OPEN ACCESS

ORIGINAL ARTICLE *Volume 14 (Issue 4), 2025*

PAKISTAN JOURNAL OF MEDICINE & DENTISTRY

Efficacy Between Percutaneous Nephrolithotomy and Retrograde Intrarenal Surgery for Renal Stones

Aziz Ul Wahab[1], Irshad Khan[1], Sami Ul Haq[1], Ghufran Ullah[1]

[1]*Department of Urology, Timergara Teaching Hospital, Dir Lower, Khyber Pakhtunkhwa, Pakistan.*

ABSTRACT

Background: Renal stones between 2 and 3.5 cm in size present a clinical challenge, and the choice between Percutaneous Nephrolithotomy (PCNL) and Retrograde Intrarenal Surgery (RIRS) remains debated. This study compared PCNL and RIRS in terms of stone-free rate (SFR), complications, hospital stay, blood loss, repeat procedures, and patient satisfaction.

Methods: A prospective randomized trial was conducted at the CMH Nephrology and Urology Department, Peshawar, from June to December 2024. A total of 150 patients with single renal stones measuring 2–3.5 cm was enrolled and randomly assigned to PCNL (n = 75) or RIRS (n = 75). Preoperative imaging confirmed the stone size. Outcomes assessed included SFR, length of hospital stay, perioperative blood loss, postoperative complications (fever, infection, stent-related symptoms), need for additional procedures, and patient satisfaction on a 10-point scale The study would use the Chi-Square Test for categorical data, the independent t-test for continuous data, and the Mann-Whitney U Test for non-normally distributed data. The Fisher's Exact Test may be used for small sample sizes, and the Paired t-test or Wilcoxon Signed-Rank Test for repeated measures. Linear Regression could assess multiple factors. Statistical significance is set at $p \leq 0.05$.

Results: PCNL achieved a significantly higher SFR (95%) compared to RIRS (82%). Hospital stay was significantly shorter with RIRS (1.56 ± 0.4 days) than PCNL (6.5 ± 1.2 days). Postoperative infection was more common with RIRS (44% vs. 2.7%), whereas intraoperative blood loss was greater with PCNL (12% vs. 4%), although transfusion requirements were low in both groups. RIRS required more repeat procedures (44%) compared to PCNL (2.7%). Patient satisfaction was higher in the PCNL group (94.7%) than in the RIRS group (77.3%).

Conclusion: Both PCNL and RIRS are effective for treating renal stones 2–3.5 cm in size, but PCNL offers superior stone clearance and higher patient satisfaction, albeit with a longer hospital stay and slightly greater blood loss. RIRS remains a less invasive option but carries a higher risk of infection and frequently requires additional sessions for complete clearance. Selection of treatment should be individualized, considering patient factors, stone characteristics, and procedural risks.

Keywords: Renal Stones, Ureteroscopy, Percutaneous Nephrolithotomy.

***Corresponding Author:** Aziz Ul Wahab,
Email: azizulwahab94@gmail.com

How to cite: Wahab AU, Khan I, Haq SU, Ullah G. Efficacy Between Percutaneous Nephrolithotomy and Retrograde Intrarenal Surgery for Renal Stones. Pak J Med Dent. 2025 September ;14(4): A-B. Doi: https://doi.org/10.36283/ziun-pjmd14-4/036.

Received: Mon, July 21, 2025 **Accepted:** Sun, September 28, 2025**. Published:** Mon, September 29, 2025

INTRODUCTION

Renal stone disease remains a significant health concern worldwide, with its highest prevalence reported in the "Stone Belt" region, which includes Pakistan, India, Burma, Egypt, Thailand, Sudan, Indonesia, and the Philippines[1,2,]. This region experiences a disproportionately high burden of urinary tract stones, resulting in considerable morbidity, including recurrent infections, hydronephrosis, renal impairment, and even kidney loss[3]. In Pakistan, renal stones are among the most common urological problems encountered in clinical practice, contributing substantially to hospital admissions and healthcare costs[4].

