

Retrograde intrarenal surgery and percutaneous nephrolithotomy for the treatment of stones in horseshoe kidney; what are the advantages and disadvantages compared to each other?

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Introduction Kidney stones occur more frequently in patients with a horseshoe kidney (HSK) anomaly. Abnormal anatomy may make the stone removal procedures more difficult. Therefore we aimed to evaluate and compare retrograde intrarenal surgery (RIRS) and percutaneous nephrolithotomy (PCNL) for the treatment of renal stones in the HSK anomaly.

Material and methods In this descriptive study, patients with HSK anomaly who underwent RIRS and PCNL procedures were retrospectively evaluated. Demographic and renal stone characteristics, success and complications associated with the surgical methods were compared across patients.

Results A total of 49 patients were evaluated, 28 underwent RIRS and 21 underwent PCNL. No differences were determined between the groups concerning the demographics of patients and stone characteristics. A single session and final stone-free rate was 71.4% and 85.7% in RIRS, 81% and 90.5% in PCNL (both $p \geq 0.05$). However, RIRS had more re-treatment rate, while its mean length of hospital stay was shorter than PCNL ($p = 0.035$, $p = 0.001$). While no differences were detected between the associated complication rates, more of the complications encountered in the PCNL group were of a serious nature.

Conclusions In the HSK anomaly, renal stones can be treated with RIRS and PCNL procedures with high success. With its minimal morbidity, low complication rates and the minor character of the associated complications, the RIRS procedure can sometimes be preferred to avoid complications related to PCNL in HSK anomaly with big sized kidney stones.

Key Words: morbidity ↔ nephrolithotomy ↔ percutaneous ↔ success ↔ renal stone
↔ horseshoe kidney ↔ retrograde intrarenal surgery

INTRODUCTION

Horseshoe kidney (HSK) is a common renal fusion anomaly that is encountered at a rate between 1/400 and 1/666 [1, 2]. At the embryological stage, the elevation of the kidneys is obstructed by the inferior mesenteric artery, resulting in the formation of kidneys located below normal with variable blood

supply, fused lower poles, and more anterior renal pelvises due to malrotation. The insertion of the ureters is more in the superolateral. As a result, due to the disrupted drainage of the collecting duct system and ureteropelvic junction obstruction, stasis is encountered, and urinary tract infections and stone disease are seen more frequently in those with the HSK anomaly as compared to the normal

population [3]. Moreover, metabolic abnormalities have a higher prevalence in patients who have stones in HSK, resulting in more pronounced effects on the tendency of stone formation than the negative impacts of anatomical anomalies [4].

The current stone disease guidelines do not provide clear information regarding the selection of appropriate treatments for patients with anatomical anomalies such as the HSK [5, 6]. For stones larger than 2 cm in patients with anatomically normal kidneys, the first choice of treatment PCNL [5]. However, although PCNL offers high success rates, the use of other treatment modalities for stones larger than 2 cm has been gradually increasing, as its complication rates can reach up to 83% [7]. Although some studies state that PCNL-related complications are not amplified in the case of the HSK anomaly, it is clear that performing the procedure and achieving stone-free status is technically more difficult in HSK [8, 9]. The use of RIRS for treating stone disease in HSK has shown a gradual increase in parallel to technological advances, and high success and low complication rates have been reported, particularly in moderately sized stones [10]. In spite of this, there is a lack of information in the literature comparing these two successful treatments regarding their advantages and disadvantages in the treatment of stone disease in HSK. This study aims to determine and analyze the outcomes associated with PCNL and RIRS operations performed at our clinic for the treatment of renal stones in HSK and evaluate whether RIRS can be an alternative to PCNL in the treatment of stones in HSK.

MATERIAL AND METHODS

In this descriptive study, 49 patients over 18 years of age who underwent RIRS ($n = 28$) and PCNL ($n = 21$) for calculi detected in HSK between January 2010-September 2017 were retrospectively evaluated. The two procedures were compared in regards to demographic and stone characteristics, intraoperative and postoperative variables, treatment success, and complications. All patients were evaluated with basic laboratory and radiological methods. Blood count, urinalysis, creatinine, blood urea, nitrogen, and coagulation profile were studied. Patients with positive urine culture were treated, as appropriate. All patients underwent a detailed radiologic assessment with computed tomography (CT). In the study, stone size was calculated as the largest dimension in the CT. All surgical decisions were made by the consensus of experienced surgeons in our clinic. Treatment indications were decided based on stone

size, localization, the presence of a dilated calyceal system, the general condition of the patient and the patient's choice after being informed about the modalities. In patients with obesity, high comorbidity, bleeding diathesis, and in those that we were of the opinion that the stone can be reached with flexible ureteroscopy, RIRS was generally preferred. PCNL was performed with more frequency in patients with a high hydronephrosis grade, patients who had more stone burden and in those in which we were of the opinion that the stone can't be reached with flexible ureteroscopy. Complications were classified according to the modified Clavien classification system.

