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Does salvage endoscopically guided tract dilatation increase complications during sonography-guided percutaneous nephrolithotomy?

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Abstract

Background: In percutaneous nephrolithotomy, when tract dilatation fails due to short advancement, endoscopic tract dilatation can be used as a salvage technique for renal access. We aimed to report complications of this technique and compare it with uneventful dilatation cases.

Methods and materials: The study enrolled patients who underwent sonography-guided PCNL for six consecutive months in 2023. After renal puncture under the sonography guide, an Amplatz dilator was used for one-shot tract dilation. In the case of short-advancement, a bi-prong forceps was used under direct endoscopic vision for tract dilatation. The study compared the operation time, postoperative complications, and stone-free rate between successful one-shot Amplatz dilatation (SA) and those with salvage endoscopic tract dilatation (SE).

Results: The study included 108 patients with a mean age of 47.9 ± 11.6 (50.9% male). Short-advancement occurred in 63 patients (58.3%). The salvage technique was successful in 95.2% of occasions of short advancement. Pre-operative demographic and clinical data were not different in this group compared to the (SA) group. The operative time was 21.1 ± 14.5 min in the (SE) group, which was not longer than the (SA) group with 22.7 ± 12.6 min ($p = 0.2$). The stone-free rate was 81.0% in the (SE) group, which was not inferior to 73% in the (SA) group ($p = 0.3$). The transfusion rate and complications were not different as well.

Conclusion: Salvage bi-prong forceps tract dilation in the event of short advancement after one-shot Amplatz tract dilation during percutaneous nephrolithotomy is not linked to a higher complication rate or inferior clinical outcomes compared to successful one-shot dilation.

Keywords

Amplatz, bi-prong forceps, percutaneous nephrolithotomy, PCNL, renal stone, tract dilatation

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Introduction

Renal stones are one of the most important encountered problems in global healthcare systems affecting more than 9% of the general population.[1] The prevalence of this condition has followed an incremental trend over the past few decades.[2,3] Apart from its high incidence, renal stones impose a tremendous amount of burden on global healthcare measured as 0.6 million disease-adjusted life years in 2019 alone.[4] Also, the financial burden of renal stones is estimated to reach more than 3.3 billion dollars in 2030 in the United States of America.[5]

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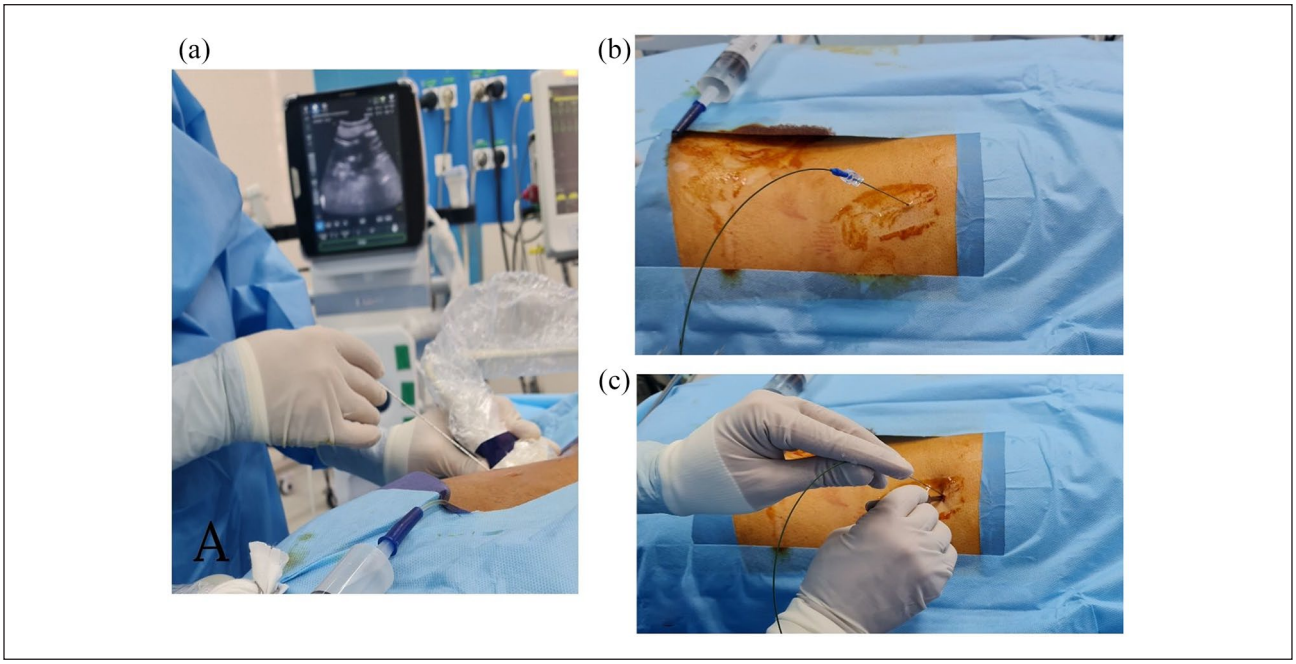