Management of renal stones has evolved significantly over the past few decades, with a major shift from open surgery to minimally invasive techniques[5]. For stones larger than 2 cm, endoscopic interventions are considered the treatment of choice[6]. Among these, Percutaneous Nephrolithotomy (PCNL) and Retrograde Intrarenal Surgery (RIRS) are the two most widely used procedures[7]. PCNL is considered the gold standard for large and complex stones, offering high stone-free rates, whereas RIRS has gained popularity as a less invasive alternative with reduced morbidity and shorter hospital stays[8]. However, despite advances in instrumentation and surgical technique, there is still no clear consensus on which procedure is superior for stones measuring between 2 cm and 3.5 cm, especially when considering patient-centered outcomes such as quality of life and satisfaction.

Previous studies have primarily focused on stone clearance rates, complications, and hospital stay, but very few have systematically compared PCNL and RIRS in a randomized manner while also including patient satisfaction as a measurable outcome[9,10]. This gap in knowledge makes it challenging for clinicians to select the most appropriate procedure for individual patients, especially in regions with high disease prevalence where treatment decisions must balance efficacy, safety, and resource utilization.

The present study aimed to compare PCNL and RIRS in the management of renal stones between 2 and 3.5 cm in size, focusing on stone-free rate (SFR), perioperative complications, hospital stay, blood loss, the need for repeat procedures, and patient satisfaction. By including patient satisfaction as a novel outcome measure, this study seeks to provide a more comprehensive evaluation to guide clinical decision-making.

METHODS

This prospective, observational cohort study was conducted between June 2024 and December 2024 at the CMH Nephrology and Urology Department, District Peshawar, with ethical approval reference #A/24EC154/2024 from the Ethical Review Committee (ERC). The study aimed to compare the clinical outcomes of Percutaneous Nephrolithotomy (PCNL) and Retrograde Intrarenal Surgery (RIRS) in patients with renal stones ranging from 2 cm to 3.5 cm. A total of 150 patients were enrolled, with 75 assigned to the PCNL group and 75 to the RIRS group. Inclusion criteria were patients with a single renal stone measuring 2 cm to 3.5 cm, confirmed by preoperative imaging (CT or ultrasound), and capable of giving informed consent.

Exclusion criteria included patients with bilateral kidney stones, previous kidney surgery, severe kidney dysfunction, and those unable to provide consent. In the PCNL group, patients underwent stone removal via a percutaneous route under general anesthesia, with a nephrostomy tube, and stone-free status was confirmed by postoperative imaging. In the RIRS group, a flexible ureteroscope was used to break up the stones through the urethra, bladder, and into the kidney using a laser, with postoperative imaging confirming stone-free status and further sessions conducted if necessary. The primary endpoint was the stone-free rate (SFR), defined as the absence of visible stones on imaging after surgery. Secondary endpoints included hospitalization time (from surgery to discharge), complications (e.g., infection, hemorrhage, postoperative fever, stent-related symptoms, nephrostomy pain, postoperative infection/urological sepsis), the need for repeat procedures (e.g., ureteroscopy stone fragment removal, ESWL), and patient satisfaction, measured on a 10-point scale. Data were collected at multiple time points: preoperatively, intraoperatively, postoperatively (on the day of surgery), and during follow-up visits at 6 weeks and 6 months. Statistical analysis was performed using SPSS v23, with continuous variables analyzed using t-tests and categorical variables analyzed using the Chi-Square Test. The level of significance was set at $p \leq 0.05$.

RESULTS

In terms of stone-free rate (SFR), a significant difference was observed between the two groups, with the PCNL group achieving a much higher stone-free rate of 95% compared to 82% in the RIRS group ($p = 0.003$). This suggests that PCNL is more effective in achieving complete stone clearance after the procedure. The higher success rate in the PCNL group may be attributed to the more invasive nature of the procedure, allowing for more direct and comprehensive stone removal. In contrast, RIRS, being a minimally invasive approach, may be limited by the stone's size and density, requiring multiple sessions in some cases, as evidenced by the need for additional sessions in 44% of the RIRS group for stones larger than 2.5 cm or with higher density. Despite this, RIRS remains a viable option, especially for patients where PCNL might not be indicated due to its more invasive nature, but the lower stone-free rate highlights the limitations of RIRS for larger stones**.**

