Nepalese Medical Journal, (2025) Vol. 7, 688 - 692

Original Article

Initial Clinical Experience of Using Visual Dilatation Technique in Percutaneous Nephrolithotomy

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ABSTRACT

Introduction: Tract dilatation in percutaneous nephrolithotomy can still be difficult to ascertain the optimal depth to prevent over-dilation, causing system perforation and vascular injury or under-dilation, making the establishment of access tract in a single attempt strenuous. This study aimed to use of visual dilator system to obtain real-time visual confirmation during percutaneous tract dilatation.

Materials and Methods: The visual dilator system used. The nephroscope was connected to standard endoscopic camera system. The dilator system backloaded with access sheath was passed over guidewire to dilate percutaneous tract and position the access sheath under visual guidance. Between December 2015 and December 2016, the visual dilator system was used during percutaneous tract dilatation in 13 percutaneous nephrolithotomy (PCNL) cases with mild or above hydronephrosis.

Results: All tracts were successfully dilated in a single attempt. The intervening tissue layers, approach into target calix, and the access sheath placement could be visually monitored through the dilator wall to confirm accurate dilatation. Mean dilatation time was 3.4-0.9 minutes, hemoglobin drop was 1.4-0.8 g/dL, primary stone-free rate and that after auxiliary treatment were 11/13 (84.6%) and 13/13 (100%), respectively. We experienced over-dilatation in one of the initial cases. No complications were experienced in rest of the cases.

Conclusions: PCNL access tract dilation using the visual dilatation technique is clinically feasible and provided a real-time visual monitoring and confirmation of accuracy in dilatation. It may improve the overall safety and efficacy of the PCNL procedure.

Keywords: Nephrolithiasis; Nephroscope; Visual Dilatation

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Submitted: October 14, 2024
Accepted: December 11, 2024

Source of Support: None
Conflict of Interest: None

Citation: Shah AK, Shrestha A, Basnet RB. Initial Clinical Experience of Using Visual Dilatation Technique in Percutaneous Nephrolithotomy. NMJ 2025;7(1): 688-92. DOI: 10.3126/nmj.v7i1.80448

INTRODUCTION

Percutaneous Nephrolithotomy (PCNL) is an established first-line therapy for complex upper urinary tract stones.[1-4] It has been recognized that establishing an optimal access tract into the target calix is the fundamental step of the procedure. After correct puncture into the target calix is confirmed, accuracy in assessing the optimal extent of dilator progression is required to accomplish atraumatic tract dilation, which is crucial for a successful completion of the procedure with minimal complications.

Access to the renal collecting system during PCNL can be attained under guidance of fluoroscopy, Ultrasonography (US), or a combined method. US allow quick, accurate, and radiationfree guidance during initial puncture.[3,5] However, during tractdilation in complete US-guided PCNL, the echogenicity of the guidewire and the dilator is inadequate to accurately locate the dilator progression into the targeted calyx.[6,7] This may lead to over advancement of the dilator or access sheath into the collecting system, leading to complications like collecting system perforation, hemorrhage, and extravasation. In addition, renal hypermobility in the supine or semi-supine position and kidney displacement from during use of Amplatz or Alken type dilators may cause under-dilation making establishment of the access tract in a single attempt difficult. In this study, we describe and evaluate the initial clinical feasibility of using the novel "visual dilator system" for real-time visual monitoring of entire percutaneous access dilation process.

MATERIALS AND METHODS

The "visual dilator system" consists of a transparent hollow dilator made of polyvinyl chloride (China Medical Device Industry Co. Ltd., Zhang jiang, China) and a 12 F semi-rigid mini nephroscope (Richard Wolf GmbH, Germany) which can be inserted into the dilator's hollow shaft and positioned at its conical tapered end. The nephroscope is connected to a standard endoscopic camera system and light source. During dilation, the working guidewire can be inserted through a 1-mm opening located at the dilator tip and along the working channel of the ureteroscope. The irrigation system (Endomat, Storz, Germany) is used to irrigate saline through the working channel of the scope to maintain optimum clarity of vision during dilation. The dilator system is backloaded with an Amplatz peel-away sheath for positioning into the target calix under visual guidance after confirmation of optimal dilation. The specification of the transparent dilator is given in Table 1.

