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ORIGINAL PAPER

Outcomes of retrograde flexible ureteroscopy and laser lithotripsy for stone disease in patients with anomalous kidneys

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Abstract Due to the presence of structural and anatomical differences that accompany anomalous kidneys, currently available endourological modalities such as SWL and PNL may be insufficient, or additional laparoscopic assistance may be required. The present study aims to evaluate the efficacy and safety of retrograde flexible ureterorenoscopic stone treatment in patients with kidney anomalies. Over the last 3 years, 25 patients with renal stones in anomalous kidneys were consecutively treated by flexible ureterorenoscopy and holmium:YAG laser lithotripsy. Among the 25 patients, fiberoptic or digital flexible ureterorenoscopies were performed for the management of horseshoe kidneys ($n = 3$), cross-fused ectopic kidney ($n = 1$), renal ectopies [$n = 13$; associated with pelvic ($n = 6$) or lumbar kidneys ($n = 7$)], renal malrotations ($n = 4$), and duplicate ureters ($n = 4$). For lithotripsy, 200 or 273 μm probes were used, and for stone retraction 1.3–1.9 Fr ZeroTip baskets were used. Success was defined as the complete absence of stones as evaluated with a CT scan 1 month after the operation. The mean patient age was 39.4 ± 15.75 years, and the mean stone size was 194.64 ± 103.93 mm^2 (range 50–393). Complete stone clearance was achieved in 16 patients (64 %) after a single session. Seven of the patients with residual stones underwent a second session and the remaining three patients were subsequently treated with SWL. The overall complete clearance rate was 88 % (22 patients) with ancillary procedures. There were no serious postoperative complications except for one case (4 %) of urosepsis. Flexible ureterorenoscopy with holmium laser lithotripsy is a safe option for the treatment of renal stones in anomalous kidneys with satisfactory success rates.

Keywords Flexible ureteroscopy · Urolithiasis · Anomalous kidneys

Abbreviations

SWL	Shock wave lithotripsy
PNL	Percutaneous nephrolithotomy
MB	Md. Murat Binbay
CT	Computed tomography
IVP	Intravenous pyelography
CTU	Computed tomography urography
BMI	Body mass index
F-URS	Flexible ureterorenoscopy

Introduction

Anomalous kidneys are classified based on the number of kidneys, renal fusion, rotational anomalies, the duplex collecting system, and vascular anomalies. In the case of abnormal kidney vascularity, the renal pelvis and ureter may be found outside their anatomical locations, which might explain the associated increased frequency of stone disease and metabolic disorders. A horseshoe kidney is the most common renal fusion anomaly with an incidence of 1/400 (0.25 %) [1]. The incidence rate of ectopic pelvic kidneys detected during autopsies ranges from 1/2,100 to 1/3,000, while the frequency

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Table 1 Preoperative findings

	Lumbar ectopy ($n = 7$)	Pelvic ectopy ($n = 6$)	Horseshoe kidney ($n = 3$)	Cross ectopy ($n = 1$)	Malrotated kidney ($n = 4$)	Duplicated ureter kidney ($n = 4$)	Total ($n = 25$)
Mean age (years)	42.85 ± 15.46	39 ± 15.72	43.33 ±16.14	22	28.75 ± 15.9	46 ± 15.73	39.4 ± 15.75
Gender							
Male	5	6	1	–	4	1	17 (68 %)
Female	2	–	2	1	–	3	8 (32 %)
Laterality							
R	2	2	1	–	4	3	12 (48 %)
L	5	4	2	1	–	1	13 (52 %)
BMI (kg/m^2)	27.71 ± 5.02	26.81 ± 5.33	27.3 ± 5.7	21.09	24.67 ± 6.27	26.97 ± 5.52	26.57 ± 5.22
Mean stone size (mm^2)	237.71 ± 94.37	168.83 ± 101.71	253 ± 103.69	85	201.25 ± 109.05	135 ± 103.13	194.64 ± 103.93
Stone localization							
Lower calix	4	2	2	–	3	3	14 (43.75 %)
Middle calix	1	–	1	–	1	1	4 (12.50 %)
Upper calix	3	1	1	1	1	–	7 (21.87 %)
Pelvis	1	5	–	–	1	–	7 (21.87 %)
History of failed therapy							
SWL	–	1	2	1	3	–	7 (28 %)
Flexible URS	1	–	–	–	–	–	1 (4 %)
PNL	–	–	–	–	2	–	2 (8 %)
Open surgery	–	–	1	–	–	1	2 (8 %)

of contralateral cross ectopia is 1/1,000. The lower success rates of current endourological procedures such as SWL and PNL might be related to the presence of anomalous kidneys and their associated structural differences; furthermore, it might not always be possible to perform these procedures or laparoscopic assistance might be required [2–4].