Table 1: Comparison of PCNL and RIRS Outcomes

Parameter	PCNL (n=75)	RIRS (n=75)	p-value
Age (mean ± SD)	45.0 ± 11.8	43.5 ± 12.2	0.50
Gender (M/F)	46/29	42/33	0.55
Comorbidities (%)	26 (34.7%)	11 (14.7%)	0.01
Length of Hospital Stay (mean ± SD)	6.5 ± 1.2 days	1.56 ± 0.4 days	<0.001
Stone-Free Rate (%)	95%	82%	0.003
Blood Loss (Hb Drop)	9 (12%)	3 (4%)	0.04

Blood Transfusion (%)	2 (2.7%)	1 (1.3%)	0.65
Postoperative Fever (%)	1 (1.3%)	14 (18.6%)	<0.001
Infection (%)	2 (2.7%)	33 (44%)	<0.001
Stent-related Symptoms (%)	0	26 (34.6%)	<0.001
Pain from Nephrostomy Tube (%)	3 (4%)	---	NA
Post-op Infection/Urosepsis (%)	2 (2.7%)	33 (44%)	<0.001
Ancillary Procedures/Repeat Sessions	2 (2.7%) by URS/RIRS for fragments pushed to out-of-reach calyces after >6 months	1 (1.3%) ESWL after 6 months for stones 2 to 2.5 cm, density <900 HU	0.67
Need for Additional Sessions (RIRS)	Stones >2.5 cm, Density ≥900 HU: 33 (44%)	Stones >3 cm, Density ≥1100 HU: 10 needed a third session	<0.001
Patient Satisfaction (%)	71 (94.7%)	58 (77.3%)	0.02

DISCUSSION

The findings of this study suggested that PCNL was more effective than RIRS in achieving a stone-free state for renal stones measuring 2–3.5 cm. This observation was consistent with earlier reports that identified PCNL as the gold standard for larger stones due to its superior clearance rates[11,12]. Since the initial introduction of PCNL in 1976, it had been standard practice to place a nephrostomy tube for 3–5 days postoperatively[13]. This practice was also followed in the present study, which may be considered one of its limitations. The nephrostomy tube was traditionally thought to facilitate free drainage of urine and clots, allow access for a secondary procedure if residual fragments were present, and provide hemostasis through tract tamponade[14,15]. However, the presence of the tube also carried risks, and one patient in this study experienced a prolonged urinary leak as a result[16].

The evolution toward tubeless PCNL, first reported in the late 1990s, addressed some of these issues by replacing the external drain with a double-J stent. This approach was associated with shorter hospital stays, reduced analgesic requirements, improved pain scores, and lower overall procedural costs[17,18,19]. More recently, completely tubeless PCNL techniques have been explored, allowing patients to be discharged within a few days with excellent outcomes in terms of pain, recovery, and clinical success[20,21].

Higher rates of postoperative infection observed in the RIRS group were likely attributable to the rupture of residual stone fragments, leading to bacterial release and urinary stasis[22,23]. Although RIRS offered advantages in terms of reduced invasiveness and quicker recovery, it did not appear to be the most effective option for patients with larger stone burdens[24,25]. Patient satisfaction in this study showed a strong correlation with stone-free status, reinforcing the importance of preoperative counseling to set realistic expectations regarding outcomes and the possibility of requiring multiple sessions with RIRS.

This study had several limitations, including its single-center design, a relatively small patient sample, and a short follow-up period. Stone clearance rates by anatomical location were not separately analyzed, and no chemical composition analysis was performed, which might have provided further insight into stone recurrence risk. Future studies should incorporate these parameters and explore the use of complete tubeless PCNL to further improve patient recovery and satisfaction.

In terms of clinical decision-making, PCNL continued to be regarded as the gold standard for stones larger than 2 cm, offering the highest success rates in a single session. Nevertheless, RIRS remained a valuable alternative, particularly for patients in whom PCNL was contraindicated, such as those with severe obesity, bleeding disorders, or spinal deformities preventing safe positioning. Advances in flexible scopes, suction systems, and laser technology were likely to further improve RIRS outcomes in the future. Careful patient selection, consideration of anatomical factors, and thorough counseling were emphasized as key steps in optimizing outcomes and minimizing the need for additional procedures.

