

One-shot versus gradual dilation technique for tract creation in percutaneous nephrolithotomy: a systematic review and meta-analysis

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Abstract The aim of this study is to evaluate the efficacy and safety of one-shot versus gradual dilation technique for tract creation in percutaneous nephrolithotomy (PCNL). A systematic research of Pubmed, Embase and the Cochrane Library was performed to identify all relevant studies. The quality of the included trials was assessed and the data were extracted independently by two reviewers. The Cochrane Collaboration's Review Manager (RevMan) 5.0.2 software was used for statistical analysis. Four randomized controlled trials were included in analysis involving 346 patients in total. Of these patients 174 were in the one-shot group and 172 in the gradual group. Our meta-analysis showed that there were no significant differences in successful dilation rate [risk ratio (RR): 0.96; 95 % confidence interval (CI): 0.92–1.00, $p = 0.05$], transfusion rate (RR: 0.62; 95 % CI: 0.20–1.96; $p = 0.42$), and hemoglobin decrease [mean difference (MD): -0.34 ; 95 % CI: from -0.67 to -0.00 ; $p = 0.05$] between one-shot dilation and gradual dilation. One-shot dilation had significant shorter access time (MD: -1.03 ; 95 % CI: from -1.57 to -0.49 ; $p = 0.0002$) and X-ray exposure time (MD: -42.71 ; 95 % CI: from -45.05 to -40.37 ; $p < 0.00001$) than gradual dilation. Our results show that One-shot dilation is an effective and safe procedure for tract creation in PCNL, with shorter access time and X-ray exposure time and without increased complications. As only four studies with small study populations were

available, more high-quality larger trials with longer follow-up are recommended.

Keywords Percutaneous nephrolithotomy · Gradual · One-shot · Tract

Abbreviations

PCNL	Percutaneous nephrolithotomy
RCTs	Randomized controlled trials
RR	Risk ratio
CI	Confidence interval
MD	Mean difference
Mini-PCNL	Minipercutaneous nephrolithotomy

Introduction

Percutaneous nephrolithotomy (PCNL) is generally considered as an effective and safe management of large renal stones with minimally invasive procedures [1]. The creation of the nephrostomy tract is one of the most fundamental steps in PCNL. Three standard dilation instruments are available: Amplatz fascial dilators, metal telescopic dilators, and balloon dilators [2]. Balloon dilation is regarded as the most widely accepted and safest system, but its high cost limits its routine application. Dilation with the Amplatz set or metal telescopic dilators is less expensive, but both of the multiple incremental dilation techniques require longer exposure time to X-ray and are more time-consuming.

To reduce access time and radiation exposure during the access, a “one-shot” method which consists of a single dilation of the track with a 25 or 30F dilator was introduced

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[3]. Some studies have shown that the one-shot method is as safe and effective as standard techniques and less time-consuming [4]. In contrast, some studies have shown that one-shot dilation may cause more parenchymal damage than gradual dilation [5]. Therefore, it is necessary to conduct a systematic review and meta-analysis to evaluate the efficacy and safety of one-shot dilation technique for tract creation in PCNL.

Materials and methods

Search strategy

We searched the databases using PubMed (updated to July 2012), Embase (updated to July 2012), the Cochrane Central Register of Controlled Trials and the Cochrane Database of Systematic Reviews. The search strategy was “(Nephrostomy, Nephrolithotomy, Percutaneous, PCNL) [MeSH Terms] AND (one shot OR one step OR one stage OR gradual OR progressive OR standard OR sequential OR dilators OR Amplatz fascial dilators OR metal telescopic dilators OR balloon dilators) [Title/Abstract]”. The search was restricted to human subjects, and reference lists from retrieved documents were also searched. In addition, we hand-searched reference lists from relevant publications and conference proceedings from the AUA, EAU and SIU between 2007 and 2012. Two authors (LY and YL) independently screened all citations and abstracts using this search strategy to identify potentially eligible studies. Randomized controlled trials (RCTs) that compared one-shot versus standard (gradual dilation) strategy for tract creation in PCNL were included if they met the criteria regardless of language. Discrepancy was resolved in consultation with the third reviewer.

Data extraction

Data were extracted independently by both authors (LY and XP) using a pre-designed data extraction form, and any discrepancy was resolved in consultation with WJ. The following information was extracted: data source, eligibility, methods, participant characteristics, interventions, and results. The primary measured outcomes were access tract dilation time, X-ray exposure time, and successful dilation rate. The secondary outcomes were blood loss and complications. We contacted the authors of included studies to find out if there were any missing data or inaccurate information. Thereafter, we divided the patients into one-shot and gradual group according to patients' procedure of tract creation in PCNL.

