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# Flexible ureteroscopy and laser lithotripsy in unilateral multiple renal stones

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## Abstract

**Background and Objectives**: To identify the factors contributing to stone-free rates and postoperative complications of flexible ureteroscopy and laser lithotripsy in unilateral multiple renal stones.

**Methods:** A total of 20 patients had retrograde intrarenal surgery procedures to treat unilateral multiple renal stones, less than 50 mm collectively were reviewed from May 2021 to December 2021. Stone numbers were calculated, and stone size was measured as the cumulative stone diameter of all intrarenal stones. The clinical insignificant residual stones were defined as the absence of stone fragments <4 mm in the kidney at the end of the procedures. Baseline patient characteristics, operation time, hospital stay, stone-free rates, and complications were recorded.

**Results:** Retrograde intrarenal surgery was performed on 20 patients (12 males and 8 females). The overall success rate was 80%. Depending on the sizes of the stones, patients with stones <20 mm had a stone-free rate of 100% (10/10 patients), and patients with stone size ≥ 20mm had a stone-free rate of 60% (6/10) with a ($p < 0.003$). The number of stones per renal unit was two in 13 patients with a stone-free rate of (92.3%), three in 7 patients, and a stone-free rate was (57.1%) with a ($p= 0.06$). Postoperative complications were encountered in 4 patients (20%), and all were treated conservatively.

**Conclusions:** Retrograde intrarenal surgery provides a satisfactory stone-free rate with a low complication rate when treating multiple renal stones. However, the success rate, stone-free rate, and the number of sessions significantly depend on the size and the number of stones.

**Key words:** Multiple renal stones; Retrograde Intrarenal Surgery; Ureteroscopy.

## Introduction

The lifetime prevalence of kidney stones is approximately 7% for women and 13% for men.[1, 2] The 5-year recurrence rate is 35% to 50% without treatment.[3] Advancements in renal stone treatment occurred through holmium laser technology and improved flexible ureteroscopes (FURS) like reduction in diameter, greater working channels, better imagining definition, improved deflection mechanism, and smaller stone baskets. The indications of retrograde intrarenal surgery (RIRS) have been broadened, and it is now a popular endourologic surgery for treating renal stones with high success rates. It is considered a safe and effective therapeutic option for stones of various sizes.[4, 5] Flexible ureteroscopy with laser lithotripsy RIRS treats large > 2 cm renal stones. Recent studies show a high stone-free rate (SFR) and a low complication rate.[6] In addition, recent publications show that F-URSL may be an alternative option to percutaneous nephrolithotomy (PCNL), with similar SFRs, a shorter hospital stay, and fewer complications but more sessions

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per patient.[7-9] PCNL and shockwave lithotripsy (SWL) has been the renal calculi treatments. However, the emergence of small ureteroscopes with improved active deflection and superior vision has broadened the scope of ureteroscopy (URS) for kidney calculi, as it can reduce the dangers of percutaneous renal surgery, such as fever in 10.8% of cases, transfusion in 7%, thoracic complication in 1.5%, sepsis in 0.5%, organ injury in 0.4%, embolization in 0.4%, and death in 0.05% bleeding and can be performed as an outpatient procedure.[10] Furthermore, due to various developments in laser technology, equipment, settings, and associated prices, the use of lasers in endourology has broadened during the last three decades. Common endourology lasers include the Holmium (Ho: YAG), Potassium titanyl phosphate (KTP: YAG), commonly referred to as the green light laser, and Thulium (Tm: YAG and fiber (TFL)) lasers. In addition, adjusting the energy and frequency settings can be used for stone fragmentation, dusting, pop-corning, and pop-dusting.[11, 12] Because the Ho: YAG laser's wavelength of 2140nm is significantly absorbed in water, it travels just 0.3-0.5mm in fluid media, making it excellent for urological application in small spaces like the ureter or renal pelvis.[13] The modified Clavien- Dindo classification system (MCCS) is the most utilized evaluation method. This consists of grades; low-grade (Grade I-II), medium-grade (Grade III a - III b), and high (Grade IV-V).[14] Similarly, non-contrast computed tomography (NCCT) is the standard imaging method for diagnosing urolithiasis. NCCT provides stone measurements (size and volume), stone location, and stone density (Hounsfield units (HU) measures.[15] The popularized term clinically insignificant residual fragment (CIRF) is defined as fragments equal to and less than 4 mm, asymptomatic, non-infectious, and associated with sterile urine[16]. This study aimed to identify the factors contributing to stone-free rates and postoperative complications of flexible ureteroscopy and laser lithotripsy in unilateral multiple renal stones of various sizes.