Table 1: Specification of the Visual Dilator System

Length of dilator, mm	200	200
Outer diameter, F (mm)		22 (7.3)
Inner diameter, mm		4.5
Wall thickness, mm		1.4
Length of pointed tip, mm		10
Diameter of the tip opening, mm		1

Patients with single, multiple or staghorn who were candidate of PCNL were included. Exclusion criteria were: (1) age≤3 years or ≥90 years, (2) renal insufficiency with GFR ≤ 10% of the total GFR, (3) serious heart and lung diseases, and (4) hemorrhagic disease.

During December 2015 till December 2016, a total 13 cases of prone PCNL were included in this study, after permission was obtained from the institutional review committee, at Department of Urology, National Academy of Medical Sciences, Bir Hospital, Nepal. Written consent was taken after explaining related possible complications to the patient and his/her family members.

Preoperative evaluation of patients included routine blood and urine tests, coagulation profile, urine culture, ultrasonography and CT scan for complex renal stones. Patients with normal test reports and negative urine culture were enrolled for PCNL while cases with positive urine culture were treated with sensitive antibiotics before the procedure.

After spinal anesthesia, a 6F ureteral catheter placement and a 14F Foley catheterization were done. Patients were placed in prone position and retrograde pyelogram was performed to facilitate fluoroscopy guided initial puncture using 15 cm, 18-G puncture needle. The success of the puncture was confirmed with the urine outflow from the puncture needle. A skin incision about 1 cm in size was given at the puncture position and a 0.97 mm zebra guide wire was placed into the target renal calyx. The subcutaneous tissue and muscle fascia were dilated using 10 F, 14 F and 18 F fascial dilators. A 12 F mini-nephroscope backloaded with a visual dilator and a 22F Amplatz working sheath was used to further dilate the PCNL access tract. During the dilation, a perfusion pump was used to continuously infuse warm saline through the nephroscope to wash blood clots and tissue fragments to maintain clear vision. During the dilatation, the subcutaneous tissue, perirenal fat tissue, renal parenchyma, approach into the collecting system of targeted calyx can be visualized in real-time, thus ensuring successful dilatation.

After successful dilation, 22F Amplatz sheath was introduced into the target renal and the dilator was removed. Under nephroscopy, calculi were fragmented using pneumatic lithotripter and fragments were removed to attain fluoroscopic clearance. A double J stent (6F) were placed after confirming no significant bleeding. Nephrostomy tube was placed only in cases with residual calculi requiring second look PCNL, severe bleeding or collecting system perforation. Patients were discharged on second postoperative day if no significant complication.

RESULTS

All tracts were effectively dilated in a single attempt. In all cases, the intervening tissue layers, approach into target calix, and the access sheath placement could be visually monitored through the dilator wall to confirm accuracy in dilatation. (Fig. 2,3). The preoperative and operative data of the patients are shown in Table 2.

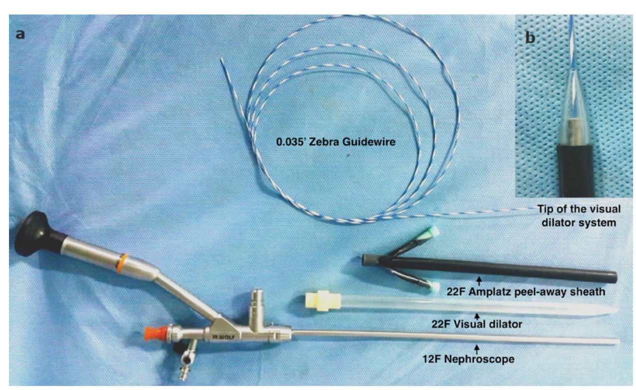

Figure 2: Visual Dilator System: (a) 12F Wolf mini nephroscope, visual dilator, 22F amplatz peel-away sheath, zebra guidewire, (b) tip of the dilator system