Figure 1. Renal access process. (a) Obtaining renal access under the ultrasound guide. (b) Inserting the J-tip guide wire into the renal pelvis. (c) Making a sharp skin incision.

Even though small stones with no complications such as urinary tract infections, recurrent urinary retention, or obstructive uropathy can be managed medically or in an expectant manner, surgical interventions are prompted for larger or complicated stones.[6–8] Percutaneous nephrolithotomy (PCNL) is usually reserved for renal stones larger than 15 mm or stones smaller than 15 mm that are unresponsive to extracorporeal shockwave lithotripsy.[9]

PCNL procedure consists of the following steps: renal access (Figure 1), dilatation of the tract to the kidney (Figures 2 and 3), lithotripsy, lithotomy, and finally placement of a nephrostomy tube.[10] The dilatation step of the PCNL procedure can be achieved with various methods including sequential method with dilators or one-shot dilatation using an Amplatz sheath or balloon dilators.[11,12] However, in cases of renal hypermobility, occasionally the dilators or the Amplatz sheath do not enter the pyelocaliceal system properly which increases the risk of access failure[12,13] (Figure 1). The current standard of care includes a secondary attempt for renal access in cases of access failure in these cases[14]; however, in 2013, Lezrek et al. proposed a method of dilatation using bi-prong forceps for salvage of the previously made tract (salvage endoscopic tract dilatation; Figure 3). This technique was formerly introduced for cases in which a big calyceal stone prevents the Amplatz tip into the calyx.[15] On the other hand during sonography-guided PCNL especially when managing obese patients or in case of intercostal access, monitoring the dilator is problematic, moreover, the dilator tip is difficult to distinguish by ultrasound and may over-advance to the adjacent organs and cause complications.[16–19] Therefore, we adopted this dilatation method to our armamentarium during PCNL as a salvage for cases where the first attempt of dilatation is unsuccessful to prevent possible complications related to over-advancement of the Amplatz dilator during dilatation. This technique has been reported in series,[13,16] however, we aimed to compare cases that required this technique to those in whom Amplatz dilatation was completed uneventfully during PCNL. The study compared the operation time, postoperative complications, and stone-free rate between successful one-shot Amplatz dilatation (SA) and those with salvage endoscopic tract dilatation (SE).

Methods and materials

Study population

In this study, we prospectively assessed the patients undergoing PCNL in our center for six consecutive months during 2023. The inclusion criteria of our study were all patients older than 18 years old with renal stones bigger than 15 mm or stones smaller than 15 mm that were unresponsive to ESWL and underwent PCNL. Patients with previous intervention including PCNL or open stone surgery were included. The exclusion criteria of the study were patients younger than 18 years old, those with coagulopathy, and morbid obesity, those having a positive urine culture, and those not accepting to enter the study.

