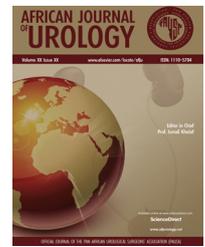




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Original article

Outcome of retrograde flexible ureterorenoscopy and laser lithotripsy for treatment of multiple renal stones



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KEYWORDS

Renal stones;
Retrograde;
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Abstract

Objective: To evaluate the efficacy and safety of retrograde intrarenal surgery (RIRS) using flexible ureterorenoscopy (F-URS) and laser lithotripsy as a treatment option for multiple renal stones greater than 1 cm.

Patients and methods: Between June 2015 and February 2017, 42 patients who were treated with RIRS via F-URS and laser lithotripsy were evaluated. Stones were divided into two categories according to stone burden, 11–20 mm and 21–30 mm. Patient's demographics, stones characteristics, operative outcomes and complications were evaluated prospectively. Stone free rate (SFR) was determined 4 weeks postoperatively using findings on non-contrast computed tomography (NCCT).

Results: Mean stones burden was 25.7 mm (range from 1.3 to 30 mm), 8 patients had 11–20 mm stones burden with SFR 100% and 34 had 21–30 mm stone burden with SFR 91.2%. The overall SFR was 92.8%. Multiple stones were two in 31 patients (73.8%), three in 9 (21.4%) and four in 2 (4.8%). Regarding stone number per kidney and SFR, SFR was 100%, 77.7% and 50% for kidneys with two, three and four stones respectively. In terms of stone location in the pelvi-calyceal system and corresponding SFR, there were renal pelvic stones in 6 (14.3%) patients with 100% SFR, upper calyx and/or mid calyx and/or renal pelvis in 12 (28.6%) with SFR 91.6% and lower calyx with or without other locations in 24 with SFR 91.6% also. Complications were minor and included, UTI in 3 patients (7.1%), hematuria of 4 days duration in 2 (4.8%), severe DJ stent irritative symptoms in one (2.4%) and minor ureteral perforations in one (2.4%).

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Conclusion: RIRS via F-URS and laser lithotripsy is a safe and effective treatment option with high success rate for patients with multiple renal stones of 11–30 mm stone burden. It is indicated when other stone treatment modalities contraindicated or have failed. However, for complex or challenging stones, staged procedures may be required.

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Introduction

Technical developments and patients requests for rapid stone removal have led to changes in clinical stone management. According to European Association of Urology (EAU) guidelines, extracorporeal shock wave lithotripsy (ESWL) is recommended as a first line treatment for renal stones <20 mm and percutaneous nephrolithotomy (PCNL) for renal stones >20 mm. However, there has not been any consensus about management of multiple intrarenal stones in both EAU and American Urological Association (AUA) guidelines [1]. When ESWL is used for managing multiple intrarenal stones success rate drops to 50%, especially for lower calyx stones [2]. Moreover, because of unfavorable calyceal anatomy, hard stones and obesity, renal stones often require repeated treatment or auxiliary procedures [3]. Although the stone free rate (SFR) following PCNL is between 78% and 96%, the invasive nature of the procedure and significant possible associated complications are still a matter of concern. Additionally, in patients with significant co-morbidities such as morbid obesity and bleeding diathesis, PCNL may be not the best choice [4]. Because of the limitations of ESWL and PCNL, and with recent advances in flexible ureterorenoscopy (F-URS), and laser technology, urologists have been exploring non-invasive procedure such as RIRS in the management of renal stones in the pelvicalyceal system with a wide range of SFR of 50% to 94.2% has been reported [5]. The indication of RIRS using flexible URS with laser lithotripsy were broadened to include ESWL failure, morbid obesity, musculoskeletal deformities, bleeding diathesis, and occupations that require complete stone clearance (e.g. pilots) [6,7]. In this study, our purpose is to evaluate flexible URS and holmium laser lithotripsy for treating multiple unilateral renal stones greater than 1 cm.

