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Residual Stone Fragment after Percutaneous Nephrolithotomy; Shockwave Lithotripsy Vs Retrograde Intrarenal Surgery

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Abstract

Background and objectives: The integration of technology into percutaneous nephrolithotomy procedures has yet to eliminate the issue of residual stone fragments, which cause recurrence or blockage of ureters. The aim of the study is to evaluate and contrast effectiveness of extracorporeal-shockwave-lithotripsy with retrograde-intrarenal-surgery in residual stone fragments therapy following an initial standard percutaneous nephrolithotomy procedure.

Methods: The analysis was retrospectively conducted on adult patients with residual stone fragments after doing percutaneous nephrolithotomy. These patients had either extracorporeal-shockwave-lithotripsy or retrograde-intrarenal-surgery at Sulaymaniyah Teaching Hospital and Harem hospital from January 2020 to January 2024. We assessed the stone free rate up to 90 days after the reintervention using ultrasonography, kidney, ureter and bladder radiography for the kidneys, Problems occurring at a 90-day were documented using the Clavien-Dindo system classification.

Results: The examination comprised forty-six patients, with a mean age of 44.78 ± 12.38 years. Twenty-six patients were in retrograde-intrarenal-surgery group, while twenty were in extracorporeal-shockwave-lithotripsy group. The stone size in retrograde-intrarenal-surgery group mean was 9.50 ± 2.12 mm, compared to 9.55 ± 2.01 mm in extracorporeal-shockwave-lithotripsy group. The immediate stone-free rate was 84.6% in retrograde-intrarenal-surgery group and 30% in the extracorporeal-shockwave-lithotripsy group, while the final stone free rate after 3 months of follow-up was 97% for retrograde-intrarenal-surgery and 95% for extracorporeal-shockwave-lithotripsy group, while the final stone free rate after 3 months of follow-up was 97% for retrograde-intrarenal-surgery and 95% for extracorporeal-shockwave-lithotripsy.

Conclusion: Following percutaneous nephrolithotomy, leftover stones are more effectively treated with retrograde-intrarenal-surgery than extracorporeal-shockwave-lithotripsy. Patients who underwent retrograde intrarenal surgery had greater rates of achieving stone-free status than those with extracorporeal-shockwave-lithotripsy treatment.

Keywords: Percutaneous Nephrolithotomy, Renal Stone Disease, Retrograde-intrarenal-surgery, Extracorporeal-shockwave-lithotripsy

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Introduction

Residual stone fragments (RSF) provide a major threat to the reappearance or development of new stones. Pieces with a diameter below four mm are considered clinically insignificant, may be naturally passed. Residual fragments >4 mm is considerable owing to risks of recurrence and ureteral obstruction thus need urgent treatment.[1] During the era of open stone surgery, any post operative residual stone of different size was considered a procedural failure. The presence of residual fragments (RF)s larger than 5 mm is typically considered a sign of extracorporeal-shockwave-lithotripsy (ESWL) failure since its introduction. The introduction of clinically insignificant residual fragments (CIRF) into the literature has complicated the definition of (RF), which currently has complex and arbitrary criteria.[1,2]Following percutaneous nephrolithotomy (PCNL), RFs have an important effect on the standard of life and clinical progression of patients, (PCNL) an advanced method for removing kidney stones was first introduced in 1950s.[3] Percutaneous nephrolithotomy (PCNL) is effective for removing large renal calculi, residual fragments can lead to recurring stone formation, infections and need for further care.[4,5] Retrograde intrarenal surgery (RIRS) and (ESWL) are frequently used methods to treat these remaining fragments. Recent studies compared ESWL and RIRS for treating kidney stone fragments. Extra-corporeal shockwave lithotripsy (ESWL) uses shockwaves to break the stones but efficacy depends on stone size, composition and location.[6] Extra-corporeal shockwave lithotripsy (ESWL) is widely recognized as a secure, non-invasive, highly successful and cost-effective alternative to endoscopic procedures, it is widely adopted as a standard treatment method globally.[7,8] Retrograde intrarenal surgery (RIRS) is an effective complement technique to flexible ureterorenoscopy (URF) as the scope is inserted by the urinary tract into the bladder and moved to the ureter onto the renal calices of the kidney. The scope is slowly pushed into the kidney (intrarenal). The stone is observed by the scope and moved or broken using an ultrasonic probe, vaporized with a laser probe or grasped using tiny forceps.[9] Using a ureteroscope and laser energy, offers higher stone-free rates than ESWL.[10]Studies have shown that (RIRS) is more effective than (ESWL) for clearing stones, but it carries a slightly higher risk of complications.[11] Patient factors like anatomy and stone burden influence treatment choice, with (RIRS) preferred for complex cases and less favorable anatomies for (ESWL).[12] Extra-corporeal shockwave lithotripsy (ESWL) and (RIRS) are options for treating residual stone fragments post-PCNL, each with its own pros and cons. This paper compares their effectiveness and safety to guide clinical decisions and enhance patient outcomes.