## Patients and methods

After the approval of the ethical committee of the Kurdistan Higher Council of Medical Specialties, the data were collected prospectively between May 2021 and December 2021 from 20 patients in Sulaimani province who had unilateral multiple renal stones treated with RIRS. A written Informed consent was obtained from all the participants to participate in the study. Inclusion criteria were adults over eighteen, more than one kidney stone, and a stone size of less than 50 mm was reviewed—previously operated on for stone disease, any weight, and patients with ureteric tightness who got a JJ stent one month before the study were all eligible. Exclusion criteria were congenital renal anomalies (ectopic kidney, horseshoe kidney, duplex system), ureteropelvic junction obstruction, untreated urinary tract infection, pregnancy, coagulopathy, and patients who refused to participate in the study. A sample of twenty individuals with renal stones underwent RIRS based on the inclusion and exclusion criteria. All patients had a complete medical history and physical examination, abdominal ultrasonography (USG), Abdominal CT-KUB scan to evaluate the size and position of the stone, and a total blood count (CBC), CRP, serum creatinine, urinalysis, urine culture, and sensitivity. The data was collected through a prepared questionnaire. The information was provided by patients and taken by the surgeon. All patients received antibiotic therapy as prophylaxis with cefuroxime (1gm) or adapted antibiotic in patients with a positive urine culture. A JJ stenting was inserted before RIRS procedures in 2 patients (10%)

because of ureteral tightness and infected obstructed uropathy. All procedures were performed under general anesthesia. The semi-rigid URS was inserted into the ureter to the renal pelvis using a sensor guide wire (0.035 Fr.) to dilate the ureter. If there was an inability to bypass adult semi-rigid URS (8-9.8 Fr.) into the renal pelvis, a small size semi-rigid URS (6-7.5 Fr.) was inserted to bypass the tight portion of the ureter, and then a semi-rigid URS drawback and ureteral access sheath (UAS) (10 Fr. and 45 cm in length) inserted into renal pelvis over the guidewire (on the empty bladder to avoid sheath kinking on guidewire) under direct vision by fluoroscopy. Moreover, the inner UAS was extracted to facilitate the insertion of FURS into the renal pelvis (7.5 Fr. 95cm in length and its angulation is 180goniometer). The holmium laser system is(Karls Storz, Calculase III, power 30 WATS, and 230 microns laser Fiber) with a power setting of 0.8-1.2 J and frequency of 10-15 Hz. that is adjusted accordingly. Once FURS was inside the renal pelvis, relocate the stone and direct it with the help of a Dormia basket (1.9 mm zero tips) to a location that allows us to work in a straight line like the upper calyx or renal pelvis. Subsequently, if the stone was not basketball, we fragmented it in situ and took it by basket into a suitable location. At the end of the procedure, patients underwent endoscopic and fluoroscopic examinations to check for stone fragments that were not big enough to pass spontaneously. Fluoroscopy was performed to check for residual stone and extravasation of contrast from the ureter and kidney. Operation time was recorded from the cystoscope's insertion to the JJ stent's placement. At the end of the procedure, it's our policy to routinely place a 5-6 Fr JJ stent for 2-4 weeks and an indwelling Foley catheter for 12-24 hours. Hence, the patient was discharged in zero, 1st, or 2nd days post-operation from the hospital. The method was successful if no stone or a stone <4 mm was noticed in the collecting system. Because residual stones <4 mm are spontaneously expelled and too small to be extracted with a basket or grasper; such stones were regarded as clinically insignificant residual fragments After two to four weeks, CT KUB was performed for follow-up and to detect stone clearance before the JJ stent removal. Data collection, entry, and coding were performed using Microsoft Excel Version 2016 (Microsoft Corporation, Redmond, WA). Besides, the "IBM SPSS Statistics version 25" was used to analyze the data, and both descriptive and inferential statistics were used. Furthermore, a P-value of $\leq 0.05$ was considered a statistically significant association. Also, Pearson Chi-Square was used to determine the significance of the association between categorical independent and dependent variable pairs. Finally, the Student's T-Test (Paired-Samples T-Test) was used to compare pairs of numerical independent and dependent variables.

