# Tract Dilation for PCNL

**Lazaros Tzelves, Nariman Gadzhiev, Titos Markopoulos, Bhaskar Somani, and Andreas Skolarikos**

**Abstract** Percutaneous nephrolithotomy success and safety largely depend on two steps: renal puncture and percutaneous tract dilation. The tract dilation can be performed using several techniques like Alken or Amplatz dilators, balloon single-use dilator, or the most recently developed one-shot technique. All the methods were initially dependent on the use of fluoroscopy for guidance, but recent expertise on the use of ultrasound permitted tract dilation under complete ultrasound guidance, eliminating the harmful effects of radiation exposure.

**Keywords** PCNL · Tract dilation · Amplatz · Alken · Balloon dilation · One-shot dilation

## 1 Introduction

Since its introduction in 1976 by Fernstrom and Johansson, percutaneous nephrolithotripsy (PCNL) has revolutionized the management of urolithiasis. It is the minimally invasive nature of this procedure that leads to high stone-free rates (SFRs), while at the same time permitting surgeons to offer excellent clinical outcomes avoiding the complications related to copious open surgery for removal of complex and/or large stone volumes (Skolarikos et al. 2022). It is nowadays considered the

L. Tzelves
Department of Urology, University College London Hospital, London, UK

N. Gadzhiev
Department of Urology, Pavlov First Saint Petersburg State Medical University, Saint Petersburg, Russia

T. Markopoulos · A. Skolarikos (✉)
Department of Urology, School of Medicine, Sismanoglio Hospital, National and Kapodistrian University of Athens, Athens, Greece
e-mail: andskol@yahoo.com

B. Somani
University Hospital Southampton NHS Trust, Southampton, UK

 
J. D. Denstedt and E. N. Liatsikos (eds.), *Percutaneous Renal Surgery*,
https://doi.org/10.1007/978-3-031-40542-6_12

gold-standard option for stones >2 cm in maximum diameter (Skolarikos et al. 2022). To master the fundamental principles of this procedure, endourologists have to reach and surpass the learning curve which is steep. Along with puncture of the renal parenchyma, percutaneous tract dilation is one of the most critical steps of PCNL. It is the success of these two steps that greatly affect the duration of operation, total fluoroscopic time, rate of bleeding complications, perforation of the renal collecting system, urine leakage, and injury to adjacent organs (Geraghty et al. 2022).

## 2 Tract Dilation Under Fluoroscopic Guidance

Fluoroscopy has been utilized for many years during endourological procedures and PCNL to guide stone localization, needle entry into collecting systems, insertion of guidewires and access sheaths, as well as creation and dilation of the percutaneous tract. The size of the tract to be created during standard PCNL is supposed to accommodate the insertion of a sheath with an inner diameter of 30Fr and outer diameter of 34Fr, while during mini-PCNL usually sheaths less than 20–24Fr are inserted.

There are several methods for dilation of the tract: use of metallic, sequential, coaxial Alken dilators (Alken et al. 1981), use of polyurethane, serial, Amplatz dilators (Castaneda-Zuniga et al. 1982), use of the single step balloon dilators (Clayman et al. 1983) and creation of the tract by one-stage dilation using a single 25–30Fr Amplatz dilator (Frattini et al. 2001) (Fig. 1). Each of these techniques has its advantages and disadvantages which will be analyzed further but is imperative to understand that the dilator should not be advanced further than the calyx because otherwise the collecting system or ureteropelvic junction and even surrounding organs and vessels may be perforated (Fig. 2). The desired point of entry of the distal end of the dilator is just into the calyx and proper positioning should be confirmed with the nephroscope and adjustments should be made over the guidewire if needed (Figs. 3 and 4). Another important technical detail is that skin incision should extend to an adequate depth into underlying fascial layers so that dilators can be easily advanced without kinking and bending.

Alken metallic dilators are serial rigid dilators advanced over the guidewire in a coaxial manner without the need to remove the previous dilator before the next one is advanced (Alken et al. 1981) (Fig. 5). After the guidewire is properly inserted into the pelvicalyceal system or ideally down to the ureter/bladder, an 8Fr guide rod is advanced initially, and its distal end is recognized with a ball at its tip so that it is easy to confirm position under fluoroscopic guidance (Alken et al. 1981). Subsequently, dilation continues up to 30Fr. They are reusable and considered to lead to less blood loss due to the tamponade effect of the dilators on small vessels of the renal parenchyma. A major advantage is that metallic dilators can override dense and fibrotic tissue, encountered after previous renal surgeries, making them ideal for these cases. The main disadvantage is the increased fluoroscopy and procedural time needed until dilators of all sizes are inserted sequentially, while at the same time due to repeated manipulations over the guidewire, there is an increased chance of displacement or kinking due to the force applied.