Patients and methods

A retrospective study was performed on adult patients with residual stone fragments after a standard PCNL treated with RIRS or ESWL in Sulaymaniyah Teaching Hospital and Harem Private Hospital from January 2020 to January 2024. Data were collected from both hospitals' databases, including patient files and electronic records. The collected data was composed of demographic patient data that include sex, age, Body mass index, height, weight, family history, past medical history, ASA classification, preoperative renal function test, then data related to previous renal stone, Guy's criteria, stone burden and location before PCNL procedure were all retrieved. Figures of residual stones, numbers, size, location, whether they are diagnosed with Sonography or Kidney, ureter, bladder KUB film were gained, if the patient underwent further intervention of ESWL or RIRS their data obtained.

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Management of residual stone fragments after standard PCNL was decided based on the urologist's assessment and patient preference, without randomization procedure. Adult patients were included in this study with residual stone fragments between 5 mm and 15 mm. Patients with residual stone fragments smaller than 5 mm are not considered for RIRS in our hospitals, and patients with stones more significant than 15 mm are not candidate for ESWL. This research excluded those who had kidney anomalies, urinary diversions, were pregnant, and had received combination operations at the time of RIRS, such as PCNL, transurethral resection of the prostate (TURP), and bilateral operations. Once the research protocol received approval from the Kurdistan Higher Council of Medical Specialties KHCMS ethics committee and all participants provided written informed permission retrospective data collection began. All patient data who had standard PCNL for different types of stone burdens according to Guy's grading system and who were suspected or diagnosed with residual stones were collected and followed. The patients were categorized into two classes, the primary group including those who received ESWL while the second group included individuals who had RIRS to treat their remaining stones. Shockwave lithotripsy was performed using a HK. ESWL-VI machines (Shenzhen Huikang Medical Apparatus, China) as an outpatient protocol three to six weeks following PCNL. A kidney stone was detected and the operation was observed using fluoroscopy. The shockwaves were administered at 90 Hz with a maximum strength of 18 KV and up to 4000 impulses under sedation. They got out of the hospital 2 hours after the procedure with analgesic medication for one week and alpha-blockers for one month. Patients underwent ESWL follow-up for three months, and the procedure was repeated 3 times throughout that period if residual stones were still present until a stone free was achieved. If, after that period, the stone remained or a shift of treatment to another urological procedure happened, that patient data is not included in the study. The procedure RIRS was carried out using general or spinal anesthesia, with a minimum of six weeks following PCNL. A Nitinol 0.035" guidewire (Coloplast, DK) and a PTFE 0.035" guide wire were placed manually up to the renal pelvis, semi-rigid ureteroscopy was conducted in all surgeries to assess the presence of ureteral stricture, ureteral wall compliance, and to examine for any stone pieces in the ureter. A 10/12F x 35 cm ureteral access sheath (UAS) from Coloplast, Denmark, was introduced into the upper ureter, either an INNOVEX single-use ureteroscope or a Karl Storz 11278AU1 Flex X2 Flexible Ureteroscope was used to directly examine all renal calyces before lithotripsy. Irrigation was achieved by suspending a one-liter saline bag 40 cm above the patient and then regularly flushing with saline using a 20 mL syringe. The procedure of laser lithotripsy was carried out using a CALCULASE III, a reusable Holmium laser fiber, 230 µm. The laser machine used was a 35-watt desktop laser model CALCULASE® III, by KARL STORZ. The laser parameters used were a frequency of 12-18 Hz and an energy output of 0.4-0.6 J. Stone pieces measuring over 2 mm were extracted using a 1.5 F tipless stone basket manufactured by Coloplast, DK. After the operations, pyelography was conducted using the UAS, and a 6Fr silicone double J stent was put and left in for a maximum of 3 weeks. Descriptive statistics were used to analyze the data and compare the baseline characteristics of patients in the ESWL and RIRS groups. Depending on their distribution, the t-test or Mann-Whitney U test is used to compare continuous variables.