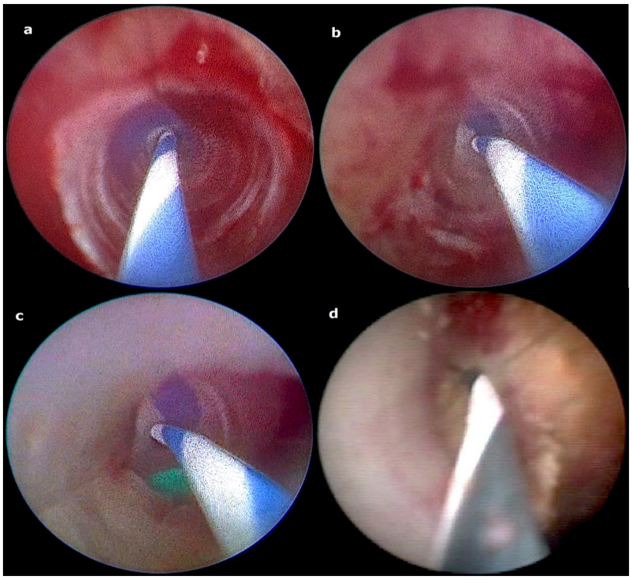

Figure 3: Intraoperative view during visual dilatation through (a) fascial layer (b) renal parenchyma, (c) ureteric catheter seen through visual dilator (d) inside the target calyx (visible renal calculus through dilator)

Table 2: Patient demographics and operative data

Parameters		n (range)
Mean age± SD		38.9±14.7 year (15-73)
Gender	Male	8
	Female	5
BMI± SD, Kg/m^2		26.2±2.4 (21.7-29.3)
Stone type	Single	8
	Multiple	4
	Staghorn	1
Mean stone size± SD, mm		23.4±6.9(10-35)
Degree of hydronephrosis	Nil-mild	9
	Moderate-severe	4
Calyx punctured	Upper calyx	2
	Middle calyx	8
	Lower calyx	3
No. of tracts		Single
Mean dilatation time± SD, min		3.4±0.9(2.5-7.5)
Mean operative time± SD, min		71.7±17.0 (44-96)
Mean blood loss (ΔHb)± SD, g/dL		1.4±0.8 (0.5-2.4)
Primary stone free rate		11/13
Auxillary procedure (RIRS)		2
Final stone free rate		13/13
Complications	Fever	1
	Collecting system injury	1
	Clinically insignificant hematuria	3
	Extravagation	1
	Blood Transfusion	0
	Pneumothorax	0
	Colon injury	0

SD, standard deviation; BMI, body mass index

The mean dilatation time was 3.4 - 0.9 minutes, hemoglobin drop was 1.4 - 0.8 g/dL, primary stone-free rate and that after auxiliary treatment were 11/13 (84.6%) and 13/13 (100%), respectively. We experienced overdilatation in one of the initial cases with no severe complication. No other complications such as collecting system perforation, loss of access, transfusion, and surrounding organ injury were experienced in rest of the cases. The X-ray exposure time during dilatation was low.

DISCUSSION

Accurately ascertaining the extent of dilator progression needed for atraumatic tract dilation is crucial, as well as a challenging aspect during establishment of an access tract in PCNL.[6-8]

Percutaneous access can be guided either by fluoroscopy, US, or a combination of both techniques, depending on surgeon preference, experience, and its availability.[9] Nephrostomy tract dilation is commonly performed with amplatz sequencial dilator, Alken metallic telescopic dilator or balloon dilator.[10]for although PNL was established as a treatment in the 1970s, its use diminished with the introduction of extracorporeal shockwave lithotripsy (ESWL Balloon dilation is regarded as the advanced and safe dilatation system, though it has the disadvantage of relative high cost and high failure rate in cases of prior surgery or perirenal fibrosis. Other common methods of assessing the dilator progression by either comparing the length of dilator inserted to the measured length of the puncture needle from skin to renal collecting system or from free flow of saline through the dilators when infused through the ureteral catheter might still compromise the accuracy and safety of the procedure.