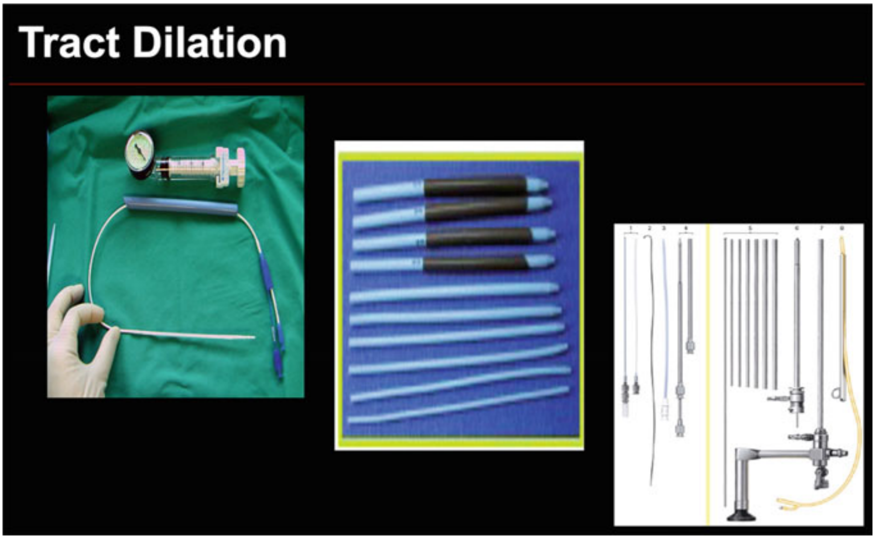


**Fig. 1** Tract Dilation—Balloon Dilation, Amplatz dilators, Metallic Dilators

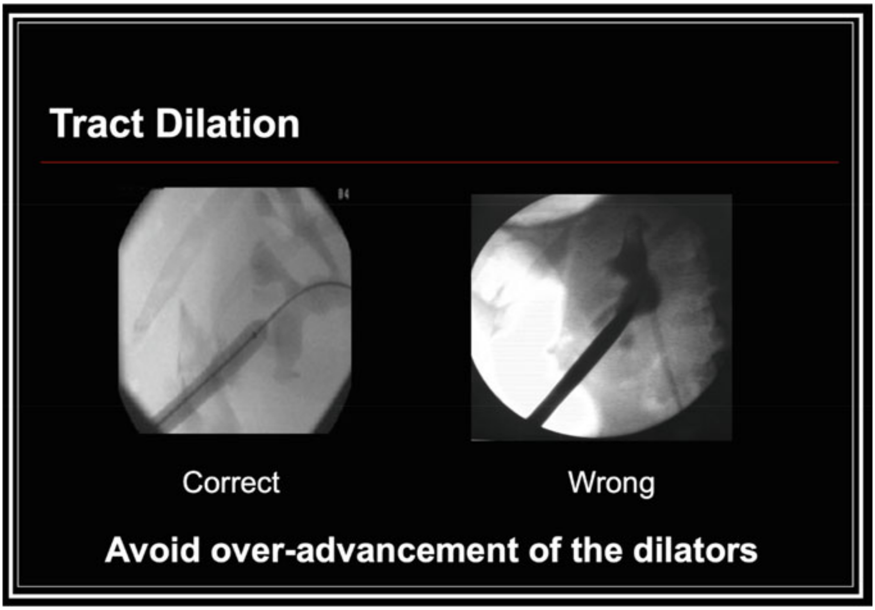


**Fig. 2** Correct advancement of the dilator

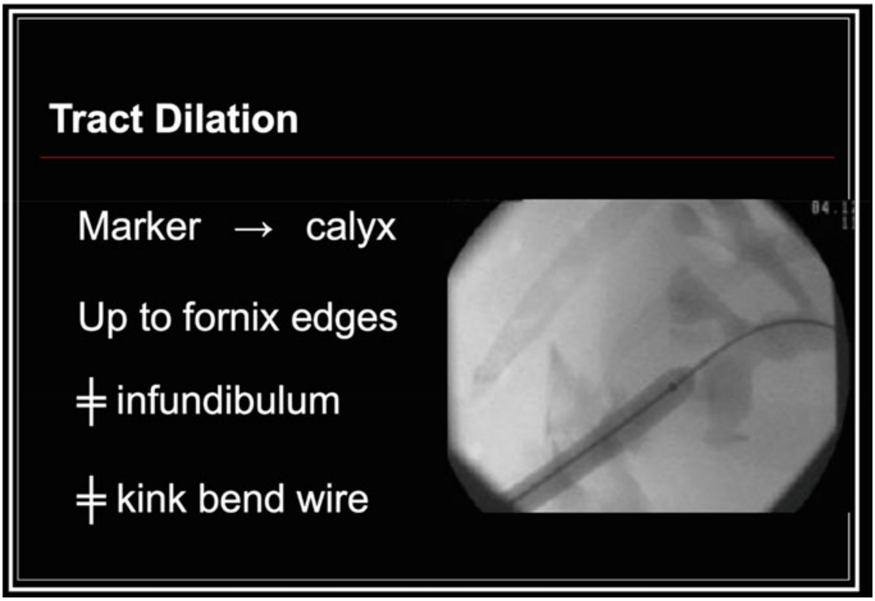


**Fig. 3** Balloon dilation of the PCNL tract—Landmarks

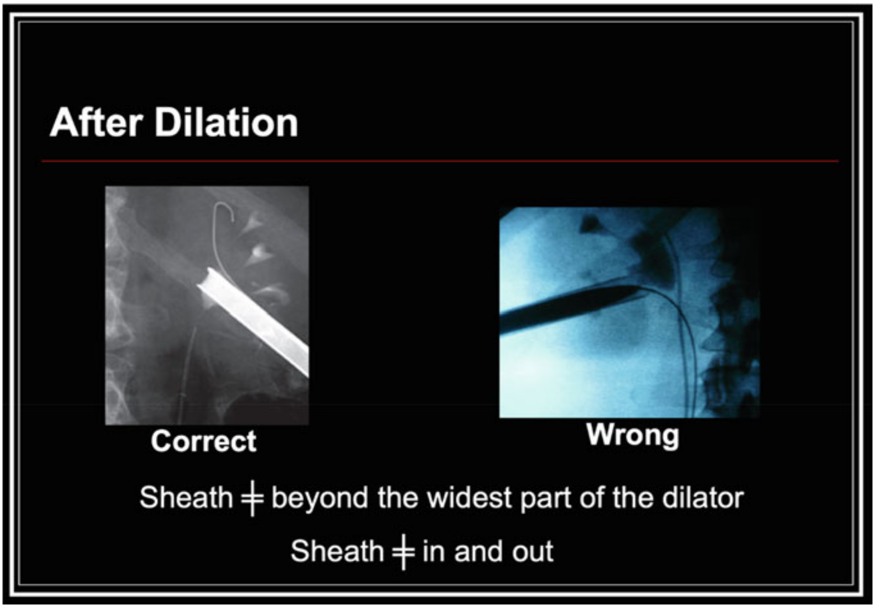


**Fig. 4** Proper advancement of the sheath after tract dilation

**Fig. 5** Peter Alken's metallic dilators

In a similar manner, Amplatz semi-rigid dilators are sequential dilators that are progressively advanced over an initial 8Fr guiding catheter, but in contrast with Alken dilators, they are not inserted coaxially since the smaller diameter dilator should be removed before the next one is advanced at increments of 2Fr (Castaneda-Zuniga et al. 1982). Since they are composed of softer material, they are considered to be less traumatic for tissue than metallic dilators. Drawbacks of this technique are increased use of fluoroscopy and time needed to create access and increased chance of tract loss or guidewire kinking during the sequential exchange of dilators. Amplatz dilators are used once, therefore increasing procedural costs, while the tamponade effect is lost due to the removal of smaller-size dilators before the next one is advanced leading to hemorrhage.

