Urolithiasis (2013) 41:79–83
DOI 10.1007/s00240-012-0534-7

ORIGINAL PAPER

# Retrograde intrarenal surgery in patients with horseshoe kidneys

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Received: 29 May 2012 / Accepted: 8 December 2012 / Published online: 21 December 2012


**Abstract** Retrograde intrarenal surgery (RIRS) in patients with horseshoe kidneys (HSKs) remains poorly studied. The present study aimed to assess clinical success and stone-free rates in HSK patients with renal stones treated with flexible ureteroscopy. RIRS was attempted in 20 patients with 25 renal stones in HSK from December 2008 to January 2012. The patients were evaluated with imaging studies including plain abdominal radiography, intravenous urogram, abdominal ultrasonography or non-contrast tomography scan. Success rate was defined as stone-free or residual fragment less than 4 mm. Pre-operative, operative and postoperative data were retrospectively analyzed. A total of 20 patients were included in the present study (12 males, 8 females). 9 of 25 renal stones (36 %) were located in the lower calyx of the kidney, whereas 7 (28 %) in the middle calyx, 5 (20 %) in the renal pelvis and 4 (16 %) in the upper calyx. The mean stone size was 17.8 ± 4.5 mm. The stone-free rate was 70 % after a single procedure. 6 patients required shock wave lithotripsy and two of these were completely stone-free. Average hospital stay was 1.4 ± 0.7 days. Minor complications as classified by Clavien I or II occurred in 25 %. No major complications (Clavien III–V) occurred in the study group. RIRS is an effective and safe treatment modality for renal stones in patients with HSK. The procedure has minimal morbidity and high success rate.

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**Keywords** Flexible ureteroscopy · Horseshoe kidney · Laser lithotripsy · Renal calculi

## Introduction

Horseshoe kidney (HSK), a congenital partial fusion of the kidneys resulting in a horseshoe shape, is the most common congenital genitourinary abnormality, with an incidence of up to 1 in 400 live births [1]. Stone formation occurs in 20 % of patients with HSK [2, 3]. It has been suggested that certain risk factors such as impaired urinary drainage, recurrent urinary infections and metabolic abnormalities predispose HSK patients to lithiasis [2, 3]. Endourological treatment modalities for such kidney stones include shock wave lithotripsy (SWL), retrograde intrarenal surgery (RIRS), percutaneous nephrolithotomy (PCNL), and laparoscopy [4]. While the urinary drainage is restricted and the distance of skin to stone is greater in patients with HSKs, the stone-free rate (SFR) of SWL in these patients is lower than those with normal kidneys [5]. Although percutaneous stone extraction is the most widely used treatment modality for renal stones in HSKs, the procedure can be associated with significant complications [6].

Advances in flexible ureteroscopes and intracorporeal lithotripsy have provided the management of upper urinary tract calculi endoscopically. Ureteroscopy, which offers an alternative treatment with minimal morbidity, has increased the rate of successful treatment of renal calculi; however, success rate of ureteroscopy remains poorly investigated in patients with HSKs. The present study aimed to determine the clinical success and SFRs in HSK patients with renal stones treated with flexible ureteroscopy (f-URS), and to evaluate the patient- and stone-related factors contributing to success.

## Materials and methods

We performed a retrospective analysis of 20 evaluable patients with HSKs and renal stones, who underwent RIRS in two referral hospitals in Turkey from 2008 December to January 2012. To detect the degree of hydronephrosis, and the location and size of the stones, the patients underwent various imaging techniques including renal ultrasonography (USG), plain abdominal radiography and intravenous urogram (IVU). Appropriate antibiotics were administered preoperatively according to urinalysis and urine cultures. All patients underwent the procedures under general anesthesia in the lithotomy position. At the beginning of the procedures, we performed semirigid ureteroscopy using an 8.5/11.5 F, 42.5-cm-long, semirigid ureteroscope with a 6 F working channel (Wolf, Knittlingen, Germany) for dilatation of the ureter, and placement of a hydrophilic guidewire into the renal pelvis. After removing the semirigid ureteroscope, a ureteral access sheath (UAS) (9.5/11.5 F or 12/14 F) was placed. If the ureteroscope could not be advanced easily, ureteral orifice dilation was performed in selected cases using balloon dilators. F-URS was performed using a 7.5 F, 67.5-cm-long, conventional flexible ureteroscope (Karl Storz, Tutlingen, Germany) with a 3.6 F working channel. For lithotripsy, the holmium:yttrium–aluminum garnet laser (Ho-YAG laser) with a 273 μm fiber was used in all cases. The laser energy was at 0.6–1.0 J and frequency was at 5–10 Hz. When applicable, to enable better visualization during lithotripsy, we relocated the stones in the lower calyces to the upper calyces by basketing. A double-J stent was placed based on the discretion of the surgeon at the end of the procedure.

