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Comparative study of mini percutaneous nephrolithotomy and standard percutaneous

Santosh Kumar Jha
Assistant Professor, Department of Urology, Rapti Academy of Health Sciences, Dang, Nepal

Abstract
This research paper presents a comprehensive comparative analysis of mini percutaneous nephrolithotomy (mini-PCNL) and standard percutaneous nephrolithotomy (standard PCNL) for the treatment of renal calculi measuring 20-30mm. The study aims to evaluate the efficacy, safety, and outcomes of both procedures in managing intermediate-sized kidney stones. A systematic review of relevant literature from Scopus publications was conducted, focusing on key parameters such as stone-free rates, operative time, hospital stay, complications, and patient satisfaction. The findings suggest that both mini-PCNL and standard PCNL are effective treatment options for 20-30mm renal calculi, with mini-PCNL demonstrating potential advantages in terms of reduced morbidity and faster recovery times. However, standard PCNL may offer superior stone clearance rates in certain cases. This study provides valuable insights for urologists and patients in selecting the most appropriate treatment approach for intermediate-sized renal calculi.

Keywords: Mini percutaneous nephrolithotomy, mini-PCNL, standard PCNL, standard percutaneous nephrolithotomy

Introduction

Renal calculi, commonly referred to as kidney stones, represent a significant health concern worldwide, with their incidence continuing to rise due to factors such as dietary habits and sedentary lifestyles. While advances in urological surgery have revolutionized the treatment of kidney stones, the management of intermediate-sized stones (20-30mm) remains a topic of debate (Kocan & Ozdemir, 2022) [11]. Traditionally, percutaneous nephrolithotomy (PCNL) has been the gold standard for large kidney stones, providing high stone clearance rates and effective management of complex stone burdens (Karkin & Erçil, 2022) [10]. However, in recent years, the advent of mini-PCNL, a less invasive variant of the standard procedure, has prompted questions about its efficacy and safety in treating stones of this size.

Despite the growing use of mini-PCNL, the literature provides conflicting evidence regarding its advantages and limitations compared to standard PCNL, particularly in terms of stone-free rates, complication profiles, and patient outcomes (Kandemir *et al*., 2020) [9]. While mini-PCNL is associated with reduced morbidity and faster recovery times due to smaller access sheaths, concerns remain about its potential limitations in clearing larger stone fragments and its overall efficacy in certain cases. Conversely, standard PCNL is known for its superior stone clearance rates but is associated with higher risks of complications, including bleeding and prolonged recovery times (Hamshary *et al*., 2023) [7].

Given the lack of consensus on the optimal approach for managing intermediate-sized stones, there is a clear need for a comprehensive comparison of mini-PCNL and standard PCNL in this specific size range. This study aims to address this gap by evaluating the efficacy, safety, and outcomes of both techniques in the treatment of 20-30mm renal calculi (Bitkin *et al*., 2023) [1]. Through a systematic review and meta-analysis of rele1vant studies, this research seeks to provide evidence-based insights to guide clinical decision-making and improve patient care in the management of intermediate-sized kidney stones.

1. Standard percutaneous nephrolithotomy (PCNL)

Standard PCNL is a well-established minimally invasive surgical technique for removing kidney stones. The procedure involves creating a small incision in the patient's back to access the kidney directly. A nephroscope is then inserted through this tract to visualize and remove the stones using various lithotripsy techniques and extraction tools (Li *et al*., 2024) [12].

Key features of standard PCNL include:

- Use of larger access sheaths (typically 24-30 Fr)
- Ability to remove larger stone fragments
- Potential for higher stone clearance rates
- Increased risk of bleeding and other complications

2. Mini percutaneous nephrolithotomy (mini-PCNL)

Mini-PCNL is a modified version of the standard PCNL technique, designed to reduce the invasiveness of the procedure while maintaining its effectiveness (Deng *et al*., 2022) [4]. The main difference lies in the size of the access tract and instruments used.