Quality assessment

The quality of included studies was assessed by two authors (SP and QS) according to the Cochrane Collaboration Reviewers' Handbook and the QUOROM guidelines [6, 7]. The quality items were generation of randomization sequences, being double blind, allocation concealment, description of withdrawals and dropouts and intent to treat analysis.

Statistical methods

All meta-analyses were performed using RevMan 5.0.2. For continuous data (tract dilation time and X-ray exposure time), mean difference (MD) with 95 % confidence intervals (CI) was used. For dichotomous data (successful dilation rate and blood transfusion), relative ratio (RR) was used with 95 % CI. Statistical heterogeneity among trials was evaluated by I^2 test. I^2 values of 25, 50 and 75 % correspond to low, medium and high levels of heterogeneity. A p value <0.05 was considered statistically.

Results

According to the search strategy determined previously, there were four RCTs with 346 cases included after study assessment [5, 8–10], which were identified for analysis in this review (Fig. 1). All studies were published in English. In the four comparative studies, 174 patients were in the one-shot group and 172 patients in the gradual group. One

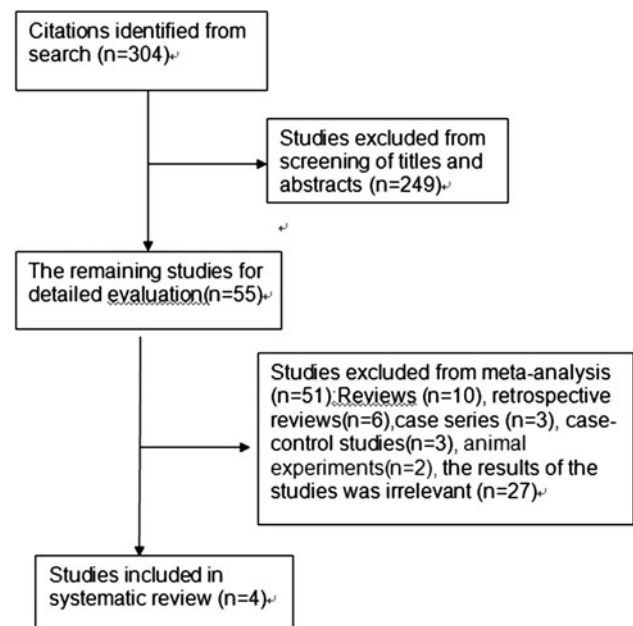


Fig. 1 The literature screening process

study compared one-shot versus progressive dilation in patients with previous open nephrolithotomy [9]. The baseline characteristics and quality assessment of the included studies are summarized in Table 1.

Successful dilation rate

Successful dilation rate was reported in two studies including 267 patients [5, 8]. Heterogeneity was not observed in the pooled analysis ($p = 0.44$; $I^2 = 0\%$). Meta-analysis of these studies showed that it was on the edge of statistical significance in successful dilation rate between the one-shot and the gradual group (96.09 vs. 100 %, RR: 0.96, 95 % CI: 0.92–1.00, $p = 0.05$) (Fig. 2).

Access time(s) and X-ray exposure time

Access time data were available in three included clinical trials including 293 patients [5, 9, 10]. Heterogeneity was observed in the pooled analysis ($p < 0.00001$; $I^2 = 98\%$). Meta-analysis of the three studies demonstrated a significantly shorter access time for tract creation in the one-shot group compared with the gradual group (MD = -1.03 , 95 % CI: from -1.57 to -0.49 ; $p = 0.0002$) (Fig. 3a). But in the study by Aminsharifi et al. [5], the access time was too much longer than the other two studies. After deleting the data of this study, one-shot group also had less access time than the gradual group with a statistically significant difference (MD = -1.44 , 95 % CI: from -1.94 to -0.93 ; $p < 0.00001$) (Fig. 3b).

Two studies including 262 patients reported X-ray exposure time [5, 10]. Meta-analysis of the two studies showed that one-shot dilation had less X-ray exposure time than gradual dilation with a statistically significant difference (MD: -42.71 , 95 % CI: from -45.05 to -40.37 ; $p < 0.00001$) (Fig. 3c) and with no statistical heterogeneity ($I^2 = 0\%$).

