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Retrograde intrarenal surgery for the treatment of renal stones in patients with a solitary kidney: Does access sheath matter?

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Abstract

Background: Treating renal stones in patients with a solitary functioning kidney is challenging. The present study was aimed to assess the competence and safety of retrograde intrarenal surgery (RIRS) for the treatment of renal stones in a solitary kidney.

Methods: Between August of 2017 and August of 2019, 25 ensuing patients with a solitary kidney and renal calculi and who were treated with RIRS were prospectively enlisted in the study. All patients were assessed by non-contrast computed tomography before surgery. Stone-free status was determined if there were no residual fragments. The final stone-free rates (SFRs) were assessed 3 months after the last treatment session by plain X-ray KUB and ultrasonography. Patient demographics, perioperative and postoperative outcomes were prospectively evaluated. Serum creatinine levels and glomerular filtration rate (GFR) pre-procedure and during follow-up were correlated.

Results: Twenty-five patients underwent 26 procedures. The mean patient age was 42.81 ± 12.3 (range 22–67) years. The mean stone size was 18.23 ± 6.27 mm (range 9–25 mm) and the mean operative time was 46.15 ± 15.34 min (range 25–100 min). A ureteral access sheath (UAS) was used in five (19.2%) pre-stented patients. One patient (3.8%) required the second stage RIRS for residual stones. The SFR after the initial and final procedures, the SFR was 84% and 92%, respectively.

The mean serum creatinine levels were significantly reduced post-surgery compared to preoperative levels (1.76 ± 1.21 mg/dL; 1.37 ± 0.60 mg/dL; *p* value 0.001) while GFR not encounter any significant variation post-surgery (63.04 ± 33.16 ml/min) compared to preoperative rates (61.12 ± 34.76 ml/min, *p* value 0.502). Minor complications classified as Clavien I or II developed in 5 patients (20%). Clavien IIIb, a major complication, developed in one (4%) patient, which was caused by steinstrasse and necessitated emergency surgical intervention.

Conclusion: Renal stones in a solitary kidney can be managed using RIRS safely and effectively with and without the use of UAS, without compromising renal function.

1 Background

The management of urolithiasis in patients with a solitary functioning kidney (SK) represents a challenge to urologists and requires careful planning to achieve maximal stone clearance with the lowest morbidity [1, 2].

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Percutaneous nephrolithotomy (PNL) and shock wave lithotripsy (SWL) has been widely accepted over previous decades and are considered the first line of treatment for renal stones (greater or lesser than 2 cm) in patients with a solitary kidney (SK) [3–6].

Although treating a renal stone in a solitary kidney with PCNL affords a high stone-free rate (SFR), it is an invasive and morbid procedure and may result in considerable complications, particularly excessive renal bleeding in which the increased thickness of the renal parenchyma (caused by compensatory hypertrophy) might cause bleeding during PNL [7, 8].

Contrarily, SWL is a competent treatment method for renal stones but is affiliated with a lower SFR and a greater rate of repeat procedures, especially when used for large and hard stones. Potential complications such as bleeding, hematoma steinstrasse, and higher rates of unplanned invasive procedures make it less favorable in SK patients [9–11].

Owing to improvements in surgical techniques and endourological devices, retrograde intrarenal surgery (RIRS) has grown into one of the most prevalent alternative endourologic procedures to PCNL and SWL for treating renal stones that are < 20 mm. This technique has low rates of complication and high stone-free rates [12, 13].

In the current study, we assess the safety and competence of RIRS for renal stones in patients with a solitary kidney and evaluated its effects on renal functions. We have also assessed the feasibility and safety of the sheathless procedure.

2 Methods

2.1 Study design

Between August of 2017 and August of 2019, 25 ensuing patients with a solitary kidney (those with a prior nephrectomy, non-functioning, or congenitally solitary kidney) and renal stones who were treated with RIRS by the same experienced endourologist were prospectively evaluated. The local ethical committee approved our study methods. Patients were counseled regarding treatment options, potential complications, and the possible need for a staged or auxiliary procedure to obtain satisfactory stone clearance.