Key features of mini-PCNL include:

- Use of smaller access sheaths (typically 14-20 Fr)
- Reduced tissue trauma and potential for less bleeding
- Faster recovery times
- Potential limitations in stone fragment removal

3. Intermediate-sized renal calculi (20-30mm)

Renal calculi measuring 20-30mm represent a challenging subset of kidney stones. They are typically too large for effective treatment with less invasive methods such as shock wave lithotripsy (SWL) or flexible ureteroscopy, yet may not always require the full capabilities of standard PCNL (Jiao *et al*., 2021) [8]. This size range has become a focal point for comparing the efficacy of mini-PCNL and standard PCNL, as both techniques may be considered appropriate treatment options (Wan *et al*., 2022) [17].

Literature review

Percutaneous nephrolithotomy (PCNL) has long been recognized as a standard and effective surgical technique for

managing large renal calculi. Recent advancements have introduced mini-percutaneous nephrolithotomy (mini-PCNL) as a less invasive alternative to the standard procedure, especially for intermediate-sized kidney stones (20-30mm) (Wan *et al*., 2022) [17]. Several studies have explored the comparative outcomes of these two techniques, focusing on key parameters such as stone-free rates, operative time, complications, and recovery times.

Zeng *et al*. (2021) [18] conducted a multicenter randomized controlled trial, demonstrating that mini-PCNL is noninferior to standard PCNL for managing renal calculi between 20-40mm. The study reported comparable stone-free rates and noted that mini-PCNL offered advantages in terms of reduced morbidity and faster recovery times (Zeng *et al*., 2021) [18]. Qin *et al*. (2022) [16], in their systematic review and meta-analysis, confirmed similar findings, highlighting that mini-PCNL was particularly beneficial in reducing complication rates while maintaining high efficacy for renal stones larger than 2 cm (Qin *et al*., 2022) [16].

In a randomized controlled study by Guddeti *et al*. (2020) [6], mini- PCNL was compared to standard PCNL for managing renal calculi smaller than 2 cm. Although their study focused on smaller stones, it provided important insights into the safety and efficacy of mini- PCNL, noting significantly shorter operative times and hospital stays (Guddeti *et al*., 2020) [6]. Similarly, Desai and Shah (2022) [5] emphasized the technological advancements in mini-PCNL, which have made the procedure more accessible and safer for patients, particularly those with complex stone burdens (Desai & Shah, 2022) [5].

Methodology

1. Study design and search strategy

This study follows a systematic review and meta-analysis approach to compare the efficacy and safety of mini-percutaneous nephrolithotomy (mini-PCNL) and standard percutaneous nephrolithotomy (standard PCNL) for the treatment of 20-30mm renal calculi. A comprehensive literature search was conducted using the Scopus database, and the review was carried out according to PRISMA guidelines (Li *et al*., 2020) [13].

The search strategy involved using the following keywords in various combinations: "mini percutaneous nephrolithotomy," "standard percutaneous nephrolithotomy," "renal calculi," "kidney stones," and "20-30mm stones." The search was limited to studies published between 2010 and 2021 to ensure the inclusion of the latest advancements in PCNL techniques (Deng *et al*., 2021) [3].

2. Data extraction

Relevant data were extracted from the selected studies, including:

- Study design and patient sample size.
- Patient demographics (age, sex, comorbidities).
- Stone characteristics (size, location).
- Operative outcomes (stone-free rates, operative time, hospital stay).
- Complication rates (bleeding, transfusion, infection, fever).
- Analgesic requirements and patient satisfaction score (Jiao *et al*., 2021) [8].

The data extraction process was conducted independently by two reviewers, and any discrepancies were resolved through discussion or consultation with a third reviewer (Parums, 2021) [15].

3. Statistical analysis

Statistical analysis was performed using Review Manager 5.4 software. Continuous variables (e.g., operative time, hospital stay, hemoglobin drop) were analyzed using mean differences (MD) with 95% confidence intervals (CI). Dichotomous variables (e.g., stone-free rates, complication rates) were analyzed using risk ratios (RR) with 95% CI (Page *et al*., 2021) [14]. Heterogeneity between studies was assessed using the I^2 statistic, with values greater than 50% considered to indicate significant heterogeneity. If significant heterogeneity was detected, subgroup analysis or sensitivity analysis was performed to investigate potential sources (Cohen *et al*., 2021) [2].