Blood loss and transfusion rate

Three studies including 132 patients reported the data of blood loss for PCNL in both the groups [5, 8, 9]. Heterogeneity was not observed in the pooled analysis ($p = 0.93$; $I^2 = 0\%$). Meta-analysis of these studies demonstrated that it was on the edge of statistical significance in blood loss between the one-shot and the gradual group (MD = -0.34 , 95 % CI: from -0.67 to -0.00 ; $p = 0.05$) (Fig. 4a).

Four studies reported on transfusion rates [5, 8–10]. Aminsharifi et al. [5] reported that no blood transfusion was needed in their trial; therefore, it is impossible to integrate their data with the others. Heterogeneity was not observed in pooled analysis ($p = 0.91$; $I^2 = 0\%$). Three studies including 298 patients showed that the one-shot

Table 1 Baseline characteristics and quality assessment of the included studies

Study	Gender (M/F)*	Mean age	Mean stone size (cm)	Dilator	Size of dilator	Adequate sequence generation	Allocation concealment	Blinding	ITT	Patients lost to follow
Frattini [8]	One-shot	59	2.3 ± 0.7	Amplatz dilator	25F, 30F	Unclear	Unclear	Unclear	Not stated	None
	Gradul	54	2.9 ± 0.9	Alken telescoping dilators	10F to 30F					
Amjadi [9]	One-shot	42	3.7 ± 1	Amplatz dilator	27F, 28F	Yes	Unclear	Unclear	Not stated	None
	Gradul	44	3.2 ± 1.1	Alken telescopic dilators	12F to 28F					
Falahatkar [10]	One-shot	57	3.9 ± 1.6	Amplatz dilator	28F, 30F	Yes	Unclear	Unclear	Not stated	Not stated
	Gradul	51	3.4 ± 1.2	Metal telescopic dilators	10F to 30F					
Aminsharifi [5]	One-shot	44	2.69 ± 0.97	Amplatz dilator	28F, 30F	Yes	Yes	Yes	Yes	None
	Gradul	43	3.09 ± 1.29	Alken metallic dilators	10F to 30F					