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Results

From January 2020 to January 2024, 73 patients with RSFs after ESWL or RIRS treated PCNL in both Sulaymaniyah Teaching Hospital and Harem Private Hospital. A total of 46 patients met the criteria for inclusion in the study. A group of twenty patients managed by ESWL was compared to another group of twenty-six patients who treated with RIRS. The medical records were compared across different groups in Table (1) are presented, which summarizes demographic data, demonstrates that gender, age, BMI, ASA classification, Blood Urea, Serum Creatinine, and Preoperative Hemoglobin. None of these variables show the presence of significant statistical variations between the ESWL and RIRS groups (p-values > 0.05), although the mean blood urea levels are higher in the RIRS group, that difference lacks statistical significance (p=0.274). The RIRS group has higher mean serum creatinine levels, but the difference is insignificant (p=0.342). It's evident that mean preoperative hemoglobin levels are slightly lower in the RIRS group, but the variance is not significant statistically (p=0.154). All this indicates that the two groups are well-matched in terms of these baseline characteristics, allowing for a fair comparison of treatment outcomes without the influence of these variables.

Table (1): Presents the characteristics of individuals who have residual stone fragments undergoing ESWL and RIRS

Characteristics	ESWL (n=20)	RIRS (n=26)	p-value (<0.05)
Genders; Male: Female n (%)	12: 8 (60: 40%)	16:10 (61.5:38.5%)	0.918
Age range (mean ± SD), years	29 to 71 (46.45 ± 13.71)	25 to 67 (43.50 ± 11.37)	0.441
BMI range (mean ± SD), kg/m2	20.7 to 32.4 (26.21 ± 3.52)	18 to 34 (26.85 ± 3.72)	0.554
ASA, n (%)			0.550
I	12 (60%)	14 (53.8%)	
II	5 (25%)	6 (23.1%)	
III	3 (15%)	6 (23.1%)	
Blood Urea (mean ± SD), unit	39.19 ± 17.96	45.69 ± 21.84	0.274
S Creatinine (mean ± SD), unit	1.23 ± 0.68	1.47 ± 1.01	0.342
Preop Hb (mean ± SD), unit	14.08 ± 1.54	13.32 ± 2.01	0.154

The distribution of PCNL Guy's classification is not significantly various in the ESWL and RIRS groups (p > 0.05), indicating similar complexity of cases in both groups. Table (2). The mean size and density of the stones in the two groups are not significantly different (p > 0.05). However, there is a significant difference in the location of residual stones among the groups (p < 0.05). Specifically, the RIRS group has more residual stones in the pelvis than the ESWL group.