The complications related to tract dilation are mainly perforation or tear of the collecting system, bleeding, and loss of access.[6] Bleeding is the most common and worrisome complication during PCNL[10]. It can occur during initial puncture, tract dilation, stone manipulation, and even during recovery period. Over advanced dilation can cause tear or perforation of the infundibulum, renal pelvis, or ureteropelvic junction, either directly by the dilator or indirectly by the stone pushed by the dilator. Parenchymal laceration or injury to interlobular arteries so caused can lead to significant bleeding. It might even cause extravasation, infundibular stenosis, ureteral stricture, or avulsion. Over advancement of the sheath into the renal parenchyma as well can be potentially traumatic causing intraoperative bleeding.[11,5,12,3] In contrast, under- advancement of the dilator results in "short" dilation necessitating re-dilation or maneuvering of the access sheath into the target calix under direct nephroscopy. Also, the sheath when advanced over an incompletely dilated calix can tear the renal parenchyma trapped between the dilator and the sheath. In addition, far too medially directed dilation could cause injury to hilar vessels (segmental arterial branch) and develop arteriovenous fistula or pseudoaneurysm necessitating selective angioembolization or even nephrectomy.[9]

Thus, even after successful initial puncture, tract dilation when not performed accurately can potentially be traumatic leading to complications such as perforation, bleeding, and loss of access. Since these complications can occur during puncture, stone manipulation, or even postoperatively (blood loss), it is difficult to predict their individual relation to tract dilation separately and is seldom mentioned in the literature.[13] Perforation has been associated with two-fold increase in intraoperative bleeding, however.[14] In the literature, different pelvic perforation rates as high as 16.6% using an Amplatz dilator and 11.2% using a balloon dilator have been reported.[2,7,3,13,15,16] Renal pelvis perforation during dilation or sheath placement may also cause small bowel or colon injury.[2,3,17]

Anteromedial excursion of the kidney during dilation further increases difficulty in correct assessment of dilator progression, making nephrostomy tract creation particularly challenging. This situation can therefore increase the possibility of perforation and loss of access. Researchers have appreciated a higher incidence of kidney hypermobility and related difficulty during tract dilation in supine or semisupine PCNL.[18-23]

The novel technique of dilatation using visual dilatation system has been successfully validated in the "proof of concept" study during tract dilation and positioning of the access sheath in both in-vivo and ex-vivo animal models without any perforation, excessive bleeding (in the in-vivo model), or loss of tract.

In this clinical study, we could successfully perform PCN tract dilatation using visual dilatation system in all cases with advantage of direct visual monitoring of the entire process of dilator progression from the puncture site, through tissue layers outside the renal capsule, renal parenchyma, and finally into the pelvicaliceal system. This real-time visual control associated with retained tactile sensation of dilator progression over the guidewire promoted effective dilation avoiding both over advancement (thereby potentially reducing the risk of pelvicaliceal perforation or vascular lesion) and underdilatation (thereby potentially improving the efficacy). The access sheath was advanced under visual guidance into the target calix only after confirming that the dilator tip was completely inside the infundibulum, thereby avoiding parenchymal tear trapped between the sheath and dilator.

The dilation through the renal parenchyma was performed in one step to minimize tract bleeding. Past studies have shown that one-step dilation is safe, efficient, and, in addition, overcomes the possibility of increased bleeding from loss of the temponading effect during exchange of sequential dilators.[18,23,24]

One of the most challenging aspect of PCNL for young urologists during their learning curve is the initial puncture and controlled tract dilation needed to gain optimal access to the collecting system. Inadvertent and inaccurate dilator progression can cause traumatic dilation jeopardizing the safety and efficacy of the procedure. As such, we believe that optimal initial puncture associated with direct visual control on dilatation process could prove helpful to overcome tract dilation-related difficulty and hence to gain competence in PCNL.[12]

This study demonstrates our preliminary experience with the technique and has a number of limitations. First, the study was performed only in a limited number of clinical cases. Second, it lacks comparison of this technique with other available dilation modalities. A randomized study of this technique in a larger sample of clinical cases with comparison with other contemporary methods will better evaluate its actual strengths, weaknesses, and relative efficacy. Finally, the visual dilator system being radiolucent, its tip cannot be visualized clearly under fluoroscopy. In our opinion, a radiopaque marker incorporated at the tip of the dilator will allow its better fluoroscopic visualization to further improve the safety and efficacy of the procedure.

CONCLUSIONS

The novel "visual dilator system" to accurately establish PCNL working channel is feasible, safe and effective. It provides real-time visual control to gain optimal dilatation and access sheath placement to improve the safety and efficacy of PCNL. Further large sample size randomized controlled study with other dilatation methods is warranted to confirm our findings.

Acknowledgements:

Special thanks to the Department of Urology, NAMS, Bir Hospital.

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