## Results

RIRS was performed on 20 patients (12 males and 8 females); the mean patient age was 44.35 ± 14.85 (from 21 to 80). The mean stone size was 25.7 ± 5.1 mm (15 to 44 mm). Table (1)

**Table (1):** General patients and stones characteristics

| Categories | Mean | Standard deviation | Range |
|---|---|---|---|
| Age | 44.35 | 14.85 | 21-80 |
| Body mass index | 27.15 | 3.44 | 22-34 |
| Hemoglobulin g/dl | 13.10 | 1.51 | 10.6-15.6 |
| W.B.C. | 7070.00 | 1095.97 | 5100-9000 |
| Platelet | 272.20 | 67.82 | 176-410 |
| S. creatinine | 0.62 | 0.18 | 0.3-0.9 |
| Blood urea | 29.11 | 8.61 | 18.0-43.0 |
| Mean stone No./patient | 2.35 | 0.49 | 2-3 |
| Mean stone size | 25.7 | 5.1 | 15-44 |
| Hounsfield unit (HU) | 1029.25 | 192.63 | 710-1420 |
| Operation duration/min. | 92.75 | 18.24 | 55-130 |

Descriptive statistics performed using SPSS V25 Regarding the distribution of stones in each kidney, Table (2).

**Table (2):** Stone Number and location in the kidneys

| Categories | Frequency | Percentage |
|---|---|---|
| No. of stones | | |
| 2 | 13 | 65.0 |
| 3 | 7 | 35.0 |
| Laterality of stone | | |
| Right | 11 | 55.0 |
| Left | 9 | 45.0 |
| Stone location by CT. | | |
| Pelvic & lower pole | 7 | 35.0 |
| Pelvic upper pole | 1 | 5.0 |
| Pelvic mid pole | 2 | 10.0 |
| Lower pole alone | 2 | 10.0 |
| Upper & lower poles | 2 | 10.0 |
| Upper & mid poles | 3 | 15.0 |
| Lower, upper mid poles | 2 | 10.0 |
| Lower & mid poles | 1 | 5.0 |

Descriptive statistics performed using SPSS V25

There were 10 patients with a stone burden of <20 mm, and their SFR was 100%, and 10 patients with a stone burden of ≥20 mm had an SFR of 60% (4/10) (P 0.003). The remaining 4 (40%) patients underwent a staged RIRS procedure. The number of stones per renal unit was two in 13 patients with an SFR of (92.3%), three in 7 patients, and an SFR of (57.1%) (p 0.06). The size of residual stone fragments was 5-8mm. According to HU of the stones, in patients whose HU was <1000, the SFR was 88.9%, and 72.2 % of patients whose HU was >1000 were stone-free (p 0.37) Tables (3) and (4).

**Table (3):** Success rate of RIRS concerning Size and Number of the stones

| Intra & postoperative data | | |
|---|---|---|
| | No. of patients | Success rate |
| Stone free rate according to stone size | | No. (%) |
| < 20 mm | 10 | (10/10)100% |
| ≥ 20 mm | 10 | (6/10)60% |
| Overall success rate | | |
| | 16 | (16/20)80% |
| Stone free rate according to stone number | | |
| Two stones | 13 | (12/13)92.3% |
| Three stones | 7 | (4/7)57.1% |

Descriptive statistics performed using SPSS V25 SFR concerning different types of variables was found only statistically significant with the size and number of the stones Table (4).