A postoperative plain film and USG were performed to determine complete stone clearance or obstructions. IVU and USG were repeated 1 month later to rule out the presence of residual stone fragments and ureteral strictures. In patients with residual stone fragments, non-contrast computed tomography (CT) was performed. The size of all residual stone fragments was determined by measuring the maximum diameter of the stone on non-contrast CT. Success was defined as stone-free status or the presence of only residual fragments <4 mm, as measured at the largest dimension of the stone.

Data analyses were done using SPSS software, version 19.0 (SPSS, CA, USA). The continuous variables are presented by mean ± standart deviations (SDs) and they were analyzed by Mann–Whitney *U* test. The Chi-square test or Fisher's exact probability test were used to evaluate categorical values. In all tests, $p < 0.05$ was considered statistically significant.

## Results

The pre-operative and postoperative data of the patients are presented in Table 1. Twenty patients with HSKs (25 renal stones), including 12 males and 8 females, were included in the present study. Of the 25 renal stones, 9 (36 %) were located in the lower calyx of the kidney, 7 (28 %) were in the middle calyx, 5 (20 %) were in the renal pelvis, and 4 (16 %) were in the upper calyx. Of the 9 lower calyceal stones, 4 were relocated to the upper calyx and fragmented completely. In the remaining 5 lower calyceal stones, the relocalization of the stones were not possible due to the acutely angled entrance of calyces to the renal pelvis. These stones were fragmented in the lower calyces incompletely.

Of the 20 patients, 16 (80 %) had a history of previous intervention: PCNL in four patients (20 %), open pyelolithotomy in four patients (20 %), SWL in four patients (20 %), and more than one of these procedures in four patients (20 %). The mean age of the patients was 40.9 ± 15.9 years. The mean stone size was 17.8 ± 4.5 mm (12–30 mm). Stone composition was determined in 14 (70 %) patients, and the most common composition was calcium oxalate. The mean operative time was 40.5 ± 11.2 min. The mean screening time for fluoroscopy was 29.4 ± 14.8 s. The SFR was found to be 70 % after a single procedure. SWL was performed in six

**Table 1** Patient and stone characteristics

| Variable | Value |
|---|---|
| Age (years) | 40.9 ± 15.9 |
| Gender (*n*) | |
| Female | 8 (40 %) |
| Male | 12 (60 %) |
| Previous renal intervention (*n*) | |
| SWL | 4 (20 %) |
| PNL | 4 (20 %) |
| Open surgery | 4 (20 %) |
| More than 1 | 4 (20 %) |
| Stone size (mm) | 17.8 ± 4.5 |
| Stone status (*n*) | |
| Single | 15 (75 %) |
| Multiple | 5 (25 %) |
| Stone side (*n*) | |
| Right | 8 (40 %) |
| Left | 12 (60 %) |
| Stone location (*n*) | |
| Renal pelvis | 5 (20 %) |
| Upper calyx | 4 (16 %) |
| Middle calyx | 7 (28 %) |
| Lower calyx | 9 (36 %) |
| Mean operation time (min) | 40.5 ± 11.2 |
| Mean fluoroscopy time (s) | 29.4 ± 14.8 |
| Mean hospitalization time (day) | 1.4 ± 0.7 |
| Stone-free rate (*n*) | 14 (70 %) |
| Minor complication rates | 5 (25 %) |

patients with residual calculi. Of these, two were completely stone-free after SWL.

Dilation of the ureteral orifice was performed in 4 (20 %) patients and UASs were placed in all patients. A double-J stent was placed in 15 (75 %) patients and removed approximately 14 days postoperatively. Average hospital stay was 1.4 ± 0.7 days. Five patients (25 %) experienced minor complications (Clavien I or II). Three of these patients had fever at postoperative day one, which were treated with intravenous antibiotics and resolved within 24 h. The remaining two patients experienced hematuria needing no transfusion. Hematuria resolved within 3 days postoperatively. Major complications as classified Clavien III–V did not occurred in the study group.

The stone size was 16.0 ± 3.2 mm (12–22 mm) in the clinically successful procedures and 22.0 ± 4.6 mm (17–30 mm) in the failed procedures ($p = 0.006$). Additionally, the lower pole location was 22.2 % in the clinically successful procedures, whereas it was 71.4 % in the failed procedures ($p = 0.021$). The characteristics of two groups were summarized in Table 2.