Patients and methods

Between June 2015 and February 2017, 42 patients treated using F-URS and holmium–YAG laser stone fragmentation were prospectively evaluated. Patients with unilateral, multiple renal stones, distributed anywhere in pelvicalyceal system of 11–30 mm stone burden were selected. Stones burden was determined by the sum of the largest diameter of each stone as detected by non-contrast computed tomography (NCCT) of kidney ureter and bladder. According to the stones burden, stones were divided into: 11–20 mm and 21–30 mm stones. Retrograde intrarenal surgery (RIRS) was indicated according to patient's preference, certain patient's characteristics like morbid obesity, coagulopathy, congenital renal anomalies and ESWL or PCNL treatment failure. Patients with associated ipsilateral ureteric stone or stricture, calyceal diverticular stones, stag horn stones, pelvi-ureteric junction obstruction

or medullary sponge kidney were excluded. Operations were performed after informed consents were taken from all patients and ethical board approval was obtained. Patient's demographics, stones characteristics, operative procedures and postoperative data were recorded.

Ureteroscopy using semi rigid ureterorenoscope (9.5 Fr Karl Storz Ureterorenoscope, Germany) was performed to exclude presence of any pathology and to dilate the ureter avoiding ureteral trauma related to blind insertion of ureteral access sheath (UAS). The UAS (12/14 Fr Cook Medical, Bloomington, IN, USA) has been advanced over the guide wire up to pelvi-ureteric junction (PUJ) under fluoroscopic x-ray control. If the access sheath (UAS) cannot be inserted, F-URS (Karl Storz-X™ Tuttlingen, Germany) was advanced directly over guidewire into renal pelvis. However when intrarenal access cannot be achieved because of ureteral tightness, double J (DJ) stent was passed and RIRS procedure was postponed for two weeks. Stone fragmentation was performed with holmium–YAG laser using either laser machines of different power (Versa Pluse Power Suit 100W, Lumenis, USA) in combination with 200 μm fiber or (Calculase- II 20W, Holmium Laser, Karl Storz, Germany) with 270 μm laser fiber. Energy level was set at 0.6–1.4 J and a rate of 5–10 Hz frequency levels was adjusted. A zero tip nitinol basket (NGage nitinol stone basket extractor 2.2 Fr 115 cm basket, Cook Medical, Bloomington, IN, USA) was used for relocation of lower pole stones to upper calyx or renal pelvis. When the lower pole stone was too big to be engaged in the basket, it was divided by laser into two or three parts then re-located. Painting maneuver (painting like movement of laser fiber tip, 2–3 mm from the stone after adjusting the laser machine sitting at a relatively lower power and higher frequency) was used to induce stone dusting which produced tinny pieces easily washed and could be passed out spontaneously when a pressurizing irrigation system was used. However, stones fragment larger than 3 mm were extracted using tipples nitinol stone basket catheter. At the end of the procedures, Patients with incomplete stone fragmentation or residual stone fragments had DJ stent fixation and a second stage RIRS procedure two weeks later. Stone free rates were evaluated four weeks postoperatively using un-enhanced CT KUB. Success was defined as complete stone clearance or residual stone fragment less than 3 mm. All patients had postoperative follow-up assessment at the 3rd and 6th month with NCCT KUB. Data were analyzed by using standard statistical software, SPSS ver., 18.0 (SPSS Inc., Chicago, IL, USA). The results for continuous variables were expressed as mean ± standard deviation. The chi-square test was applied to compare categorical variable and *t*-test and ANOVA test were used to compare non-categorical variables. *P* value <0.05 was considered statistically significant.

Table 1 Patient characteristics and indications for RIRS.