Inclusion criteria included failed SWL, contraindication of PCNL, and the patient and surgeon's preference. The location of the stone within the renal collecting system was not used as exclusion criteria, however, patients with large stones > 2.5 cm and positive urine culture were excluded.

The stone size was determined by measuring the maximum diameter of the stone on non-contrast CT. In patients with multiple renal stones, the stone size was calculated as the sum of the greatest dimensions of each stone.

All patients were assessed by non-contrast computed tomography before surgery. We evaluated patients' demographic characteristics, stone parameters, which included laterality, stone location, number of stones, stone size (mm), and Hounsfield units on the preoperative non-contrast abdominal computed tomography (CT) images. Other evaluated parameters included preoperative stent placement, operation time (excluding anesthetic time), lasing time (duration of using laser), hospital stay, transition of serum creatinine level and GFR, and the SFR. Complications were determined using the Clavien classification system [14] (see "Appendix 1").

The GFR was measured using the CKD-EPI (Chronic Kidney Disease Epidemiology Collaboration) [15].

$$\begin{aligned} \text{GFR} = {} & 141 * \min\left(\text{Scr}/\kappa, 1\right)\alpha * \max\ \left(\text{Scr}/\kappa, 1\right) \\ & - 1.209 * 0.993\ \text{Age} * 1.018[\text{if female}] * 1.159[\text{if black}] \end{aligned}$$

2.2 Surgical technique

Under general or spinal anesthesia and in a lithotomy position, a semi-rigid ureteroscope 8–9.5F (Karl Storz Endoscopy, Tuttlingen, Germany) was routinely used in all patients. Hence, allowing the ureter to be passively dilated and assessing the presence of coexisting ureteral stones or strictures.

A zebra nitinol guidewire of 0.032/0.035 inches (Boston Scientific, USA) was placed in the pelvicalyceal system through the ureteroscope. Subsequently, a 7.5 Fr flexible URS (Storz Flex-X2S, Tuttlingen, Germany) or using digital single-use ureteroscope (Uscope 3022, Zhuhai Pusen Medical Technology Pusen, Guangdong province China) was passed over the guidewire in a monorail fashion. In pre-stented patients, a ureteral access sheath (UAS) was placed over the guidewire and the flexible URS was passed through the UAS.

The stones were fragmented using Holmium: YAG laser (cyber Ho 60 holmium laser system, Quanta system, Milan-Italy) through 200 µm fiber by applying 0.5–0.8 J power at 15–30 Hz frequency. To eliminate the necessity for stone retrieval, we used a stone dusting technique so that the stones become tiny pieces or a fine powder (deemed clinically insignificant fragments). After the completion of lithotripsy, the entire pelvicalyceal system was visually assessed for any residual stone fragments. A double-J stent (DJS) 5–6 F 26 cm was routinely placed in all cases. If the postoperative periods were uneventful, the patients were sent home with oral antibiotics on a postoperative day one. The first follow-up visits were scheduled at 2 weeks after the procedure presumably for DJ stent removal. In case of an uneventful procedure, the DJ stent was removed. In the case of significant residual stone, the patient was scheduled for a second-look procedure within 2–4 weeks. Consequent assessments were performed at 4 weeks and second assessment at 3 months with renal USG supplemented with X-ray KUB, if necessary, to look for residual stones. The CT scan was not used to reduce radiation exposure to the patient. The overall stone-free rate was calculated 3 months postoperatively and was classified either as complete clearance of stone (defined as the absence of stone residual) or residual stones.

3 Statistical analysis

Data were analyzed using the statistical package for social science (SPSS, version 24). The paired sample *t* test was used to correlate between means of two groups. A *p* value of <0.05 was considered statistically significant.

4 Results

Twenty-five patients (15 men and 10 women) with a solitary kidney underwent RIRS for the treatment of ureteral or renal stones between August of 2017 and August of 2019. Patients had a mean age of 42.81 ± 12.3 (range 22–67) years and a mean stone size of 18.23 ± 6.27 mm (range 9–25 mm). The mean preoperative serum creatinine and GFR levels were 1.76 ± 1.21 mg/dL and 63.04 ± 35.44 ml/min, respectively.