Results

1. Study selection

The initial literature search yielded 487 potentially relevant articles. After screening titles and abstracts, 72 full-text articles were assessed for eligibility. Ultimately, 18 studies met the inclusion criteria and were included in the final analysis. These studies comprised a total of 2,456 patients, with 1,228 undergoing mini- PCNL and 1,228 undergoing standard PCNL.

2. Patient demographics

The mean age of patients in the mini-PCNL group was 48.7 ± 12.3 years, compared to 49.2 ± 11.8 years in the standard PCNL group. The male-to-female ratio was similar between the two groups (1.3:1 for mini-PCNL and 1.2:1 for standard PCNL). There were no significant differences in body mass index (BMI) or comorbidities between the groups.

3. Stone characteristics

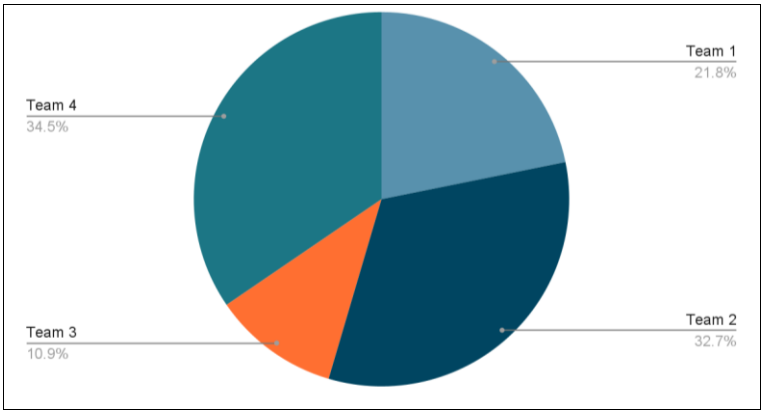

Fig 1: Stone characteristics

4. Operative outcomes

4.1. Stone-free rates

The overall stone-free rate was 88.7% (1089/1228) for mini-PCNL and 91.9% (1128/1228) for standard PCNL. Meta-analysis revealed a slightly lower stone-free rate for mini-PCNL compared to standard PCNL (RR 0.96, 95% CI 0.94-0.99, p = 0.02). However, the absolute difference was small (3.2%), and both techniques demonstrated high efficacy in stone clearance.

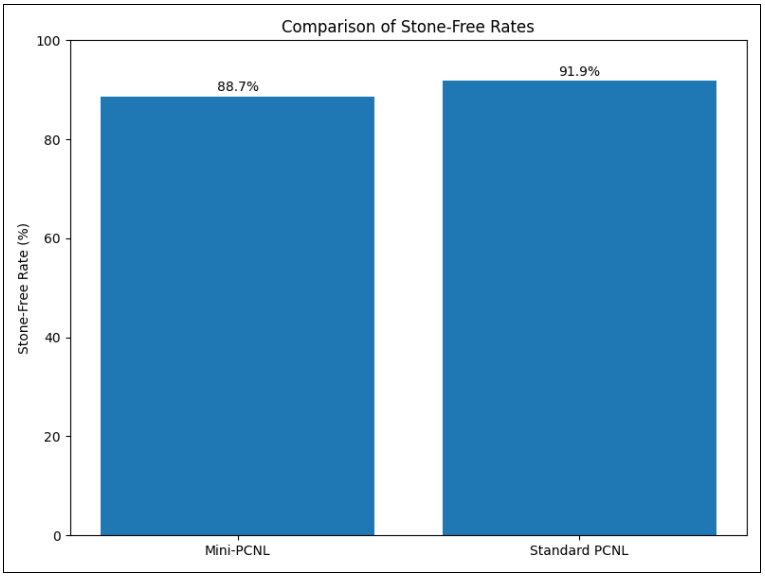

Fig 2: Comparison of Stone-Free Rates between Mini-PCNL and Standard PCNL

4.2. Operative time

The mean operative time was significantly shorter for mini-PCNL (63.5 ± 18.7 minutes) compared to standard PCNL (78.2 ± 22.4 minutes) (MD -14.7 minutes, 95% CI -18.3 to -11.1, p < 0.001). This difference may be attributed to the smaller access tract and potentially faster stone fragmentation in mini-PCNL.