Single-step balloon dilator overpasses the need for repetitive dilation of Alken and Amplatz dilators leading to decreased use of fluoroscopy and quicker creation of the percutaneous tract (Clayman et al. 1983). Before the balloon dilator is advanced over the guidewire, the working sheath is loaded on the balloon catheter and then the dilator is advanced over the working guidewire into the pelvicalyceal system (Clayman et al. 1983). The balloon is inflated with contrast up to 30 atm and this pressure is maintained for 30–60 s. The atm applied is guided from the "waist" that appears during balloon dilation, which signifies the area of maximum resistance.

The indication of adequate dilation is when the "waist" disappears (Clayman et al. 1983). At the point of maximum balloon dilation, the working sheath is advanced under continuous fluoroscopic guidance just distally to the end of the maximum balloon dilation and not further beyond this point (Clayman et al. 1983). Although this is considered one of the safest techniques, the literature contains some controversial data regarding bleeding complications. Most studies suggest that the use of balloon leads to reduced bleeding, but results from the Clinical Research Office of the Endourological Society Percutaneous Nephrolithotomy Global Study over 5537 patients, indicate that compared to telescopic/serial dilation, single-step balloon dilation led to increased rates of bleeding (9.4% versus 6.7%, $p < 0.001$), more transfusions (7.0% versus 4.9%, $p = 0.001$) and greater drop in mean hematocrit levels (4.5% versus 2.5%) (Lopes et al. 2011). These findings were mainly attributed to the heterogeneity of technique among the centers recruiting patients (Lopes et al. 2011). Although the main disadvantage is the increased costs since it is single use, it can decrease the use of fluoroscopy and procedural time devoted to tract dilation but literature has shown increased failure rates, especially if there is a history of renal surgery, reaching up to 25% (Joel et al. 2005).

The one-stage dilation method was introduced by Frattini et al. in 2001 who proposed that after successful puncture and guidewire insertion, a single 25–30Fr dilator to be loaded on the Alken guide rod or an 8Fr polyurethane dilator and subsequently a 34Fr sheath to be advanced (Frattini et al. 2001). Fahmy et al. assessed the use of single-step tract dilation in 70 children with stone burden 2–4 cm using a 20Fr Amplatz working sheath after tract dilation (Fahmy et al. 2011). In this randomized controlled trial (RCT), in the first group, Alken dilators were used, while in the second group a single step 20Fr Amplatz dilator was advanced (Fahmy et al. 2011). Authors reported that dilation was successful in all cases and there were no significant differences between the groups regarding operative time, total fluoroscopy time, length of stay (LOS), and SFRs (Fahmy et al. 2011). The overall complication rate was higher in the group of Alken dilators (28.5% versus 14.2%, $p = 0.018$), the need for intraoperative transfusion was lower in the single-step dilation (2.8% versus 11.4%, $p = 0.045$), fluoroscopy time during dilation favored single step dilation (8.8 versus 23.3 s, $p = 0.042$), while hemoglobin drop was greater in cases where Alken dilators were used (1.5 versus 0.6 gr/dl, $p = 0.026$) (Fahmy et al. 2011). Ghoneima et al. performed an RCT to assess the feasibility and safety of one-shot dilation compared to sequential dilation in a tubeless PCNL (Ghoneima et al. 2022). In the group where only one 30Fr Amplatz dilator was used, authors reported decreased dilation time (34.4 versus 166.2 s, $p < 0.001$), decreased fluoroscopy time during dilation (15.6 versus 98.5 s, $p < 0.001$), decreased total operative time (73.2 versus 97.9 min, $p < 0.001$), decreased need for transfusion (4.2% versus 17.2%, $p = 0.015$), decreased urine leakage (1.4% versus 15.5%, $p = 0.003$), but similar SFRs and rest complication rates were observed (Ghoneima et al. 2022). Although most studies indicate the advantageous effects of single-step dilation, Aminsharifi et al. in their study suggested that this technique may lead to more parenchymal damage than gradual dilation (Aminsharifi et al. 2011). Authors quantified the decrease in renal function and renal scar formation using 99m-Tc DMSA scan one month after PCNL in two distinct groups: one where single-step dilation was performed and the second where Alken dilators were inserted (Aminsharifi et al. 2011). Although their findings complied with literature regarding shorter access time and radiation exposure in the single-stage dilation group, they detected a significant drop in 99m-Tc uptake in this group one month postoperatively ($-2.4 \pm 0.3\%$, $p = 0.001$), while in the group of Alken dilators, no significant drop was noted (Aminsharifi et al. 2011).

