World J Urol
DOI 10.1007/s00345-016-1881-8

ORIGINAL ARTICLE

Role of flexible uretero-renoscopy in management of renal calculi in anomalous kidneys: single-center experience

Abhishek Gajendra Singh[1] · Jaspreet Singh Chhabra[1] · Ravindra Sabnis[1] · Arvind Ganpule[1] · Ankush Jairath[1] · Darshan Shah[1] · Mahesh Desai[1]

Received: 23 May 2016 / Accepted: 8 June 2016

Abstract
Introduction Flexible uretero-renoscopy (FURS) is an accepted modality for management of renal calculi in orthotopically placed kidney. Though it has been used in management of calculi in anomalous kidneys, the literature is scarce.
Aim and objective To define the role of FURS in the management of stones in anomalous kidneys.
Materials and methods We performed a retrospective analysis of all the patients with anomalous kidneys who primarily underwent FURS from January 2010 to December 2015 at our institute. In our study, we included patients with anomalies of lie, fusion and rotation. A total of twenty-five patients with twenty-five renal units having renal calculi in anomalous kidneys were evaluated. Indications for FURS included stone size less than or equal to 2 cm, contraindication to PCNL like bleeding tendencies, patients on anticoagulants or patients who refused ESWL and PCNL. Complete clearance of stone was defined as no residual fragment greater than 2 mm at the end of 4 weeks. The parameters evaluated were patient demographics, type of renal anomaly, stone size, location, laterality, patient's presentation, need for preoperative stenting, operative time, need for postoperative DJ stent, hospital stay, analgesic requirement, number of stages or auxiliary procedures required for stone clearance, success rate and complications.
Results Twenty-five patients with calculi in anomalous kidneys were managed with FURS. These 25 patients had a total of 37 stones. Out of 25 patients, 14 had ectopic kidneys with 19 stones, 5 had malrotated kidneys with 6 stones, 5 had horseshoe kidneys with 11 stones and one had a left-to-right crossed fused ectopia with a single stone. Average age of presentation was 38.28 ± 12.59 years. Majority of the patients had the stones located in pelvis ($n = 11$) or lower calyx ($n = 11$). Eight stones were in middle calyx ($n = 8$), five in upper calyx ($n = 5$) and two in upper ureter ($n = 2$). Fifteen patients had a single stone, and 10 of them had 2 or more stones. Average size of stone was 14.71 ± 4.11 mm and average density being 1210.8 ± 237.7 Hounsfield units. Five patients had a preplaced DJ stent. Average Operative time was 74 ± 21.2 min, and patients had an average hospital stay of 59.48 ± 17.8 h. DJ stent was placed postoperatively in 21 patients, and four were managed with a ureteric catheter. Complete clearance was achieved in 22 (88 %) patients, three patients required two stages and one required the third stage. Three patients (12 %) could not be managed with FURS and required percutaneous stone clearance.
Conclusion Primary FURS is an effective and less invasive modality for management of renal calculi less than 2 cm in kidneys with anomalies of lie, fusion and rotation. It can offset the low clearance rate and high complication rate of ESWL and PCNL, respectively. Ureteral access sheath is an important tool to overcome anatomical challenges of anomalous kidney. Basket and Laser are indispensable accessories for FURS in anomalous kidneys.

Keywords Anomalous kidney · Flexible uretero-renoscopy · Ureteral access sheath

Introduction

Flexible uretero-renoscopy (FURS) is an accepted modality for management of renal calculi in orthotopically placed

✉ Abhishek Gajendra Singh
drabhisheksingh82@gmail.com

[1] MPUH, Nadiad, India

Published online: 15 June 2016

kidney. Though it has been used in management of calculi in anomalous kidneys, the literature is scarce. Incidence of anomalies of kidney varies as per the type of anomaly; in general, it ranges from 1/300 to 1/1000 live births [1, 2]. Technological advancement has made FURS a more simple and effective procedure, which can be used in situations where percutaneous nephrolithotomy (PCNL) or extracorporeal shock wave lithotripsy (ESWL) has failed, contraindicated or cannot be used for some reason. There is an increased risk of stone formation in patients having renal anomalies of lie, fusion and rotation [3–5]. Renal calculi in anomalous kidney are a challenging situation for the treating urologist; therefore, all the treating modalities should be kept in mind before making a surgical decision.