Variables	Number
● Patients number	42
○ Male	32
○ Female	10
● Age (years)	
○ Mean ± SD	42.69 ± 10.54
○ Range	22–65
● BMI (kg/m ²)	
○ Mean ± SD	25.6 ± 6.2
● Steep lower pole infundibulopelvic angle	4 (9.5%)
● Indications of RIRS	
○ Patients preference	22 (52.38%)
○ Morbid obesity	6 (14.3%)
○ Previous ESWL or PCN failure	6 (14.3%)
○ Mal-rotated	4 (9.5)
○ Anticoagulant medication	2 (4.7%)
○ Solitary kidney	1 (2.4%)
○ Pelvic kidney	1 (2.4%)

SD: standard deviation.

Results

RIRS was performed in 42 patients (32 males and 10 females), mean patient age was 42.69 ± 10.54 (range from 22 to 65) years. Mean BMI was 25.6 ± 6.2 kg/m² (range 20–40). RIRS was indicated on the basis of patient's preference in 22 (52.38%) patients and because of solitary kidney in one (2.4%), pelvic kidney in one (2.4%), mal-rotated kidney in 4 (9.5%), anticoagulants medications in 2 (4.8%), morbid obesity in 6 (14.3%), and failure of previous treatment in 6 (14.3%) patients. Patient characteristics and RIRS indications are listed in Table 1. The mean stone burden was 25.7 ± 5.1 mm (range from 13 to 30 mm). There were 8 patients with stone burden of 11–20 mm and their SFR were 100% while 34 patients with stone burden of 21–30 mm had SFR of 91.2% (31/34). The number of stones per renal unit was two in 31 patients (73.8%), three in 9 (21.4%) and four in 2 (4.8%) patients and the corresponding SFR were 100%, 77.7% and 50% respectively. Regarding the distribution of stones in each kidney, stones were in the renal pelvis in 6 (14.3%), upper pole calyx ± mid calyx ± renal pelvis in 12 (28.6%) and lower pole calyx ± any other locations in 24 (57.1%) patients

and the corresponding SFR were 100%, 91.6% (11/12), and 91.6% (22/24) respectively. Stones characteristics are shown in Table 2.

Double J stenting was inserted before RIRS procedures in 8 (19%) patients because of ureteral tightness, in all patients who had second procedures (24 patients 57.1%) and post-RIRS in (9/42 patients 21.4%). Ureteral access sheath (UAS) was successfully fixed in 32 patients (76.2%). Regarding lower calyceal stones, out of 24 patients, 6 (25%) had complete in situ fragmentation, 18 (41.7%) had stone relocated to upper calyx either intact or after initial fragmentation into parts. Intraoperatively, 34 patients (81%) had stones fragmented into small particles which spontaneously washed out by irrigation fluid while in 8 patients (19%) basket stone fragments retrieval were required. Eighteen patients (42.9%) required single RIRS procedure to remove their stones, of these 8 had 11–20 mm stone burden with 100% success and 10 had 21–30 mm stones with 29.4% success. The remaining 24 (57.1%) patients underwent staged RIRS procedure in two sessions; all had 21–30 mm stones with success rate of 87.5%. The mean operative duration was 95 ± 22 (range 65–140) min. The mean operative time according to stones size was 85 ± 21 and 102 ± 23 min for 11–20 mm and 21–30 mm stone burden, respectively. The overall stone free rate (SFR) was 92.8%. However, depending on the stones sizes, patients with stones from 11 to 20 mm and 21 to 30 mm had SFR of 100% (8/8 patients) and 88.2% (31/34), respectively ($P < 0.001$). According to number of the stones per patient, SFR was 100% (31/31 patients), 77.7% (7/9) and 50% (1/2) for patients with 2, 3 and 4 stones, respectively. RIRS was unsuccessful in three patients (7.2%), two of them had history of previous ESWL Failure due to steep infundibulopelvic angle of lower calyx and the remaining patient had a history of failed PCNL due to mal-rotated kidney position. All of unsuccessful patients had stones burden of 21–30 mm. Only minor complications were encountered in seven patients (16.6%) and all were treated conservatively. Intra- and postoperative records are shown in Table 3.