Table (2): Compares various features of patients undergoing shock wave lithotripsy (ESWL) and retrograde intrarenal surgery (RIRS)

Feature	SWL (n=20)	RIRS (n=26)	p-value (<0.05)
PCNL Guy's Classification, n (%)			0.787
1	0 (0%)	0 (0%)	

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2	7 (35%)	7 (26.9%)	
3	8 (40%)	13 (50%)	
4	5 (25%)	6 (23.1%)	
Stone density HU before PCNL (mean ± SD), unit	777.90 ± 229.36	722.35 ± 286.40	0.469
Stone side, n (%)			0.277
Right	11 (55%)	10 (61.5%)	
Left	9 (45%)	16 (38.5%)	
Stone size range (mean ± SD), mm	6 to 14 (9.55 ± 2.01)	6 to 14 (9.50 ± 2.12)	0.935
Residual stone location, n (%)			0.040*
Upper	5 (20%)	3 (10%)	
Middle	8 (32%)	7 (23.3%)	
Lower	9 (36%)	13 (43.3%)	
Pelvis	3 (12%)	7 (23.3%)	
Number of residual stones, n (%)			0.878
Single	12 (60%)	15 (57.7%)	
Multiple	8 (40%)	11 (42.3%)	
Imaging methods of diagnosis or residual stones, n (%)			0.210
U/S	13 (65%)	12 (46.2%)	
KUB	7 (35%)	14 (53.8%)	

Overall outcomes, which are detailed in Table (3) showed that ESWL has a significantly lower immediate stone-free rate (30%) compared to RIRS (84.6%), with a p-value of 0.00014, shows a highly significant difference. After one month, ESWL shows a stone-free rate of 65% compared to 92.3% for RIRS, the statistical significance of the difference is indicated by the p-value of 0.033. At 3 months, the SFR for ESWL increases to 95%, and RIRS maintains 100%. The p-value of 0.330 indicates no statistically significant differences, suggesting that both treatments are equally beneficial in the long run. Patients undergoing RIRS had a significantly longer hospitalization time (mean 12.46 ± 4.37 hours) than those undergoing ESWL (mean 3.05 ± 0.83 hours). The p-value is highly significant (0.26x10^-10). Most patients in both groups experienced no complications according to (Clavien-Dindo Classification) (90% for ESWL and 96.2% for RIRS). However, Minor complications in the Clavien-Dindo grade (I/II) were slightly more common in the ESWL group (10%) in contrast to the RIRS group (3.8%), although this difference did not have an important statistical impact (p=0.441). There were no significant complications with Clavien (IIIb) among the two groups. ESWL has one patient (5%) with an ER visit, successfully treated with analgesics, while RIRS has none. Statistical significance variation is not shown by the p-value of 0.330. RIRS appears to be more effective in achieving a stone-free state more quickly but requires longer hospitalization time than ESWL due to being more invasive than ESWL. Both treatments are comparable in terms of long-term safety and efficacy.

Table (3): Presents the outcomes for patients undergoing ESWL and RIRS for residual stone fragments after PCNL

Outcomes	SWL (n=20)	RIRS (n=26)	p-value
Stone free after, n (%)			
0 months (immediately)	6 (30%)	22 (84.6%)	0.00014*
1 months (4 weeks)	13 (65%)	24 (92.3%)	0.033*

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3 months (12 weeks)	19 (95%)	26 (100%)	0.330
Hospitalization time range (mean ± SD), hours	2 to 5 (3.05 ± 0.83)	7 to 26 (12.46 ± 4.37)	0.26x10-10 *
Clavien-Dindo, n (%)			0.441
0	18 (90%)	25 (96.2%)	
I/II (minor complications)	2 (10%)	1 (3.8%)	
IIIb (major complications)	0 (0%)	0 (0%)	
ER visits, n (%)	1 (5%)	0 (0%)	0.330

