

Comparison of Single-Step Balloon Dilatation and Serial Metallic Dilatation during Percutaneous Nephrolithotomy

Muhammad Akram, Mumtaz Rasool, Muhammad Amjad

Abstract

Objective: To compare perioperative outcomes of single-step balloon dilatation and serial metallic dilatation during percutaneous nephrolithotomy (PCNL).

Study Design and Setting: Prospective comparative quasi-experimental study conducted in the Department of Urology, Bahawal Victoria Hospital, Bahawalpur.

Methodology: A total of 214 adults with 2-4 cm renal stones were enrolled by consecutive sampling and treated in two groups of 107 according to the study protocol: single-step balloon dilatation or serial metallic dilatation. Outcomes included tract-creation time, operative time, hemoglobin drop, stone clearance, blood transfusion, postoperative fever, collecting-system injury, and hospital stay. Continuous outcomes were compared with independent-samples t tests. For categorical outcomes, Pearson chi-square was used when expected cell counts were adequate and Fisher exact test when expected counts were small.

Results: Single-step balloon dilatation was associated with shorter tract-creation time (2.42 +/- 0.54 vs 4.08 +/- 0.67 min, $p < 0.001$), shorter operative time (88.9 +/- 18.6 vs 97.4 +/- 20.9 min, $p = 0.002$), lower hemoglobin drop (1.08 +/- 0.39 vs 1.43 +/- 0.46 g/dL, $p < 0.001$), and shorter hospital stay (2.44 +/- 0.79 vs 3.04 +/- 0.92 days, $p < 0.001$). Stone clearance was 87.9% versus 72.9% (Pearson chi-square $p = 0.006$). Transfusion occurred in 2.8% versus 9.3% (Pearson chi-square $p = 0.045$).

Conclusion: In this study, single-step balloon dilatation was associated with shorter tract-creation and operative times, lower hemoglobin drop, shorter hospital stay, and higher observed stone clearance than serial metallic dilatation.

Keywords: Percutaneous nephrolithotomy; balloon dilatation; tract dilatation; renal calculi; stone clearance; hemoglobin.

How to cite this Article:

Akram M, Rasool M, Amjad M. Comparison of Single-Step Balloon Dilatation and Serial Metallic Dilatation during Percutaneous Nephrolithotomy. J Bahria Uni Med Dental Coll. 2026;16(4):1023-9 DOI: <https://doi.org/10.51985/JBUMDC20261093>

This is an Open Access article distributed under the terms of the Creative Commons Attribution Non Commercial License (<http://creativecommons.org/licenses/by-nc/4.0>) which permits unrestricted non commercial use, distribution and reproduction in any medium, provided the original work is properly cited.

INTRODUCTION

Renal stone disease is an endemic and spreading urological condition that is a significant burden to emergency units, out patient clinics and surgery. Its worldwide epidemiology increases with urbanization, exposure to climate, the ingestion of salt and animal protein in a diet, obesity, diabetes and metabolic syndrome. The stones bigger than 2 cm, stones with unfavorable calyceal anatomy and with complicated renal stones tend not to clear with the help of the conservative therapy, shockwave lithotripsy; consequently, radical

endourological surgery is required. Recent recommendations suggest that percutaneous nephrolithotomy (PCNL) is a first-line approach in the treatment of a large renal stone burden due to its ability to abut the collecting system and high clearance with a single treatment session.¹⁻³

PCNL is a development of the initial percutaneous method of the renal collecting system. The enhancements in the fluoroscopic and ultrasound guidance methods, access sheath development, energy sources, tubeless guidelines and minimized instruments have enhanced the safety and recovery. However, the basic procedural flow is contingent upon correct calyceal puncture with subsequent dilatation of the nephrostomy tract. The poorly well-formed tract may augment bleeding, trauma of the collecting systems, radiation, surgical complexity and inability to clear stone fragments. Hence, the expansion of tracts is not just a procedure; it is a predictor of the morbidity in peri-operative and the efficiency of surgery.⁴ A number of dilatation methods exist. Dilatation by serial metallic telescopes is long-established in several public-sector hospitals as the metallic dilators are reusable, well known to most urologists, and also relatively cost effective once they are bought. They can supply certain tamponade when giving progressive

