower in the Saldinger group (101.44 ± 14.90 ml) versus Single-Step (155.76 ± 9.63 ml, $p < 0.001$). Hospital stay was slightly longer in the Saldinger group (3.05 ± 0.43 days) than in Single-Step (2.79 ± 0.43 days, $p = 0.009$). Postoperative pain scores (VAS) and analgesia requirement were comparable between groups ($p = 0.225$ and $p = 0.251$, respectively). Hematuria grading showed no significant difference ($p = 0.385$). **Conclusion:** The Single-Step dilation technique significantly reduces procedure time and the hospital stay compared to the Saldinger technique, although which is associated with higher intraoperative blood loss. We did not find significant differences in post-operative pain, analgesia requirements, or hematuria severity between the two groups. These findings suggest that the Single-Step technique may be preferred for its efficiency, while the Saldinger technique offers advantages in reducing blood loss.

Key words: Mini PCNL, Renal Stones, Saldinger Technique, Single-step Dilator, Surgical Outcomes, Tract Dilation.

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INTRODUCTION

Kidney stones are mostly presented in the urology clinics world-wide. It can be treated conservatively or by surgical management. The percutaneous nephrolithotripsy (PCNL) was popularized in 1980 for the first time and became a very popular procedure with passage of time due to improved quality of nephoscope, the source of energy to fragment the stone, position of the patient during surgery, puncture site, dilatation tract, size of the nephroscope and post operative placement or not placing of nelaton drain in the tract. The Second wave of improvement in PCNL procedure was associated with miniaturization of instruments that changed the access sheath from 30Fr (French) in standard-PCNL, to 14–20 Fr in mini-PCNL.[1]

Mini percutaneous nephrolithotomy (Mini PCNL) is considered effective and minimally invasive surgery for treating renal calculi, particularly in cases where extracorporeal shock wave lithotripsy and the ureteroscopy are less effective.[2] Indications for mini-PCNL include renal Calculi more than 2cm of size, with lower pole calculi more than 1cm in size, kidney stones not responding to shockwave-therapy in the past or not accessible by ureterorenoscopy (e.g., Stone in the caliceal diverticulum), calculi in complex urinary tracts (e.g., diversions of urinary tract , the horseshoe kidneys, and transplanted kidney cases), and the last but not he least big sized stone in upper ureter.[3] The success of the Mini PCNL significantly relay on the technique of tract dilation, which ensures optimal approaches to the collecting system of kidney with minimal complications.[4]

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Mini-PCNL in elders gave good stone-clearance rates, decreased risk of blood loss, shorten the hospital stay and decreased requirement of postoperative analgesia.[5]

Two commonly employed techniques for tract dilation are the Saldinger technique which is a method of serial (stepwise) tract dilation used during PCNL and the single-step dilator 18 Fr, which simplifies the process by directly establishing access with a single dilator. Each method has its own advantages and limitations. The Saldinger technique is praised for its gradual and controlled approach, reducing the risk of tissue trauma and excessive bleeding. In contrast, the single-step dilator 18 Fr is designed to expedite the procedure, potentially reducing operating time.[6] Recent studies have highlighted the importance of optimizing tract dilation techniques to improve surgical outcomes in Mini-PCNL.[4,7] This study aims to compare these two techniques in a prospective design, focusing on procedure time, per-operative blood loss, hospital stay, postop pain, and postop hematuria, with a view to identifying the most effective and patient-friendly approach.