The main advantages and disadvantages of each technique are shown in Table 1.

Several meta-analyses tried to address the differences between these techniques and provide a clear insight into the pros and cons of each one of them. Peng et al. in their study included 7 RCTs with 697 patients in total, comparing one-shot versus serial dilation (Peng et al. 2019). In their pooled analysis they found that although SFRs, success in dilation, LOS, and complication rates were similar between groups, the one-shot technique offered 110 s decreased access time, 0.23 gr/dl decreased blood loss but similar transfusion rates, and shorter fluoroscopy time in all included studies, although a pooled analysis was not performed for this outcome due to extreme heterogeneity in definition (Peng et al. 2019). In a more recent analysis, Peng et al. (2020) compared balloon with Amplatz dilation using data from 6 RCTs and 1317 patients in total. They reported similar overall complication rates, transfusion rates, SFRs, LOS, operative time, fluoroscopy time, and success rates among the two groups, but less hemoglobin drop by 0.21 gr/dl and shorter access time by 2.6 min when balloon dilation was used (Peng et al. 2020). Finally, Wu et al. in their

**Table 1** Advantages/disadvantages of percutaneous tract dilation techniques

| Alken metallic dilators | Amplatz semi-rigid plastic dilators | Single-step balloon dilator | One-stage dilation method |
|---|---|---|---|
| Less blood loss due to tamponade effect | Softer material causing less tissue trauma | Tamponade effect of the dilated balloon | Reduced cost |
| Reusable | Single use | Single use | No need to use a whole set of dilators |
| Rigid material able to be advanced through fibrotic tissue | Increased time needed to create tract | Less time consuming | Less time consuming |
| Increased time needed to create tract | Increased use of fluoroscopy | Decreased use of fluoroscopy | Decreased use of fluoroscopy |
| Increased use of fluoroscopy | Increased chance of tract loss or guidewire kinking due to force applied repetitively | 8–25% failure rate, especially in cases with dense fibrotic tissue from previous surgery | Less successful in patients with previous renal surgery |
| Increased chance of tract loss or guidewire kinking due to force applied repetitively | | | |

analysis compared all 4 methods between them by pooling data from 11 studies and 1415 patients (Wu et al. 2020). They found that the fluoroscopy time was decreased by 30.7 s in one-shot dilation compared to Alken dilators and by 26.4 s in balloon versus Alken dilators, but was similar between the balloon and one-shot dilation (Wu et al. 2020). Access time was shorted by 2.15 min for one-shot versus Alken dilators, while hemoglobin drop was less in one-shot dilation compared to Alken dilators (−0.19 gr/dl), less in balloon versus Amplatz dilation (−0.65 gr/dl), but similar between balloon versus one-shot dilation and Amplatz versus Alken dilators (Wu et al. 2020). Finally, overall SFRs, LOS, transfusion rates, and success rates were similar between the groups (Wu et al. 2020).

## 3 Creation of Percutaneous Tract in a Modified or Supine Position

Creation of a percutaneous tract in a supine or modified position can prove challenging due to existing anatomic structures through the course of dilators compared to the prone position; however, it is important for endourologists to be familiar with this technique, since supine PCNL reduces cardiopulmonary complications in high-risk patients and also permits simultaneous retrograde access for performing endoscopic combined intrarenal surgery (Mourmouris et al. 2018). In their study, Chung et al. proposed a modified tract dilation technique in patients undergoing PNCL in a prone or modified position, which compared to the standard technique led to reduced fluoroscopy time (68.9 versus 212.1 s, $p < 0.05$), decreased LOS (5.9 versus 6.7 days, $p < 0.05$) and increased success rate (77.2% versus 63.6%, $p < 0.05$), although total operative time, complication and transfusion rates were similar (Chung et al. 2021). The authors proposed steps in order to decrease the mobility of the kidney during advancing the dilators in a supine position by applying traction to the guidewires at two points: one at its exit from the dilator towards the kidney and the other from the urethra since the guidewire was advanced into the bladder and grabbed with a cystoscopic forceps (Chung et al. 2021). Although there is the theoretical risk of damaging the pelvicalyceal system from the excessive force over the guidewire, in this study no such event was noted, implying that the use of a hydrophilic guidewire instead of a more rigid shows a protective effect (Chung et al. 2021).