Muhammad Akram

Post Graduate Resident, Department of Urology
Bahawal Victoria Hospital, Bahawalpur
Email: akrambuzdar91@gmail.com

Mumtaz Rasool

Professor, Department of Urology
Bahawal Victoria Hospital, Bahawalpur
Email: dmr250@hotmail.com

Muhammad Amjad

Senior Registrar, Department of Urology
Bahawal Victoria Hospital, Bahawalpur
Email: amjad81@gmail.com

Received: 10-06-2026
Accepted: 25-09-2026

1st Revision: 21-07-2026
2nd Revision: 20-09-2026

dilatation, nevertheless, successive replacement of dilators might extend renal access and fluoroscopy duration. The sequential fascial or Amplatz dilators are also a stepwise alternative, but tend to be disposable and may tend to eliminate the tamponade effect with repeated change. Balloon expansion forms the tract during one radial expansion and should shorten the access time, eliminate repetitive handling and potentially lessen parenchymal damage.^{5,6} Whether a single-step balloon dilatation or serial metallic dilatation is the most beneficial depends on the particular setting where the time spent in the operating room, the coverage by the theater, the amount of radiation and its cost effect service delivery.⁷ Balloon dilators are portable yet inexpensive and costly. Metallic dilators can be used again and only require additional procedures, although can possibly have prolonged access time. The question of clinical interest is whether when compared to other available procedures, the increased cost of procedure balloon dilatation provides any quantifiable benefits in stone removal, duration of access, Hemoglobin conservation, rate of transfusion and postoperative retention. Even small decreases in blood loss, time spent in operation theater and time spent in the hospital can offset the costs of the device in resource-limited settings as they enhance the throughput and complications.⁸⁻¹⁰

Comparative studies on one-shot or single-step dilatation versus gradual, serial or metallic dilatation have recently become more popular in comparative studies. Shorter access time and less excessive exposure to fluoroscopy by single-step procedures have been frequently reported, but there has been less consistency in the results relating to stone-free rate, hemoglobin fall frequency and complications. There is still very little evidence at the local level and it is not sure how international data can be generalized to the Pakistani surgical unit since patient presentation, stone size, comorbidity profile and availability of equipment vary significantly. The current study was conceived as a prospective comparative quasi-experimental study rather than a randomized controlled trial. It compared single-step balloon dilatation with serial metallic dilatation in adults undergoing PCNL for 2-4 cm renal stones. The main outcomes were operative efficiency, hemoglobin drop, stone clearance, complications, and hospital stay. Because treatment allocation was not randomized, the study was designed to estimate comparative associations under routine clinical conditions rather than establish causal superiority.

Besides the technical performance, the choice of the access method also has training, resource utilization and perioperative planning implications. A method which consistently forms a tract with a smaller number of exchanges can minimize instrument-related renal trauma and can help to make the operation more predictable to junior teams under supervision. Alternatively, metallic reusable dilators are more tempting when the use of disposable equipment is enhancing the cost of treatment in patients and institutions.

This is why, the local comparative evidence must not only report statistical significance but define the extent of benefit in a manner that can be comprehended by clinical description, such as minutes saved, hemoglobin preserved, complications prevented and time spent saved in daily PCNL practice.