Discussion

Kidney stone disease (nephrolithiasis) is the process of developing crystalline concretions mainly in the kidneys, a growing urological condition that affects around 12% of the global population.[13] Percutaneous nephrolithotomy (PCNL) is performed therapeutic method used to remove big kidney stones.[2] In spite of its wide application 45% of the patients still show the presence of remaining stone pieces where they tend to cause a return of symptoms, UTI, or the reformation of stones.[5,14] Stone-related morbidity resulting from RFs dependent on the size of the stones.[3] Clinically Insignificant Residual Fragments (CIRFs) refer to smaller RFs having a diameter of 4 mm or less.[15] Additionally, the presence of residual fragments in individuals with struvite stones following PCNL might result in infectious complications.[16] This retrospective research aimed to examine the procedure results of remaining stone fragments from >5 mm to <15 mm after PCNL using ESWL and RIRS. Our results suggest that RIRS is a more efficient method for residual stones after PCNL than ESWL, in addition to that it revealed patients treated with ESWL had a decreased stone free rate (SFR) and success rate compared to patients treated with RIRS in the short term. RIRS achieves stone-free status more quickly; however, both treatments yield comparable results in the longer term.[11] The study found that postoperative complications were comparable among the groups. The ESWL group had more minor complications, only one patient in the RIRS group experienced a minor complication, which was successfully treated with antibiotics. A new meta-analysis of fourteen trials assessing ESWL and RIRS revealed that the SFR of ESWL was less than that of RIRS, the complications were comparable between the procedures.[17] The findings of this study revealed that ESWL showed a lower SFR and success rate compared to RIRS for treating residual stone fragments after PCNL in short term, but comparable results in longer term. However, this does not mean that ESWL cannot be used effectively, or that RIRS can manage all stone fragments after percutaneous nephrolithotomy.[6,10] Extracorporeal shockwave lithotripsy (ESWL) has the benefit of being a non-invasive therapy that may be performed on an outpatient basis.[18] Additionally ESWL may require multiple sessions and repeat treatment to be effective and better case selection may achieve better ESWL outcomes.[7,10] This study also showed that hospitalization significantly shorter for ESWL compared to RIRS (12.46h vs. 3.05h, p=0.26 x 10-10 *), this is because of noninvasive nature of ESWL.[7] The study has some limitations and constraints. It was performed retrospectively in two institutions, and candidates were chosen depends on the size of the stone ranging from >5 mm to <15 mm to create similar groups. An additional limitation is using both sonography and x-ray of kidney, ureter, and bladder (KUB) to evaluate the SFR. Use of sonography to help

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in medical choices for remaining or undetectable stones is limited by low level of sensitivity and unable to accurately measure the size of the stone.[19] In addition to that specificity and sensitivity range of KUB film is 44% to 77%.[20]

Conclusion

Clinically significant residual stone fragments after traditional PCNL, are more effectively treated with RIRS than ESWL. Retrograde intrarenal surgery RIRS is safe and advanced procedure but more invasive than ESWL however its more capable in achieving SFR in shorter time. On the other hand, ESWL is less invasive procedure with shorter hospitalization time, which can be employed for selected patients.

