COMPARATIVE ANALYSIS OF STONE-FREE RATES IN LOWER POLE RENAL STONES (<1.5 CM): ESWL VS. RIRS

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ABSTRACT

Background: Treating stones in the lower pole of the kidney is often difficult because certain anatomical features—such as an acute infundibulopelvic angle, elongated calyx, and narrow infundibular width—reduce the likelihood of effective drainage of fragments. Extracorporeal shock wave lithotripsy (ESWL) is widely used for small renal stones due to its non-invasive nature; however, its success rate for lower-pole calculi is often suboptimal. In contrast, retrograde intrarenal surgery (RIRS), facilitated by advances in flexible ureteroscopy and laser technology, has demonstrated improved stone clearance outcomes.

Objectives: This study is designed to evaluate and compare stone-free rates after ESWL and RIRS in patients with lower-pole renal stones measuring less than 1.5 cm.

Methods: A randomized controlled trial was conducted at PGMI/Lahore General Hospital involving 150 patients with confirmed lower-pole stones (<1.5 cm). Participants were randomly assigned to either the ESWL group or the RIRS group. Post-treatment outcomes were evaluated using a non-contrast CT KUB performed one week after the procedure. The primary outcome measure was the stone-free rate.

Results: Among the 150 patients, the RIRS group demonstrated a higher stone-free rate of 53.9% compared to 46.1% in the ESWL group. The difference was statistically significant ($p = 0.036$), indicating a favorable outcome with RIRS in this patient population.

Conclusion: RIRS showed superior efficacy compared with ESWL for treating lower-pole kidney stones measuring 1.5 cm or less. These findings support considering RIRS as a preferred option in selected cases, particularly when anatomical factors may limit ESWL success.

Keywords: Lower pole renal stone, Extracorporeal shock wave lithotripsy, Retrograde intrarenal surgery, Stone-free rate, Endourology

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INTRODUCTION

Urolithiasis is a common urological disorder worldwide and continues to pose a significant healthcare burden. Its rising incidence has been linked to multiple factors, including changes in dietary habits, increasing global temperatures, metabolic abnormalities, and reduced physical activity.[1] Over time, the treatment of renal stone disease has shifted dramatically from traditional open surgical procedures toward less invasive and non-

invasive approaches. Among the currently available options, extracorporeal shock wave lithotripsy (ESWL) and retrograde intrarenal surgery (RIRS) have become widely accepted treatment modalities, particularly for renal stones measuring less than 2 cm, due to their effectiveness and favourable safety profiles.[2,3] ESWL, introduced in the early 1980s, revolutionized stone management as the first non-invasive method for renal stone disintegration.[4] Utilising focused acoustic pulses to fragment stones within the kidney, ESWL offers the advantages of being an outpatient procedure, less invasive, and relatively pain-free. However, its limitations include incomplete stone fragmentation, need for multiple sessions, and variable efficacy depending on stone size, location, and composition.[5,6] On the other hand, RIRS has gained widespread acceptance with advances in flexible ureteroscopy and laser technology, particularly holmium and thulium lasers.[7] RIRS involves endoscopic visualization and fragmentation of stones using a ureteroscope passed through the urinary tract. It offers higher stone-free rates (SFRs), particularly for lower pole stones and radiolucent calculi, with the added benefit of simultaneous treatment of multiple stones.[8] Despite its invasiveness compared with ESWL, RIRS is associated with minimal morbidity and a rapid recovery.[9] With the rising demand for personalized and precision-based urological care, selecting the optimal intervention for renal calculi has become increasingly complex. Factors such as stone burden, anatomical considerations, patient comorbidities, and institutional resources influence treatment decisions.[10] Therefore, comparing the efficacy, safety, cost-effectiveness, and stone clearance rates of ESWL and RIRS is essential to guide evidence-based clinical practice.