Conversely, in recent years, improvements in flexible tool technology and holmium lasers have permitted flexible ureterorenoscopy (F-URS) to become more widely applicable for many patients.

To date, a few studies of F-URS in patients with calculi in anomalous kidneys have been reported. However, these investigations have been limited to pelvic and horseshoe kidneys. Weizer et al. [5] reported retrograde management of renal stones in patients with four pelvic and four horseshoe kidneys with a success rate of 75 %. We report our experience with retrograde treatment of patients with renal calculi in ectopic, pelvic, horseshoe, and malrotated kidneys as well as duplicated ureters.

Materials and methods

Twenty-five patients underwent F-URS with a holmium laser for the treatment of renal calculi in anomalous kidneys between April 2009 and July 2011. All patients had symptomatic renal calculi. All operations were performed by a single surgeon (MB). Anomalous kidneys were determined by computed tomography (CT), intravenous pyelography (IVP), and CT urography (CTU). Demographic data and information such as medical and surgical history, age, gender, BMI, and size and location of the stones were retrieved from patient medical records (Tables 1, 2). The procedures were performed only under general anesthesia and after urinary infections were eradicated. The procedures were carried out with the patients in the standard lithotomy position. After draping, we routinely performed cystoscopy, and a guidewire (0.038 in.) with a 6 F dual-lumen ureteral catheter was inserted via the transurethral route. During cystoscopy, we searched for any intravesical abnormalities, the anatomical locations of ureteral orifices and possible signs of duplicated ureters. Simultaneously, we performed retrograde pyelography to map the collecting system. A 11/13 or 12/14 F Flexor Access Sheath (Cook Surgical, Indianapolis, IN) was tried out in all patients. With the aid of the guidewire, we advanced the endoscope into the renal pelvis. A 7.5 F fiberoptic (Storz FLEX-X 2, Tuttlingen, Germany) or 8.7 F digital F-URS (DUR-D Gyrus ACMI, Southborough, MA, USA) was used. A holmium laser fiber size of 200 or 273 μm was chosen according to the stone location

Table 2 Postoperative findings

	Lumbar ectopy ($n = 7$)	Pelvic ectopy ($n = 6$)	Horseshoe kidney ($n = 3$)	Cross ectopy ($n = 1$)	Malrotated kidney ($n = 4$)	Duplicated ureter kidney ($n = 4$)	Total ($n = 25$)
Balloon dilatation							
Yes	–	4	–	–	2	–	6 (24 %)
No	7	2	3	1	2	4	19 (76 %)
Access sheath							
Yes	6	5	1	1	3	2	18 (72 %)
No	1	1	2	–	1	2	7 (28 %)
Ureteroscope type							
Fiberoptic	4	4	1	1	2	4	16 (64 %)
Digital	3	2	2	–	2	–	9 (36 %)
Laser fiber size (μm)							
200	4	5	3	1	2	2	17
273	4	3	–	1	3	3	14
Stone transposition							
Yes	1	2	1	–	3	–	7 (28 %)
No	6	4	2	1	1	4	18 (72 %)
Mean fluoroscopy time (min)	2.01 ± 1.79	4.21 ± 1.75	2.33 ± 1.12	9	1.9 ± 1.72	3.97 ± 1.77	3.15 ± 1.68
Mean operation time (min)	37.57 ± 20.95	63.33 ± 22.65	38.33 ± 1.15	65	38.5 ± 23.57	56.25 ± 22.52	48.08 ± 22.43
Stone-free rate							
Single session	4	4	2	0	4	2	16 (64 %)
With ancillary therapy	7	6	2	0	4	3	22 (88 %)
Ancillary treatments							
SWL	–	1	1	–	–	1	3 (12 %)
Re-flex URS	1	2	–	1	1	1	6 (24 %)
Complications							
Renal colic	–	1	–	–	–	–	1 (4 %)
Pyelonephritis	–	1	–	–	–	–	1 (4 %)
Urosepsis	–	–	–	–	–	1	1 (4 %)

and composition. Holmium laser energy and frequency were determined during the operation. We used a 1.3–1.9 Fr ZeroTip basket (Boston Scientific, Natick, MA) for stone transposition and extraction. Surgical data including operation time, type(s) of F-URS used, requirement for balloon dilatation, use of access sheaths and access sheath size, laser probe size, transposition of the stone (if it occurred), perioperative complications and the need for a postoperative ureteral stent were recorded. Success was defined as complete stone clearance as determined by CT performed 1 month later, and the need for additional interventions was recorded.