**Table (4):** SFR according to different categories

| Categories | Stone residual < 4mm | | Stone residual ≥ 4mm | | Total | p-value |
|---|---|---|---|---|---|---|
| | No. | % | No. | % | | |
| Gender | | | | | | |
| Male | 11 | 91.7 | 1 | 8.3 | 12 | 0.25 |
| Female | 5 | 62.5 | 3 | 37.5 | 8 | |
| Chief complaint | | | | | | |
| Pain | 14 | 77.8 | 4 | 22.2 | 18 | 0.76 |
| Hematuria | 1 | 100.0 | 0 | 0.0 | 1 | |
| Pyelonephritis | 1 | 100.0 | 0 | 0.0 | 1 | |
| Number of stones | | | | | | |
| Two | 12 | 92.3 | 1 | 7.7 | 13 | 0.06 |
| Three | 4 | 57.1 | 3 | 42.9 | 7 | |
| Laterality | | | | | | |
| Right | 9 | 81.8 | 2 | 18.2 | 11 | 0.82 |
| Left | 7 | 77.8 | 2 | 22.2 | 9 | |
| Stone size | | | | | | |
| < 20 mm | 10 | 100.0 | 0 | 0.0 | 10 | 0.003 |
| ≥ 20 mm | 6 | 60.0 | 4 | 40.0 | 10 | |
| Hounsfield unit (HU) | | | | | | |
| < 1000 | 8 | 88.9 | 1 | 11.1 | 9 | 0.37 |
| ≥ 1000 | 8 | 72.7 | 3 | 27.3 | 11 | |

Descriptive statistics were performed using SPSS V25, in addition to the Chi-square test, to find out the association between the different categories of variables

The UAS was successfully fixed in 19 patients (90%). Regarding lower calyceal stones, all the stones relocated to the upper calyx either intact or after initial fragmentation into parts by a stone basket. Basketing was performed in 18 patients (90%); the other two patients had stone fragmentation in situ and spontaneously washed out by irrigation fluid. The mean operative time according to stone size was 78.5 ± 10.01 minutes, ranging between 60-90 minutes for stone <20 mm, and 104 ±12.43 minutes range between (90 – 130) for stone size ≥20mm, respectively (p <=0.001). The mean white blood cell count (WBC) level before the operation was 7.070, and after the procedure was 12.885(p =<0.001) Table (5).

**Table (5):** Operative time and blood changes after RIRS

| Variable | Mean | Standard deviation | Range | p-value |
|---|---|---|---|---|
| Mean operation time/minutes | | | | |
| Stone size <20mm | 78.5 | 10.01 | 60-90 | ≤0.001 |
| Stone size ≥20mm | 104 | 12.43 | 90-130 | |
| White blood cell count | | | | |
| Before operation | 7070 | 1095.97 | 6400-9000 | ≤0.001 |
| After operation | 12.885 | 2243.79 | 7000-17000 | |
| Hemoglobulin level | | | | |
| Before operation | 13.1 | 1.51 | 10.6-15.6 | 0.86 |
| After operation | 13.04 | 1.51 | 10.6-15.6 | |
| Serum creatinine (mg/dl) | | | | |
| Before operation | 0.62 | 0.18 | 0.3-0.9 | 0.71 |
| After operation | 0.66 | 0.23 | 0.3-1.1 | |

Descriptive statistics were performed using SPSS V25 in addition to a T-test to evaluate the differences between means regarding intraoperative complications; only one patient (5%) had mild extravasation of contrast from the renal calyx. Postoperative complications of MCCS were encountered in 4 patients (20%), grade I in one patient, and grade II in three patients (5%) and (15%), respectively, and all were treated conservatively Tables (6) and (7).