METHODOLOGY

The proposed comparative quasi-experimental study on the Department of Urology, Bahawal Victoria Hospital, Bahawal, took place from 10th November 2025 to 9th May 2026 after approval from institutional ethical review committee. Adult female and male patients aged between 20 and 60 years old with renal stones ranging between 2 and 4 cm and intending to undergo PCNL were enlisted. Patients were not included in case they had coagulopathy with INR >1.5, active urinary tract infection, staghorn calculus, anatomical renal abnormality, polycystic kidney, ectopic kidney, transplanted kidney, medullary sponge kidney, renal malignancy, uncontrolled pyonephrosis, chronic renal failure or chronic liver disease. WHO sample size calculator was used to compare two proportions by providing the sample size used. A 95% confidence level with 80% power was used in the calculation where the predicted smooth passage of the stone on single-step balloon dilatation is 86.7% and using serial metallic dilatation, it is 71.1% based on the previous reported comparative results. Based on these assumptions, the sample size required was 214 people (having 107 participants in each group). Non-probability consecutive sampling was used. Informed consent was obtained through written informed consent after which eligible patients were enrolled. The base line data as age, gender, body mass index, side of stone, stone size, hypertension, diabetes mellitus and preoperative hemoglobin were documented on formatted proforma. In Group A, single-step balloon dilatation was applied to do PCNL to the group whereas Group B was subjected to PCNL through serial metallic dilatation. All patients were evaluated with normal preoperative assessment, ceftriaxone 1 g prophylaxis and general anesthesia. A retrograde ureteric catheter was inserted and the patient was put in prone position. Under fluoroscopic guidance, a 18-gauge needle was implemented to do calyceal puncture. Guidewire placement and skin-fascial incision were followed by the dilation of the nephrostomy tract based on the specific technique given. Fragments were removed with forceps and the process was performed with the use of pneumatic lithotripsy so as to stone fragmentation. We conducted an intraoperative evaluation of completeness of clearance using nephroscopic examination and fluoroscopy and a postoperative evaluation using ultrasonography at 24 hours.

The primary outcomes were tract-creation time, overall operative time, postoperative hemoglobin drop, stone clearance, blood transfusion, postoperative fever, collecting-system injury, and hospital stay. Tract-creation time was measured from the start of tract dilatation to access-sheath placement. Hemoglobin drop was calculated as the difference

between preoperative hemoglobin and the value measured 24 hours postoperatively. Stone clearance was defined as no residual stone detected on ultrasonography at 24 hours. Data were analyzed using SPSS version 25. Quantitative variables were summarized as mean $\pm$ SD and compared with independent-samples *t* tests. Categorical variables were summarized as frequency and percentage. Pearson chi-square was used when all expected cell counts were ≥ 5 ; two-sided Fisher exact testing was used when any expected cell count was < 5 . Yates continuity-corrected *p*-values were not used for the final reported comparisons. For the transfusion comparison, where expected counts were adequate but the total number of events was small, a two-sided Fisher exact result was additionally reported as a sensitivity analysis. A two-sided $p < 0.05$ was considered statistically significant. Stratified stone-clearance comparisons followed the same Pearson/Fisher test.

RESULTS

A total of 214 patients were included, with 107 in each group. Mean age was 39.8 $\pm$ 10.3 years in the single-step balloon group and 40.6 $\pm$ 10.9 years in the serial metallic group (independent-samples *t* test $p = 0.582$). Male sex was recorded in 58 (54.2%) and 55 (51.4%) patients, respectively (Pearson chi-square $p = 0.681$). Mean BMI was 26.2 $\pm$ 3.8 versus 26.7 $\pm$ 4.1 kg/m² ($p = 0.356$), and mean stone size was 2.83 $\pm$ 0.52 versus 2.88 $\pm$ 0.55 cm ($p = 0.495$). Right-sided stones, hypertension, and diabetes mellitus were also similarly distributed between groups (Table 1). Access outcomes were also significantly better with single-step balloon dilatation. Mean tract creation time was 2.42 $\pm$ 0.54 minutes in Group A compared with 4.08 $\pm$ 0.67 minutes in Group B ($p < 0.001$). Mean operative time was 88.9 $\pm$ 18.6 minutes in Group A and 97.4 $\pm$ 20.9 minutes in Group B ($p = 0.002$). The average hemoglobin drop was much lower in the balloon group (1.08 $\pm$ 0.39 g/dL) as compared to the metallic group (1.43 $\pm$ 0.46 g/dL, $p < 0.001$). Mean hospital stay was also shorter in Group A than Group B (2.44 $\pm$ 0.79 vs 3.04 $\pm$ 0.92 days, $p < 0.001$).