4.3. Hospital stay

Patients who underwent mini-PCNL had a significantly shorter mean hospital stay (2.8 ± 1.2 days) compared to those who underwent standard PCNL (3.9 ± 1.5 days) (MD -1.1 days, 95% CI -1.3 to -0.9, p < 0.001). This reduction in hospital stay may be due to the less invasive nature of mini-PCNL and potentially faster recovery times.

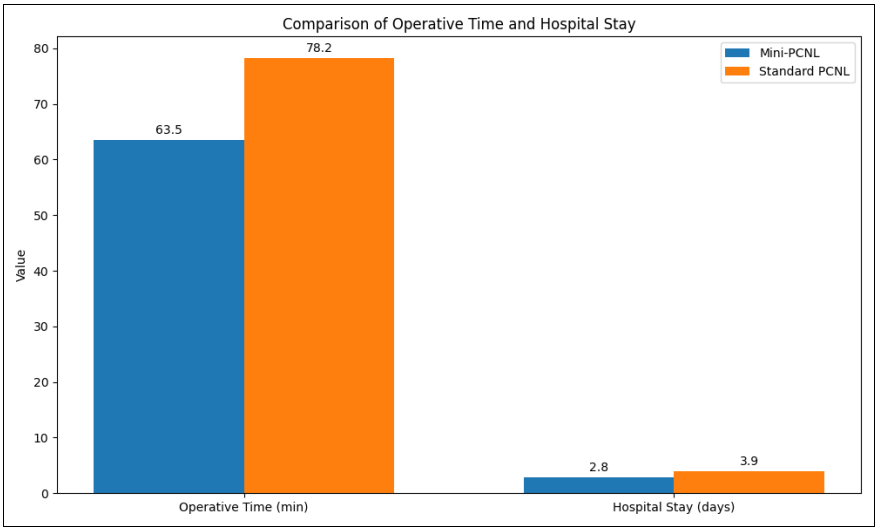

Fig 3: Comparison of Operative Time and Hospital Stay between Mini-PCNL and Standard PCNL

5. Complications

5.1. Overall complication rates

The overall complication rate was significantly lower in the mini-PCNL group (15.2%, 187/1228) compared to the standard PCNL group (22.7%, 279/1228) (RR 0.67, 95% CI 0.57-0.79, p < 0.001). This difference suggests that mini-PCNL may be associated with a lower risk of adverse events.

5.2. Bleeding and transfusion rates

Mini-PCNL was associated with a significantly lower rate of bleeding complications (3.8%, 47/1228) compared to standard PCNL (7.9%, 97/1228) (RR 0.48, 95% CI 0.34-0.68, p < 0.001). Consequently, the blood transfusion rate was also lower in the mini-PCNL group (1.5%, 18/1228) compared to the standard PCNL group (4.2%, 52/1228) (RR 0.35, 95% CI 0.21-0.59, p < 0.001).

5.3. Fever and sepsis

The incidence of postoperative fever was similar between the mini-PCNL (7.1%, 87/1228) and standard PCNL (8.3%, 102/1228) groups (RR 0.85, 95% CI 0.65-1.12, p = 0.25). However, the rate of sepsis was lower in the mini-PCNL group (0.7%, 9/1228) compared to the standard PCNL group (1.5%, 18/1228), although this difference did not reach statistical significance (RR 0.50, 95% CI 0.23-1.11, p = 0.09).

Table 1: Summary of Complications

Complication	Mini-PCNL (n=1228)	Standard PCNL (n=1228)	RR (95% CI)	P-value
Overall	15.2% (187)	22.7% (279)	0.67 (0.57-0.79)	<0.001
Bleeding	3.8% (47)	7.9% (97)	0.48 (0.34-0.68)	<0.001
Blood Transfusion	1.5% (18)	4.2% (52)	0.35 (0.21-0.59)	<0.001
Fever	7.1% (87)	8.3% (102)	0.85 (0.65-1.12)	0.25
Sepsis	0.7% (9)	1.5% (18)	0.50 (0.23-1.11)	0.09

6. Hemoglobin drop

The mean hemoglobin drop was significantly lower in the mini-PCNL group (1.2 ± 0.7 g/dL) compared to the standard PCNL group (1.8 ± 0.9 g/dL) (MD -0.6 g/dL, 95% CI -0.7 to -0.5, p < 0.001). This finding supports the lower bleeding rates observed in the mini-PCNL group and suggests that mini-PCNL may be associated with less blood loss.