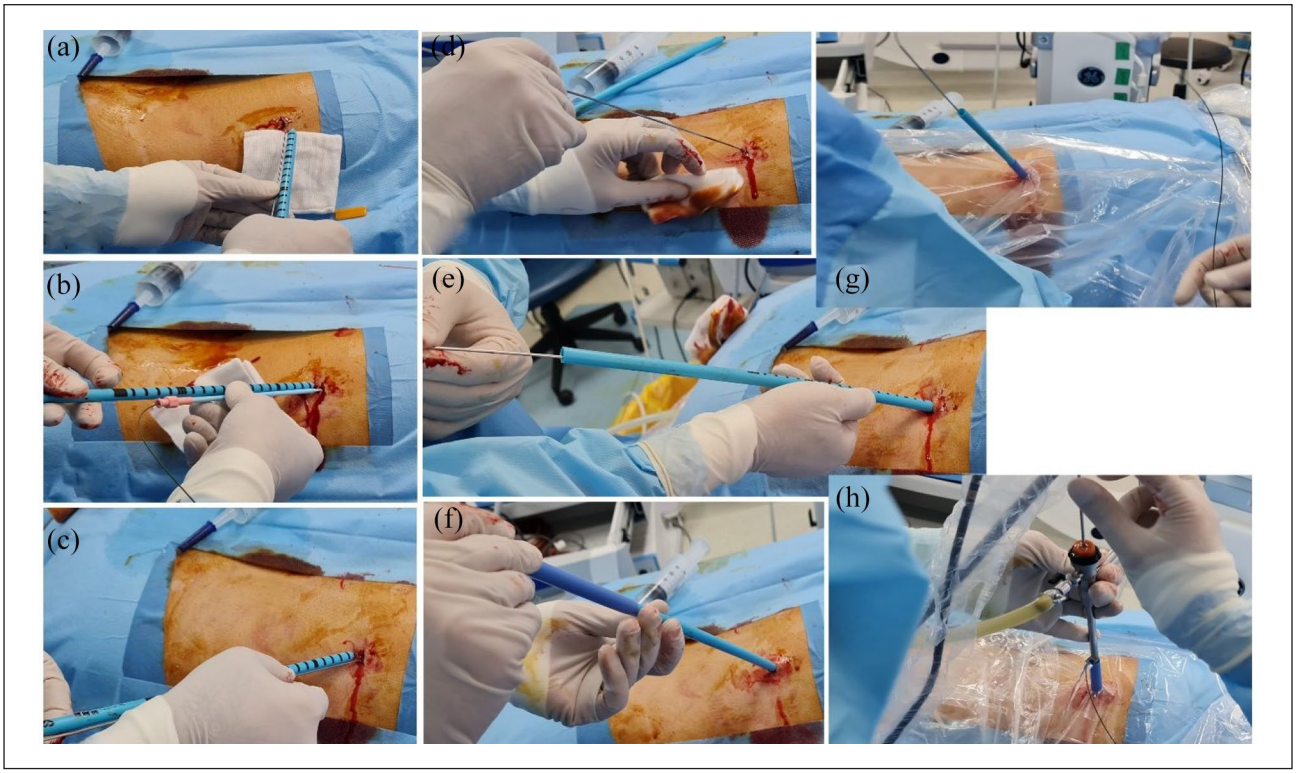


Figure 2. Dilation process. (a) The tract length is measured as the distance from the skin to the pyelocaliceal system. (b) The first dilation is performed using a fascial dilator, based on the reference tract length. (c) The reference tract length determines the depth of the Alken antenna. (d) The Alken antenna is inserted into the pyelocaliceal system on the guide wire. (e) The Amplatz dilator is then inserted over the antenna into the pyelocaliceal system. (f) The Amplatz sheath is inserted into the pyelocaliceal system on the dilator. (g) Once the sheath is in place, both the Alken antenna and Amplatz dilator are removed. (h) Finally, the nephroscope is inserted into the sheath.