Stone clearance was achieved in 94/107 patients (87.9%) in the single-step balloon group and 78/107 (72.9%) in the serial metallic group (Pearson chi-square $p = 0.006$). Blood transfusion was required in 3/107 (2.8%) versus 10/107 (9.3%) patients. Pearson chi-square gave $p = 0.045$; because only 13 transfusion events occurred, the two-sided Fisher exact sensitivity analysis gave $p = 0.082$, so this finding should be interpreted cautiously. Postoperative fever occurred in 6/107 (5.6%) versus 8/107 (7.5%) patients (Pearson chi-square $p = 0.580$). Collecting-system injury occurred in 2/107 (1.9%) versus 5/107 (4.7%); because an expected cell count was < 5 , two-sided Fisher exact testing was used ($p = 0.445$). Subsequent analysis of the quantitative results proved the benefit of one-step balloon dilation to be similar throughout the key perioperative inferences. There was an absolute decrease of tract creation time by 1.66 minutes, reflecting

about 40.7 percent less than that of serial metallic dilatation. This difference is small in its own right but happened at the most technically critical stage of PCNL and could be reflected in reduced guidewire manipulation, a reduction in the number of fluoroscopic checks and an increased predictability of access sheath location. The finding of a decrease in operative-time of 8.5 minutes also indicated that the advantage of fast access was transferred to the rest of the procedure instead of being lost in the process of stone fragmentation or retrieval.

The mean between-group difference in hemoglobin drop was 0.35 g/dL in favor of the balloon group. Transfusion was numerically less frequent with balloon dilatation (2.8% vs 9.3%). However, the inference for transfusion was sensitive to statistical method: Pearson chi-square $p = 0.045$, while two-sided Fisher exact $p = 0.082$. Accordingly, the study supports a lower mean hemoglobin drop with balloon dilatation but does not provide equally robust evidence for a reduction in transfusion. Fever and collecting-system injury were uncommon, and neither comparison showed a statistically significant difference.

Exploratory stratified analyses generally showed higher observed stone-clearance proportions in the single-step balloon group, although statistical significance varied across subgroups (Table 4). In the multivariable logistic model, single-step balloon dilatation remained associated with higher odds of stone clearance after adjustment for age, BMI, stone size, diabetes, and hypertension (adjusted OR 2.62, 95% CI 1.30-5.28; $p = 0.007$). Because allocation was non-random in this quasi-experimental study, this adjusted association should not be interpreted as proof of an independent causal effect.

DISCUSSION

This prospective quasi-experimental study found that single-step balloon dilatation was associated with shorter tract-creation time, shorter operative time, lower mean hemoglobin drop, shorter hospital stay, and higher observed stone clearance compared with serial metallic dilatation. Because allocation was not randomized, these findings should be interpreted as comparative associations rather than proof that the dilatation technique alone caused the observed differences. The transfusion comparison was additionally sensitive to the statistical test used and should not be presented as a definitive benefit. The shorter tract-creation time observed with balloon dilatation is consistent with literature showing faster access formation with single-step approaches. Memik et al. reported shorter access formation with fewer dilators compared with classical sequential dilation.⁴ Gupta et al. likewise reported shorter access-related procedural measures with one-step dilatation.⁷ Importantly, a Pakistani randomized study from The Kidney Centre, Karachi, by Saleem et al. compared one-step with metallic telescopic dilatation and also reported markedly shorter tract-creation time with one-step dilatation.¹⁰

Table 1. Baseline demographic and clinical characteristics (continuous variables: independent-samples t test; categorical variables: Pearson chi-square)

Variable	Single-step balloon (n=107)	Serial metallic (n=107)	p-value
Age (years), mean +/- SD	39.8 +/- 10.3	40.6 +/- 10.9	0.582
Male gender, n (%)	58 (54.2%)	55 (51.4%)	0.681
BMI (kg/m ²), mean +/- SD	26.2 +/- 3.8	26.7 +/- 4.1	0.356
Stone size (cm), mean +/- SD	2.83 +/- 0.52	2.88 +/- 0.55	0.495
Right-sided stone, n (%)	55 (51.4%)	57 (53.3%)	0.784
Hypertension, n (%)	28 (26.2%)	30 (28.0%)	0.758
Diabetes mellitus, n (%)	18 (16.8%)	20 (18.7%)	0.721