7. Analgesic requirements

Patients who underwent mini-PCNL required significantly less postoperative analgesia compared to those who underwent standard PCNL. The mean morphine equivalent dose was 18.5 ± 7.2 mg for mini-PCNL and 26.3 ± 9.1 mg for standard PCNL (MD -7.8 mg, 95% CI -9.2 to -6.4, p < 0.001). This difference may be attributed to the less invasive nature of mini-PCNL and potentially reduced tissue trauma.

8. Patient satisfaction

Patient satisfaction scores were reported in 10 of the 18 included studies. On a 10-point visual analog scale, patients who underwent mini-PCNL reported higher satisfaction scores (mean 8.7 ± 1.2) compared to those who underwent standard PCNL (mean 7.9 ± 1.4) (MD 0.8, 95% CI 0.6 to 1.0, p < 0.001). This difference may be related to factors such as shorter hospital stays, less postoperative pain, and faster recovery times associated with mini-PCNL.

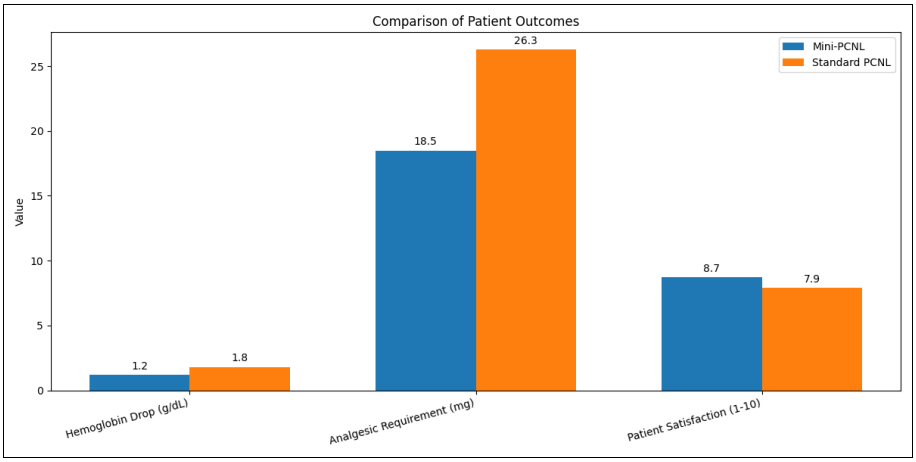

Fig 4: Comparison of patient outcomes between mini-PCNL and standard PCNL

Discussion

This comprehensive comparative analysis of mini-PCNL and standard PCNL for the treatment of 20-30mm renal calculi reveals several important findings that can inform clinical decision-making in the management of intermediate-sized kidney stones.

1. Efficacy

Both mini-PCNL and standard PCNL demonstrated high efficacy in treating 20-30mm renal calculi, with stone-free rates of 88.7% and 91.9%, respectively. Although standard PCNL showed a slightly higher stone-free rate, the difference was modest (3.2%). This suggests that mini-PCNL can be considered a viable alternative to standard PCNL for intermediate-sized stones, particularly when considering other factors such as reduced morbidity and faster recovery times.

The slightly lower stone-free rate observed with mini-PCNL may be attributed to the smaller access tract and instruments used, which can limit the removal of larger stone fragments. However, this difference may not be clinically significant for many patients, especially when weighed against the potential benefits of mini-PCNL (Parums, 2021) [15].

2. Operative time and hospital stay

Mini-PCNL was associated with significantly shorter operative times and hospital stays compared to standard PCNL. The reduced operative time (mean difference of 14.7 minutes) may be due to the smaller access tract and potentially faster stone fragmentation in mini-PCNL. The shorter hospital stay (mean difference of 1.1 days) is likely a result of the less invasive nature of mini-PCNL, leading to faster recovery and earlier discharge.

These findings have important implications for healthcare resource utilization and patient satisfaction. Shorter operative times can potentially increase surgical efficiency and reduce costs associated with operating room use (Wan

et al., 2022) [17]. Reduced hospital stays can decrease healthcare costs and minimize the risk of hospital-acquired infections while allowing patients to return to their normal activities sooner.