Discussion

Flexible ureterorenoscope with small caliber, higher image resolution that can bend to either side makes access into renal calyces possible and easy. In addition, the development of holmium laser and its fine 2.00 μm fibers coupled with the development of novel

Table 2 Stone demographics.

	Number (%)	SFR (%)	<i>P</i> value
● Stone burden (mm)			
○ Mean ± SD	25.6 ± 5.1		
○ 10–20	8 (19.1%)	8/8 (100%)	<0.28
○ 21–30	34 (80.9%)	31/34 (91.2%)	
● Stone multiplicity/RU			
○ 2	31 (73.8%)	31/31 (100%)	<0.022
○ 3	9 (21.4%)	7/9 (77.7%)	
○ 4	2 (4.8%)	1/2 (50%)	
● Laterality			
○ RT	20 (47.6%)	–	
○ LT	22 (52.4%)	–	
● Stone distribution/RU			
○ Renal pelvis	6 (14.3%)	6/6 (100%)	=0.725
○ Upper calyx ± mid calyx ± renal pelvis	12 (28.6%)	11/12 (91.6%)	
○ Lower calyx ± other sites	24 (57.1%)	22/24 (91.6%)	

Significant ($P < 0.05$), RU: renal unit.

Table 3 Intra- and postoperative data.

	Patients number	Success rate (%)
• Lower pole stone manipulation		
○ Relocation	10/24	10/10 (100%)
○ Breaking + relocation	8/24	7/8 (87.5%)
○ In situ fragmentation	6/24	5/6 (83.3%)
• Required RIRS procedure		
○ Single session		
- 10–20 mm stones	8/8	100%
- 21–30 mm stones	10/34	29.4%
○ Two session		
- 10–20 mm stones	–	–
- 21–30 mm stones	21/24	87.5%
• Stone free rate		
○ 10–20 mm stones	8/8	100%
○ 21–30 mm stones	31/34	91.2%
• Operative duration (min)		
○ Mean + SD	95 ± 22	
○ Range	65–140	
○ 10–20 mm stones	85	
○ 21–30 mm stones	102	
• Fluoroscopy time (s)		
○ Mean + SD	42 ± 0.69	
○ Range	0.8–2.5	
• Hospital stay (day)		
○ Mean + SD	1.43 ± 0.69	
○ Range	0.8–25	
• Complications		
○ UTI	3 (7.1%)	
○ Prolonged hematuria	2 (4.8%)	
○ Severe stent irritative symptoms	1 (2.4%)	
○ Ureteral perforation	1 (2.4%)	

endoscopic baskets have allowed RIRS as very important alternative in the treatment of renal stones anywhere in the pelvicalyceal system [1]. There are several advantages of RIRS over ESWL which include, detailed intrarenal examination, active fragmentation of all stones, to tiny gravels easily washed out and cleared [8]. Resolu et al. investigated the factors affecting the success rate of RIRS performed on 207 patients and found that stone size, location, composition, renal malformation, lower pole infundibulopelvic angle and anticoagulant medication intake significantly affected the success rates [9]. In our study, we found that, only the stone size and stone number affect the success rates significantly ($P < 0.05$). Our finding is comparable with that of Elbir et al. who investigated RIRS in 19 patients (6.8%) with anticoagulant medication and 17 (6.1%) with renal anomalies and reported that, it had no significant effect on SFR [10]. The difference in the factors affecting the success rates of RIRS between our study and that of Resolu and his colleagues may be because of higher number of patients treated by the later which probably provided bigger number and a wider variety of challenging renal anomalies that may affect RIRS outcome.