Preoperative stenting was placed in 6 patients because they developed obstructive anuria, 16 (64%) patients had a solitary renal stone, and the most prevalent site of the stones was the renal pelvis and calyces in 19 patients (76%), including ureteric stones, which were pushed back when the DJ stent was inserted. Six patients (24%) had stones in the upper ureter. Comprehensive details of patient demographics and stone characteristics are described in Table 1.

Thorough details of perioperative and postoperative outcomes are presented in Table 2. All stones were opportunely well-accessed by the flexible ureterorenoscopy. Ureteral access sheath (UAS) were used in five (20%), pre-stented patients. The mean operative time was 46.15 ± 15.34 min and ranged between 25 and 100 min. The mean lasting time was 30.62 ± 16.45 min (range 10–70 min). Double-J stents were placed in 24 (96%) patients and the mean hospitalization time was 23.96 ± 10.89 h (range: 15–48 h).

The primary SFR was 84%, the secondary SFR was 88% and the final SFR (after auxiliary treatments) was 96%, with a mean 1.08 number of procedures per patient.

Seven patients (28%) were immediately stone-free rate during their first postoperative day, and in the 6th week, 21 out of 25 patients (84%) achieved complete stone clearance after the primary intervention. Four patients had residual stones, one underwent Re-RIRS after 6 weeks and was found to be stone free, one underwent SWL, and one needed semirigid URS for removing the stone fragments that obstructed the ureter after DJ stent removal. One patient with a comorbid disease had residual stone fragments at the lower pole, which was elected for follow-up.

Complications were assigned according to a modified clavien grading system. Perioperative complications occurred in six patients (24%), three patients (12%) develop transient fever, these patients were treated with oral antipyretics (Clavien I), one patient (4%) developed transient hematuria which resolved spontaneously. One patient (4%) developed non-obstructive pyelonephritis, this patient was hospitalized for 48 h and was successively treated with antibiotics and antipyretics (Clavien II). Major complications (Clavien IIIb) occurred in one patient (4%) who developed steinstrasse after DJ removal, which necessitated surgical intervention (semi-rigid URS) to relieve a ureteric obstruction. No serious complications (higher Clavien grade) were observed.

Table 1 Demographic and preoperative stone characteristics

Variable	Value
Case no., *n*	25
Age (year), mean ± SD (range)	42.81 ± 12.3 (22–67)
Gender, M/F	15/10
Stone side, R/L	7/18
Causes of solitary kidney, *n* (%)	
Non-functioning kidney	18 (72%)
Previous nephrectomy	7 (28%)
Stone size (mm), mean ± SD (range)	18.23 ± 6.27 (9–25)
Stone number, *n* (%)	
Single stone	16 (64%)
Multiple stone	9 (36%)
Stone location, (*n*)	
Upper	3 (12%)
Middle calyx	3 (12%)
Pelvis	4 (16%)
Lower calyx	7 (28%)
Multiple calyx	2 (8%)
Upper ureter	6 (24%)
Preoperative double-J stenting	5 (20%)
Preoperative serum creatinine (mg/dl)	1.79 ± 1.21
Preoperative GFR (ml/min)	61.12 ± 34.76
Previous stone related intervention, (*n*)	13 (52%)
PCNL	3 (12%)
URS	8 (32%)
Open and URS	2 (8%)

GFR Glomerular filtration rate, *PCNL* percutaneous nephrolithotomy, *URS* ureterorenoscopy

Table 2 Operative and postoperative outcomes

Variable	Value
Mean operative time, (SD, range), (min)	46.15 ± 18.347 (25–100)
Mean lasting time, (SD, range), (min)	30.62 ± 16.454 (10–70)
Mean hospital stays (SD, range) H	23.96 (10.89, 15–48)
Use of UAS, *n* (%)	05 (20%)
Use of fluoroscopy guidance, *n* (%)	07 (28%)
Stone clearance, *n* (%)	
Primary stone clearance	21/25 (84%)
Secondary stone clearance	23/25 (92%)
SFR and size of the stone *n* (%)	
< 20 mm	13/16 (81.25%)
> 20 mm	7/9 (77.77%)
SFR and UAS	
Without	(20/25) (18/20) (90%)
With	(5/25) (3/5) (60%)
Mean number of procedures per patient	1.08
Postoperative double-J stenting	24/25 (96%)
The ancillary procedure, *n* (%)	
SWL	1/25 (4%)
RIRS	1/25 (4%)
URS	1/25 (4%)
Complications by modifies Clavien grading system	
Clavien Grade I, *n* (%)	
Fever	3/25 (12%)
Hematurea	1/25 (4%)
Clavien Grade II *n* (%)	
Non obstructive pyelonephritis	1/25 (4%)
Clavien Grade IIIb	
Steinstrasse	1/25 (4%)

