ORIGINAL PAPER

UROLITHIASIS

Impact of prior shock wave lithotripsy on outcomes of retrograde intrarenal surgery for 1–2 cm lower pole kidney stones: a comparative analysis by the EAU–YAU Endourology & Urolithiasis Working Group

Rifat Burak Ergül[#,1,2,3], Yasin Yitgin[#,4,5], T. Emre Şener[2,6], Arman Tsaturyan[2,7], Francesco Esperto[2,8], Begona Ballesta Martinez[2,9], Ali Talyshinskii[2,10], Victoria Jahrreiss[2,11], Lazaros Tzelves[2,12], Emine Yitgin[13], Tzevat Tefik[1], Amelia Pietropaolo[2,14]

[1]*Department of Urology, Istanbul Faculty of Medicine, Istanbul University, Istanbul, Turkey*
[2]*EAU Young Academic Urologists (YAU) Urolithiasis and Endourology Working Group Arnhem, The Netherlands*
[3]*Mus State Hospital, Mus, Turkey*
[4]*Department of Urology, Faculty of Medicine, Istinye University, Istanbul, Turkey*
[5]*Istanbul Nisantasi University, Faculty of Medicine, Istanbul, Turkey*
[6]*Department of Urology, Marmara University School of Medicine, Istanbul, Turkey*
[7]*Department of Urology, Yerevan State Medical University, Yerevan, Armenia*
[8]*Department of Urology, Campus Biomedico University of Rome, Italy*
[9]*Department of Urology, University Hospital del Vinalopo, Alicante, Spain*
[10]*Department of Urology and Andrology, Astana Medical University, Astana, Kazakhstan*
[11]*Department of Urology, Medical University of Vienna, Vienna, Austria*
[12]*2nd Department of Urology, Sismanoglio General Hospital, National and Kapodistrian University of Athens (NKUA), Greece*
[13]*Department of Anesthesiology, Faculty of Medicine, Istinye University, Istanbul, Turkey*
[14]*Department of Urology, University Hospital Southampton NHS Foundation Trust, Southampton, United Kingdom*

[#] *Rifat Burak Ergül and Yasin Yitgin have equally contributed to this study.*

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Corresponding author
Amelia Pietropaolo
Consultant Urological Surgeon
University Hospital Southampton NHS Foundation Trust
Tremona Road,
Southampton SO16 6YD
ameliapietr@gmail.com

Introduction The study compared the outcomes of retrograde intrarenal surgery (RIRS) performed as a second-line treatment following failed extracorporeal shock wave lithotripsy (SWL) with those of primary RIRS in patients with 1–2 cm lower pole kidney stones.

Material and methods A total of 83 patients who underwent RIRS for 1–2 cm lower pole renal calculi between February 2019 and September 2024 were retrospectively analyzed in this single-center study. Patients were divided into two groups: those who underwent RIRS after failed SWL (n = 43) and those who underwent primary RIRS (n = 40). Preoperative demographics, stone characteristics, operative parameters, and postoperative outcomes were compared. Statistical analyses were performed using R software.

Results There were no significant differences between the groups in terms of age, gender, body mass index, stone size, laterality, density, or Ito scores. The failed SWL group had significantly longer operative time (60 [55–75] vs 55 [40–66] min, p = 0.041), RIRS time (45 [37.5–55] vs 40 [30–46] min, p = 0.043), and fluoroscopy time (4 [3–7] vs 2 [2–4] s, p = 0.001). The stone-free rate was lower in the failed SWL group (79% vs 92%), but the difference was not statistically significant (p = 0.153). Postoperative urinary tract infections and complication rates were similar between groups (p >0.05).

Conclusions RIRS remains an effective and safe option for managing lower pole kidney stones after failed SWL. However, previous SWL may increase procedural complexity, as reflected by longer operative and fluoroscopy times. Given the retrospective single-center design and limited sample size, the study's findings should be considered exploratory and interpreted with appropriate caution pending validation in larger, multicenter cohorts.

Key Words: retrograde intrarenal surgery ‹› shock wave lithotripsy ‹› lower pole kidney stones ‹› stone-free rate ‹› urolithiasis

INTRODUCTION

Nephrolithiasis is a highly prevalent global health issue. Its worldwide prevalence is estimated to be approximately 8–9%, and in the United States alone, the annual healthcare burden is estimated to be around USD 3.8 billion. Due to its recurrent nature, kidney stone disease negatively affects patients' quality of life and imposes a substantial burden on healthcare systems [1].