* F female, M male

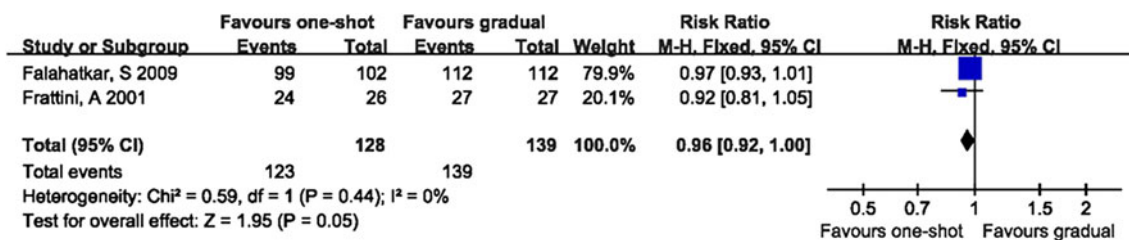


Fig. 2 Pooled estimate of successful dilation rate using random-effect model

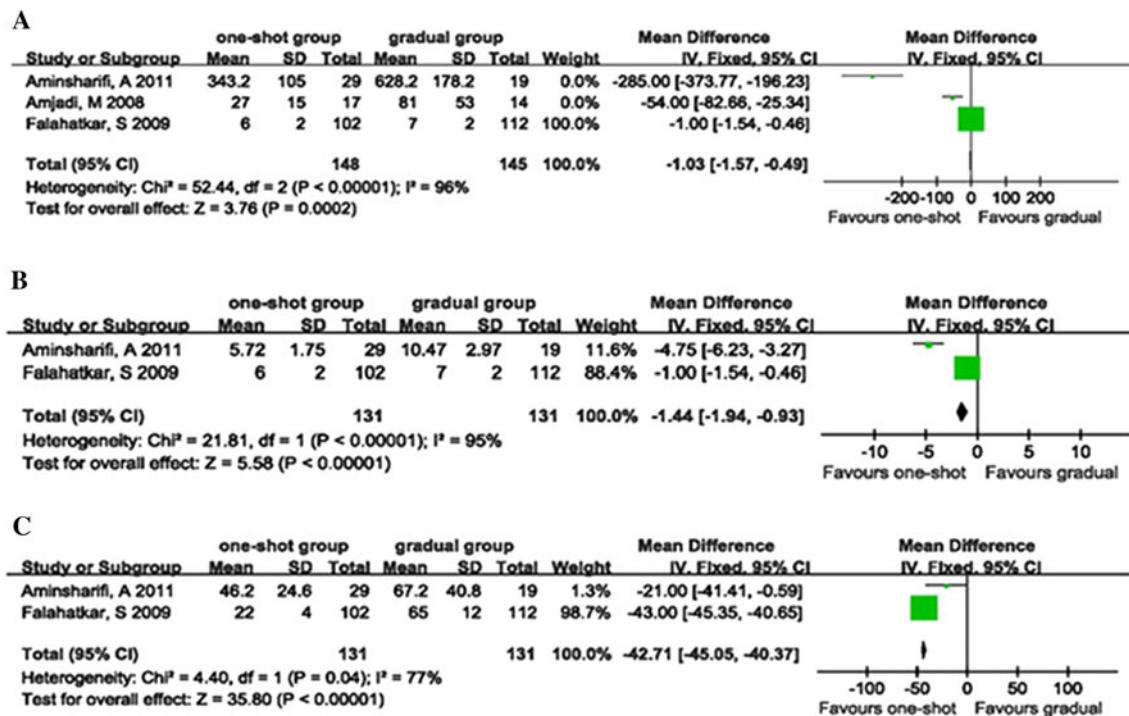


Fig. 3 a Pooled estimate of access time using fixed effect model. b Pooled estimate of access time using fixed effect model after deleting Aminsharifi's study. c Pooled estimate of X-ray exposure time using fixed effect model

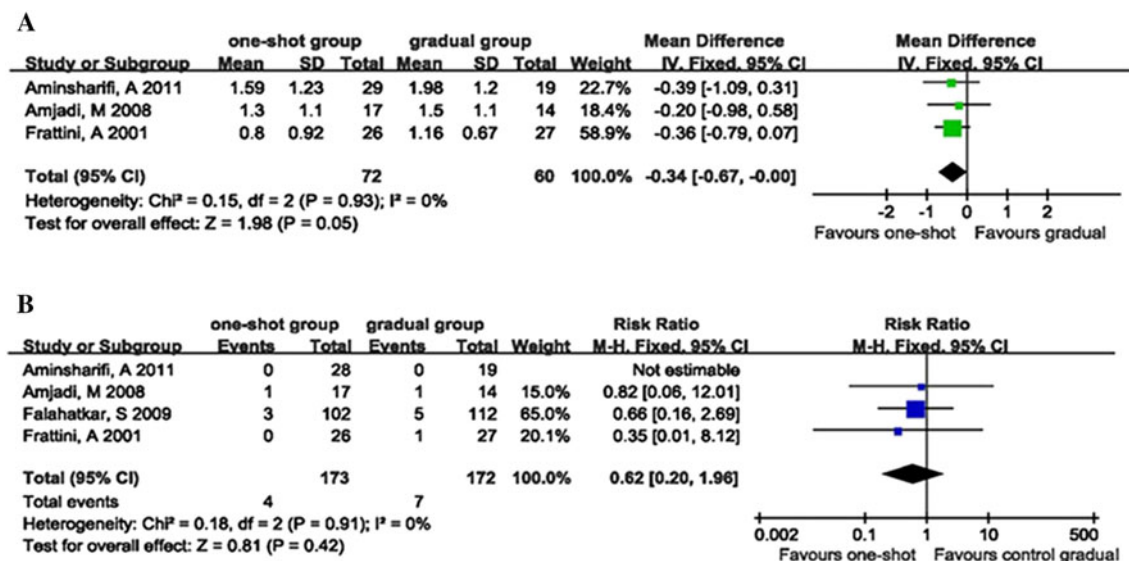


Fig. 4 a Pooled estimate of blood loss using fixed effect model. b Pooled estimate of transfusion rate using random-effect model

group had a slightly lower transfusion rate, but without statistical significance (RR = 0.62; 95 % CI: 0.20–1.96; $p = 0.42$) (Fig. 4b).

Discussion

To reduce the damage of PCNL, many attempts and different techniques have been proposed. One-shot dilation, which consists of a single dilation of the track with a 25 or 30F dilator, was invented to facilitate the tract creation of PCNL.