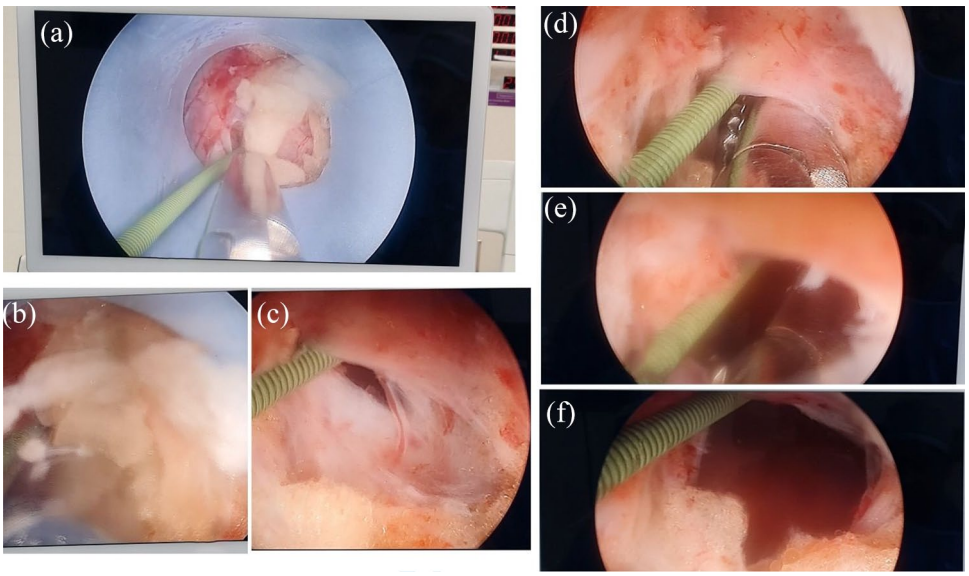


Figure 3. Salvage endoscopically guided tract dilatation using the bi-prong forceps. (a) Short tract dilation occurs when the sheath stops just behind the calyceal system. (b) Fat tissue located outside the renal parenchyma. Since we do not dilate the tract beyond the reference access length, we can ensure that over-dilatation has not occurred. (c) The guide wire remains properly positioned. (d) A bi-prong forceps is introduced alongside the guide wire, maintaining the same direction, and is guided under direct endoscopic vision. (e) As the forceps' jaws open, they cause dilation of the renal parenchyma. (f) Entering the pyelocaliceal system.

Surgical technique

After the preparation of the patients and general anesthesia, a ureteral catheter was inserted after cystoscopy in the lithotomy position for every patient. Then the patient was positioned in the prone position. Then under the guidance of ultrasonography (Figure 1(a)), renal puncture was performed with a Chiba needle (Figure 1(b) and (c)). A 0.035-inch J-tip guidewire was inserted through the needle (Figure 2(a)) and the tract was dilated using 11-French fascial dilators (Figure 2(b)). An Alken metal guide was inserted into the guide wire (Figure 2(d)). Afterward, one-shot dilatation was performed using an Amplatz sheath, and the tract was dilated to 28–30 French. This step was done without real-time fluoroscopy or ultrasound guide but Amplatz advanced on an Alken metal guide placed on the guide wire (Figure 2(e)) and introduced the same depth of the tract length measured by the needle entered the calyx at the first step (Figure 2(a)). An access sheath was inserted on the Amplatz similarly (Figure 2(f) and (g)). Finally, a nephroscope was introduced to the sheath (Figure 2(h)). In cases of short-advancement of the sheath, the puncture site of the renal parenchyma was visualized (Figure 3(a)), Fat tissue located outside the renal parenchyma. Since we do not dilate the tract beyond the reference access length, we can ensure that over-dilatation has not occurred (Figure 3(b)). We make sure that the guide wire remains properly positioned (Figure 3(c))Then the dissection and dilatation of the renal parenchyma or renal capsule were achieved using bi-prong forceps that was passed close to and the same direction of the guide wire under direct endoscopic vision (Figure 3(d)–(f)). The nephroscope was then inserted into the desired calyx and the Amplatz sheath was entered into the pyelocaliceal system over the nephroscope. In case the dilatation process failed because of for example kinking of the guidewire, another access was obtained and the case was marked as unsuccessful access. When access was established, a pneumatic lithotripsy device was used for stone fragmentation and the stones were extracted using a grasper. Residual stones were checked by fluoroscopy and removed. Finally, an 18-Fr foley catheter was fixed to the site as a nephrostomy tube.