## 4 Tract Dilation Under Ultrasonographic Guidance

Exposure to ionizing radiation leads to tissue damage either when a certain threshold is acutely surpassed (deterministic effect) which is not that common or even with repeated low doses which gradually accumulate and can lead to mutations and carcinogenesis (stochastic effect). Both patients and operating room staff are exposed to harmful doses of radiation during endourological procedures (Vassileva et al. 2020, 2021) but also during their diagnosis and follow-up leading to an accountable burden (Tzelves et al. 2022a). One of the most effective ways to reduce radiation exposure is the use of ultrasound, which not only eliminates radiation but also facilitates the detection of radiolucent stones and better visualization of renal calyx anatomy (anterior versus posterior) and recognition of surrounding structures and vessels (when using Doppler function). Nowadays, there are centers performing PCNL entirely under ultrasonographic guidance which has stood the test of time and proven its effectiveness and safety (Tzelves et al. 2022b).

To perform a completely fluoroscopy-free PCNL, tract dilation should be performed under ultrasonographic guidance as well. The main obstacle in this is that Amplatz and Alken dilators have low echogenicity in contrast to the high echogenicity of the guidewire. Therefore, a method to observe the course of dilators is to detect the point where the guidewire signal is lost and thereby estimate the position of the dilator tip. However, this method can be obscured by adipose tissue and is not applicable to patients with increased body mass index. In obese patients, the estimated depth can be measured by the needle length that was inserted to enter the calyx, therefore providing a metric.

Another method to perform the tract dilation under ultrasonographic guidance, the two-step technique, was proposed by Li et al., who advanced 8–16Fr fascial dilators over the guidewire to a pre-determined depth according to needle length used for puncture (Li et al. 2014). Subsequently, a 16Fr peel-away sheath was placed and a ureteroscope was inserted through the sheath to confirm proper positioning (Li et al. 2014). In case of short dilation, the 16Fr sheath was advanced over the ureteroscope (Li et al. 2014). Following this, a 15Fr metallic dilator was placed and the tract was dilated up to 24Fr (Li et al. 2014).

Finally, balloon dilation can also be applied to dilate the tract under ultrasonographic guidance. Jin et al. compared this technique against serial metallic dilators (Jin et al. 2020). The balloon was inflated up to 30 atm for 60 s, while the course and final position of the balloon was monitored and confirmed only by ultrasound (Jin et al. 2020) In the comparator group, the two-step technique was used as described above (Jin et al. 2020). Authors reported that SFRs need for ancillary procedures, transfusion, and infection rates were similar between the two groups, while the time needed for tract dilation was less for the balloon group (3.4 versus 4.3 min, $p < 0.001$) and similarly a reduced total operative time was observed (62.2 versus 70.2 min, $p = 0.024$) (Jin et al. 2020). The only RCT existing is the study by Pakmanesh et al. who compared Amplatz dilators to balloon dilation in ultrasound-guided PCNL (Pakmanesh et al. 2019). In the Amplatz group, a single 28–30Fr dilation was used with the desired depth estimated according to the length of the inserted needle to perform a successful puncture, while in the balloon group, a 28–30Fr balloon dilator was used and monitored by ultrasound (Pakmanesh et al. 2019). Authors reported that short dilation was more frequent in the Amplatz group (57.6% versus 36.4%), although not reaching statistical significance, while the time needed for tract dilation, SFRs, and complications were similar (Pakmanesh et al. 2019). Importantly, the cost of the balloon was higher than Amplatz dilators (603 versus 718 US dollars, $p = 0.0001$) (Pakmanesh et al. 2019). They also observed that lower pole access led to significantly more short dilations compared to middle or lower pole access (61% versus 18% versus 40% respectively, $p = 0.01$) (Pakmanesh et al. 2019). Not only the location of the punctured calyx seems to affect tract dilation success when using the balloon under ultrasound guidance. Li et al. suggested that the degree of hydronephrosis is important since in patients with moderate or severe pelvicalyceal system dilation, balloon insertion was nearly 100% successful, in contrast with non-dilated systems (Li et al. 2014). Other factors leading to the reduced success of balloon dilation are obesity, previous open surgery, and staghorn stones (Usawachintachit et al. 2016), therefore It is advisable that novice surgeons may use fluoroscopy under these circumstances.