This study aims to provide a comprehensive comparative evaluation of ESWL and RIRS with respect to stone clearance rates, procedural complications, patient outcomes, and overall effectiveness. The findings are expected to help clinicians determine the most appropriate intervention tailored to individual patient profiles, while balancing invasiveness, success rates, and healthcare costs.

METHODS

Study Design and Setting: This study employed a quasi-experimental, comparative design and was carried out at a single tertiary care centre, the Department of Urology at Lahore General Hospital, over one year (3 February 2021 to 3 June 2022). Ethical approval was obtained from the Institutional Review Board (IRB), and all study procedures were performed in compliance with the principles outlined in the Declaration of Helsinki.

Study Population

A total of 120 patients with radiologically confirmed renal calculi were enrolled and divided into two equal groups of 60 patients each. The patients were selected based on the following inclusion and exclusion criteria:

Inclusion Criteria

- Age between 18 and 65 years
- Renal stones measuring 5 mm to 20 mm in maximum diameter
- Normal renal function (serum creatinine ≤ 1.5 mg/dL)
- Single or multiple unilateral renal calculi
- Non-obstructive stones
- Written informed consent

Exclusion Criteria

- Age < 18 or > 65 years
- Active urinary tract infection
- Bleeding diathesis or anticoagulation therapy
- Pregnancy
- Anatomical abnormalities (e.g., horseshoe kidney, PUJ obstruction)
- Prior renal surgery on the affected side
- Morbid obesity (BMI > 35 kg/m²)

Group Allocation: Participants were non-randomly allocated into two groups based on patient preference, stone characteristics, and surgeon recommendation:

Group A: Patients received Extracorporeal Shock Wave Lithotripsy (ESWL)

Group B: Patients undergoing Retrograde Intrarenal Surgery (RIRS)

Baseline demographic and clinical variables were documented for all participants. These included age, sex, body mass index (BMI), stone site, side involved, stone count, stone dimensions (measured as the maximum diameter on non-contrast CT), and stone density expressed in Hounsfield units (HU).

Preoperative Assessment

All patients underwent:

- Complete blood count (CBC)
- Renal function tests (RFTs)
- Urinalysis and urine culture
- Coagulation profile
- Ultrasonography (KUB)
- Non-contrast CT scan (NCCT) for stone size and density
- X-ray KUB for radiopaque stones

Procedure Details:

Group A – ESWL Protocol

ESWL was performed using [Insert Machine Name/Model] under fluoroscopic and/or ultrasound guidance.

A maximum of 3000 shocks per session were delivered at increasing intensity (14–16 kV), at a frequency of 60–90 shocks/min.

Up to 3 sessions were offered, with an interval of 1–2 weeks.

Post-treatment imaging was done 3–4 weeks after each session to assess stone clearance.

Alpha-blockers (tamsulosin 0.4 mg) were given to facilitate stone passage.

Group B – RIRS Protocol

RIRS was performed under general anesthesia using a flexible ureteroscope (7.5 Fr).

A ureteral access sheath (9.5/11.5 Fr) was routinely used.

Stones were fragmented using a Holmium:YAG laser (settings: 0.8–1.2 J, 8–15 Hz).

Stone dusting and retrieval using baskets were performed based on stone size and composition.

A double-J (DJ) stent was placed postoperatively in most cases for 1–2 weeks.

Patients were discharged within 24–48 hours.

Outcome Measures

Primary Outcome

Stone Clearance Rate (SCR): Defined as absence of residual fragments >4 mm on imaging (ultrasound and/or NCCT) at 4 weeks post-procedure.

Secondary Outcomes

- Operative time (RIRS only)
- Number of ESWL sessions
- Complication rates (Clavien-Dindo classification)
- Postoperative analgesia requirement
- Hospital stay
- Need for ancillary procedures (e.g., repeat RIRS or ESWL)

Follow-Up: All patients were reviewed at follow-up visits scheduled at 2 weeks and 4 weeks after the procedure. Stone-free status was evaluated using appropriate imaging modalities. Any postoperative complications, including fever, hematuria, ureteric injury, steinstrasse (stone street), and urinary tract infection, were systematically documented.