Results

A total of 25 patients (17 males and 8 females with a mean age of 39.4 ± 15.75 years (range 4–65 years) with renal stones in anomalous kidneys (7 lumbar ectopic and 6 pelvic ectopic kidneys, 4 renal malrotations, 4 kidneys with duplicate ureters, 3 horseshoe kidneys and 1 cross-fused ectopic kidney) underwent F-URS. A total of two pediatric cases aged 4 (malrotated kidney) and 11 (horseshoe kidney) years were included in our study. All stones were radiopaque. Five of the patients had solitary kidney. These five patients had lumbar ectopic ($n = 3$), pelvic ectopic ($n = 1$) or horseshoe ($n = 1$) kidneys. Of these 25 patients, five patients had undergone a surgical intervention ($n = 5$; 20 %), PNL ($n = 2$; renal malrotation), open nephropyelolithotomy (for stones in a horseshoe kidney or kidney with ureter duplication, respectively) or F-URS ($n = 1$; failed therapy at an outside institution). Seven patients (3 renal malrotations, 2 horseshoe kidneys, 1 cross-fused ectopic kidney, and 1 pelvic ectopic kidney) had undergone SWL at least one time.

Preoperative stone burden was evaluated by non-contrast abdominal CT, and the mean stone size was 194.64 ± 103.93 mm^2 (range 85–393 mm^2). Patients had one (19 of 25, 76 %), two (5/25), or three (1/25) stones in their treated renal units. A total of 32 calculi (7 upper, 4 middle, 14 lower calyceal, and 7 pelvic stones) were treated. Four patients demonstrated a narrow band pelvicalyceal system according to their retrograde pyelograms, and 12 patients had significant hydronephrosis. A ureteral access sheath was placed in 18 of 25 cases. In the remaining ones, a ureteral access sheath was not placed because of a narrow ureter part. Stone transposition was performed in seven patients. For stone transposition and stone extraction, we used a 1.3–1.9 Fr ZeroTip basket catheter.

The mean operative time was 48.08 ± 22.43 min (range 14–115 min). Complete stone-free status was achieved in 16 of 25 (64 %) patients with a single therapy session. Higher success rates (100 %) were obtained for malrotated kidneys with a single session therapy. Re-F-URS or SWL procedures were performed in patients who have symptomatic and/or 4 mm or bigger residual fragments according to their preferences after the first operation. With a second session, the success rate of F-URS increased up to 76 %. The overall complete clearance rate was 88 % (22 patients) with consideration to all ancillary procedures (SWL, Re-FURS, and medications) during the follow-up period of 4–30 months. Urosepsis was detected in one patient who had previously sterile urine culture and renal unit with duplicate ureters. An access sheath was not used during the operation. The patient was successfully treated with intravenous antibiotics. Pyelonephritis was seen as a minor complication in one patient. Another patient presented with renal colic.

Comment

Horseshoe kidneys

In horseshoe kidneys, the success of SWL is lower than for normal kidneys. Failure of SWL has been associated with focusing difficulties due to anteriorly localized renal pelvis, medial calyces masked with vertebra, a requirement for the supine position, renal malrotations, ectopic renal pelvis, fused lower pole, high insertion ureter, stasis due to vascular variations, drainage disorders, stone size, stone localization and BMI [6–8].

Horseshoe kidney stones occur mostly due to imperfections in the anatomical structures known to promote the development of the pelvis or lower calyces, and failure of the kidney to ascend to its normal anatomical site during embryonic life means that the kidneys of these patients are located lower than their normal position. Therefore, most of the time access into the lower pole is difficult, although entry into the upper pole can be managed via intercostal access. However, the likelihood of retrorenal colon is higher in these cases. In these patients, a PNL success rate of up to 93.2 % was achieved with the current series [9]. The main problems encountered in these patients are the higher incidence rates of major complications including sepsis, myocardial infarction, colonic injury, and possible bleeding risk [9, 10]. Additionally, similar to solitary stones, renal stones treated with laparoscopic nephrolithotomy and isthmic pyelolitotomy have been published in the literature [3, 11]. Accordingly, it can be emphasized that the laparoscopic technique can be applied in selected patients.