## 5 Conclusion

Percutaneous tract dilation in PCNL is of similar importance as renal puncture, as operation success and bleeding complications are mostly affected by these two steps of the procedure. For many years, tract dilation was performed solely under fluoroscopic guidance with the main methods being Alken metallic or Amplatz polyurethane sequential dilators, single-step balloon dilation, or one-shot dilation. Each technique offers specific pros and cons, although in cases with previous renal surgeries and the existence of fibrotic tissue along the tract, the use of metallic dilators is advisable. Gaining expertise in the use of ultrasound led to PCNL being completely performed under ultrasound guidance in several centers and tract dilation can also be performed using either Amplatz/Alken or balloon dilators without the need for fluoroscopic guidance. The familiarity of the surgeon with each of these methods should be taken into serious consideration before choosing the technique (Fig. 6).

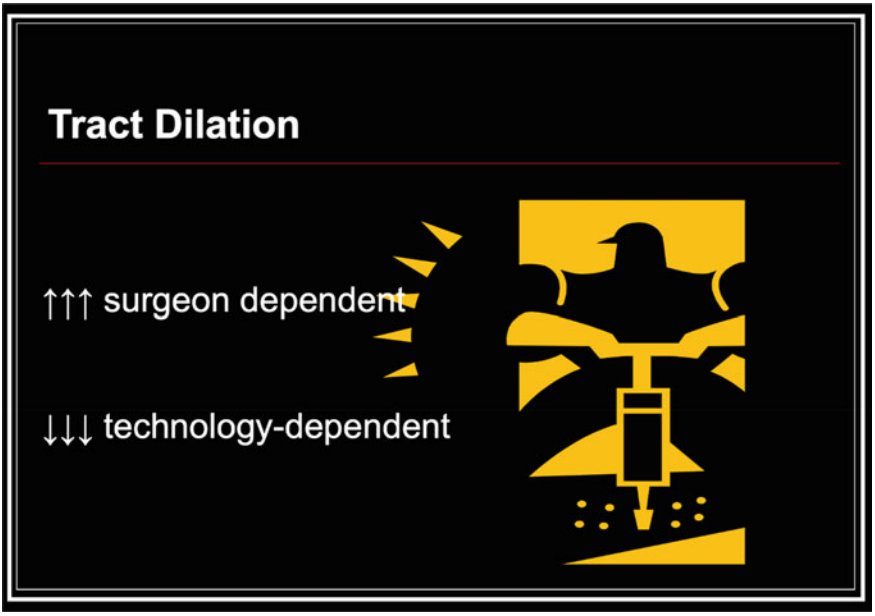


**Fig. 6** Track dilation is surgeon dependent

## References


Alken P, Hutschenreiter G, Günther R, Marberger M. Percutaneous stone manipulation. J Urol. 1981;125(4):463–6.

Aminsharifi A, Alavi M, Sadeghi G, Shakeri S, Afsar F. Renal parenchymal damage after percutaneous nephrolithotomy with one-stage tract dilation technique: a randomized clinical trial. J Endourol. 2011;25(6):927–31.

Castaneda-Zuniga WR, Clayman R, Smith A, Rusnak B, Herrera M, Amplatz K. Nephrostolithotomy: percutaneous techniques for urinary calculus removal. 1982. J Urol. 2002;167(2 Pt 2):849–53; discussion 54.

Chung JW, Ha H, Park DJ, Ha YS, Lee JN, Chun SY, et al. Efficacy and safety of modified tract dilation technique using simultaneous pulling of proximal and distal ends of a guidewire for percutaneous nephrolithotomy in modified supine position. Investig Clin Urol. 2021;62(2):186–94.

Clayman RV, Castaneda-Zuniga WR, Hunter DW, Miller RP, Lange PH, Amplatz K. Rapid balloon dilatation of the nephrostomy track for nephrostolithotomy. Radiology. 1983;147(3):884–5.

Fahmy AMW, Elbadry M, Moussa A. Single step track dilatation for percutaneous nephrolithotomy in children. Int Urol Nephrol. 2011;54(11):2789–95.

Frattini A, Barbieri A, Salsi P, Sebastio N, Ferretti S, Bergamaschi E, et al. One shot: a novel method to dilate the nephrostomy access for percutaneous lithotripsy. J Endourol. 2001;15(9):919–23.