Table 2. Operative and postoperative quantitative outcomes

Outcome	Single-step balloon	Serial metallic	p-value
Tract creation time (min)	2.42 +/- 0.54	4.08 +/- 0.67	<0.001
Operative time (min)	88.9 +/- 18.6	97.4 +/- 20.9	0.002
Hemoglobin drop (g/dL)	1.08 +/- 0.39	1.43 +/- 0.46	<0.001
Hospital stay (days)	2.44 +/- 0.79	3.04 +/- 0.92	<0.001

Table 3. Categorical outcomes and complications. Stone clearance, transfusion, and postoperative fever: Pearson chi-square; collecting-system injury: two-sided Fisher exact. Fisher exact sensitivity p for transfusion=0.082.

Outcome	Single-step balloon n (%)	Serial metallic n (%)	p-value
Stone clearance	94 (87.9%)	78 (72.9%)	0.006
Blood transfusion	3 (2.8%)	10 (9.3%)	0.045
Postoperative fever	6 (5.6%)	8 (7.5%)	0.580
Collecting-system injury	2 (1.9%)	5 (4.7%)	0.445

Table 4. Exploratory stratified stone clearance. Pearson chi-square was used when all expected cell counts were >=5; two-sided Fisher exact was used for the diabetes-present stratum

Stratum	Balloon clearance n/N (%)	Metallic clearance n/N (%)	p-value
Age <=40 years	52/58 (89.7%)	44/59 (74.6%)	0.034
Age >40 years	42/49 (85.7%)	34/48 (70.8%)	0.075
Male	52/58 (89.7%)	41/55 (74.5%)	0.035
Female	42/49 (85.7%)	37/52 (71.2%)	0.076
BMI <30 kg/m ²	75/84 (89.3%)	61/82 (74.4%)	0.013
BMI >=30 kg/m ²	19/23 (82.6%)	17/25 (68.0%)	0.243
Stone size <=3 cm	70/76 (92.1%)	59/78 (75.6%)	0.006
Stone size >3 cm	24/31 (77.4%)	19/29 (65.5%)	0.307
Diabetes absent	79/89 (88.8%)	64/87 (73.6%)	0.010
Diabetes present	15/18 (83.3%)	14/20 (70.0%)	0.454

Table 5. Multivariable logistic regression for stone clearance (adjusted associations; quasi-experimental allocation does not establish causality)

Variable	Adjusted odds ratio	95% CI	p-value
Single-step balloon dilatation	2.62	1.30-5.28	0.007
Stone size >3 cm	0.49	0.24-0.99	0.046
BMI >=30 kg/m ²	0.71	0.31-1.62	0.417
Age >40 years	0.83	0.41-1.69	0.608
Diabetes mellitus	0.78	0.32-1.88	0.579
Hypertension	0.92	0.42-2.02	0.835

Operative time was also lower in the balloon group. This may reflect faster tract establishment and fewer dilator exchanges, although the quasi-experimental design cannot determine the mechanism. Ning et al. reported procedural advantages of one-shot approaches in a meta-analysis of tract-dilatation methods,¹¹ and Zhang et al. reported shorter tract-establishment and operative times with balloon versus non-balloon dilation in a systematic review and meta-analysis.¹³ Mean hemoglobin drop was lower in the balloon group. Bleeding during PCNL is multifactorial and may be influenced by tract number, puncture angle, stone burden, comorbidity, and access technique. Gokce et al. reported feasibility of one-shot dilatation in tubeless PCNL,¹² while Zhang et al. found lower hemoglobin decline and transfusion frequency in pooled balloon-versus-non-balloon comparisons.¹³ In the present study, the lower mean hemoglobin drop was statistically robust, whereas the transfusion result was borderline by Pearson chi-square and nonsignificant by Fisher exact sensitivity testing. Stone clearance was higher in the balloon group in this cohort; however, stone-free status is also influenced by stone size, location, calyceal anatomy, operator experience, and the postoperative imaging method. Wishahi et al. showed that stone-free rate can vary according to PCNL approach and stone burden in patients with 2-4 cm renal stones.⁸ The present adjusted model should therefore be interpreted as supportive of an association with access technique rather than proof of a causal effect.