Materials and methods

We performed a retrospective analysis of all the patients with anomalous kidneys who primarily underwent FURS from January 2010 to December 2015. In our study, we included patients with anomalies of lie, fusion and rotation. A total of twenty-five patients with twenty-five renal units having renal calculi in anomalous kidneys were evaluated. Two surgeons performed all the uretero-renoscopies. Indications for FURS included a stone size less than or equal to 2 cm, contraindication to PCNL and/or patients who refused ESWL and PCNL, and those patients wanted a lesser invasive procedure than PCNL. All the patients had a preoperative imaging in form of computed tomography (CT)—intravenous urography (IVU) with 3D reconstruction.

Flexible ureteroscopes used for FURS were FLEX-X^2 by KARL STORZ™ (Tuttilingen, Germany), which has a sheath size of 7.5 fr, working length of 67 cm, working channel of 3.6 fr and 270° angle of deflection or P6 by Olympus (Olympus surgical, Orangeburg, NY), which has an outer diameter of 7.95 fr, working length of 67 cm, working channel of 3.6 fr, and 275° angle of deflection.

It was made sure that in all the cases, urine was sterile at the time of the procedure and all the procedures were performed under general anesthesia. The patients were placed in a lithotomy position with 20° head up. After preparing the parts, a cystoscopy was done using 19 French (Fr) cystoscopy sheath with a 30° lens, and ureteric orifice was cannulated with 0.035-in straight-tip hydrophilic guide wire (Glidewire™, Terumo, Tokyo, Japan) over a 5-Fr ureteric catheter. The ureter was dilated using sequential Teflon dilator from 6 to 14 Fr (COOK MEDICAL™, Bloomington, USA). A ureteral access sheath (UAS) 12/14 Fr ($n = 9$) or 9.5/11.5 Fr ($n = 16$) (COOK MEDICAL™, Bloomington, USA) was placed in upper ureter or till a point where it went in easily without resistance. Thereafter, flexible ureteroscope was introduced, stone-visualized and fragmented using laser. If the stone was in lower calyx or any other awkward calyx, it was engaged using 2.2 Fr N Gage™ nitinol basket (COOK MEDICAL™, Bloomington, USA) or 3 Fr N Circle tipples nitinol basket (COOK MEDICAL™, Bloomington, USA) and placed in upper calyx or favorable calyx. Stone was fragmented using 20 W Holmium laser Swiss Laser Clast™ (Electro Medical Systems, NYON, SWITZERLAND), and laser settings used were 0.5–1 J energy and 10–15 Hz frequency depending on the density and size of the stone. A 200–365-µm fiber was used for fragmentation. Stones were pulverized using a dusting protocol or fragmented to a size smaller than the tip of the laser fiber. After completion of procedure, a ureteric catheter (6 fr) or a DJ (Double J) stent (6 fr) was kept at surgeon's discretion. A foley's per urethral catheter and ureteric catheter were kept in situ for 24 h. DJ stent when placed was removed at 4 weeks. If patient required a second sitting of FURS, it was planned 2 weeks after the primary procedure and a DJ stent was left in situ. Complete clearance was defined as no residual stone fragment greater than 2 mm at the end of 4 weeks. All patients were given alpha-blockers namely Tamsulosin 0.4 mg once daily and encouraged to increase fluid intake to improve stone clearance and also to decrease stent related symptoms. A plain radiograph KUB and USG KUB was repeated after 4 weeks to look for complete clearance of stone.

The parameters evaluated were patient demographics, type of renal anomaly, stone size, location, laterality, patient's presentation, need for preoperative stenting, operative time, need for postoperative DJ stent, hospital stay, analgesic requirement, number of stages or auxiliary procedures required for stone clearance, success rate and complications.

Results (Table 1)

Twenty-five patients with calculus disease in kidneys with anomalies of lie, fusion or rotation were managed with FURS. These 25 patients had a total of 37 stones (Table 1). Out of 25 patients, 14 had ectopic kidneys (EK) with 19 stones (Fig. 1), 5 had malrotated kidneys (MK) with 6 stones, 5 had horseshoe kidneys (HSK) with 11 stones and one had a left-to-right crossed fused ectopia (CFE) with a single stone (Table 1). Average age of presentation was 38.28 ± 12.59 years (Table 1). Majority of the patients had the stone located in pelvis ($n = 11$) or lower calyx ($n = 11$). Eight stones were in middle calyx ($n = 8$), five in upper calyx and two in upper ureter ($n = 2$) (Table 1).