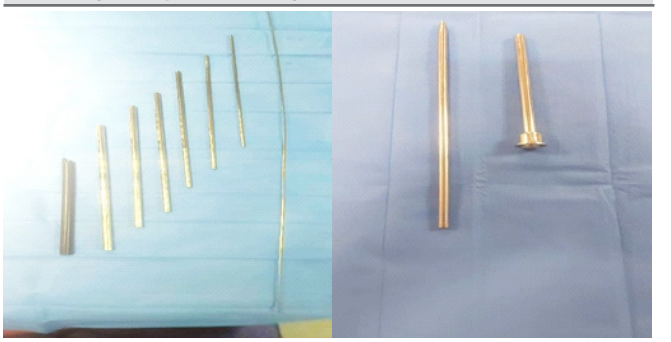
METHODS

This prospective analytic study was done at the Children Hospital, Faisalabad, from January 2023 to December 2024 after approval from ethical committee (19447-31-01-24). The study included pediatric patients aged 3 to 15 years who were diagnosed with renal calculi greater than 01cm and scheduled to undergo Mini percutaneous nephrolithotomy (Mini PCNL). Patients were excluded if they had coagulopathies or bleeding disorders, active (UTI) urinary tract infections, were pregnant, or had anomalous renal anatomy. Those with a history of previous history of nephrolithotomy were also excluded to maintain homogeneity of the study population.

The total of 80 eligible patients were enrolled and randomly allocated into two equal groups of 40 each. Group A underwent tract dilation using the Saldinger technique. First of all, the calyx was identified and the 16-G puncture needle was introduced into the required calyx. After confirmation of access in the system the guidewire in introduced into the puncture needle, then needle is brought out and Six French (FR) facial dilator was introduced and brough out after it olive tip introduced over the guidewire into the system, than metallic dilators in-sleeved over the olive tip serial wise, this is Saldinger technique and flexible nonmetallic amplatz sheath is used over it. while in group B single step dilatation, after passing guidewire into the puncture needle a single step dilator 18 FR is used to introduce over the guidewire and metallic amplatz sheath is used over it.

FIGURE-1

Metallic serial dilatation set for saldinger technique (Left), and single step dilator (Right)



The primary outcomes assessed were procedure time (in minutes) and per-operative blood loss (in milliliters). Secondary outcomes included duration of stay in hospital (in days), postoperative pain calculated using the Visual Analog Scale (VAS), and postoperative hematuria. Hematuria was quantified using a hematuria grading (HG) system, which classifies the severity of bleeding documented on the presence and characteristics of blood clots and visible stones. This system typically ranges from HG-0 (no hematuria) to HG-4 (severe hematuria with blood clots interfering with surgery). All procedures were performed under standardized operative protocols by experienced urologists. Postoperative monitoring and assessment were conducted in a uniform manner across both groups to minimize observer bias.

Data were entered and analyzed with the help of using SPSS version 25.0. Continuous variables were measured as mean ± standard deviation (SD) and compared with help of using independent samples t-test. We used the chi Square test to analyze the categorical variables. A p-value of less than 0.05 was considered as statistically significant.

RESULTS

This prospective analytic study was conducted at the Children Hospital, Faisalabad. The mean age was almost identical across groups, with the Saldinger group having a mean ± SD of 9.24 ± 2.09 years, compared to 9.27 ± 1.73 years in the Single-step group. Age distribution revealed that 48.1% of patients in the Saldinger group and 51.9% in the Single-step group were aged ≤10 years, while 53.6% and 46.4% of patients respectively were older than 10 years. In The chi-square test the results showed no statistically significant difference in age distribution between the two groups (p = 0.639). Gender distribution also did not differ significantly; males comprised 45.8% in the Saldinger group and 54.2% in the Single-step group, while females made up 56.3% and 43.8% of the respective groups (p = 0.361). These findings indicate a well-balanced distribution of demographic characteristics between the two groups.