## Discussion

Various endourological treatment modalities are available to treat renal stones in HSKs such as PCNL, SWL, RIRS and laparoscopy. There have been several studies of SWL and PCNL in patients with HSKs; however, only few studies examined the effectiveness of RIRS in HSK patients.

**Table 2** Comparison of characteristics of successful and failed procedures

| Variables | Success ($n = 14$) | Failure ($n = 6$) | $p$ value |
|---|---|---|---|
| Age (years) | 36.7 ± 16.6 | 50.7 ± 8.8 | 0.062 |
| Gender | | | |
| Female | 6 (42.9 %) | 2 (33.3 %) | 0.690 |
| Male | 8 (57.1 %) | 4 (66.7 %) | |
| Previous intervention | 10 (71.4 %) | 6 (100 %) | 0.267 |
| Stone side | | | 0.111 |
| Right | 4 (28.6 %) | 4 (66.7 %) | |
| Left | 10 (71.4 %) | 2 (33.3 %) | |
| Stone status | | | 0.131 |
| Single | 12 (85.7 %) | 3 (50 %) | |
| Multiple | 2 (14.3 %) | 3 (50 %) | |
| Stone size (mm) | 16.0 ± 3.2 | 22.0 ± 4.6 | 0.006 |
| Stone location | | | 0.021 |
| Lower calyx | 4 (22.2 %) | 5 (71.4 %) | |
| Renal pelvis or other calyx | 14 (77.8 %) | 2 (28.6 %) | |

The EAU guidelines on urolithiasis recommended PCNL as the first treatment choice for intrarenal calculi >2 cm [7]. Although high success rates have been reported for PCNL, the rate of major complications associated with the PCNL procedure have been reported to occur between 0.03 and 10 % [8]. PCNL has been also used successfully to treat renal calculi in HSKs with a SFR of 77–93.2 %; however, the reported complication rates vary from 14.3 to 29.2 % [9–11]. Complications of PCNL in HSKs include sepsis, pneumothorax, urinary tract infection, bleeding, urine leakage and postoperative fever [4]. Colonic injury is also one of the major complication of PCNL in HSKs because of the posterolateral displacement or retrorenal position of the colon [12]. Some investigators have recommended routine CT evaluation before PCNL to observe the posterolaterally displaced or retrorenal colon [13]. Medial access to the renal collecting system during PCNL is also another recommendation to avoid colonic injury [14]. Although complication rates decrease along with increasing experience in PCNL, major complications may still occur [15].

In the EAU guidelines on the management of urolithiasis, SWL was recommended as the first treatment choice for intrarenal calculi <2 cm [7]. In the literature, SFRs reported in HSK after SWL vary between 28 and 80 %, which is less than in normal kidneys [16, 17]. Ray et al. [6] reported the overall SWL stone-free and success rates to be 39.1 and 63.6 % at 3 months, respectively. This may reflect that fragmentation of stones alone is not enough for stone clearance in HSK because of restricted urinary drainage and altered anatomy [6]. In our study, we performed SWL in six patients with residual calculi after RIRS, but we achieved stone-free status only in two of them.

The advances in flexible ureteroscopes have led to an increase in the number of ureteroscopic procedures performed for renal calculi. Nowadays, RIRS offers an alternative to PCNL or SWL. The procedure potentially achieves higher SFRs than SWL and is associated with lower morbidity than PCNL [18, 19]. Breda et al. [20] reported a SFR of 85.1 % for intrarenal stone burden >2 cm and 100 % for intrarenal stone burden <2 cm. In their study group, major and minor complication rates were only 1.9 and 7.8 %, respectively.

In our institution, we perform PCNL as first-line therapy for renal stones >2 cm and SWL for renal stones <2 cm. At the other site, we provide RIRS as an alternative procedure to all patients and decide on the type of the surgical procedure according to the patient preference mentioning complication and success rates of all procedures. In the present study, all patients with HSK who underwent RIRS for renal stones were analyzed retrospectively. Patient selection for the procedure included renal stones less than

2 cm, multicalyceal stones, failed other treatments and patients preference. To our knowledge, RIRS is a better treatment of choice in patients with multicalyceal stones in HSK since multiple access may be required in PCNL procedures to treat these stones and the technique can be associated with high complication rates. In addition, patients who have renal calculi <2 cm in HSK can be treated by a single-session RIRS with a high success and low complication rate, so we can speculate that RIRS is a good treatment choice in these patients.