In all the above patients, ureteropelvic junction obstruction was ruled out by imaging studies. Pain was the most common presentation, two patients presented with sepsis

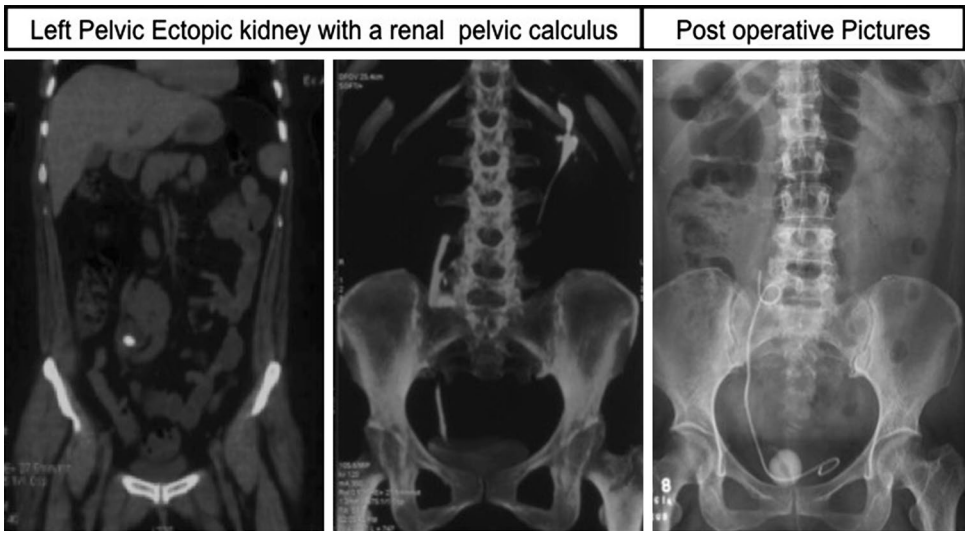

Fig. 1 Showing pelvic ectopic kidney with a renal pelvic calculus and a post-FURS Xray KUB

Table 1 Results

Average age	38.28 ± 12.59 years
Male/female	17:8
BMI (kg/m^2)	23.45 ± 7.34
Single: multiple stones	15:10
Left kidney: right kidney	15:10
Total number of renal units	25 (EK = 14, HSK = 5, MK = 5, CFE = 1)
Total number of stones	37 (EK-19, HSK-11, MK-6, CFE-1)
Distribution of stones	P-11, LC-11, MC-8, UC-5, UU-2
Preoperative Sr.creatinine (mg/dl)	0.89 ± 0.35
Average Stone size	14.71 ± 4.11 mm
Average density in hounsfield units (HU)	1210.8 ± 237.7
Average OR time	74 ± 21.2 min
Average stay	59.48 ± 17.8 h
VAS score at 24 h	2.1 ± 0.41
Average analgesic requirement (mg of tramadol)	78.7 ± 13.4
Postoperative double-J stent: ureteric catheter	21:4
After first stage patients successfully treated	18 (72 %)
After second stage patients successfully treated	21 (84 %)
After third stage patients successfully treated	22 (88 %)
Complications	Clavien grade 1–3
	Clavien grade 2–2
	Clavien grade 3–1

EK ectopic kidney, *HSK* horseshoe kidney, *MK* malrotated kidney, *CFE* crossed fused ectopia, *P* pelvis, *IC* inferior calcyx, *MC* middle calcyx, *UC* upper calcyx, *UU* upper ureter, *VAS* visual analogue scale

and one with obstructive uropathy. Fifteen patients had a single stone, and ten of them had two or more stones. Average size of stone was 14.71 ± 4.11 mm, with an average density of 1210.8 ± 237.7 Hounsfield units (HU). Five patients had a preplaced DJ stent: two for fever with sepsis, one for obstruction with suppressed function, one for tight ureter and one for acute kidney injury. Average operative time was 74 ± 21.2 min, and patient had an average hospital stay of 59.48 ± 17.8 h. DJ stent was placed postoperatively in 21 patients, and four were managed with a ureteric catheter. Three patients (12 %) developed fever which was managed with antipyretics (clavien grade 1 complication), two patients (8 %) developed urinary tract infection which required change of antibiotics (clavien grade 2 complication) and one patient (4 %) required DJ stenting due to severe renal colic and hydronephrosis postureteric catheter

removal (clavien grade 3a complication). Complete clearance was achieved in 22 (88 %) patients, three patients required two stages and one required three stages. In two patients with ectopic kidney, stones could not be cleared due to steep angulation. PCNL in supine position was done in one patient; this patient had a stone load of 25 mm in middle calyx and pelvis. In the other patient, a Microperc was done and this patient had a 10.6-mm calculus. In one patient with HSK, stone could not be cleared with FURS due to awkward angulation and a Mini PCNL was done. Totally, 12 % patients could not be managed with FURS and required percutaneous stone clearance.