Our meta-analysis showed that one-shot dilation had shorter access time and X-ray exposure time than gradual dilation. There were no significant difference in successful dilation rate, blood loss and transfusion rate between the one-shot group and the gradual group. The successful dilation rate of one-shot group is slightly lower than the gradual group (96.09 vs. 100 %), however, on the edge of statistical significance ($p = 0.05$). Five of one-shot group were unsuccessful, of which four cases had a history of renal surgery [8, 10]. Frattini et al. [8] considered that the heavy resistance of the fascial layers in a previously operated kidney prevented fascial dilator passage and they did not recommend one-shot dilation for patients with a history of previous renal surgery. Ziaee et al. [11] studied the safety and efficacy of the one-shot dilation in patients with previous renal scar. They applied one-shot dilation technique with 100 consecutive patients and compared the operative parameters, such as access time, radiation exposure time during access, success rate of access technique, and bleeding complication among two other groups of with and without a history of ipsilateral open stone surgery. No significant differences were found regarding successful dilation rate, access time, radiation exposure during access, and hemoglobin drop between the two groups. They concluded that one-shot dilation was a safe and effective method in almost every adult patients and previous ipsilateral open stone surgery did not impact access time, radiation time during access, postoperative hemoglobin drop and bleeding complications. Lojanapiwat et al. [12] also demonstrated that previous open stone surgery did not affect PCNL techniques and outcomes, even when a gradual dilation approach is replaced by a one-shot dilation. With the accumulation of experience of one-shot dilation and the improvement of technique, one-shot dilation of nephrostomy would be a candidate for PCNL regardless of previous renal scar.

Aminsharifi et al. [5] compared renal parenchymal damage after PCNL between one-shot and gradual tract dilation by detecting the decrease in technetium-99m dimercaptosuccinic acid (99m-Tc DMSA) on the 4 weeks

postoperatively. 4 weeks after the operation, 14 of 29 patients with one-shot dilation developed a new scar on their access site compared with 2 of 19 patients who underwent gradual dilation ($p = 0.007$). They thought that the one-shot acute dilation might result in a larger radial force vector being imparted into the renal tissue than that with gradual tapering. But according to the authors, their study lacks an adequate number of patients and they might ignore some small scars with a planar technique for 99m-Tc DMSA renal scans, which produced two-dimensional images to assess the parenchymal damage of kidney. The follow-up time is too short, also limits the reliability of the conclusion. Travis et al. [4] demonstrated that the single-increment dilatation was a safe technique with minimal hemorrhage or parenchymal damage and healing at 6 weeks by a fine linear scar.

Since the introduction of PCNL, the complication of bleeding has always been a concern. Conservative measures of bleeding include adequate hydration, prevention of hypothermia, clamping the nephrostomy tube [13]. Moderate hemorrhage demands blood transfusion in addition to conservative measures. The severity of bleeding needs embolisation or nephrectomy. Large series report a 3–10 % rate of acute bleeding requiring transfusion [14]. According to our meta-analysis, the total transfusion rate was 2.9 % and the one-shot group had a slightly lower transfusion rate, but without statistical significance ($p = 0.42$). The lower transfusion rate was due to the development and improvement of technique and equipment with one-shot PCNL.

To our knowledge, this study is the first systematic review with meta-analysis on PCNL in the one-shot and gradual dilation. Nevertheless, limitations of this review should also be noted. First, the review was limited to the randomized studies to synthesize data on the highest available level of evidence, only four RCTs included in the analysis. The article would be more convincing if more comparative studies on one-shot versus gradual dilation were available. Second, the definitions of access time and X-ray exposure time of tract creation varied in different researches, resulting in a high Heterogeneity, which may affect the outcomes [5, 9, 10]. Last, the quality of reporting varied between the studies. Some trials had limited methodological quality, particularly studies with a small sample size [5]. Although these inevitable methodological shortcomings reduce the level of evidence in this review, we believe that one-shot dilation would play a more important role in the tract creation in PCNL except mini percutaneous nephrolithotomy (mini-PCNL). Thus, urologists could first choose one-shot dilation for tract creation in PCNL. Even if failure occurs, it is easy to shift from the one-shot to the standard dilation technique.

Conclusion

The results of this meta-analysis and systematic review suggested that one-shot tract dilation was as safe and efficacious as the gradual dilation with decreased access time and X-ray exposure time. Both patients and doctors can receive benefit from one-shot tract dilation in PCNL. Because of the small sample and low quality of some included studies, it highlights that large scale, multicenter RCTs are needed for a further powerful conclusion.

Conflict of interest The authors declare that they have no conflict of interest.

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