CONCLUSION

PCNL and RIRS are effective alternatives for treating renal stones larger than 2 cm. However, PCNL has higher stone-free rates and lower infection rates and is the preferred technique for larger stones in most circumstances. Further studies are needed to inform the development of standard treatments tailored to patient-related factors and stone composition.

FUNDING

None

CONFLICT OF INTEREST

None

ETHICAL APPROVAL

Ethical approval was obtained from the institutional ethics review committee of
CMH Nephrology and Urology Department, District Peshawar, with ethical approval reference #A/24EC154/2024 from the Ethical Review Committee (ERC).

AUTHORS' CONTRIBUTIONS

All authors contributed equally as per ICMJE policy

REFERENCES

1. Islam W, Naser F, Hasan M, Rahman MM, Rahman M, Hossain S. Spectrum of chemical analysis of 150 consecutive upper urinary tract stones with critical analysis in respect of demographic and geographical distribution. International Surgery Journal. 2021 May 28;8(6):1694-8.
2. KUMARI, A., DOKWAL, S., MITTAL, P., KUMAR, R., GOEL, R., BANSAL, P., KUMAR, H.D. and BHUTANI, J., Introduction: Nephrolithiasis is a complex disease affecting all age groups globally. As the causative factors for nephrolithiasis rises significantly, its incidence, prevalence and recurrence continues to baffle clinicians and patients. Aim: To study the prevalence of different types of renal stones.
3. Awedew AF, Han H, Berice BN, Dodge M, Schneider RD, Abbasi-Kangevari M, Al-Aly Z, Almidani O, Alvand S, Arabloo J, Aravkin AY. The global, regional, and national burden of urolithiasis in 204 countries and territories, 2000–2021: a systematic analysis for the Global Burden of Disease Study 2021. EClinicalMedicine. 2024 Dec 1;78.
4. Pietropaolo A, Keller EX, Sener TE, Hamed BZ, Tsaturyan A, Ventimiglia E, Juliebø-Jones P, Beisland C, Mikoniatis I, Tzelves L, De Coninck V. Economic burden of imaging and interventions in endourology: A worldwide cost analysis from European Association of Urology Young Academic Urology Endourology and Urolithiasis Working Party. Journal of Endourology. 2025 Apr 1;39(4):389-98.
5. Güzel R, Yildirim Ü, Sarica K. Contemporary minimal invasive surgical management of stones in children. Asian Journal of Urology. 2023 Apr 3;10(3):239.
6. Van Wanrooij RL, Bronswijk M, Kunda R, Everett SM, Lakhtakia S, Rimbas M, Hucl T, Badaoui A, Law R, Arcidiacono PG, Larghi A. Therapeutic endoscopic ultrasound: European Society of Gastrointestinal Endoscopy (ESGE) technical review. Endoscopy. 2022 Mar;54(03):310-32.
7. Peng L, Meng C, Xia Z, Liang R, Gan L, Li K, Cao D, Li Y. Determining the safety and effectiveness of percutaneous nephrolithotomy and retrograde intrarenal surgery in treating nephrolithiasis in patients with solitary kidneys. Urolithiasis. 2022 Dec 1;51(1):2.
8. Kang DH, Cho KS, Chung DY, Jeong WS, Do Jung H, Kim DK, Lee JY. Stone-free rates of mPCNL, PCNL, and RIRS: A systematic review and network meta-analysis. Urogenital Tract Infection. 2022 Apr 30;17(1):14-25.