Study groups

The patients were divided into two groups based on the need for a bi-prong tract dilatation technique. The first group included those in whom the Amplatz sheath was correctly placed in the pyelocaliceal system as a successful one-shot Amplatz dilatation group (SA). The second group included those in whom short-advancement occurred that is, the Amplatz was in the renal parenchyma or out of the renal capsule at the beginning of the nephroscopy and the endoscopic dilatation was performed using bi-prong forceps as salvage (SE). We compared the outcomes between these two groups.

Data gathering

A checklist containing demographic information, preoperative data like stone surface area, preoperative hemoglobin, creatinine, and glomerular filtration rate (GFR), as well as operative and post-operative data including postoperative complications, stone-free status as assessed by CT-Scan 1 month postoperatively. The duration of needle puncture, tract dilatation, and nephroscopy were recorded separately. In the SE group, the time spent for tract dilatation using bi-prong forceps under direct endoscopic vision was included in the nephroscopy time. Patients were discharged the day after surgery if no complications occurred.[20] Hemoglobin drops, changes in creatinine and GFR, and the duration of postoperative hospitalization were filled up for the patients. The complications for PCNL were evaluated as proposed by the Clavian-Dindo classification.

Ethics. The study proposal received approval from the ethics committee of the Kerman University of Medical Sciences. The approval code assigned to it was IR.KMU.AH.REC.1402.098. This study was conducted in compliance with the Declaration of Helsinki and following the ethics committee's approval.

Statistical analysis

The data were entered into IBM SPSS version 26.0. the qualitative variables were reported as frequency and percentages. The quantitative variables were reported as mean and standard deviation. We compared the outcomes between the two groups using the chi-squared test/Fischer's exact test for qualitative variables. Since the Shapiro-Wilk Test showed that our data did not follow normal distribution, we used the nonparametric Mann–Whitney *U* test for quantitative variables between the two groups. *p*-Values less than 0.05 were considered statistically significant.

Results

In this study, a total of 108 patients were evaluated. Short-advancement occurred in 63 patients (58.3%) and dilatation was achieved using bi-prong forceps (salvage endoscopic tract dilatation). The patients in the two groups were compared regarding their baseline characteristics such as age, sex, stone area, laterality of the stone, and past medical and surgical history related to nephrolithiasis. The two groups were not different regarding their pre-operative information. Table 1 summarizes the baseline characteristics of the population and the comparison of the two groups.

The salvage technique was successful in 95.2% of occasions of short dilatation. Considering the operative

Table 1. Baseline demographic characteristics of the patients between two groups: successful one-shot Amplatz dilation group (SA) and salvage endoscopic tract dilatation (SE).