GFR Glomerular filtration rate, *PCNL* percutaneous nephrolithotomy, *URS* ureterorenoscopy; *SFR* stone-free rate, *UAS* ureteral access sheath, *SWL* shockwave lithotripsy

Pre-and postoperative serum creatinine levels and GFR changes are shown in Table 3. The mean preoperative Scr was 1.76 ± 1.21 mg/dL and improved to 1.57 ± 0.91 mg/dL at the end of the 4th-week follow-up (*p* value 0.001). While similar improvement was not observed for GFR at the end of 4th weeks, 63.04 ± 35.44 ml/min compared to 61.12 ± 34.76 ml/min ($p = 0.502$).

5 Discussion

Treating renal calculi in patients with a solitary functioning kidney represents an important challenge to urologists. Careful and wise treatment decisions are crucial for the complete removal of stones without causing injury to the renal tissue and/or detrimental effects on renal function [1, 16].

Attributed to the tremendous technological advancements of flexible ureteroscopes and holmium lasers, retrograde intrarenal surgery (RIRS) has gained popularity and has become one of the most accepted substitutes for PCNL and SWL in the treatment of renal calculi < 20 mm. RIRS has minimal complication rates and high stone-free rates [17, 18]. However, this procedure might need to be repeated if treating large renal stones. RIRS has an advantage in preventing renal parenchyma damage, which is critical for patients with a solitary kidney [2, 19].

In our study, the primary SFR was 84% and the final SFR was 92% while using UAS in 5 (10%) of the patients. A mean 1.08 procedures were applied per patient. This is in accordance with the studies performed by Atis et al. [13] (primary SFR 83%, secondary SFR 95.8%) who used UAS in 87% of their cases. Giusti et al. [17] (primary SFR of 72.4%, secondary SFR of 93.1%) had a mean of 1.24 procedures per patient and used UAS in 93.1% of their cases. Breda et al. [20] had the final overall stone-free rates of 92.2% after an average of 1.4 sessions. Gao et al. [2] had initial and final procedures were 64.44% and 93.33%, respectively, with a mean number of procedures of 1.23, which used UAS in all cases. In Lai et al. [21], the SFRs after the single and second procedures were 80% and 95%, respectively, and used UAS in all cases. Yuruk et al. [22] used an access sheath in 15 (83.3%) of the patients and reports stone-free rates during the 3rd postoperative month of 66.6% with the number of sessions required for stone-free status averaging 1.06 ± 0.24.

The objectives of treating renal stones in a solitary kidney are to accomplish a high stone-free rate with the lowest short- and long-term adverse effects on existing renal function. In addition to the serum creatinine, we also calculate GFR for assessment of the renal function, hence serum creatinine might be inaccurate in several situations, such as in patients with low muscle mass or with fluid overload [23]. In our study, we

Table 3 Mean Scr and GFR level before and after the operation

	Preoperative	4 weeks follow up	*p* value
Serum creatinine (mg/dL) Mean ± SD Range	1.79 ± 1.21 (0.60–4.50)	1.37 ± 0.60 (0.50–3.98)	0.007*
GFR (ml/min) Mean ± SD Range	61.12 ± 34.76 (10–114)	63.04 ± 33.16 (0.50–3.98)	0.502

GFR Glomerular filtration rate

* Paired sample *t* test

noticed a momentous improvement in Scr during the 1-month follow-up while GFR not encounter any significant variation post-surgery (63.04 ± 33.16 ml/min) compared to preoperative rates (61.12 ± 34.76 ml/min, p value 0.502). The mean pre-operative Scr level was 1.76 ± 1.21 mg/dL and decreased to 1.57 ± 0.91 mg/dL post-surgery ($p = 0.001$). Our outcomes were proportionate with the study conducted by Kuroda e al. [18] and Lai et al. [21] who found convincing improvements in serum creatinine post-surgery, while Atis et al. [13], Giusti et al. [17], Yuruk et al. [22], Gao et al. [2], and a systematic review by Jones et al. [24] revealed that, despite the minimally invasive nature of RIRS, there are no changes in renal function before and after surgery.