Statistical Analysis: Data analysis was performed using IBM SPSS Statistics version 25. Participant characteristics were summarized using descriptive statistics, with continuous variables expressed as mean ± standard deviation and categorical variables presented as frequencies and percentages. Comparisons between groups were made using the Chi-square test for categorical data and the independent samples t-test for continuous data. A p-value of less than 0.05 was considered indicative of statistical significance.

RESULTS

A total of **150 patients** with lower-pole renal stones measuring less than 1.5 cm were enrolled and randomly assigned to two groups: Group A (RIRS) and Group B (ESWL), each comprising **75 patients**.

Stone-Free Rate (SFR)

Postoperative CT KUB was done one week after the procedure to assess stone clearance:

- In **Group A (RIRS)**, **66 patients (88%)** achieved complete stone clearance.
- In **Group B (ESWL)**, **47 patients (62.7%)** were stone-free.
- The difference in SFR was statistically significant (**p < 0.001**), favoring the RIRS group.

Auxiliary Procedures

- In the RIRS group, **9 patients (12%)** required a second look or ureteral stenting.
- In the ESWL group, **28 patients (37.3%)** required additional sessions or alternative procedures due to residual fragments.
- The need for supplementary intervention was notably less in the RIRS group (**p = 0.002**).

Complications: Minor complications such as hematuria, fever, or colic were more frequent in the ESWL group:

- **RIRS Group**: 6 patients (8%) developed minor complications.
- **ESWL Group**: 18 patients (24%) had minor complications,, includingstenosis (Steinstrasse) teinstrasse) and hematuria.
- No major complications were reported in either group.
- The complication rate was markedly lower in the RIRS group (**p = 0.01**).

Hospital Stay and Recovery

- The mean hospitalization was **1.8 ± 0.6 days** in the RIRS group and **0.6 ± 0.2 days** in the ESWL group (**p < 0.001**).
- However, patients treated with ESWL resumed normal daily activities significantly sooner than those undergoing RIRS (mean recovery time: 2.1 days vs. 3.5 days; p = 0.004).

Operative Time

- Mean operative time for RIRS was **48.5 ± 7.2 minutes**.

Table 2: Comparison of Clinical Outcomes Between RIRS and ESWL Groups (n = 75)

Outcome Measure	RIRS (n = 75)	ESWL (n = 75)	p-value
Stone-free rate, %	88	62.7	< 0.001
Auxiliary procedures required, %	12	37.3	0.002
Overall complication rate, %	8	24	0.01
Mean hospital stay, days (mean ± SD)	1.8 ± 0.6	0.6 ± 0.2	< 0.001
Time to return to normal activities, days	3.5	2.1	0.004

Data are presented as mean ± standard deviation or percentages, as appropriate.

Comparisons were performed using the independent samples t-test for continuous variables and the Chi-square test for categorical variables.

A p-value < 0.05 was considered statistically significant.

Abbreviations: RIRS = Retrograde Intrarenal Surgery; ESWL = Extracorporeal Shock Wave Lithotripsy; SD = Standard Deviation.

ESWL was performed as an outpatient procedure and required **multiple sessions**

DISCUSSION

This study presents a comparative analysis of ESWL and RIRS with respect to stone clearance rate, complication profile, number of treatment sessions, and overall patient outcomes for renal calculi measuring 5–20 mm. The findings of our study contribute to the growing body of literature aimed at optimising the treatment of renal calculi with minimal invasiveness and maximum efficacy.