Variable	Successful Amplatz (SA; $N=45$)	Salvage endoscopic (SE; $N=63$)	p-Value
Male sex	25 (55.6%)	30 (47.6%)	0.4
Laterality			
Right	17 (37.8%)	35 (55.6%)	0.06
Single kidney	2 (4.4%)	0 (0.0%)	0.09
Renal anomaly	6 (13.3%)	4 (6.3%)	0.3
History of PCNL	10 (22.2%)	12 (19.0%)	0.6
History of open nephrolithotomy	6 (13.3%)	7 (11.1%)	0.7
Age (years)	48.22 ± 13.47	47.78 ± 10.25	0.9
Weight (kg)	76.62 ± 12.98	78.44 ± 17.02	0.5
BMI (kg/m^2)	27.15 ± 3.86	28.07 ± 4.92	0.3
Stone surface area (mm^2)	712.48 ± 534.37	713.89 ± 681.22	0.3
Tract length (cm)	9.76 ± 2.12	9.04 ± 1.64	0.1
Needle puncture time (s)	66.44 ± 58.63	69.02 ± 82.32	0.9
Amplatz dilatation time[a] (min)	2.19 ± 1.10	2.22 ± 1.01	0.7

Data are presented as mean ± SD or N (%), Mann–Whitney U test was used for continuous variables. Chi-square test/Fischer's exact test for qualitative variables.

[a]Excluding the time spend for tract dilatation under direct endoscopic vision in the SE group.

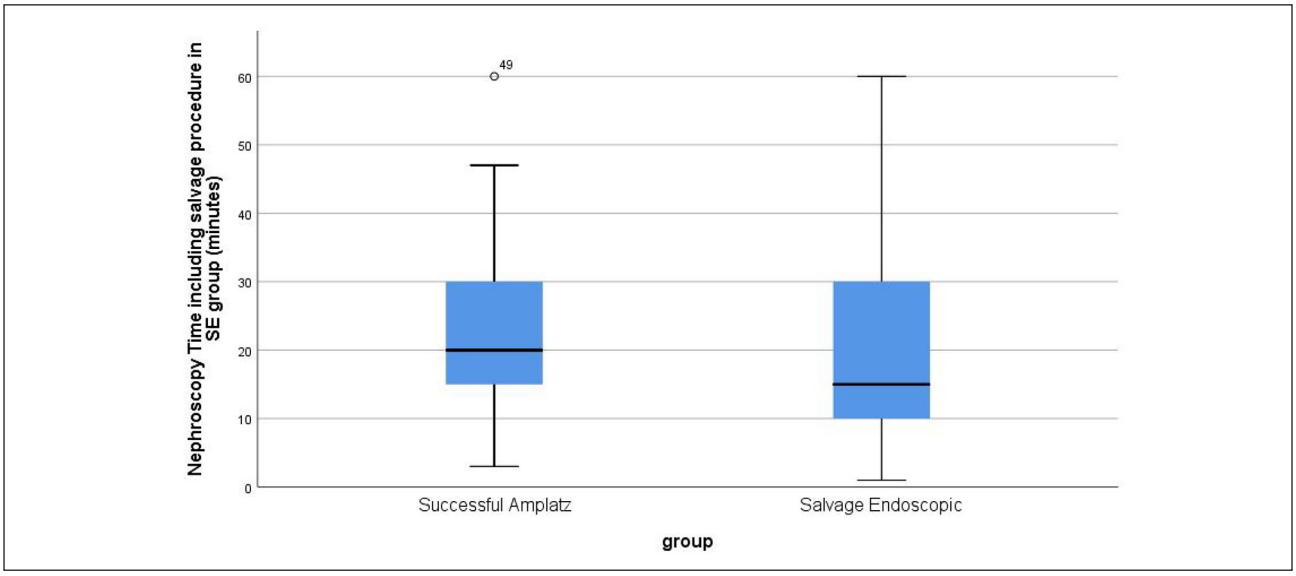


Figure 4. Simple boxplot of nephroscopy time including salvage procedure in the SE group (minutes) by group.

parameters, the two groups were not statistically different in cases of time needed for renal access ($p=0.9$). More importantly, we noticed that in the SE group, the time spend for tract dilatation did not increased total nephroscopy time ($p=0.2$; Figure 4).

The surgical outcomes of the patients were also compared between the two groups. Post-operative stone-free status was higher in the SE group (81.0% vs 73.3%) but the difference was not statistically significant. The two groups were also compared regarding post-operative hemoglobin drop, and changes in creatinine and GFR. The two groups were not different in cases of the alterations in lab values. Moreover, salvage endoscopic tract dilation showed no additional complications compared to the routine procedure. Table 2 summarizes the comparison of operative and post-operative parameters of the two groups.