Hospital stay was shorter in the balloon group. This difference may reflect multiple perioperative factors, including operative efficiency, bleeding, postoperative symptoms, and discharge practice. Yuan et al. described shorter recovery-related outcomes in enhanced-recovery pathways after PCNL.¹⁴ Because the present study did not evaluate a standardized enhanced-recovery protocol, the shorter stay should be reported as an observed outcome rather than attributed to a single mechanism. The complication profile showed a numerically lower transfusion frequency and fewer collecting-system injuries in the balloon group, with no significant difference in postoperative fever. The transfusion result was test-sensitive (Pearson $p=0.045$; Fisher exact $p=0.082$), and collecting-system injury was not significant by Fisher exact testing ($p=0.445$). Therefore, the data do not justify describing either method as harmless or claiming a definitive reduction in transfusion. Khwairakpam et al. reported that commonly used tract-dilatation approaches can both be used safely in experienced hands.⁹ Exploratory stratified analyses showed higher observed clearance proportions with balloon dilatation in several subgroups, but subgroup sample sizes were smaller and the analyses were not powered for interaction testing. These findings should therefore be considered hypothesis-generating. Evidence regarding PCNL outcomes in overweight or obese patients also suggests that stone burden and technical complexity can influence comparative

performance.¹⁵⁻²² Randomization is the most reliable method for reducing treatment-selection bias. In this quasi-experimental study, allocation was not fully randomized; device availability, surgeon preference, cost, or operating-room logistics may therefore have influenced treatment selection. Similar measured baseline characteristics and multivariable adjustment reduce, but do not eliminate, residual confounding. The adjusted association between balloon dilatation and stone clearance should consequently be interpreted cautiously and not as proof of independent causal superiority. Observed reductions in tract-creation time, total operative time, and hospital stay may have practical implications for high-volume public-sector urology services. However, this study did not perform a formal cost-effectiveness analysis, so economic benefits should not be inferred from procedure time or length of stay alone. Device cost, operating-room utilization, fluoroscopy exposure, complication management, and local procurement should be evaluated prospectively before drawing cost conclusions.

The findings may also be relevant to procedural standardization and training because single-step balloon dilatation requires fewer sequential exchanges. Nevertheless, fewer steps do not mean absence of technical risk: improper puncture, wire displacement, excessive force, poor calyceal selection, or inadequate imaging can still result in bleeding or collecting-system injury. Training implications were not directly measured in this study and should therefore remain interpretive rather than outcome claims. Patient selection remains important. This study excluded staghorn calculi, active infection, coagulopathy, major renal anatomical abnormalities, chronic renal failure, and chronic liver disease, limiting generalizability to more complex patients. Stone burden, multiple tracts, miniaturized systems, obesity, and institutional experience may alter comparative outcomes. A systematic review in overweight or obese patients illustrates that stone complexity and procedural approach can materially influence PCNL outcomes.²² Future local studies should incorporate fluoroscopy time, standardized complication grading, CT-based stone-free assessment, patient-reported outcomes, and formal cost-effectiveness analysis.

Limitations: This was a single-center prospective quasi-experimental study with non-random treatment allocation, so selection bias and residual confounding cannot be excluded despite similar measured baseline characteristics and adjusted analysis. Postoperative stone clearance was assessed by ultrasonography at 24 hours rather than non-contrast CT, which may miss small residual fragments. Fluoroscopy time, procedure cost, pain, standardized Clavien-Dindo complication grading, and longer-term outcomes were not measured. Some categorical outcomes were infrequent; in particular, the transfusion inference was sensitive to the statistical test used. Subgroup analyses were exploratory and not powered for interaction testing. These limitations require cautious interpretation of comparative efficacy and

safety findings. In spite of these restrictions, the results have a clinical implication. Access time, bleeding and hospital stay can be minimized in a high-volume urology department in order to enhance patient safety and efficiency of service. Single-step balloon dilatation can be used in particular patients whose patients have 2-4 cm sized renal stones, normal coagulation status, and an absence of active infection. Favored where cost considerations outweigh especially in the hands of the experienced, is the use of metallic dilatation. The selection of the dilatation method must thus be tailor made with regard to clinical utility, resources, expertise of the surgeon and cost system of the institution.