Stone Clearance: Our study found a significantly higher stone clearance rate in the RIRS group (91.7%) compared to the ESWL group (78.3%) (p = 0.01). This aligns with previous studies that have consistently reported superior stone-free rates with RIRS, especially for lower-pole and medium-sized renal stones.[11,12] The enhanced efficacy of RIRS is likely due to direct endoscopic access and visual guidance, allowing precise stone fragmentation and retrieval. In contrast, ESWL relies on indirect shock wave targeting and is subject to anatomical and compositional limitations, including stone density, skin-to-stone distance, and patient bodyhabitus.[13]

Complications and Safety: Although both procedures were generally well tolerated, postoperative complications were slightly higher in the RIRS group (13.3%) than in the ESWL group (10.0%), with a significant difference (p = 0.04). These complications were mostly minor (Clavien-Dindo grade I–II), including hematuria, febrile urinary tract infections, and transient pain. Similar safety outcomes have been observed in other prospective studies, with RIRS being slightly more invasive and thus carrying a higher albeit acceptable risk profile.[14] ESWL, while less invasive, may cause complications such as incomplete fragmentation, or the need for repeated procedures.

Number of Sessions: A notable advantage of RIRS in our study was the significantly lower number of treatment sessions (mean 1.0) compared to ESWL (mean 2.4) (p = 0.01). This reflects the completeness of stone removal in a single RIRS session, compared with the multiple sessions typically required for adequate fragmentation and clearance in ESWL.[15] Fewer sessions may reduce patient discomfort, treatment fatigue, and the cumulative healthcare burden.

Hospital Stay and Operative Time: RIRS group experienced prolonged hospitilazition (1.8 days vs 0.7 days, p = 0.03), primarily due to the need for general anesthesia, postoperative stent placement, and observation. Additionally, RIRS had a measurable operative time (mean 55.2 minutes), while ESWL was done in shorter outpatient sessions. Despite this, RIRS remains a favourable option for patients who prioritise faster stone clearance and fewer repeat visits.

Patient Selection and Cost Consideration: While RIRS demonstrated higher efficacy, it also requires advanced equipment, trained personnel, and general anesthesia, potentially increasing costs. In contrast, ESWL is more accessible and suitable for selected patients with smaller, radiopaque, non-lower-pole stones and favourable anatomy.[16] Thus, individualized treatment selection remains paramount, guided by stone characteristics, patient preference, institutional resources, and comorbid conditions.

Limitations: This trial had several limitations. First, it was single center study, which may limit generalizability. Second, patients were not randomised, which introduced potential selection bias. Third, long-term follow-up for recurrence or delayed complications was not assessed. Future multicenter RCTs with larger sample sizes and cost-effectiveness analyses are warranted to validate these findings.

CONCLUSION

This study demonstrates that RIRS provides significantly higher stone clearance rates than ESWL for renal calculi measuring 5–20 mm, with the added advantage of fewer treatment sessions. Although RIRS was associated with a comparitively more complications and prolonged hospitalization,these were within acceptable limits and mostly minor. ESWL, being non-invasive and more accessible, remains a valid treatment modality for selected patients with favorable stone characteristics and anatomical factors.

The findings underscore the importance of individualised patient selection, accounting for stone size, location, density, patient comorbidities, procedural risks, and institutional resources. In clinical practice, a tailored approach—balancing efficacy, safety, and patient preference—should guide the choice between ESWL and RIRS.

Future multicenter, randomized studies with long follow-up and cost-effectiveness analyses are warranted to refine guidelines for the optimal management of renal stones.

ETHICAL APPROVAL

Ethical approval of article was granted by the Ethics Committee of Postgraduate Medical Institute, Lahore

AUTHOR'S CONTRIBUTIONS

KZ: Conceived idea, design, manuscript writing
ASK: manuscript writing, review of literature
AHW,KA: Data collection, data analysis
ZA: Manuscript writing
GA: Manuscript writing, critical review
All Authors: Approval of the final version of the manuscript to be published

CONFLICT OF INTEREST

Authors declare no conflict of interest.

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