Discussion

In our study, we observed that in 95.2% of cases with short advancement of the Amplatz sheath, we were successful in obtaining kidney access using the salvage endoscopic tract dilatation technique. Compared with the successful first attempt Amplatz dilatation group, the SE did not show a

Table 2. Comparison of the operative and post-operative data between two groups: successful one-shot Amplatz dilation group (SA) salvage endoscopic tract dilatation (SE).

Variable			Successful Amplatz (SA; $N=45$)	Salvage endoscopic (SE; $N=63$)	p-Value
Nephroscopy time (minutes)[a]			22.7 ± 12.6	21.1 ± 14.5	0.2
Post-operative hospitalization (days)			1.91 ± 1.95	1.78 ± 1.25	0.5
Post-operative hemoglobin drop (g/dl)			1.53 ± 1.06	1.79 ± 1.71	0.6
Creatinine change (mg/dl)			0.12 ± 0.421	0.11 ± 0.163	0.5
Change in GFR (ml/min)			−6.77 ± 11.459	−6.79 ± 10.412	0.7
Stone free rate			33 (73.3%)	51 (81.0%)	0.3
Complication rate	Total		14 (31.1%)	21 (33.3%)	0.8
	Grade I	Transient fever	6 (13.3%)	11 (17.5%)	0.5
	Grade II	Blood transfusion	6 (13.3%)	4 (6.3%)	>0.9
		Urinary tract infection	1 (3.8%)	3 (6.5%)	>0.9
		Pneumonia	1 (3.8%)	1 (2.2%)	>0.9
	Grade IIIa	JJ stent due to urine leakage	2 (7.7%)	1 (2.2%)	0.1
		Urinoma	0 (0.0%)	1 (2.2%)	>0.9

Data are presented as mean ± SE or *N* (%), Mann–Whitney *U* test was used for continuous variables. Chi-square test/Fischer's exact test for qualitative variables.

[a]In the SE group, time spend for salvage tract dilatation under direct endoscopic vision is included in nephroscopy time.

lower stone-free rate. Furthermore, this process did not increase the operation time, complication rate, and hospitalization duration compared to the control.

The salvage endoscopic technique was first introduced for tight stones in the calyces that prevent the Amplatz tip during dilatation.[15] Later Lezrek et al. developed this method in the case of mobile kidneys. In their explanation, once the guidewire was inserted into the desired calyx, an Amplatz dilator was employed to create the pathway. Occasionally, in cases where the kidney exhibited excessive mobility, the Amplatz dilator would not penetrate the renal parenchyma and would halt near the kidney capsule. In such instances, when the nephroscope was introduced through the Amplatz sheath, the guidewire location became visible on the monitor (Figure 1). Subsequently, bi-prong forceps were directed to the vicinity of the guidewire entry point, facilitating the dissection of the kidney parenchyma and renal capsule (Figure 1). This step allowed for easy insertion of both the Amplatz dilator and the nephroscope into the pyelocaliceal system.[21]

In this study, the time needed for proper dilatation was also compared between the two groups which showed no significant difference. This finding indicates that using bi-prong forceps (salvage endoscopic tract dilatation) does not significantly increase the time needed for tract dilatation compared to the routine procedure.

