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Safety and efficacy of retrograde intrarenal surgery for the treatment of renal stone in solitary kidney patients

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ABSTRACT

Purpose: We present our experience of retrograde intrarenal surgery (RIRS) for the treatment of renal stones in patients with solitary kidneys and evaluate the safety and efficacy of this treatment modality.

Materials and methods: Between March 2011 and July 2015, the clinical records of 60 patients with renal stones in solitary kidneys who underwent RIRS were retrospectively reviewed. Demographic characteristics, preoperative urinary culture, blood biochemistry, stone location, and surface area were documented. The final stone-free rates (SFRs) were assessed one month after the last treatment session by computed tomography (CT). Preoperative, operative, and postoperative parameters were analyzed. Serum creatinine (Scr) and glomerular filtration rate (GFR) were measured preoperatively, one month postoperatively, and at each follow-up visit.

Results: The mean stone burden was $628 \pm 27.2\,mm^2$ (range 301–1199). The mean operative time was 84.4 ± 21.3 min (range 40–115). The mean drop in postoperative hemoglobin was 0.6 ± 0.21 g/dL (range 0.1–0.7). Twelve patients (20%) required second-stage RIRS for residual stones. The SFRs after the single and second procedures were 80% and 95%, respectively. The mean preoperative Scr level was 111.6 ± 45.59 μmol/L, and the mean postoperative Scr level was 96.7 ± 34.12 μmol/L. The change was statistically significant ($p = .008$). The same findings were observed for GFR. The mean preoperative GFR was 65.04 ± 25.37 ml/min, and the mean postoperative GFR was 76.89 ± 27.2 ml/min ($p = .023$). Minor complications occurred in nine patients (15%). One patient experienced septic shock and acute renal failure due to steinstrasse. This patient required hemodialysis and percutaneous nephrostomy drainage. One patient developed perirenal abscess and was treated with percutaneous drainage.

Conclusion: RIRS is a safe and effective procedure for the treatment of renal stones in patients with solitary kidneys. RIRS did not adversely affect renal function at either the short-term or the long-term follow-up.

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Introduction

Percutaneous nephrolithotomy (PCNL) and extracorporeal shockwave lithotripsy (ESWL) are widely accepted modalities for the treatment of renal calculi in solitary kidney patients [1,2]. The PCNL is associated with a higher risk of significant hemorrhage in solitary kidneys due to the compensatory hypertrophy of the renal parenchyma [3]. Treating a renal stone in a solitary kidney with ESWL may be acceptable for a stone size of <2 cm. However, ESWL is associated with a lower stone-free rate (SFR) and higher rates of unplanned invasive procedures [4,5].

Retrograde intrarenal surgery (RIRS) has been advocated as an alternative to PCNL or ESWL in the treatment of renal stones. It has been shown to achieve high SFR with a low rate of complications [6–9]. There have been few reports in the literature on the use of RIRS for the treatment of renal stones in solitary kidneys. In this study, we evaluated the safety and efficacy of performing RIRS in these patients and evaluated its effects on renal functions.

Materials and methods

This study was approved by the Ethics Committee of our institution, the Fifth Affiliated Hospital of the Guangzhou Medical University. Sixty patients with solitary kidneys who were treated with RIRS for renal

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stones between March 2011 and July 2015 were retrospectively reviewed. The solitary kidneys were congenital in 12 cases (20%), caused by a previous contralateral nephrectomy in 27 cases (45%), and caused by a non-functioning contralateral unit in 21 cases (35%). The stone burden was assessed by the stone's surface area and calculated according to European Association of Urology guidelines. Medical comorbidities of the patients were assessed using Charlson Comorbidity Index (CCI).

The patient characteristics analyzed include age, gender, BMI, causes of solitary kidney, previous renal intervention history, and CCI scores. Preoperative tests, such as CBC, coagulation studies, serum biochemistry, urine culture, ultrasonography, and plain X-ray were recorded. Computerized tomography (CT) scans were taken routinely to assess the stone's characteristics and location. All patients had double-J stents (DJ) placed as outpatient 10–14 days before the procedure. Preoperative antibiotics were administered according to the results of the urine culture.