**Table (6):** Postoperative complications concerning different variables

| Categories | Clavien-Dindo grading | | | | | | Total | p-value |
|---|---|---|---|---|---|---|---|---|
| | No complication | | Grade I | | Grade II | | | |
| | No. | % | No. | % | No. | % | | |
| Gender | | | | | | | | |
| Male | 10 | 83.3 | 1 | 8.3 | 1 | 8.3 | 12 | 0.45 |
| Female | 6 | 75.0 | 0 | 0.0 | 2 | 25.0 | 8 | |
| Number of stones | | | | | | | | |
| Two | 11 | 84.6 | 1 | 7.7 | 1 | 7.7 | 13 | 0.37 |
| Three | 5 | 71,4 | 0 | 0.0 | 2 | 26.8 | 7 | |
| Stone location by CT scan | | | | | | | | |
| Pelvis and lower pole | 7 | 100.0 | 0 | 0.0 | 0 | 0.0 | 7 | 0.49 |
| Pelvis upper pole | 1 | 100.0 | 0 | 0.0 | 0 | 0.0 | 1 | |
| Pelvis mid pole | 2 | 100.0 | 0 | 0.0 | 0 | 0.0 | 2 | |
| Lower pole alone | 1 | 50.0 | 0 | 0.0 | 1 | 50.0 | 2 | |
| Upper and lower poles | 2 | 100.0 | 0 | 0.0 | 0 | 0.0 | 2 | |
| Upper and mid poles | 1 | 33.3 | 1 | 33.3 | 1 | 33.3 | 3 | |
| Lower upper mid poles | 1 | 50.0 | 0 | 0.0 | 1 | 50.0 | 2 | |
| Lower and mid poles | 1 | 100.0 | 0 | 0.0 | 0 | 0.0 | 1 | |
| Past medical history | | | | | | | | |
| Negative | 11 | 91.7 | 0 | 0.0 | 1 | 8.3 | 12 | 0.23 |
| Positive | 5 | 62.5 | 1 | 12.5 | 2 | 25.0 | 8 | |
| Past surgical history | | | | | | | | |
| Negative | 6 | 75.0 | 0 | 0.0 | 2 | 25.0 | 8 | 0.45 |
| Positive | 10 | 83.3 | 1 | 8.3 | 1 | 8.3 | 12 | |
| Stone size | | | | | | | | |
| < 20 mm | 8 | 80.0 | 1 | 10.0 | 1 | 10.0 | 10 | 0.51 |
| ≥ 20 mm | 8 | 80.0 | 0 | 0.0 | 2 | 20.0 | 10 | |
| Site of stone residual | | | | | | | | |
| Lower pole | 2 | 75.0 | 0 | 0.0 | 1 | 25.0 | 1 | 0.11 |
| Mid pole | 0 | 0.0 | 0 | 0.0 | 1 | 100.0 | 1 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Size of stone residual if greater than 4 mm | | | | | | | | |
| 5mm | 1 | 100.0 | 0 | 0.0 | 0 | 0.0 | 1 | 0.18 |
| 6 mm | 1 | 50.0 | 0 | 0.0 | 1 | 50.0 | 2 | |
| 7 & 8 mm | 1 | 100.0 | 0 | 0.0 | 0 | 0.0 | 1 | |
| Hospital stay/days | | | | | | | | |
| Zero | 8 | 100.0 | 0 | 0.0 | 0 | 0.0 | 8 | 0.06 |
| One | 7 | 77.8 | 1 | 11.1 | 1 | 11.1 | 1 | |
| Two | 1 | 33.3 | 0 | 0.0 | 2 | 66.7 | 3 | |
| Dormia basket used | | | | | | | | |
| Yes | 14 | 77.8 | 1 | 15.6 | 3 | 16.7 | 18 | 0.76 |
| No | 2 | 100.0 | 0 | 0.0 | 0 | 0.0 | 2 | |
| Access sheath used | | | | | | | | |
| Yes | 16 | 84.2 | 0 | 0.0 | 3 | 15.8 | 19 | ≤0.001 |
| No | 0 | 0.0 | 1 | 100.0 | 0 | 0.0 | 1 | |
| JJ Stent used before operation | | | | | | | | |
| Yes | 16 | 80.0 | 1 | 5.0 | 3 | 15.0 | 2 | 0.36 |
| No | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | |

Descriptive statistics were performed using SPSS V25, in addition to the Chi-square test, to find out the association between the various categories of variables regarding hospital stay post-operation, 8 patients (40%) were discharged on zero-day, 9 patients (45%) on the first postoperative day and 3 patients (15%) on 2nd postoperative day.