According to the current study's methodology, patients in whom primary access creation failed in the standard procedure, underwent salvage endoscopic tract dilatation. Consequently, salvage endoscopic tract dilatation prevented the need for re-do track creation, which would need about twice the time for tract creation compared to primarily successful access in the case of sonography-guided PCNL and more importantly, in the case of fluoroscopy-guided PCNL, is associated with increased radiation exposure to the surgeon, operating staff as well as the patient. Based on the ALARA rule, radiation exposure should be limited as low as reasonably achievable. Therefore, by mastering this technique surgeons may decrease radiation exposure in case of short-advancement. We recently published the results of our randomized clinical trial comparing standard fluoroscopically guided PCNL with ultrasound-guided PCNL. In the ultrasound-guided group, this salvage technique was utilized in 45% of the cases. Interestingly, the outcomes of both study groups were comparable, while also eliminating the risk of radiation exposure in patients with nonopaque renal stones.[22] Present study shows the safety of this approach on a larger scale.

Salvage endoscopic tract dilatation is especially beneficial during sonography-guided PCNL, in which the dilatation process is difficult to observe using sonography. The rate of short-advancement is higher during sonography-guided PCNL.[16] In a study by our group, Amplatz dilatation, and balloon dilatation were compared in a randomized clinical trial of 66 patients with renal stones who underwent sonography-guided PCNL. In that study, we found that Amplatz dilatation had higher rates of short-advancement access compared to balloon dilatation, especially when lower calyx was desired to be accessed. However, this limitation was not completely avoided by using a Balloon dilator; meanwhile, balloon dilator was significantly more expensive.[12] However, the drawbacks of the Amplatz dilatation method could be averted by the use of

bi-prong forceps as seen in the current study which is less costly compared to a balloon dilator. Regarding renal trauma, results of a comparative animal study showed that acute and late trauma to the kidney is comparable using the balloon versus sequential Amplatz dilator.[23] In a study by Ghoneima et al. performed on 129 patients in 2022, the authors compared one-shot Amplatz dilatation (the method used in our study) with the sequential dilatation method. They found that one-shot dilatation was safer and more efficient since patients undergoing one-shot dilatation had shorter operation and dilatation time, as well as lower hemoglobin drop, need for analgesics, need for blood transfusion, and complications.[24] Others suggested a two-step tract dilatation in which they dilated the tract up to 16-French and checked the tract to the calyx using a 6-French ureteroscope. At this step, if the sheath was short to the calyx, they entered the kidney using the ureteroscope under direct vision and advanced the sheath on the ureteroscope into the kidney. Then, they inserted a balloon dilator into the kidney removed the sheath, and finally replaced it with a 24-French sheath after balloon dilatation. They reported 95% success on 18 patients.[25] The dilatation time was 10 min compared with 2 min in our method. The operative time was around 60 min whereas it was 20 min in our patients. The difference in their method is that they used a ureteroscope to perform short-advancement dilation during the initial step, while we utilized nephroscopy at the final step for the same purpose. Additionally, we employed bi-prong forceps as a dilator under direct visualization. The nephroscope has the advantage of enhanced vision, especially in a bloody environment, thanks to a bigger lens as well as a wider irrigation channel. It is noteworthy that their two-step method did not guarantee the correct placement of the final 24 F access sheath to the calyx. Their success rate was 95% which is similar to our result. We believe that the salvage endoscopic tract dilatation method is faster and less expensive. However, a head-to-head comparison would reveal the advantage of these methods especially in sonography-guided PCNL.

We formerly reported our results on this technique in a case series with an accompanying video in 2016 on 31 patients undergoing salvage endoscopic tract dilatation. The mean dilatation time was 6 ± 6 min, the operation time was 44 ± 29 min, and complications were encountered in 32% of the cases. The operation time in our current study was shorter than our previous report which could be due to improved surgical technique and experience during time. The rate of complications showed no difference in our study compared to our previous experience.[13]

No additional studies have been found regarding this surgical technique, highlighting a significant research gap in this area. Considering this, further studies with larger sample sizes conducted across various centers are necessary for a better evaluation of the technique.

Conclusion

Salvage endoscopically guided tract dilatation using bi-prong forceps in the event of short advancement after one-shot Amplatz tract dilation during percutaneous nephrolithotomy is not linked to a higher complication rate or inferior clinical outcomes compared to successful one-shot dilation.

Declaration of conflicting interests

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