Continuous epidural anesthesia was used in all the patients. The procedures were performed in the lithotomy position. After retrieval of the DJ and retrograde pyelography, a 0.035-inch guidewire was placed into the upper tract. A 14 F ureteral access sheath (UAS) of appropriate length was inserted over the guidewire. A flexible ureteroscope was next advanced over the same guidewire, reaching to the renal pelvis. A complete inspection of the pelvicalyceal system was performed and small stones were removed using a nitinol basket. Stones located in the pelvis and the upper pole were fragmented using a 365-μm laser fiber with an energy setting of 1–1.5 J and a rate of 8–12 Hz. Stones located in middle or lower pole were fragmented using 200-μm laser fiber at an energy setting of 0.8–1 J and a rate of 10–15 Hz. After adequate stone fragmentation, the larger fragments were removed with a stone basket; the smaller fragments were either irrigated out or left *in situ* for the patient to pass. At the end of the procedure, a fluoroscope was used to check for large residual fragments. The UAS was removed along with the ureteroscope. Ureteral injuries were visually assessed. A DJ was left in all the patients at the end of the procedure.

All patients were assessed with CT for SFR one month after the first procedure. This allowed time for patients to spontaneously pass the remaining stone fragments. We designate completely stone-free as the absence of any stone fragments or with only insignificant residual fragments (CIRFs), which are defined as 2 mm or less, asymptomatic, nonobstructive, and noninfectious residual fragments in the kidney [6–9]. The DJs were removed in the completely stone-free patients. In patients with significant residual stones, auxiliary procedures, such as second-stage RIRS, ESWL, or minimally invasive PCNL (MPCNL), were performed. The SFRs of these patients were assessed again by CT scans one month later.

All patients continued to be evaluated for at least 12 months after the procedure. After the first month's postoperative follow-up, patients were asked to return every 3 months during the first year and every 6 months thereafter. Assessments of urinalysis, serum creatinine (Scr), KUB, and ultrasound were taken. For each patient, Scr and glomerular filtration rates (GFRs) were measured before and after the procedure, as well as at each follow-up visit. The GFR was calculated using the Cockroft and Gault formula.

Statistical analysis was performed with SPSS 17.0 (SPSS Inc., Chicago, IL). Continuous variables were compared using Student's *t*-test. A value of $p < .05$ was considered statistically significant.

Results

Sixty patients were accrued into this study. This included 27 men (45% of all patients) and 33 women (55%). The mean age was 51.75 ± 11.13 years (range 26–74). The mean BMI was 22.98 ± 4.51 kg/m^2 (range 19.76–31.62). The mean stone burden was 628 ± 27.2 mm^2 (range 301–1199). Eighteen patients had a previous ESWL on the ipsilateral side. Twenty-one renal stones were located on the right side, and 39 on the left. Preoperative urine cultures were positive in 12 patients (20%). All the infections were treated with culture-specific antibiotics. Patients' comorbidities were recorded using CCI scores. Patients' demographics and preoperative data are shown in Table 1.

Perioperative and postoperative data are shown in Table 2. The mean operative duration was 84.4 ± 21.3 min (range 40–115). The mean drop in the postoperative hemoglobin was 0.6 ± 0.21 g/dL (range 0.1–0.7). No blood transfusion was required. The mean fluoroscopy time was 33 ± 12.3 s (range 17–56). The mean hospital stay was 2.4 ± 1.9 days (range 3–5). The SFR was 80% after first procedure. Twelve patients had residual stones that required second-stage operations or auxiliary procedures. The SFR reaches 95% after the second procedure. At the 12-month follow up, 48 out of 60 patients were completely stone-free. Nine patients had clinically insignificant stones. Three patients did not reach a stone-free state. These three patients had clinically significant residual stones (largest 6 mm) in the lower pole calyces that could not be reached with

Table 1. Demographic and preoperative characteristics.

Variable	Value
Age (years), mean ± SD, range	51.75 ± 11.13, 26–74
Gender, M/F	27/33
BMI (kg/m^2), mean ± SD, range	22.98 ± 4.51, 19.76–31.62
Stone side, L/R	39/21
Cause of solitary kidney, no. (%)	
Congenital	12 (20%)
Previous nephrectomy	27 (45%)
Nonperfused kidney	21 (35%)
Stone type, no. (%)	
Single	48 (80%)
Multiple	12 (20%)
Stone location	
Pelvic	9 (15%)
Upper pole	15 (25%)
Middle pole	18 (30%)
Low pole	6 (10%)
Mix	12 (20%)
Stone burden (mm^2), mean ± SD, range	628 ± 27.2 mm^2, 301–1199
Previous ESWL no. (%)	18 (30%)
Charlson Comorbidity Index (CCI)	
0 (%)	12 (20%)
1 (%)	9 (15%)
2 (%)	24 (40%)
3 (%)	12 (20%)
4 (%)	3 (5%)
Positive preoperative urine culture, no. (%)	12 (20%)

Table 2. Perioperative and postoperative characteristics.