Discussion

The incidence of urolithiasis in kidneys with anomalies of fusion, lie or rotation is higher than the normally placed kidneys [6]. The anatomy and location of these kidneys make management of urolithiasis challenging [6]. At this stage, it would be inappropriate to state that it is a treatment of choice in urolithiasis in anomalous kidneys, but it has definitive advantage in a subset of patients.

Largest experience in managing urolithiasis in anomalous kidneys is with ESWL, with an average stone clearance rate of around 67.8 % (54–82 %) [6]. ESWL is a noninvasive option, but the stone clearance is modest and drainage of kidney in these situations is in circumspect. The fragmentation by ESWL is not into dust as is the case with laser lithotripsy, and these fragments have a potential to become a nidus for a new stone formation [7].

PCNL is another commonly used method for managing the calculi in anomalous kidneys, largely used in HSK. The stone clearance in PCNL is high about 87.5 % [8]. The drawback of PCNL in these situations is occurrence of major complication. In the series mentioned above, 3 out of 24 (12.5 %) patients experienced hemorrhage, nephropleural fistula and pneumothorax [8]. Other challenges associated with PCNL in anomalous kidneys include patient positioning; pelvic kidneys (PK) may require PCNL in supine position and transperitoneal access, which has a potential of bowel injury. There is a need for ultrasound guided access to safeguard adjacent structures, i.e., colon in HSK and small bowel in PK. Ultrasound guided access requires training and equipment, which may not be available at all centers.

Laparoscopic pyelolithotomy and laparoscopically aided PCNL are two modalities used in these clinical situations [9, 10]. In a series of 15 patients managed with laparoscopically monitored PCNL, there was prolonged urinary leak and average hospital stay was 4.8 days [10]. These procedures are more morbid as compared to standard endourological procedures [10].

FURS is an indispensable option in the armamentarium of urologist for managing the calculi in patients with renal anomaly of lie, fusion or rotation. FURS has the potential to offset the anatomical, physiological and technical challenges of stone clearance in anomalous kidneys. Many of the series published on FURS in anomalous kidney have used this method as a salvage procedure after failure of ESWL or PCNL [11]. In a series of eight patients by Weizer et al. [6], six patients had undergone a prior procedure, which included four patients with PK all of whom had undergone an ESWL. In our series, it was used as a primary modality with a stone clearance rate comparable to PCNL and better than ESWL with minimal complication rate.

FURS in anomalous kidneys is technically different from FURS in orthotropic kidney. Technical differences include: the course of ureter is not straight, Pelvi-ureteric junction (PUJ) may be tight, a long length of flexible ureteroscope is outside the urethra which could be difficult to manipulate, flexible scope has to negotiate awkward angles one at the PUJ and the other at infundibulo-pelvic junction; this angle may be extremely acute in case of inferior calyx. In case of pelvic ectopic kidney (PK), course of the ureter may be tortuous, whereas in HSK there may be a high insertion of ureter and in MK, pelvis may be slightly anterior or posterior; these variations make negotiating PUJ difficult.

Use of a UAS in FURS in anomalous kidneys straightens the ureter, and allows better drainage after fragmentation. As the scope is straight till the upper ureter, it allows greater deflectibility of the scope in the pelvicalyceal system and thus the probability of entering the awkward calyx improves [12]. Weizer et al. used the UAS in 50 % of the cases, but in our series UAS was used in all the patients. In one patient, the ureter could not be dilated, so a DJ stent was placed and FURS was done after 2 weeks using a UAS. Andreoni et al. [13] have also proposed in placing UAS just above the ureteropelvic junction which allows easy retrieval of fragments in these patients apart from the usual advantages of aiding in quick and atraumatic reintroduction of flexible ureteroscope. In our experience, placing UAS beyond PUJ in anomalous kidneys makes scope movement within the PCS difficult and entry into inferior calyx may become even more difficult. In one patient with PK in our series, we could enter the lower calyx only when we withdrew the UAS from upper ureter to the level of lower ureter. Although ureteric injuries and ureteric strictures are a probability with UAS, we in our series did not experience any major ureteric injuries with UAS.