Conflict of interest

No conflict of interest is confirmed by the author

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References

1. Qiu M, Zhang T, Zhang Y, Liang T, Chen J, Gao H. Physical Techniques to Remove Residual Stone Fragments in the Urinary System. Urol Int. 2024;108(1):9–19.
2. Smith AD, Preminger GM, Kavoussi LR, Badlani GH, Rastinehad AR, editors. Smith's Textbook of Endourology. Wiley; 2019.
3. Wong VKF, Que J, Kong EK, Abedi G, Nimmagadda N, Emmott AS, et al. The Fate of Residual Fragments After Percutaneous Nephrolithotomy: Results from the Endourologic Disease Group for Excellence Research Consortium. J Endourol. 2023 Jun 1;37(6):617–22.
4. Malik I, Wadhwa R. Percutaneous Nephrolithotomy: Current Clinical Opinions and Anesthesiologists Perspective. Anesthesiol Res Pract. 2016; 2016:9036872.
5. Brain E, Geraghty RM, Lovegrove CE, Yang B, Somani BK. Natural History of Post-Treatment Kidney Stone Fragments: A Systematic Review and Meta-Analysis. J Urol. 2021 Sep;206(3):526–38.
6. Lee SM, Collin N, Wiseman H, Philip J. Optimisation of shock wave lithotripsy: a systematic review of technical aspects to improve outcomes. Transl Androl Urol. 2019 Sep;8(Suppl4): S389–97.
7. Petrides N, Ismail S, Anjum F, Sriprasad S. How to maximize the efficacy of shockwave lithotripsy. Turk J Urol. 2020 Nov;46(1): S19–26.
8. Akram M, Jahrreiss V, Skolarikos A, Geraghty R, Tzelves L, Emilliani E, et al. Urological Guidelines for Kidney Stones: Overview and Comprehensive Update. J Clin Med. 2024 Feb 16;13(4).
9. Aghamir SMK. Successful retrograde intrarenal surgery (RIRS) for a 2-centimeter stone in a chronic renal failure (CRF) patient. Int J Surg Case Rep. 2021 Oct; 87:106375.
10. Ozgor F, Sahan M, Yanaral F, Savun M, Sarilar O. Flexible ureterorenoscopy is associated with less stone recurrence rates over Shockwave lithotripsy in the management of 10–20-millimeter lower pole renal stone: medium follow-up results. Int Braz J Urol. 2018;44(2):314–22.
11. Chung DY, Kang DH, Cho KS, Jeong WS, Jung H Do, Kwon JK, et al. Comparison of stone-free rates following shock wave lithotripsy, percutaneous nephrolithotomy, and retrograde intrarenal surgery for treatment of renal stones: A systematic review and network meta-analysis. PLoS One. 2019;14(2): e0211316.

https://doi.org/10.56056/amj.2026.443

12. Snicorius M, Bakavicius A, Cekauskas A, Miglinas M, Platkevicius G, Zelvys A. Factors influencing extracorporeal shock wave lithotripsy efficiency for optimal patient selection. Wideochir Inne Tech Maloinwazyjne. 2021 Jun;16(2):409–16.
13. Alelign T, Petros B. Kidney Stone Disease: An Update on Current Concepts. Adv Urol. 2018; 2018:3068365.
14. Emmott AS, Brotherhood HL, Paterson RF, Lange D, Chew BH. Complications, Re-Intervention Rates, and Natural History of Residual Stone Fragments After Percutaneous Nephrolithotomy. J Endourol. 2018 Jan;32(1):28–32.
15. Kingma RA, Doppen C, Bus MTJ, Altobelli E, de Jong IJ, Roemeling S. The significance of clinically insignificant residual fragments after percutaneous nephrolithotomy: an analysis into the relevance of complete stone clearance. World J Urol. 2024 Feb 14;42(1):78.
16. Degirmenci T, Bozkurt IH, Celik S, Yarimoglu S, Basmaci I, Sefik E. Does leaving residual fragments after percutaneous nephrolithotomy in patients with positive stone culture and/or renal pelvic urine culture increase the risk of infectious complications? Urolithiasis. 2019 Aug;47(4):371–5.
17. Chung KJ, Kim JH, Min GE, Park HK, Li S, Del Giudice F, et al. Changing Trends in the Treatment of Nephrolithiasis in the Real World. J Endourol. 2019 Mar;33(3):248–53.
18. Manzoor H, Leslie SW, Saikali SW. Extracorporeal Shockwave Lithotripsy. 2024.
19. Ganesan V, De S, Greene D, Torricelli FCM, Monga M. Accuracy of ultrasonography for renal stone detection and size determination: is it good enough for management decisions? BJU Int. 2017 Mar;119(3):464–9.
20. Montatore M, Muscatella G, Eusebi L, Masino F, Gifuni R, Giannubilo W, et al. Current Status on New Technique and Protocol in Urinary Stone Disease. Vol. 11, Current Radiology Reports. Springer; 2023. p. 161–76.

https://doi.org/10.56056/amj.2026.443