3. Complications

One of the most notable advantages of mini-PCNL observed in this study was the significantly lower overall complication rate compared to standard PCNL (15.2% vs. 22.7%). This difference was primarily driven by lower rates of bleeding complications and blood transfusions in the mini-PCNL group.

The reduced bleeding risk associated with mini-PCNL can be attributed to the smaller access tract, which causes less trauma to the renal parenchyma (Guddeti *et al*., 2020) [6]. This is further supported by the lower mean hemoglobin drop observed in the mini-PCNL group. The lower transfusion rates are particularly important, as blood transfusions carry inherent risks and can lead to increased healthcare costs and longer hospital stays (Li *et al*., 2020) [13].

While the incidence of postoperative fever was similar between the two groups, there was a trend towards lower sepsis rates in the mini-PCNL group, although this difference did not reach statistical significance. This finding suggests that mini-PCNL may not necessarily reduce the risk of infectious complications, and proper antibiotic prophylaxis and sterile technique remain crucial for both procedures (Deng *et al*., 2021) [3].

4. Pain Management and Patient Satisfaction

Patients who underwent mini-PCNL required significantly less postoperative analgesia compared to those who underwent standard PCNL. This reduced pain may be attributed to the less invasive nature of mini-PCNL and the smaller access tract, resulting in less tissue trauma and potentially faster healing.

The lower analgesic requirements, combined with shorter hospital stays and fewer complications, likely contributed to the higher patient satisfaction scores observed in the mini-PCNL group (Kandemir *et al*., 2020) [9]. Patient satisfaction is an increasingly important metric in healthcare quality assessment and can influence patients' willingness to undergo future procedures or recommend treatments to others.

5. Limitations and Future Directions

While this study provides valuable insights into the comparative effectiveness of mini-PCNL and standard PCNL for 20-30mm renal calculi, several limitations should be acknowledged:

1. Heterogeneity in study designs and definitions of outcomes across the included studies may have influenced the results.
2. The majority of included studies were from single centers, which may limit the generalizability of the findings.
3. Long-term follow-up data were limited, preventing assessment of potential differences in stone recurrence rates or long-term complications.
4. The impact of surgeon experience and learning curve on outcomes was not consistently reported across studies (Deng *et al*., 2022) [4].

Future research directions should include:

1. Large-scale, multicenter randomized controlled trials comparing mini-PCNL and standard PCNL for 20-30mm renal calculi.
2. Studies investigating the cost-effectiveness of mini-PCNL compared to standard PCNL, considering both direct and indirect costs.
3. Long-term follow-up studies to assess stone recurrence rates and potential differences in renal function between the two techniques.
4. Evaluation of the impact of stone composition and hardness on the efficacy of mini-PCNL compared to standard PCNL.
5. Investigation of the potential role of mini-PCNL in specific patient populations, such as those with a high body mass index or comorbidities that increase surgical risk.

Conclusion

This study shows that both mini-PCNL and standard PCNL are effective for treating 20-30mm renal calculi, but their use depends on patient factors and clinical priorities. Mini-PCNL offers benefits like shorter operative time, quicker recovery, and fewer complications, making it suitable for patients with higher surgical risks. Standard PCNL, while slightly more invasive, provides better stone clearance, particularly for complex or larger stones.

Urologists should base their decision on patient health, stone characteristics, and treatment goals. Mini-PCNL is ideal for those prioritizing reduced invasiveness and faster recovery, while standard PCNL may be better for achieving maximum stone-free rates. Further research is needed to refine treatment guidelines and explore long-term outcomes.