All the patients with anomalous kidneys should be evaluated to rule out PUJ obstruction, as this will lead to a difficult scope negotiation during the procedure and impaired drainage postprocedure. In our series none of the patients

had clinical or radiological evidence of PUJ obstruction [6].

Unlike in orthotopically placed kidneys, FURS in anomalous kidneys should not rely too much on spontaneous passage of small fragments, the stone should be dusted and the smaller fragments retrieved using a basket. This is particularly important when the stone is in lower calyx. We in our study have used N Gage™ (2.2 Fr) or N Circle™ (3 Fr) nitinol basket (COOK MEDICAL™, Bloomington, USA) for stone extraction or repositioning. Out of nine inferior calyceal stones successfully treated using FURS, five were repositioned into favorable location using a basket and then fragmented. In a series by Weizer et al. [6], all patients required repositioning of stone using baskets, though location of these stones has not been mentioned by the author. In another series, nine out of the seventeen (52.9 %) stones were repositioned from lower calyx to the upper calyx [11]. The Nitinol baskets do not hamper the deflectibility of the scope and make FURS more effective by retrieval of the stone fragments and also by repositioning inferior calyceal stones to a more favorable superior calyx.

Position of the stone in PCS and the total stone volume are important factors in predicting the stone clearance rate. In our study, 11 stones were in lower calyx out of which 2 could not be managed by FURS due to steep angulations and hence required PCNL. In general, the stone-free rate (SFR) with FURS for lower calyx is lower (60.4 %) when compared to the upper calyx, middle calyx or pelvis (94.4 %) [14]. In our series of patients, 9 out of 11 stones in lower calyx could be cleared with FURS, which is about 81.8 %. Also most of the stone in our series were less than 2 cm, and the average stone size was 14.7 ± 4.11 mm. One of the patients who had a pelvic and middle calyceal stone with a cumulative burden of 20 mm required PCNL. Average stone size in various other series was 13–17 mm [6, 11, 15, 16]. In general, FURS work well for anomalous kidney when the stone size is less than 2 cm and the failure rates are high when the stone size is greater than 2 cm [15].

Holmium laser used in FURS dusts the stone completely. We in our series used energy of 0.5–1 J and frequency of 10–15 Hz. A 200/272-μm fiber was used in case a steep angle had to be negotiated or else a 365-μm fiber was used. Molimard et al. [11] used energy of 0.8–1.2 J and frequency of 8–12 Hz. Atis et al. [15] used a fiber of 272 μm for all the cases.

Our average operative time was 74 ± 21.2 min as compared to the other two series, which had an operative time of 106 and 126 min, respectively [6, 11] (Table 1).

The SFR in our series after the first procedure was 72 % and after the final stage was 88 %. In a published series of eight patients, six patients could be completely cleared and a SFR of 75 % was achieved [6]. In other series, a SFR of 53 % was achieved after the first sitting, which increased to 88.2 % after the final sitting [11]. In EK, we could clear 85.7 % of stones, and in HSK and MK, SFR was 100 and 80 %, respectively. One patient of CFE had complete clearance.

Hence, in patients with anomalous kidney with altered anatomy and drainage, ESWL has a low clearance (30–70 %); PCNL has a high SFR but can be associated with complications in up to 16 % cases [17]. Primary ureteroscopy in our series has a SFR of 88 % (Table 1), which is comparable to stone clearance by FURS and PCNL for anomalously placed kidneys in other series, with a very low complication rate [2, 6, 11].

Limitation of study is that it is a noncomparative retrospective case series. Final clearance was assessed with Ultrasound KUB and X-ray KUB, but this was done with the aim of reducing radiation exposure and due to cost constrains. As the number of these patients is less, even in a very high volume center like ours it is difficult to plan a prospective study comparing various modalities.

Conclusion

FURS is an effective and less invasive modality for management of renal calculus less than 2 cm in kidneys with anomalies of lie, fusion and rotation. It can offset the low clearance rate and high complication rate of ESWL and PCNL, respectively. UAS is an important tool to overcome anatomical challenges of anomalous kidney, but it has to be placed appropriately considering the angulation of the calyx. Too high a placement of UAS can be counterproductive. Baskets and Lasers are indispensable accessories for FURS in anomalous kidneys.