It presents a comparison of continuous outcome variables between the Saldinger and Single-step groups. Mean procedure time was significantly greater in the Saldinger group (67.89 ± 9.82 minutes) compared to the Single-step group (44.65 ± 4.75 minutes), with a highly significant the p-value of <0.001. This difference was very significant (p < 0.001), highlighting that Single-Step dilation substantially reduces operative time, likely due to its more direct and simplified approach. Similarly, blood loss was markedly lower in the Saldinger group (101.44 ± 14.90 ml) than in the Single-step group (155.76 ± 19.63 ml). The observed difference reached statistical significance (p < 0.001), suggesting that the controlled, gradual nature of serial dilation in the Saldinger technique may be gave results with less vascular trauma and reduced blood loss. The mean Stay in the hospital was slightly longer in the Saldinger group (3.05 ± 0.43 days) versus 2.79 ± 0.43 days in the Single-step group. The difference proved statistically significant (p = 0.009), possibly reflecting longer recovery due to the more prolonged operative procedure in the serial dilation group. Postoperative pain, measured on a visual analog scale (VAS), was lower in the Saldinger group (3.36 ± 0.60) compared to 4.17 ± 0.80 in the Single-step group. The difference proved not statistically significant. (p = 0.225), indicating that both techniques produce a similar level of postoperative discomfort. These results suggest that while the Saldinger technique may take longer to perform, it is associated with reduced intraoperative bleeding and potentially less postoperative pain. Out of the total 80 patients, 38 (47.5%) required postop analgesia, with a slightly greater in the Single-Step group (55.3%) compared to the Saldinger group (44.7%). Conversely, 42 patients (52.5%) did not require analgesia, with a slightly higher percentage in the Saldinger group (54.8%). However, no statistically significant difference was observed between the groups (p = 0.251), indicating comparable postoperative pain management needs. Hematuria severity was assessed using a 4-grade system. The distribution showed a general trend of increasing hematuria grades being slightly more frequent in the Saldinger group. HG-0 was more common in Single-Step (71.4%), while HG-3 (severe hematuria) was more frequent in Saldinger (66.7%). Despite these trends, The difference proved not statistically significant. (p = 0.385), indicating that both techniques had a similar safety profile in terms of bleeding severity.

TABLE-I

Demographics comparison between groups

Variable	Group	Saldinger (n, %)	Single-step (n, %)	Total (n, %)	Chi-Square P-value
Age	≤10 years	25 (48.1%)	27 (51.9%)	52 (100.0%)	0.639
	>10 years	15 (53.6%)	13 (46.4%)	28 (100.0%)	
	Mean +SD	9.24 ± 2.09	9.27 ± 1.73	-	-
Gender	Male	22 (45.8%)	26 (54.2%)	48 (100.0%)	0.361
	Female	18 (56.3%)	14 (43.8%)	32 (100.0%)	

TABLE-III

Comparison of clinical outcome between Groups

		Group		Total	P-Value
		Saldinger	Single step		
Analgesia Requirement	Yes	17(44.7%)	21(55.3%)	38(100%)	0.251
	No	23(54.8%)	19(45.2%)	42(100%)	
Hematuria Grading (HG)	HG-0	2(28.6%)	5(71.4%)	7(100%)	0.385
	HG-1	14(45.2%)	17(54.8%)	31(100%)	
	HG-2	16(53.3%)	14(46.7%)	30(100%)	
	HG-3	8(66.7%)	4(33.3%)	12(100%)	
Procedure Time (min)		67.89 ± 9.82	44.65 ± 4.75	56.27±7.71	<0.001
Blood Loss (ml)		101.44±14.90	155.76 ±9.63	128.60 ± 17.43	<0.001
Hospital Stay (days)		3.05 ± 0.43	2.79 ± 0.43	2.92±0.43	0.009
Post-op Pain (VAS)		3.95 ± 0.80	4.17 ± 0.80	4.06±0.81	0.225
Total		40(50.0%)	40(50.0%)	80(100%)	