The management of kidney stones located in the lower pole presents a particular challenge because of possible difficulties in accessing the stones as well as the removal or expulsion of fragments. According to the European Association of Urology (EAU) guidelines, for lower pole stones measuring 10–20 mm, retrograde intrarenal surgery (RIRS) or percutaneous nephrolithotomy (PCNL) is recommended in cases where unfavorable anatomy limits the efficacy of extracorporeal shock wave lithotripsy (SWL), whereas SWL, RIRS, or PCNL may be considered if the anatomy is favorable [2]. It is also known that shock wave energy delivered during SWL can cause renal parenchymal injury and impair renal function. Moreover, when applied to lower pole stones, SWL is associated with higher retreatment and auxiliary procedure rates, which may influence treatment planning [3, 4]. In the literature, data regarding the optimal management strategy following failed SWL for lower pole stones remain limited [5]. Specifically, it remains unclear whether salvage RIRS after failed SWL results in different outcomes compared to primary RIRS. Some studies have suggested that RIRS performed following failed SWL may be less effective than primary RIRS in terms of stone-free rates and complications [6].

The aim of this study was to compare the outcomes of RIRS performed as a second-line treatment following unsuccessful SWL with those of primary RIRS in the management of 1–2 cm lower pole kidney stones. This comparison seeks to determine whether prior SWL has any impact on endoscopic stone clearance success or postoperative complications.

MATERIAL AND METHODS

The data of 89 patients who underwent RIRS for 1–2 cm lower pole kidney stones between February 2019 and September 2024 were retrospectively reviewed. Four patients were excluded due to missing or incomplete data. One patient with a horseshoe kidney and another with concomitant ureteral stone requiring intervention during the same session were also excluded. A total of 83 patients were included in the final analysis.

The patients were divided into two groups: group A included 43 patients who underwent RIRS following failed SWL, while group B consisted of 40 patients who underwent primary RIRS. All patients read and signed a comprehensive, approved written informed consent form preoperatively, which clearly explained both surgical procedures, along with their potential risks and benefits.

Preoperative demographic data of the patients were recorded, and a standard preoperative evaluation protocol–including laboratory tests (blood tests, urinalysis, and urine culture) and computed tomography (CT)–was routinely performed for all patients. Stone-related characteristics such as side, location, laterality, size (mm), density (Hounsfield units), and presence of calyceal dilatation were documented. Perioperative variables including operation time, RIRS time, and fluoroscopy time were also recorded. Operation time was defined as the duration from the initiation of anesthesia to the completion of the procedure, while RIRS time was defined as the time between the insertion and withdrawal of the flexible ureteroscope through the ureteral orifice. The Ito nomogram was used to standardize surgical difficulty [7].

Postoperative outcomes included stone-free rates (SFR), urinary tract infections, length of hospital stay, and postoperative complications. Stone-free status was assessed with CT imaging at the first postoperative month. Residual fragments smaller than 2 mm were considered stone-free [8]. The duration of hospital stay was calculated in hours from the end of surgery to the time of discharge. Postoperative complications were classified using the Modified Clavien-Dindo Classification System (MCDCS).

Surgical technique

All procedures were performed under general anesthesia with the patient in the lithotomy position. The operation was initiated with the placement of a 0.035-inch PTFE guidewire into the renal pelvis under fluoroscopic guidance. Semirigid ureteroscopy was performed using a 4.5/6.5 Fr ureteroscope

(Richard Wolf, Germany) for both diagnostic evaluation and active ureteral dilation. A ureteral access sheath (UAS) was not used in any of the patients. Subsequently, a flexible ureteroscope (7.95 Fr, URF-P7; Olympus, Japan) was advanced over the guidewire into the renal pelvis. An 8 Fr feeding catheter was inserted for bladder drainage. Lithotripsy was performed using a 272-micron holmium:YAG laser fiber with the dusting technique in all cases. At the end of the procedure, a 4.8 Fr JJ stent was placed in all patients. The stents were removed postoperatively within 2 to 4 weeks.

Statistical analysis

All statistical analyses were performed using R software (R Foundation for Statistical Computing, Vienna, Austria; version 2023.06.1+524). The distribution of continuous variables was assessed using the Shapiro–Wilk test. For comparisons between two groups, Student's t-test was applied to normally distributed variables, and the Mann–Whitney U test was used for non-normally distributed and ordinal variables. Continuous variables were reported as mean ± standard deviation or median with interquartile range (Q1–Q3), as appropriate. Categorical variables were expressed as frequencies and percentages (%). Group comparisons for categorical variables were conducted using the Pearson χ^2 test, and Fisher's exact test was employed when the expected frequency in any cell was less than 5. A two-tailed p-value of <0.05 was considered statistically significant.