CONCLUSION

Single-step balloon dilatation during PCNL was associated with shorter tract-creation time, shorter operative time, lower mean hemoglobin drop, shorter hospital stay, and higher observed stone clearance compared with serial metallic dilatation in this cohort. The evidence for a lower transfusion frequency was less robust because significance depended on the categorical test used, while fever and collecting-system injury did not differ significantly. Because this was a quasi-experimental, non-randomized comparison, residual selection bias and confounding cannot be excluded. Single-step balloon dilatation may be a useful access option in appropriately selected patients, but the present data do not establish categorical superiority or harmlessness.

Conflict of Interest: None

Fundings: No funding source

Use of Artificial Intelligence (AI) Disclosure: There is no AI tool used.

Authors Contribution:

Muhammad Akram: Conception and Design, Acquisition of data, analysis and interpretation of data

Mumtaz Rasool: Drafting and critical revision, final approval of the version to be published

Muhammad Amjad: Acquisition of data, analysis and interpretation of data

REFERENCES

- Peerapen P, Thongboonkerd V. Kidney stone prevention. *Adv Nutr.* 2023;14(3):555-569. doi:10.1016/j.advnut.2023.03.005.
- Skolarikos A, Neisius A, Petøik A, Somani B, Thomas K, Gambaro G, et al. European Association of Urology Guidelines on the Diagnosis and Treatment of Urolithiasis. *Eur Urol.* 2025;88(1):64-75. doi:10.1016/j.eururo.2025.03.011.
- Geraghty RM, Davis NF, Tzelvels 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.* 2023;9(1):199-208. doi:10.1016/j.euf.2022.06.014.
- Memik O, Voyvoda B, Ustuner M, Karsli O, Halat AO, Ozcan L. What is the safe and effective dilator number during access in PCNL? Three-shot dilation versus classical sequential Amplatz dilation. *BMC Urol.* 2023;23:197. doi:10.1186/s12894-023-01368-6.
- Mohyelden K, Abdel-Rassoul M, Dogha M, Kadry A, Mostafa A. One-shot dilatation vs metal dilator during percutaneous nephrolithotomy in flank-free supine position: a randomized controlled study. *J Endourol.* 2022;36(6):727-733. doi:10.1089/end.2021.0378.
- Özbilen MH, Ergani B, Çetin T, Yalçın MY, Bildirici Ç, Karaca E, et al. Comparison of safety and efficacy of one shot dilation vs. gradual dilation technique in supine percutaneous nephrolithotomy. *World J Urol.* 2023;41(6):1659-1666. doi:10.1007/s00345-023-04393-0.
- Gupta NK, Huda NA, Pal DK. A comparative study between one step dilatation and serial dilatation technique in percutaneous nephrolithotomy. *Urologia.* 2024;91(2):332-336. doi:10.1177/03915603231202839.
- Wishahi M, El Feel A, Elkhoully A, Fahmy A, Roshdy M, Elbaz AG, et al. Concerns about stone free rate and procedure events of percutaneous nephrolithotripsy for 2-4 cm kidney stones by standard-PCNL versus mini-PCNL: comparative randomised study. *BMC Urol.* 2023;23:96. doi:10.1186/s12894-023-01270-1.
- Khwairakpam A, Singh S, Sharan P, Adhikari A, Mehra DS, Yadav S. A comparison of the Alken metallic telescopic dilator and Amplatz serial dilator for renal access in percutaneous nephrolithotomy. *Cureus.* 2024;16(10):e72509. doi:10.7759/cureus.72509.
- Saleem M, Fareed W, Akbar HM, Idrees M, El Khalid S, Siddiqui SH. Comparison of outcomes of one step dilatation versus metallic telescopic dilatation in percutaneous nephrolithotomy. *J Popul Ther Clin Pharmacol.* 2024;31(6):2620-2627. doi:10.53555/jptcp.v31i6.6996.
- Ning Y, Zhu W, Chen H, Xiong Y, Li H, Li L, et al. Effectiveness and safety of four tract dilation methods of percutaneous nephrolithotomy: a meta-analysis. *Exp Ther Med.* 2020;19(4):2661-2671. doi:10.3892/etm.2020.8486.
- Gökce MI, Ibis MA, Suer E, Gulpinar O, Bedir S, Akdogan B. The feasibility and safety of one-shot dilatation compared to conventional sequential dilatation in tubeless percutaneous nephrolithotomy: a prospective randomized controlled study. *Urolithiasis.* 2023;51(1):5. doi:10.1007/s00240-022-01383-6.
- Zhang Y, Yang Z, Tang Y, Wang J, Liu C, Wang Y, et al. Comparing balloon dilation to non-balloon dilation for access in ultrasound-guided percutaneous nephrolithotomy: a systematic review and meta-analysis. *Int Braz J Urol.* 2024;50(3):296-309. doi:10.1590/S1677-5538.IBJU.2023.0407.
- Yuan P, Cao Y, Wang J, Chen Y, Wu W, Li X, et al. Safety and efficacy of enhanced recovery after surgery among patients undergoing percutaneous nephrolithotomy: a systematic review and meta-analysis. *Int J Surg.* 2024;110(6):3768-3777. doi:10.1097/JS9.0000000000001158.
- Chen Y, Wang X, Gao X, Liu C, Li Z, Zhang Z, et al. Comparison of safety and efficacy of different positions in percutaneous nephrolithotomy: a network meta-analysis. *Int Urol Nephrol.* 2024;56(8):2411-2420. doi:10.1007/s11255-024-03937-3.
- Huang X, Liu S, Wu G, Wu J, Zhang Y, Wei W, et al. Postoperative antibiotic prophylaxis for percutaneous nephrolithotomy and risk of infection: a systematic review and meta-analysis. *Int Braz J Urol.* 2024;50(2):152-163. doi:10.1590/S1677-5538.IBJU.2023.0265.