DISCUSSION

The PCNL procedure has considered the treatment of choice for kidney stones of greater than 2 cm, which was first introduction in 1976 for kidney stones removal with percutaneous nephrolithotomy under radiological control.[8] PCNL procedure was underwent through various modifications and changes with passage of time, while it is still evolving. In the past, the urologists used various types of dilators, only some of them were time tested.[9,10] Bleeding from the PCNL is gave sometimes feared side effects of PCNL-tract dilatation with the help of multi-step serial dilatation. When we are using multiple dilators the tamponade effect revealed on the parenchyma has lost. Another important issue is danger of radiation exposure to the patients and the surgical team. Urologists are trying to overcome the matters of concern to shorten the surgery time and to decrease the radiation exposure and minimize the bleeding. While using single step dilatation technique, we can overcome the above said problems. Single-step balloon dilatation was also frequently used and considered as safe and effective method; but not cost effective because it is disposable.[11] In 2001, Frattini et al. used singlestep dilatation for calyceal access in PCNL, they studied the total 78 patients and the study was performed in three divided groups based on tract dilation technique, where the first was the Alken telescoping dilators, second one was balloon dilators, and third one was the singlestep dilator. In his study the authors mad decision that the singlestep was more feasible method in majority of patients in term of radiation exposure and cost of surgery.[12]

In the recent study of Suelozgen et al. where they researched the total of no.932 patients were underwent PCNL, the singlestep dilation technique were used for tract dilatation in their study, where the mean fluoroscopy time of 139s with mean total operative time was 66 min. Stone clearance rate was 82.9%. results of the research showed that the singlestep dilation may be used as an effective in term of safety than alternative dilation method.[13] The conclusion of their study showed pro and cons and limitation of every tract dilatation technique in Mini PCNL. In the Saldinger technique per-operative blood loss is minimal.[14] Dilatation with gradual and controlled maneuver decreases the trauma to the kidney parenchyma. So, the bleeding risk is minimized.

The single-step dilator 18 Fr significantly reduced procedure time. The expedited dilation process simplifies surgical steps, making it an attractive option in high-volume settings. Attallah et al studied the comparison with single-step dilatation technique and the stepwise i.e. serial dilatation method to approach the calyceal system in PCNL procedure.[11] In this study the results declare the gross less

radiation exposure (249.18 ± 82.4s) in compare of to the stepwise dilatation method (309.17 ± 108.95s).

Another study was conducted, where PCNL was performed with one-shot dilatation labeled as group I and serial dilatation labeled as group II for access tract. Where blood loss was lesser in group I (the Haemoglobin drop in the group I was 0.89 while 1.34 gm/dL in group II), clot at entry was also lesser (6% vs 28%), while the radiation exposure found, 60.9sec in group I while 94.1sec in group II. This study revealed reduced mean operative time in group I, 46.2 min while 57.1 min in group II and decreased stay in hospital, 3 days in group I while 4 days in group II.[15] In contrast, Amirhassani S et al. observed no significant difference in bleeding, stone clearance, or complications between the single step dilatation and serial dilatation techniques.[16]

Amjadi et al. and Suelozgen et al. similarly reported in their study that the single-step dilatation technique results in significantly reduced operative time and radiation exposure, while maintaining the stone-free-rate comparable to serial dilatation.[13] In a recent study by Girisha et al. concluded that single-step dilatation of tract is considered safe, effective, and is associated with significantly less operative time and radiation exposure.[17] In another study by Nour et al. they found that the blood loss rate and other complications were comparable between single-step renal dilatation technique and serial dilatation techniques.[18]

CONCLUSION

The Single-Step dilation technique significantly reduces procedure time and the stay in hospital compared to Saldinger technique, although it revealed the higher intraoperative blood loss. While no significant differences were observed in post-operative pain, analgesia requirements, or hematuria severity between the two groups. These findings suggest that the Single-Step technique may be preferred for its efficiency, while the Saldinger technique offers advantages in reducing blood-loss.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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AUTHORSHIP AND CONTRIBUTION DECLARATION	
1	**Imran Qadir:** Conception.
2	**Firasat Majid:** Data acquisition.
3	**Naseem Javed:** Manuscript writing.
4	**Muhammad Irfan Munir:** Data analysis.
5	**Aamir Imtiaz Khan:** Interpretation.
6	**Tahir Shahzad Nawaz Babar:** Data entry.