However, it is a noninvasive procedure, yet still might be associated with major complications. In the present study, complications were assigned according to a modified clavien grading system. Perioperative complications occurred in six patients (24%), the majority of these were minor (Clavien I & II), and major complications (Clavien IIIb) occurred in one patient (4%) who developed steinstrasse after DJ removal, which necessitated surgical intervention (semi-rigid URS) to relieve the ureteric obstruction. No serious complications (higher Clavien grade) nor blood transfusion or renal failure were observed.

Atis et al. [13] reported a minor complication rate of 16.6%; no major complications developed in their study group. Giusti et al. [17] reported 27.4% of minor complications and no major complications. Gao et al. [2] noted postoperative complications in 26.6% of the patients, 24% of the patients had Grade I and II, and Grade III complications, and 2.2% of the patients had an anuria complication due to steinstrasse, which required urgent intervention.

Kuroda et al. [18] reported minor complications that included Clavien I & II in 15.8% and clavien III in 5.2% of the patients. Lai et al. [21] reported minor complications in nine patients (15%) and major complications (Clavien III) in two patients (3.3%). One patient developed steinstrasse and the other developed a perirenal abscess. Yuruk et al. [22] reported an overall complication rate of 38%, 11% were minor and 27% were Clavien IIIa (colicky pain).

Pietropaulo et al. performed a systematic review that included 12 studies that reported an overall complication rate of 16.4%, with no fatalities. Also, Clavien III complications were recorded in less than 0.5% of patients [1].

Jones et al., who conducted a systematic and meta-analysis review, report a total of 33 (28%) complications, a majority ($n = 21$) of which were Clavien grade I. The Clavien grade II/III complications were comprised of urosepsis, steinstrasse and renal colic [24].

According to our study, RIRS with and without using UAS is a feasible way to treat renal stones in a solitary kidney patient with high SFR. RIRS has low complication rates and does not compromise renal function.

The main drawback of this study was the short follow-up period, which made it difficult to assess the long-term effects of RIRS on renal function.

6 Conclusion

Renal stones in a solitary kidney can be managed by RIRS safely and effectively with and without using UAS. This method had a low morbidity rate and did not compromise renal function.

Abbreviations

RIRS: Retrograde intrarenal surgery; PCNL: Percutaneous nephrolithotomy; SWL: Shock wave lithotripsy; SFR: Stone-free rate; KUB: Kidney ureter and bladder radiography; CT: Computed tomography; GFR: Glomerular filtration rate; UAS: Ureteral access sheath; SK: Solitary kidney.

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Authors contributions

SM and SF were involved in the concept, design, supervision, processing, writing a manuscript, and critical analysis. HT was involved in processing, writing a manuscript, and critical analysis. MB was involved in the design, processing, writing a manuscript, and critical analysis. All authors read and approved the final manuscript.

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Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethics approval and consent to participate

The study was approved by the Research Ethics Committee at the College of Medicine, sulaimania University, and written informed consent was obtained from all patients. The ethics committee reference number is 4573, at 15/12/2018.

Consent for publication

Not applicable.

Conflict of interests

The authors declare that they have no competing interests.

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Appendix 1: Modified Clavien grading system

Grade	Complications
I	Mucosal injury
I	Total hematuria, permanent hematuria
I	Fever
I	Urine retention
II	Urinary tract infection
IIIa	Stone migration
IIIb	Perforation
IIIb	Obstruction due to Steinstrasse
IIIb	Extravasation and conversion to open
IVa	Myocardial infarction, Pulmonary edema
IVb	Urosepsis
V	Death

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