Authors' contribution Dr. Singh Abhishek involved in protocol/project development, data analysis and manuscript writing/editing. Dr. Chhabra Jaspreet involved in data analysis and manuscript writing/editing. Dr. Sabnis Ravindra involved in protocol/project development and manuscript writing/editing. Dr. Ganpule Arvind involved in protocol/project development and manuscript editing. Dr. Jairath Ankush involved in data collection or management. Dr. Shah Darshan involved in data analysis. Dr. Desai Mahesh involved in data analysis and manuscript writing and editing.

References

1. Weizer AZ, Silverstein AD, Auge BK, Delvecchio FC, Raj G, Albala DM, Leder R, Preminger GM (2003) Determining the incidence of horseshoe kidney from radiographic data at a single institution. J Urol 170(5):1722–1726
2. Gross AJ, Fisher M (2006) Management of stones in patients with anomalously sited kidneys. Curr Opin Urol 16(2):100–105
3. Pitts WR Jr, Muecke EC (1975) Horseshoe kidneys: a 40-year experience. J Urol 113(6):743–746

4. Smith JE, Van Arsdalen KN, Hanno PM, Pollack HM (1989) Extracorporeal shock wave lithotripsy treatment of calculi in horseshoe kidneys. J Urol 142(3):683–686
5. Evans WP, Resnick MI (1981) Horseshoe kidney and urolithiasis. J Urol 125(5):620
6. Weizer AZ, Springhart WP, Ekeruo WO, Matlaga BR, Tan YH, Assimos DG, Preminger GM (2005) Ureteroscopic management of renal calculi in anomalous kidneys. Urology 65(2):265–269
7. Carr LK, John RA, Jewett MA, Ibanez D, Ryan M, Bombardier C (1996) New stone formation: a comparison of extracorporeal shock wave lithotripsy and percutaneous nephrolithotomy. J Urol 155(5):1565–1567
8. Raj GV, Auge BK, Weizer AZ, Denstedt JD, Watterson JD, Beiko DT, Assimos DG, Preminger GM (2003) Percutaneous management of calculi within horseshoe kidneys. J Urol 170(1):48–51
9. Zafar FS, Lingeman JE (1996) Value of laparoscopy in the management of calculi complicating renal malformations. J Endourol 10(4):379–383
10. Holman E, Tóth C (1998) Laparoscopically assisted percutaneous transperitoneal nephrolithotomy in pelvic dystopic kidneys: experience in 15 successful cases. J Laparoendosc Adv Surg Tech 8(6):431–435
11. Molimard B, Al-Qahtani S, Lakmichi A, Sejiny M, de Medina SG, Carpentier X, Traxer O (2010) Flexible ureterorenoscopy with holmium laser in horseshoe kidneys. Urology 76(6):1334–1337
12. Honey RJ (1998) Assessment of new tipless nitinol stone basket and comparison with an existing flat-wire basket. J Endourol 12:529–531
13. Andreoni C, Portis AJ, Clayman RV (2000) Retrograde renal pelvic access sheath to facilitate flexible ureteroscopic lithotripsy for the treatment of urolithiasis in a horseshoe kidney. J Urol 164(4):1290–1291
14. Lim SH, Jeong BC, Seo SI, Jeon SS, Han DH (2010) Treatment outcomes of retrograde intrarenal surgery for renal stones and predictive factors of stone-free. Korean J Urol 51(11):777–782
15. Atis G, Resorlu B, Gurbuz C, Arikan O, Ozyuvali E, Unsal A, Caskurlu T (2013) Retrograde intrarenal surgery in patients with horseshoe kidneys. Urolithiasis 41(1):79–83
16. Oğuz U, Balci M, Atis G, Bozkurt OF, Tuncel A, Halis F, Aslan Y, Yildirim IO, Senocak C, Yordam M, Atan A (2014) Retrograde intrarenal surgery in patients with isolated anomaly of kidney rotation. Urolithiasis 42(2):141–147
17. Ozden E, Bilen CY, Mercimek MN, Tan B, Sarıkaya S, Sahin A (2010) Horseshoe kidney: does it really have any negative impact on surgical outcomes of percutaneous nephrolithotomy? Urology 75(5):1049–1052