Geraghty RM, Davis NF, Tzelves L, Lombardo R, Yuan C, Thomas K, et al. Best practice in interventional management of urolithiasis: an update from the European Association of Urology Guidelines Panel for Urolithiasis 2022. Eur Urol Focus. 2022.

Ghoneima W, Makki M, Lotfi MA, Mostafa A, Elkady A, Rammah AM. The feasibility and safety of one-shot dilatation compared to conventional sequential dilatation in tubeless percutaneous nephrolithotomy: a prospective randomized controlled study. Urolithiasis. 2022;51(1):3.

Jin W, Song Y, Fei X. The Pros and cons of balloon dilation in totally ultrasound-guided percutaneous Nephrolithotomy. BMC Urol. 2020;20(1):82.
Joel AB, Rubenstein JN, Hsieh MH, Chi T, Meng MV, Stoller ML. Failed percutaneous balloon dilation for renal access: incidence and risk factors. Urology. 2005;66(1):29–32.
Li J, Xiao B, Hu W, Yang B, Chen L, Hu H, et al. Complication and safety of ultrasound guided percutaneous nephrolithotomy in 8025 cases in China. Chin Med J (engl). 2014;127(24):4184–9.
Lopes T, Sangam K, Alken P, Barroilhet BS, Saussine C, Shi L, et al. The clinical research office of the endourological society percutaneous nephrolithotomy global study: tract dilation comparisons in 5537 patients. J Endourol. 2011;25(5):755–62.
Mourmouris P, Berdempes M, Markopoulos T, Lazarou L, Tzelves L, Skolarikos A. Patient positioning during percutaneous nephrolithotomy: what is the current best practice? Res Rep Urol. 2018;10:189–93.
Pakmanesh H, Daneshpajooh A, Mirzaei M, Shahesmaeili A, Hashemian M, Alinejad M, et al. Amplatz versus Balloon for tract dilation in ultrasonographically guided percutaneous nephrolithotomy: a randomized clinical trial. Biomed Res Int. 2019;2019:3428123.
Peng P-x, Lai S-c, Ding Z-s, He Y-h, Zhou L-h, Wang X-m, et al. One-shot dilation versus serial dilation technique for access in percutaneous nephrolithotomy: a systematic review and meta-analysis. BMJ Open. 2019;9(4): e025871.
Peng PX, Lai SC, Seery S, He YH, Zhao H, Wang XM, et al. Balloon versus Amplatz for tract dilation in fluoroscopically guided percutaneous nephrolithotomy: a systematic review and meta-analysis. BMJ Open. 2020;10(7): e035943.
Skolarikos ANA, Petrik A, Somani B, Thomas K, Gambaro G, et al. EAU guidelines on urolithiasis; 2022.
Tzelves L, Geraghty R, Lombardo R, Davis NF, Petřík A, Neisius A, et al. Duration of follow-up and timing of discharge from imaging follow-up, in adult patients with urolithiasis after surgical or medical intervention: a systematic review and meta-analysis from the European Association of Urology Guideline Panel on Urolithiasis. Eur Urol Focus. 2022a.
Tzelves L, Juliebø-Jones P, Manolitsis I, Bellos T, Mykoniatis I, Berdempes M, et al. Radiation protection measures during endourological therapies. Asian J Urol. 2022b.
Usawachintachit M, Masic S, Chang HC, Allen IE, Chi T. Ultrasound guidance to assist percutaneous nephrolithotomy reduces radiation exposure in obese patients. Urology. 2016;98:32–8.
Vassileva J, Zagorska A, Basic D, Karagiannis A, Petkova K, Sabuncu K, et al. Radiation exposure of patients during endourological procedures: IAEA-SEGUR study. J Radiol Prot. 2020;40(4).
Vassileva J, Zagorska A, Karagiannis A, Petkova K, Sabuncu K, Saltirov I, et al. Radiation exposure of surgical team during endourological procedures: international atomic energy agency-south-eastern European group for urolithiasis research study. J Endourol. 2021;35(5):574–82.
Wu Y, Xun Y, Lu Y, Hu H, Qin B, Wang S. Effectiveness and safety of four tract dilation methods of percutaneous nephrolithotomy: a meta-analysis. Exp Ther Med. 2020;19(4):2661–71.