To our knowledge, only few studies examined the efficacy of RIRS in HSK patients with renal stones. In 2005, Weizer et al. [21] reported efficacy and safety data for RIRS in HSK patients with renal calculi of less than 2 cm and determined a SFR of 75 % without any complications. In 2010, Molimard et al. [22] published outcomes of RIRS in 17 HSK patients with renal stones. In that particular study, the mean stone size was 16 mm, 53 % of the patients were stone-free after a single procedure, and the SFR was reported to be 88 % after an average of 1.5 procedures. The reported overall SFRs in that study were comparable to those after PCNL. Additionally, the authors did not observe any major complications, and there was no need for blood transfusions in the study group. The mean hospital stay was only 1.7 days.

In the present study, 20 HSK patients with a total of 25 renal stones were treated by RIRS. The SFR was 70 % at 1 month after the surgery. We performed SWL in 6 (30 %) patients with residual calculi, and 2 of them were completely stone-free after SWL. Compared with the published SFRs following PCNL and SWL in HSK patients, our outcomes are similar to those following PCNL and better than those following SWL. Furthermore, we did not observe any major complications, and none of the patients received blood transfusions in our study group. The mean operative time in our study is shorter when compared with the published articles on RIRS in HSK patients. This may be due to the technique used for stone fragmentation in our study group. In our clinic, we prefer dusting the stones and leaving in situ to pass rather than active retrieval of stone fragments. To our knowledge, our technique can take advantage for operative time.

The effect of stone composition on fragmentation rates during Ho-YAG laser lithotripsy has been examined by several investigators. Although it has been shown that the hardness of the stone affects the fragmentation rates during laser lithotripsy in vitro, Wiener et al. reported that it has little effect on the overall operative time [23, 24]. In the present study, we did not experience any difference in laser fragmentation, however, there were no patients diagnosed with hard stones such as cystine or brushite in our study group.

In our study, the stone size was greater and the rate of lower pole stones was higher in the failed procedures when compared to the successful procedures. The stone size and lower pole location of renal stones were found statistically significant factors for failure of RIRS in HSK. These results were in agreement with those reported in a previous study reported by Molimard et al. [22]. This may be due to the acutely angled entrance of calyces to the renal pelvis and difficulty in reaching renal stones located in the lower pole, despite advances in the new-generation flexible ureteroscopes [25]. Although the present study is one of the largest series in the literature, the number of patients is small and the study is statistically limited. Future studies with a large number of patients with HSKs are necessary to determine factors affecting SFRs after RIRS.

In the present study, although we could reach renal stones in all patients, RIRS failed in six patients in stone clearance. In four patients, the stones were located in the lower pole and it was not possible to relocate the stones to a more favorable location because of the challenge in the working angle. The stones were fragmented in the lower pole, where small fragments cannot pass spontaneously with ease. In the remaining 2 patients, the stones were >2 cm in size and located in the renal pelvis. Although we could reach and fragment the stones, the procedures were ended after a while because of the loss of visualization due to hematuria. In patients with residual stones, we chose SWL as an additional procedure, because all residual fragments were <1 cm in size.

Treatment of renal stones in HSK patients is challenging. Our strategy in treating renal stones in HSK is to perform PCNL as first-line therapy for renal stones >2 cm and RIRS for renal stones <2 cm. Despite EAU guideline, according to the patients' preference, we also perform RIRS in HSK patients for renal stones >2 cm, mentioning about the need of additional therapy. In patients with residual stones, we decide the type of the additional therapy according to the stone size. We prefer SWL for residual stones <1 cm and RIRS for residual stones 1–2 cm. From our experience, to treat HSK patients with renal stones safely and effectively, we should decide the type of the surgical procedure according to the stone size and location.

The present study has several limitations. The first is that the study is in a retrospective nature and does not include any randomization for the other treatment modalities such as PCNL and SWL that could be performed to treat these stones. Second, the operations were performed in two urology centers and more than one surgeon was involved in the operations. In the present study, renal USG and IVUs were performed to rule out residual fragments, and to avoid radiation exposure, a CT scan was performed only in patients with residual calculi. Accordingly, some residual stones might have been overlooked on USG and IVUs, which might be considered another limitation.

## Conclusions

RIRS is an effective and safe treatment choice for HSK patients with renal stones. The procedure has high success rate and minimal morbidity. However, future studies are necessary regarding the relative merits of SWL, PCNL and RIRS in this group of patients.

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