Bioethical standards

The study was approved by the Institutional Review Board (IRB) of the Istinye University, where the research was conducted (No: 2024-05).

RESULTS

The data of 83 patients who underwent RIRS for 1–2 cm lower pole kidney stones were analyzed retrospectively. RIRS was performed in 43 patients (51.8%) who had previously undergone failed SWL (group A), and in 40 patients (48.2%) who underwent primary RIRS (group B). The mean age was 52.5 ±12.4 years in group A and 49.0 ±13.6 years in group B, with no statistically significant difference (p = 0.232). Median stone size was 16 mm (12.5–20) in group A and 15 mm (11–20) in group B (p = 0.557). No statistically significant differences were observed between the two groups regarding demographic parameters (gender and body mass index), stone characteristics (laterality and density), presence of calyceal dilatation, or ITO scores. Detailed values are presented in Table 1.

Among patients in group A, the median number of SWL sessions was 2 (range: 1–3), and the median interval from the last SWL session to RIRS was 22 days (range: 14.5–34) (Table 1).

The median operation time was significantly longer in group A compared to group B (60 [55–75] vs 55 [40–66] minutes, p = 0.041). Similarly, the RIRS time was significantly longer in group A (45 [37.5–55] vs 40 [30–46] minutes, p = 0.043). Median fluoroscopy time was also significantly higher in group A (4 [3–7] vs 2 [2–4] seconds, p = 0.001) (Table 2).

Although the stone-free rate was lower in group A compared to group B (79% vs 92%), the difference was not statistically significant (p = 0.153) (Table 2). Postoperative urinary tract infection occurred in 4 patients (9.3%) in group A and in 5 patients (12.5%) in group B (p = 0.732). According to the Modified Clavien–Dindo Classification System (MCDCS), most complications were minor (Grade 1 or 2) in both groups, and no patient experienced a complication higher than Grade 2. There was

Table 1. *Baseline characteristics of patients undergoing RIRS following failed SWL vs primary RIRS*

	Group A (RIRS after failed SWL) (n = 43)	Group B (primary RIRS) (n = 40)	p-value
Age (years), mean ±SD	52.5 ±12.4	49.0 ±13.6	0.232*
Gender			
Male, n (%)	24 (55.8)	24 (60)	0.870**
Female, n (%)	19 (44.2)	16 (40)	
BMI (kg/m²), mean ±SD	26.2 ±5.1	25.7 ±5.4	0.666*
Stone size (mm), median (Q1–Q3)	16 (12.5–20)	15 (11–20)	0.557***
Laterality			
Right, n (%)	16 (37.2)	21 (52.5)	0.238**
Left, n (%)	27 (62.8)	19 (47.5)	
Calyceal dilatation			
Present	12 (27.9)	13 (32.5)	0.828**
Absent	31 (72.1)	27 (67.5)	
Hounsfield units (HU), mean ±SD)	950 ±182	916 ±188	0.409*
ITO score, median (Q1–Q3))	12 (11–15)	14 (10–16.5)	0.861***
Number of ESWL sessions, median (Q1–Q3)	2 (1–3)	–	
Time from the last ESWL session until the operation (days), median (Q1–Q3)	22 (14.5–34)	–	

* t-test
** Pearson's χ^2 test
*** Mann–Whitney U test
BMI – body mass index; ESWL – extracorporeal shock wave lithotripsy;
RIRS – retrograde intrarenal surgery

no significant difference between the groups regarding MCDCS grading (p = 0.407) (Table 2).

DISCUSSION

In this retrospective study of 83 patients with 1–2 cm lower pole kidney stones, we compared surgical and clinical outcomes of RIRS performed after failed SWL and as a primary treatment. The groups were comparable in terms of demographic and stone-related characteristics. However, operative time, RIRS time, and fluoroscopy time were significantly longer in the failed SWL group. While the stone-free rate was slightly lower in this group, the difference did not reach statistical significance. Postoperative complication rates and infection rates were also similar between the two groups. The treatment of kidney stone disease, which constitutes a significant part of daily urological practice, has evolved considerably in recent years due to advancements in endoscopic instruments, imaging techniques, and laser technologies. [9] Stone characteristics–including size and location–along with predictive parameters such as SFR and complication risk, play crucial roles in determining the most appropriate treatment strategy. However, there is still no clear consensus on the optimal treatment modality for 1–2 cm lower pole kidney stones. SWL, RIRS, and PCNL are all commonly used options for managing such cases [10, 11]. Among these, PCNL has been shown to offer the highest SFRs in 1–2 cm lower pole stones, although it is more invasive than both RIRS and SWL. On the other hand, SWL is less invasive than RIRS but is associated with lower success rates and a higher need for retreatment [10, 12, 13]. In our study, the SFRs were 79% in group A and 92% in group B–findings that are consistent with those reported in the literature.