**Table (7):** Incidence of intraoperative and postoperative complications

| Categories | Frequency | Percentage |
|---|---|---|
| Postoperative complications (Clavien-Dindo system) | | |
| No | 16 | 80.0 |
| I | 1 | 5.0 |
| II | 3 | 15.0 |
| Intraoperative complications | | |
| No | 19 | 95.0 |
| Ureteral injury | 0 | 0.0 |
| Bleeding | 0 | 0.0 |
| Small extravasation of contrast | 1 | 5.0 |

Descriptive statistics performed using SPSS V25

## Discussion

Recent European Association of Urology (EAU) guidelines recommend PCNL as the first-line treatment option for kidney stones greater than 2 cm in adults.[17] However; we believe that puncture and dilatation procedures during PCNL are still associated with a risk of bleeding and the need for transfusion or arterial embolization. Additionally, damage to the renal parenchyma during PCNL is unavoidable, leading to potential loss of renal function, especially in patients undergoing multiple percutaneous procedures. FURS performed through a natural orifice offer several potential benefits. Theoretically, this prevents irreversible loss of renal parenchyma and significantly reduces the risk of severe bleeding.[18] Therefore, FURS is particularly suitable for patients with nephrolithiasis, emphasizing parenchymal preservation (e.g., single kidney), hemorrhagic constitution, or long-term anticoagulant therapy. In addition, FURS has access to all renal calyx due to its excellent deflection, which is beneficial in treating multiple kidney stones and renal sinus cysts.[19, 20] In our study, 80% of patients achieved complete SFR. Only 4 (40%) patients had residual stone fragments ≥4mm, especially those with a high stone burden ≥20mm cumulatively and those with three stones in the kidney. See Tables (3) and (4). This relatively high SFR status could be due to advancements in FURS deflection and basketing of lower pole stones to relocations that make stone fragmentation easier to pass down. After one month of follow-up, the remaining fragments' size ranged from 5-8 mm. We believe that those small stones might be possible to be treated with expulsive medical therapy, ESWL, or the second session of RIRS, all of which have a minimal complication potential and are safe for the patients. According to our study, the SFR is higher in lesser stone burden (size 20 mm, stone number equal 2), 80% percent, and 92.3%, respectively. On the other hand, higher stone burdens (size 20, number equal to 3) have SFRs of 60 and 57.1 percent, respectively. As assessed by HU, the stone density had no impact on SFR status. MCCS of surgical complications is currently the most frequently accepted reporting approach for assessing RIRS-related complications. According to a recent meta-analysis, FURS treatment for renal stones measuring 2 to 3 cm had an overall complication rate of 16.1%, with major complications occurring in 3.2 percent of patients.[21] According to the latter classification, most RIRS complications are minor, such as fever, transient hematuria, and UTI, with no serious consequences. Only one (5%) patient in our study had an intra-operative complication: mild extravasation of contrast from the kidney at the end of the procedure, possibly due to high PCS pressure, with no postoperative morbidity. Four patients (20%) developed post-RIRS complications, including febrile UTI in three patients and transient fever for 24 hours after surgery in one patient. Nineteen patients had AUS, and three developed G2 Complications statistically significant. We used AUS for patients of every size stone, although clinicians advise it to be used for larger stones than 2cm and do not have preoperative JJ stents.[22] All of them were treated conservatively without needing postoperative intervention, blood transfusion, or intensive care unit admission. The limitation of our study was the limited number of patients and the study's duration, which can be used as a reference for further studies.

## Conclusions

Retrograde intrarenal ureteroscopy provides a satisfactory final SFR with a low complication rate when treating multiple renal stones of less stone burden and numbers. However, more than one session is required to reach a complete stone-free rate, especially for large stones ≥20mm and multiple stones >2 in the renal unit.

## Conflicts of interest

The author reports no conflicts of interest.

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