Variable	Value
Operative duration (min), mean ± SD, range	84.4 ± 21.3, 40–115
Fluoroscopy time (s), mean ± SD, range	33 ± 12.3, 17–56
Hemoglobin drop (g/dL), mean ± SD, range	0.6 ± 0.21, 0.1–0.7
Hospital duration (days), mean ± SD, range	2.4 ± 1.9, 3–5
Minor Complication rate, no. (%)	9 (15%)
Modified Clavien classification	
Grade I	3 (5%)
Grade II	6 (10%)
Stone free rate, no. (%)	
After single procedure	48 (80%)
Final	57 (95%)
Stone composition, no. (%)	
Calcium oxalate	36 (60%)
Calcium oxalate and phosphate	9 (15%)
Uric acid	6 (10%)
Struvite	9 (15%)

RIRS due to excessively narrow angles. During the long-term follow-up, another three patients developed recurrent stones at an average of nine months. They were successfully treated with RIRS.

Nine patients (15%) experienced minor complications per modified Clavien grade I and II classifications. Three patients required oral analgesics for postoperative pain (Clavien I). Six patients had transient postoperative fevers that were successfully treated with antibiotics and antipyretics (Clavien II). Major complications (Clavien III) occurred in two patients (3.3%). One patient experienced acute renal failure and septic shock due to infected upper ureteral steinstrasse. This patient was treated with hemodialysis and percutaneous nephrostomy followed by MPCNL. One patient developed perirenal abscess, which we managed by percutaneous drainage.

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

Variable	Preoperative	Postoperative, 1 month	*p* Value
Serum creatinine (umol/L)			
Mean ± SD	111.6 ± 45.59	96.7 ± 34.12	.008
Range	55–224	55–154	
GFR (ml/min)			
Mean ± SD	65.04 ± 25.37	76.89 ± 27.2	.023
Range	28.5–107.48	29.17–136.8	

Table 3 shows a comparison of preoperative and postoperative mean Scr level and GFR. The mean preoperative Scr level was 111.6 ± 45.59 μmol/L compared to 96.7 ± 34.12 μmol/L at the end of one-month follow-up ($p = .008$). A similar trend was noted for GFR. The mean preoperative GFR was 65.04 ± 25.37 mL/min compared to 76.89 ± 27.2 mL/min at the end of the one-month follow-up ($p = .023$). No statistically significant differences of these parameters between the one-month and the one-year follow-up were noted ($p > .05$).

Discussion

The RIRS has been reported as an effective and definitive therapeutic option for renal stones [6–9]. It can achieve high SFR with a low rate of complications compared to ESWL and PCNL [6–13]. Hyams et al. [14] reported using RIRS for the treatment of renal stones with diameters of 20–30 mm in 120 patients. They achieved 63% SFR when a stone-free state was defined as no residual stones or only clinically insignificant stone fragments of <2 mm were present. If the stone-free state was defined as no residual stone fragments of <4 mm, the SFR would increase to 83%. Takazawa et al. [12] reported treatment of 2–4 cm renal calculi using RIRS and achieved a SFR of 100%. Prabhakar [15] reported that RIRS could achieve a 100% SFR in treating renal stones with an average diameter of 25 mm after a single or staged procedure. Ben Saddik et al. [16] reported that treating 20–30 mm kidney stones with a flexible ureteroscope could achieve 89.3% SFR after a staged two-session procedure and 97.1% after three sessions. Riley et al. [17] reported achieving a SFR of 50% after two sessions of RIRS in patients with stone sizes of >4 cm. In literature review, the clinical outcome of RIRS for solitary kidney stones has rarely been reported.

The mean stone burden in our cohorts ranged from 301 to 1199 mm^2. The PCNL is the treatment of choice for most renal stones larger than 300 mm^2 [18] according to the AUA guidelines. The PCNL monotherapy was recommended as the preferred treatment modality with an SFR of 74%–83%, and an auxiliary procedure rate of 18% [19]. In some studies, a SFR exceeding 95% has been reported following a single session, even in complete staghorn calculi [20].