SWL has become the most preferred treatment modality for kidney stones smaller than 2 cm, largely due to its non-invasiveness, outpatient applicability, and favorable patient tolerance, as supported by both guideline recommendations and clinical practice patterns [13, 14]. However, several previous studies have reported that SWL may cause significant acute and chronic damage to the kidney and surrounding tissues, in addition to its relatively lower stone-free rates. SWL-induced renal injury can involve damage to nephrons, microvasculature, surrounding interstitium, and calyceal structures [15–17]. In our study, RIRS performed in patients with failed SWL was associated with inferior outcomes in terms of both efficacy and safety when compared to primary RIRS cases. Regarding efficacy, operative time, RIRS duration, and fluoroscopy time were significantly longer in patients who had previously undergone unsuccessful SWL. In terms of safety, although complications were more frequently observed in the failed SWL group, the difference was not statistically significant. We interpret these findings as potentially related to bleeding during RIRS that may impair endoscopic visualization as well as fibrotic changes in the calyceal anatomy induced by previous SWL sessions, which may increase the technical complexity of the procedure. Furthermore, previous SWL sessions may induce chronic inflammatory or fibrotic changes within the renal collecting system, particularly around the calyceal infundibula [18]. Shock wave-related tissue injury can lead to submucosal fibrosis, edema, and distortion of the lower pole anatomy, which may restrict the deflection and maneuverability of the flexible ureteroscope during RIRS [19]. Intraoperatively, these patients often exhibit areas of mucosal thickening or granulation, and fragmented stone

Table 2. *Clinical outcomes and complication rates following RIRS after failed SWL vs primary RIRS*

	Group A (RIRS after failed SWL) (n = 43)	Group B (primary RIRS) (n = 40)	p-value
Operation time (min), median (Q1–Q3)	60 (55–75)	55 (40–66)	0.041*
RIRS time (min), median (Q1–Q3)	45 (37.5–55)	40 (30–46)	0.043*
Fluoroscopy time (s), median (Q1–Q3)	4 (3–7)	2 (2–4)	0.001*
Stone-free status			0.153**
Yes	34 (79%)	37 (92%)	
No	9 (20.9%)	3 (7.5%)	
Hospitalization (hours), mean ±SD	18.1 ±6.5	19.3 ±12.1	0.375***
UTI, n (%)	4 (9.3%)	5 (12.5%)	0.732****
MCDCS n (%)			0.407 *
Grade 0	21 (48.8%)	25 (62.5%)	
Grade 1	15 (35.9%)	7 (17.5%)	
• Fever (only antipyretics)	8 (18.6%)	6 (15%)	
• Hematuria	7 (16.3%)	1 (2.5%)	
Grade 2	7 (16.3%)	8 (20%)	
• UTI	4 (9.3%)	5 (12.5%)	
• Renal colic	3 (7%)	3 (7.5%)	

* Mann–Whitney U test
** Pearson's χ^2 test
*** t-test
**** Fisher's exact test
ESWL – extracorporeal shock wave lithotripsy; MCDCS – Modified Clavien-Dindo Classification System (Grade 1: abnormal postoperative condition not requiring non-routine pharmacological or surgical treatment. Grade 2: requiring non-routine pharmacological treatment); RIRS – retrograde intrarenal surgery; UTI – urinary tract infection

material embedded in fibrotic tissue, all of which can prolong lithotripsy and retrieval time. Similar findings have been described in imaging-based studies showing calyceal narrowing or deformation after repeated SWL exposure [16, 17]. Edema and stone impaction after SWL can also play a role in increasing the complexity of the surgery in cases with previous failed SWL [19].

Previous studies have reported that the primary effect of shock waves involves injury to the renal papilla and medulla, along with vascular damage within the renal parenchyma [18]. Similar investigations have suggested that free radicals generated as a result of reperfusion–secondary to intrarenal vasoconstriction induced by shock waves–may contribute to tissue hypoxia and increase renal damage during both acute and chronic phases. These SWL-related changes have been demonstrated through the use of urinary biomarkers [15, 20]. Additionally, it has been suggested that extending the interval between SWL and subsequent RIRS may improve stone-free rates and reduce complication risks [21, 22]. In our study, we observed that the inflammatory processes triggered by shock wave exposure in Group A negatively affected surgical outcomes–particularly operative times–likely due to ongoing tissue alterations present at the time of intervention.