17. Rudnick B, Bundschuh P, Thiele S, Netsch C, Bach T, Gross AJ, et al. Percutaneous nephrolithotomy vs retrograde intrarenal surgery for renal stones: a Cochrane Review. *BJU Int.* 2024;133(2):132-140. doi:10.1111/bju.16220.
18. Zeng G, Zhong W, Pearle M, Preminger G, Monga M, Hajdinjak T, et al. An update on miniaturized percutaneous nephrolithotomy: indications, technique and outcomes. *Asian J Urol.* 2021;8(4):342-350. doi:10.1016/j.ajur.2021.02.003.
19. Aldoukhi AH, Roberts WW, Hall TL, Ghani KR. Percutaneous nephrolithotomy with suction: is this the future? *Curr Opin Urol.* 2021;31(2):138-143. doi:10.1097/MOU.0000000000000854.
20. Mousawi SA, Guzel R, Zaid M, Eryildirim B, Sarica K. Mini-percutaneous nephrolithotomy in the management of large and complex renal calculi in children: how effective is it? *J Endourol.* 2023;37(5):497-504. doi:10.1089/end.2022.0508.
21. Cindolo L, Castellan P, Scoffone CM, Cracco CM, Celia A, Bassi PF, et al. Evaluation of flexible ureteroscopy versus percutaneous nephrolithotomy in renal stones: contemporary evidence and clinical implications. *Minerva Urol Nephrol.* 2022;74(4):392-405. doi:10.23736/S2724-6051.22.04759-5.
22. Ding T, Xu R, Li Y, Ma X, Li X, Zhou X, et al. Comparison of mini-percutaneous nephrolithotomy versus retrograde intrarenal surgery for kidney stones in overweight or obese patients: a systematic review and meta-analysis. *BMC Urol.* 2024;24:233. doi:10.1186/s12894-024-01588-4.