On the other hand, Takazawa et al. reported successful outcomes from RIRS for renal stones larger than 2 cm. They showed a SFR of 100% for stone sizes between 2 and 4 cm and 67% for stones larger than 4 cm [12]. Riley et al. showed a 90.9% success rate for an average stone size of 3.0 cm. They achieved a 91.6% success rate with an average of 1.9 procedures for stones larger than 3 cm, 80% success with an average of 1.8 procedures for stones larger than 3.5 cm, and 50% success with an average of two procedures for stones larger than 4 cm [21].

However, the SFR was consistently found to be lower in solitary kidney patients, no matter they treated with PCNL [17] or RIRS [22]. Akman et al. calculate that the overall SFR for RIRS is 77% after a single session and 93% after additional sessions for renal calculi >2 cm [9]. These SFRs are comparable to those achieved with PCNL after second sessions [9].

In our study, the overall SFR of RIRS was 95% with an average of 1.2 procedures, which is similar to other RIRS studies in patients with bilateral kidneys and PCNL studies in solitary kidney patients. Compared to PCNL, the most important disadvantage of RIRS is the requirement for a second session. Additionally, treating large stones with RIRS is time-consuming; it can take twice as long as PCNL for treating a similarly sized stone. However, the RIRS offers lower morbidity and a shorter hospital stay.

The PCNL in patients with a solitary kidney is a challenging procedure. Although the safety and efficacy of PCNL is well-recognized, it is still associated with a high risk of complications. El-Nahas et al. [3] identified that having a solitary kidney was a significant risk factor for hemorrhage due to compensatory hypertrophy. In the CROES PCNL global study [20], the authors demonstrated a blood transfusion rate of 10.1%, a fever rate of 13.3%, a perforation rate of 4.3%, and a hydrothorax rate of 1.1% in patients with a solitary kidney. Similarly, in another PCNL study, Resorlu et al. [23] reported a postoperative fever rate of 18.8%, a urinary tract infection rate of 12.5%, a prolonged urine leakage rate of 12.5%, and a blood transfusion rate of 18.8% in solitary kidney patients.

In previous studies, RIRS had been shown to have a lower complication rate than PCNL. In our study, 15% of patients developed minor complications and no patient required blood transfusion. The 1% rate of patients with severe complications was also lower than PCNL for solitary kidney patients. Ureteral perforation and stricture were the more troublesome complications in RIRS. Several studies have shown that the overdistention created by a UAS may induce ureteral ischemia and wall injuries, which may progress to ureteral perforation and stricture [24]. To accommodate this, in this study we used 14 F UAS in every patient to facilitate the procedure and to decrease the intrarenal pressure. We also pre-stented our patients 10–14 days before the procedure to achieve passive dilation of the ureter. We did not observe any ureteral perforation or stricture with this protocol. Similarly, Traxer and Thomas [25] found in their RIRS study that pre-stenting with DJ significantly decreased the incidence of severe access sheath-related injuries.

Whether PCNL has an adverse effect on the renal function of a solitary kidney remains controversial. Streem et al. [26] reported that Scr was unchanged in five solitary kidney patients who had undergone PCNL one month prior. Canes et al. [27] reported that the renal function was preserved or even slightly improved one year after PCNL. By contrast, Akman et al. reported that kidney function worsened in 6.8% of patients with a solitary kidney after PCNL [28]. Moreover, it is not yet known whether the punctured papilla is able to regain its normal function over time [29]. Conversely, with the minimally invasive nature of the RIRS, we observed a significant improvement in Scr and GFR at the one-month follow-up. The mean preoperative Scr level was 111.6 ± 45.59 μmol/L compared to 96.7 ± 34.12 μmol/L at the one-month follow-up, with $p = .008$. The same findings were observed in GFR ($p = .023$). There were no statistical significant changes of these parameters from the one-month to the one-year follow-up ($p > .05$). Three of our patients showed deterioration of their renal functions in the long-term follow-up. However, the deterioration was attributed to their diabetic mellitus.

The RIRS therefore should be considered as a first-line treatment for stones in solitary kidney patients because of its low morbidity, its preservation of renal function, and its reduced risk of bleeding.

The limitations of this study include its retrospective nature and the small sample size from a single center. It contains unavoidable inherent and institutional bias. A multicenter prospective and randomized study with a large cohorts and a longer-term follow-up would be much more desirable.

Conclusions

The RIRS is a safe and effective treatment modality for renal stones in patients with a solitary kidney.

The procedure can achieve high SFR with low morbidities and was not shown to adversely affect the renal function at either the short-term or the long-term follow-up.

Disclosure statement

No potential conflict of interest was reported by the authors.

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