Lower pole calyx stones location is considered a challenging site because of difficult access and impaired stone clearance especially when there is unfavorable steep infundibulo-pelvic angle [11]. Steep infundibulo-pelvic angle was encountered in 4/24 patients (16.6%). We used the strategy of re-locating the lower calyceal stones in 18/24 (75%) patients to more appropriate sites that are easily accessible and favor good stone clearance. In this way we were able to overcome the lower calyx anatomical unfavorable effect on the success

rate in 17/18 patients (94.4%). We described the stones distribution into pure renal pelvis location, upper calyx with or without middle calyx with or without renal pelvis and lower calyx with any other locations and the success rates are 100% (6/6 patients), 91.6% (11/12) and 91.6% (22/24), respectively, which is statistically insignificant. Prelumtter and his colleagues reported SFR of 100% for upper pole stones, 95.8% for middle pole, and 90.9% for lower pole and concluded that stone location did not significantly affect the SFR [5]. Lim et al. reported that stone location does not affect success rate except for lower calyx stone location which prove the importance of our strategy for lower calyceal stone relocation in improving our success rate, moreover, this is also recommended by Burr et al. who reported that, the overall F-URS outcome is not limited by renal anatomical variation and due to basket retrieval of any residual fragments anatomical dependent drainage was not an issue for RIRS procedures [11,12].

In our series, SFR is statistically significantly affected by the number of stones per renal unit ($P < 0.01$). It was 100% (31/31 patients) when there were two stones per renal unite, 77.7% (7/9) for three and 50% (1/2) for four stones. This was emphasized by Albir and his colleagues who studied 160 patients with single stone versus 119 with multiple renal stones and reported that stone's number statistically affected the SFR significantly [10]. The introduction of smaller size F-URS with larger working channel, greater active deflection angles, smaller laser fibers (200 μm) and small tip-less nitinol basket (1.9 Fr) shorten the operative time [13]. Alken and coworkers reported a mean operative time of 60.3 min (range 30–130) for mean stone burden 22.2 mm [8]. Ito and colleagues had mean operative time of 80.9 min for stones <20 mm and 105.8 for stones ≥ 20 mm [14]. Al-Qahtani and colleagues reported 89 min as a mean operative time for mean stone size 26.3 mm [15]. In this study, the mean operative time was 95 ± 22 min (range from 65 to 140), 85 min for stones burden 11–20 mm and 102 for stones from 21 to 30 mm. Differences in operative time among authors may not only reflect cumulative expertise and stone characters but also to the way of time estimation, some estimate the operative time when starting cystoscopy while others when starting ureterorenoscopy.

Many authors emphasized that anticoagulant should be discontinued in patients scheduled for ESWL or PCNL and in these cases RIRS is an effective alternative treatment [11,16]. In this study, RIRS was successfully performed in two patients (4.7%) without neither cessation of anticoagulant, nor development of complications or failure. Papatsoris stated that, in challenging cases with morbid obesity, pelvic kidney or ESWL or PCNL refractory stones; RIRS has been preferred as first-line therapy [17]. Molimard et al. and Oguz et al. retrospectively evaluated the outcome of RIRS on 17 patients and 24 with renal malformation, they recommended RIRS as reliable and effective treatment for patients with renal anomalies without specific complications or affecting success rate [18,19]. We have similar findings when RIRS was performed in one patient (2.4%) with solitary kidney, four (9.5%) with mal-rotated kidneys, one (2.4%) with pelvic kidney position, and 6 (14.3%) with morbid obesity. We found that RIRS is a good choice for obese patients without any specific additional difficulty. Indeed, current EAU guidelines recommend URS as the most promising therapeutic option in obese patients [20,21]. RIRS is also a safe and effective procedure for patients who had previous ESWL and PCNL treatment failures. In this study, we had 4 patients that had history of failed ESWL due to lower pole steep infundibulo-pelvic

angle and 2 patients who had history of failed PCNL due to malrotated kidneys. In these 6 patients with challenging multiple, hard, calyceal, 21–30 mm stones burden associated with renal unfavorable anatomy, the SFR of 50% (3/6 patients) after RIRS procedures could be an acceptable result. This is supported by Lim et al., Stav et al. and Holland et al. who reported 58%, 46%, and 67% success rates respectively when RIRS was performed after failure of other stone treatment modalities [11,22,23].