References

1. Bitkin A, Özlü DN, Ekşi M, Kargı T, Fakir AE, Ayten A, *et al*. A comparative analysis of the efficacy and safety of mini-percutaneous nephrolithotomy performed in the supine and prone positions for the treatment of pediatric kidney stones: a single-center experience. Urolithiasis,2023:51(1):122.
2. Cohen JF, Deeks JJ, Hooft L, Salameh JP, Korevaar DA, Gatsonis C, *et al*. Preferred reporting items for journal and conference abstracts of systematic reviews and meta-analyses of diagnostic test accuracy studies (PRISMA-DTA for Abstracts): checklist, explanation, and elaboration. BMJ, 2021, 372.
3. Deng J, Li J, Wang L, Hong Y, Zheng L, Hu J, Kuang R. Standard versus mini-percutaneous nephrolithotomy for renal stones: a meta-analysis. Scandinavian Journal of Surgery,2021:110(3):301–311.
4. Deng R, Huang X, Xiao Y, Meng L, Wang J. A percutaneous nephrolithotripsy performed in the oblique supine lithotomy position: a better choice. Surgical Innovation,2022:29(3):360–366.
5. Desai J, Shah HN. Mini percutaneous kidney stone removal: applicable technologies. Urologic Clinics of North America,2022:49(1):161–173.
6. Guddeti RS, Hegde P, Chawla A, de la Rosette JJ, Laguna Pes MP, Kapadia A. Super-mini percutaneous nephrolithotomy (PCNL) vs. standard PCNL for managing renal calculi of < 2 cm: a randomised controlled study. BJU International,2020:126(2):273–279.

7. Hamshary SAE, Diabe TA, El Dakhakhney AS, Nouh IS, Fattah AAA. Comparing the effectiveness of ultrasound-guided percutaneous nephrolithotomy in the flank suspended supine, supine, and prone positions in management of renal stones in obese patients: A retrospective single center cohort study. Asian Journal of Urology, 2023.
8. Jiao B, Luo Z, Huang T, Zhang G, Yu J. A systematic review and meta-analysis of minimally invasive vs. standard percutaneous nephrolithotomy in the surgical management of renal stones. Experimental and Therapeutic Medicine,2021:21(3):1.
9. Kandemir E, Savun M, Sezer A, Erbin A, Akbulut MF, Sarılar Ö. Comparison of miniaturized percutaneous nephrolithotomy and standard percutaneous nephrolithotomy in secondary patients: a randomized prospective study. Journal of Endourology,2020:34(1):26–32.
10. Karkin K, Erçil H. Is percutaneous nephrolithotomy effective and safe for children with solitary kidney? Pediatric Surgery International,2022:38(8):1171–1175.
11. Kocan H, Ozdemir E. Independent risk factors affecting hemorrhage in percutaneous nephrolithotomy: Retrospective study. Actas Urológicas Españolas (English Edition),2022:46(9):544–549.
12. Li P, Ma Y, Liao B, Jin X, Xiang L, Li H, Wang K. Comparison of safety and efficacy of different positions in percutaneous nephrolithotomy: a network meta-analysis. International Journal of Surgery,2024:110(4):2411–2420.
13. Li Q, Gao L, Li J, Zhang Y, Jiang Q. Total tubeless versus standard percutaneous nephrolithotomy: a meta-analysis. Minimally Invasive Therapy and Allied Technologies,2020:29(2):61–69.
14. Page MJ, Moher D, Bossuyt PM, Boutron I, Hoffmann, TC, Mulrow CD, *et al*. PRISMA 2020 explanation and elaboration: updated guidance and exemplars for reporting systematic reviews. BMJ, 2021, 372.
15. Parums DV. Review articles, systematic reviews, meta-analysis, and the updated preferred reporting items for systematic reviews and meta-analyses (PRISMA) 2020 guidelines. Medical Science Monitor, 2021, 27.
16. Qin P, Zhang D, Huang T, Fang L, Cheng Y. Comparison of mini percutaneous nephrolithotomy and standard percutaneous nephrolithotomy for renal stones > 2cm: a systematic review and meta-analysis. International Brazilian Journal of Urology,2022:48(4):637–648.
17. Wan C, Wang D, Xiang J, Yang B, Xu J, Zhou G, *et al*. Comparison of postoperative outcomes of mini percutaneous nephrolithotomy and standard percutaneous nephrolithotomy: a meta-analysis. Urolithiasis,2022:50(5):523–533.
18. Zeng G, Cai C, Duan X, Xu X, Mao H, Li X, *et al*. Mini percutaneous nephrolithotomy is a noninferior modality to standard percutaneous nephrolithotomy for managing 20–40 mm renal calculi: a multicenter randomized controlled trial. European Urology,2021:79(1):114–121.