Holland et al. [6] presented a retrospective comparison of patients with renal stones (60% located in the lower pole) who underwent RIRS as a first-line treatment versus those who underwent RIRS as a second-line treatment, mostly after failed SWL. The SFR was 80% in the primary RIRS group and 67% in the second-line group, showing a statistically higher success rate in the primary group. Although the complication rate and length of hospital stay were higher in the second-line RIRS group, the difference was not statistically significant. Rabie et al. [23] prospectively evaluated the impact of previously failed SWL in patients with upper urinary tract stones. They found no significant difference between the groups in terms of SFR or overall success rate. Additionally, there were no significant differences in intraoperative fluoroscopy time, operative time, stone appearance during the procedure, perioperative complications, or the presence of embedded stone fragments in the ureteral mucosa. Philippou et al. [24] investigated upper urinary tract stones and reported that the SFR was 73.6% in the RIRS after failed SWL group and 82.8% in the primary RIRS group ($p = 0.186$). There were no significant differences between the groups in terms of complications, operative time, or length of hospital stay. However, the total laser energy used for stone fragmentation was significantly higher in the primary group ($p = 0.043$) [24]. Yürük et al. [25] examined patients with kidney stones who underwent primary RIRS and RIRS after failed SWL. There was no significant difference in mean operative time and fluoroscopy time between the groups ($p = 0.64$ and $p = 0.76$, respectively). The length of hospital stay and overall complication rates were also similar. At the third postoperative month, the stone-free rates did not differ significantly between the groups (82.5% vs 86.9%, $p = 0.38$) [25]. In our study, although the SFR was higher in group B, the difference was not statistically significant. However, operative time, RIRS time, and fluoroscopy time were shorter in this group ($p < 0.05$). There were no significant differences between the two groups in terms of hospital stay or complication rates. Similar to our study, other groups have reported performing PCNL after failed SWL. Iqbal et al. [26] and Zhong et al. [27] achieved good outcomes even after failed SWL, highlighting that PCNL could be a more effective procedure for this cohort of patients.

A distinctive strength of the present study lies in its methodological homogeneity. All procedures were performed without the use of a UAS, focusing exclusively on lower pole stones, and employing a standardized dusting-only holmium:YAG laser technique. This consistent approach minimizes procedural variability and provides a more controlled evaluation of the impact of prior SWL on RIRS outcomes. Such standardization distinguishes the present study from previous reports that involved heterogeneous stone locations or diverse operative techniques.

This study has several limitations that should be acknowledged. First, its retrospective design inherently carries the risk of selection and information bias. Second, the relatively small sample size, particularly when comparing subgroups, may have limited the statistical power to detect significant differences in stone-free rates and complication rates. Therefore, the findings should be interpreted as hypothesis-generating rather than confirmatory. Third, the study was conducted at a single center by a single surgical team, which may limit the generalizability of the findings to other institutions or surgical practices. Another limitation is that SWL procedures were not performed at our center, and therefore, details such as shock wave power, the number of impulses and the optimal waiting time before RIRS could not be standardized or analyzed. Additionally, intraoperative parameters such as laser energy settings were not standardized or evaluated in detail, potentially affecting the interpretation of procedural outcomes.

Lastly, long-term follow-up data were not available, preventing the assessment of stone recurrence and late complications. Future prospective, multicenter studies with larger cohorts and standardized protocols are needed to validate and expand upon these findings.

CONCLUSIONS

In the management of 1–2 cm lower pole kidney stones, RIRS performed after failed SWL is a viable second-line treatment option. Although the procedure is associated with longer operative, endoscopic, and fluoroscopy times compared to primary RIRS, it provides comparable stone-free rates and similar postoperative complication profiles. These findings suggest that prior SWL may increase procedural complexity without significantly compromising clinical outcomes. Further prospective, large-scale studies are needed to better define the impact of prior SWL on RIRS efficacy and to guide optimal treatment strategies for lower pole nephrolithiasis.

CONFLICT OF INTERESTS

The authors declare no conflict of interest.

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ETHICS APPROVAL STATEMENT

The study was approved by the Institutional Review Board (IRB) of the Istinye University, where the research was conducted (No: 2024-05).

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