The main criticism of RIRS using F-URS for treatment of multiple renal stones is the staged procedure. In our series, the overall SFR is 92.8%, however, SFR achieved after single RIRS procedure is only 42.8% which increased to 87.5% after second RIRS procedures. Based on stone burden, all (100%) patients with stones from 11 to 20 mm (8/8 patients) achieved stone free status after single RIRS procedure. However, for 21–30 mm stones, 29.4% and 87.5% achieved stone free status after single and staged RIRS procedures respectively. This is compatible with Brada et al. who investigated 24 patients with multiple unilateral renal stones ≤ 20 mm and 27 with stone burden > 20 mm. Their SFR after two RIRS procedures were 100% and 85%, respectively [24]. Takazawa et al. studied 51 patients who underwent RIRS for multiple renal stones. They reported that patients with stone burden < 20 mm and ≥ 20 mm, had SFRs after either single and staged two RIRS procedures of 92% and 100% versus 69% and 85%, respectively, which is comparable with our result [25]. Beradinelli et al. used F-URS for treating 365 patients with single and multiple renal stones, their SFR after first and second RIRS procedures was 73.6% and 78.9% respectively. The difference with their results may be related to the large number of patients in their series and most of them (64%) had single stone in the renal pelvis [26].

Today, with decreased instruments size, major complications such as ureteral avulsion are extremely rare [27,28]. We did not encounter any major complications in our series. However, we encountered minor complications in 7 patients (16.6%) according to Clavein classification. This finding is similar to that of Bai et al. who reported that 25 out of 56 patients (44%) had minor complications among their RIRS group [29]. Atis et al. reported only 3.4% minor complications in their RIRS group and this big difference may be related to their large number of patients [30]. One of the advantages of RIRS is the shorter hospital stay compared to PCNL. Koyuncu et al. reported 1.09 versus 2.4 day after RIRS and PCNL respectively [31]. Our mean hospital stay was 1.43 day (0.8–2.5 day), Al-Qahtani and colleagues, reported mean hospital stay of 1.44 day (1–3 days) which matched our result [15]. Limitations in this study include small number of patients, the definition of stone burden, lack of comparison with other stones treatment modality and short follow-up period.

Conclusions

RIRS using F-URS and laser lithotripsy is highly successful treatment option in patients with unilateral multiple intrarenal stones of 11–30 mm and associated with minor complications. Success rate is inversely related to stones burden and stones number. RIRS is reliable and safe for patients with morbid obesity, anticoagulant medications and renal anomalies, in addition, it good alternative in patients who had previous ESWL or PCNL treatment failure. The main criticism of RIRS is the requirement of staged procedures in many instances.

Authors' contributions

Hisham Alazaby – Contributed in concept, data collection, operative theater works, preparation of manuscript, and data analysis.

Mostafa Khalil – Contributed in concept, data collection, preparation of manuscript, data analysis and statistics.

Rabea Omar – Contributed in data collection, preparation of manuscript, and preparation of final.

Ahmed Mohey – Revisions of manuscript, data and statistical analysis and preparation of final shape.

Tarek Gharib – Revisions of manuscript and data and statistical analysis.

Ahmed Abou-Taleb – Contributed in data collection, preparation of manuscript and data analysis.

Ehab El-Barky – Contributed in concept, operative theater works and data and design revision.

Ethical Committee Approval

The study protocol has been approved by Ethical Committee of the Faculty of Medicine, Benha University.

Human rights

The work described has been carried out in accordance with The Code of Ethics of the World Medical Association.

Conflict of interest

No conflict of interest was declared by author.

Source of funding

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