In a study examining the success of retrograde F-URS in horseshoe kidneys, the average stone burden was 16 mm with a reported mean success rate of 88.2 % in 17 patients [12]. In our series, which had an average stone size of 253 ± 103.69 mm^2, a retrograde approach was utilized in three patients with horseshoe kidneys. For 66.6 % of these patients, complete stone clearance was achieved without any procedural complications. Despite the presence of high ureter insertion in three patients, complete stone clearance in two patients with upper and middle calyceal stones was achieved, but in patients with lower calyceal stones, stone-free status could not be obtained, despite SWL treatment. We attribute this failure to the presence of a high insertion ureteropelvic junction, which complicates manipulation during SWL.

Malrotated kidneys

For similar reasons, SWL achieves lower stone-free rates in malrotated kidneys such as is the case for horseshoe kidneys [13]. Another treatment modality for patients with malrotated kidneys is PNL. In a multicenter study results of PNL in similar age, sex, stone size and BMI parameters with malrotated and nonmalrotated kidneys show that the malrotated group need for multiple access and Hb loss higher than the nonmalrotated group, but no statistical significance was determined [14]. In our series, stone-free status was achieved with first or second session F-URS in all patients with malrotated kidney. As a result, we believe that in the absence of accompanying abnormalities, outcomes of the retrograde management do not differ between patients with or without rotational anomalies.

Pelvic and lumbar ectopic kidneys

The efficacy of SWL is very limited in pelvic ectopic kidneys. In these patients, the highest success rate cited in the literature has been 57.2 % [15]. SWL failure correlates with difficulties in focusing on the targeted stone(s) and impaired

pyeloureteral motility. In pelvic ectopic kidneys, application of PNL is possible only under direct laparoscopic vision [16–18]. On the other hand, publications related to a retrograde approach for pelvic kidney stones are rare. Weizer et al. [5] reported their experiences with retrograde management with four pelvic and four horseshoe kidney stones. In these studies, the success rate was reported as 75 % for cases with pelvic kidneys after only a single session. In our study, a success rate of 66.6 % was achieved with retrograde approach in one session in six patients. The use of a simplified access sheath with multiple accesses increases the durability of the tool and helps to maximize deflexion. However, these patients have short and tortuous ureters. Therefore, placement of the access sheath is very difficult and, in general, implanted sheaths came back during the operation. To overcome this situation, 9.5–11.5 F pediatric hydrophilic access sheaths can be used.

Lumbar ectopic kidneys can be treated like pelvic ectopic kidneys. In our clinic, we treated seven patients with lumbar ectopic kidneys by F-URS and four patients (57.1 %) became stone free with a single F-URS session. The other three patients became completely stone free with the addition of ancillary treatment modalities. In these patients, we did not see any complications. However, our experiences have demonstrated that retrograde management of lumbar kidney stones is as difficult as pelvic kidney stones, especially access with respect to placement of the probe and calyceal access.

Cross-fused ectopic kidneys

Cross ectopic kidneys are kidney anomalies that are very rarely seen. In these patients, outcomes of SWL or PNL were reported by few studies [19, 20]. However, there is no data in the literature on the F-URS experience in the management of cross-ectopic kidneys. In our clinic, we used the retrograde approach for a 22-year-old woman with a cross-ectopic kidney, but we could not reach the stone.

Duplicated kidneys

Unlike other renal abnormalities, ureteral orifices in patients with duplicated ureter are not in their normal location. In these patients, according to the Weigert–Meyer rule, the lower pole ureter drains the cranial and lateral portions of the kidney; however, the orifice of the ureter, which drains the upper pole, opens in a more caudal and medial localization. For these patients, it can be difficult to observe the ureteral orifices at the beginning of the operation. However, Rana et al. [20] treated 12 patients with bifid pelvis and eventually 11 patients became stone free. In our series, stones inside four duplicated ureters were treated with F-URS, and two (50 %) patients were rendered stone free in a single session. In one patient, when both SWL and Re-F-URS were applied in combination, the success rate increased above 75 %.

Conclusion

Most of the time, SWL and PNL therapy is inadequate for the treatment of stone disease in patients with anomalous kidneys. The main problem is that complications are seen more frequently in these patients, because their management needs more than the standard approach. F-URS with holmium laser lithotripsy is a very effective therapy for most stones in anomalous kidneys due to its less invasive nature, repeatable applicability, and acceptable complication rates.

Conflict of interest No conflict of interest.

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