9. Setthawong V, Srisubat A, Potisat S, Lojanapiwat B, Pattanittum P. Extracorporeal shock wave lithotripsy (ESWL) versus percutaneous nephrolithotomy (PCNL) or retrograde intrarenal surgery (RIRS) for kidney stones. Cochrane Database of Systematic Reviews. 2023(8).
10. Hou J, Wen X, Qu G, Chen W, Xu X, Wu G, Ji R, Wei G, Liang T, Huang W, Xiong L. A multicenter study on the application of artificial intelligence radiological characteristics to predict prognosis after percutaneous nephrolithotomy. Frontiers in Endocrinology. 2023 Sep 15;14:1184608.
11. Ureteroscopy FM. Basic Techniques. Advanced Ureteroscopy: A Practitioner's Guide to Treating Difficult Problems. 2021 Dec 1:79.
12. 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 braz j urol. 2022 Jul 25;48(4):637-48.
13. Awedew AF, Alemu CT, Yalew DZ. Efficacy and safety of various endosurgical procedures for management of large renal stone: a systemic review and network meta-analysis of randomised control trials. Urolithiasis. 2023 Jun 8;51(1):87.
14. Gauhar V, Traxer O, García Rojo E, Scarcella S, Pavia MP, Chan VW, Pretore E, Wroclawski ML, Corrales M, Tiong HY, Lim EJ. Complications and outcomes of tubeless versus nephrostomy tube in percutaneous nephrolithotomy: a systematic review and meta-analysis of randomized clinical trials. Urolithiasis. 2022 Oct;50(5):511-22.
15. Haider M, Kotecha P, Leow JL, Rajan P, Patel P, Lamb BW. Urological Surgery. InHamilton Bailey's Emergency Surgery 2025 (pp. 636-664). CRC Press.
16. Coman RA, Tzelves L, Juliebø-Jones P, Talyshinskii A, Nedbal C, Ventimiglia E, Davis N, Somani BK. Pre-and post-operative safety considerations for patients undergoing percutaneous nephrolithotomy. Expert Opinion on Drug Safety. 2025 Apr 23:1-5.
17. Aibel K, Chang R, Ochuba AJ, Koo K, Winoker JS. Pain management in percutaneous nephrolithotomy—an approach rooted in pathophysiology. Nature Reviews Urology. 2025 Jan 13:1-2.
18. Paneque T, Richey J, Abdelrazek A, Morgan K, Fitz-Gerald J, Swinney S, Connelly ZM, Khater N. Current advances in pain regimens for percutaneous nephrolithotomy: A comprehensive review. Canadian Urological Association Journal. 2023 Aug 3;17(11):E388.
19. Winoker JS, Koo K, Alam R, Matlaga BR. Opioid-sparing analgesic effects of peripheral nerve blocks in percutaneous nephrolithotomy: A systematic review. Journal of Endourology. 2022 Jan 1;36(1):38-46.
20. Gauhar V, Traxer O, García Rojo E, Scarcella S, Pavia MP, Chan VW, Pretore E, Wroclawski ML, Corrales M, Tiong HY, Lim EJ. Complications and outcomes of tubeless versus

nephrostomy tube in percutaneous nephrolithotomy: a systematic review and meta-analysis of randomized clinical trials. Urolithiasis. 2022 Oct;50(5):511-22.

21. Wilhelm K, Hein S, Kunath F, Schoenthaler M, Schmidt S. Totally tubeless, tubeless, and tubed percutaneous nephrolithotomy for treating kidney stones. Cochrane Database of Systematic Reviews. 2023(7).
22. Khusid JA, Hordines JC, Sadiq AS, Atallah WM, Gupta M. Prevention and management of infectious complications of retrograde intrarenal surgery. Frontiers in Surgery. 2021 Aug 9;8:718583.
23. Punga AM, Ene C, Bulai CA, Georgescu DA, Multescu R, Georgescu DE, Geavlete B, Geavlete P, Petrisor G. Complications of Single-Use flexible ureteroscopy vs. Reusable flexible ureteroscopy: A narrative review. Cureus. 2024 Dec 23;16(12).
24. Gauhar V, Somani BK, Heng CT, Gauhar V, Chew BH, Sarica K, Teoh JY, Castellani D, Saleem M, Traxer O. Technique, feasibility, utility, limitations, and future perspectives of a new technique of applying direct in-scope suction to improve outcomes of retrograde intrarenal surgery for stones. Journal of Clinical Medicine. 2022 Sep 27;11(19):5710.
25. Celentano G, Barone B, La Rocca R, Massanova M, Napolitano L, Prezioso D, Abate M, Mirto BF, Fusco F, Crocetto F. Ureteral access sheaths in RIRS: a retrospective, comparative, single-center study. Journal of Basic and Clinical Physiology and Pharmacology. 2024 Oct 31;35(4-5):315-21.