In the RIRS procedure, all patients were operated on under general anesthesia. In some patients, a ureteral access sheath (UAS) (9.5/11.5 F or 11/13 F) (Elit Flex, Ankara, Turkey) was placed over the guidewire. We used a flexible ureteroscope, the FLEX-X2 device produced by KARLZ STORZTM (Tuttlingen, Germany). If the stone was in a calyx of a low or unusual location, it was transferred to an appropriate location with a nitinol basket (Zero TipTM, Boston Scientific Microvasive, Marlborough, USA) and fragmentation was performed. The decision to insert a ureteral stent at the end of the procedure was made based on the surgeon's preference. If a ureteral stent was present, it was removed after 2–4 weeks.

In the PCNL procedure, all patients had ureteral catheters inserted under general anesthesia, and the prone position was assumed. Percutaneous entry was performed with an 18-gauge needle along with C- arm fluoroscopy on the appropriate calyx and/or directly on the stone after a contrast agent was administered. After a 0.035-inch j tip guidewire was inserted into the collecting duct system with metal or amplatz dilators, depending on the surgeon's choice, the access tract was dilated up to 30 F over the guidewire, and an amplatz sheath was placed. Additional access was created in the presence of difficult and large stones. All patients had nephrostomy catheters placed. Ureteral stents were placed depending on the surgeon's choice and removed after 2–4 weeks. Clearance was assessed in the postoperative period by kidney-ureter-bladder radiography (KUB) on the 1st day and by KUB and ultrasonography (US) on the 15th day (Figure 1). The 15th day stone-free status, which indicates the results after the initial treatment, was defined as single session stone-free status. Additional procedures were performed to manage treatment failure and some complications. Computed tomography was performed at the 3rd postoperative month after all procedures, and stone-free status which was evaluated after this, was defined as final stone-free status. Success was defined as a complete stone-free status. The opera-



Figure 1A. Preoperative axial CT, KUB, and postoperative KUB images of a patient who underwent RIRS for right kidney stone in HSK.



Figure 1B. Preoperative axial CT, KUB, and postoperative KUB images of a patient who underwent PCNL for right kidney stones in HSK.

tive characteristics, single session stone-free rates, final stone-free rates, and complication rates were compared for the procedures. All patients were called in for follow-up examinations at 3-month intervals within the first year and were followed up at yearly intervals later on.

Data obtained in the study was analyzed using the SPSS 16.0 (SPSS, Chicago) package software. Descriptive statistics were gathered using central tendency and distribution measurements such as numbers, percentages, means and standard deviation, medians; and the differences between categorical variables were determined using chi-square test. The Shapiro-Wilk normality test was used to check whether or not quantitative variables showed agreement with a normal distribution, and the Mann Whitney U test was used to determine the differences between non-normal independent variables. Student t-test was applied for continuous variables of the treatment groups. In the study, a p-value below 0.05 was considered statistically significant.

RESULTS

The demographic and clinical characteristics of 49 patients were compared concerning the used procedure. In regards to demographics and renal stone characteristics of procedures, no differences were determined between the groups in terms of age, sex, body mass index (BMI), Charlson Comorbidity Index (CCI), preoperative serum creatinine, stone size, number of stones, stone lateralization and localization, presence of hydronephrosis, degree of hydronephrosis and presence of stone surgery ($p \geq 0.05$) (Table 1). The chief complaint was 'pain' in both groups (60.7% in RIRS, 52.4% in PCNL).

The evaluation of postoperative results based on the implemented procedure revealed that the stone-free rate of 71.4% in the RIRS group obtained following a single session (15th day) rose to 85.7% with additional procedures. Success could not be achieved in three patients who underwent 3 session of RIRS. In the PCNL group, success increased from 81.0%

Table 1. Comparison demographic and clinical characteristics of patients based on the applied surgical procedure

	RIRS (n = 28)	PCNL (n = 21)	p-value
Age (mean \pm SD)	43.2 \pm 8.4	41.5 \pm 9.9	0.526
Sex (n) (%)			0.999
Male	23 (82.1)	18 (85.7)	
Female	5 (17.9)	3 (14.3)	
BMI (kg/m ²) (mean \pm SD)	27.0 \pm 2.6	25.9 \pm 2.3	0.163
CCI (median)	1 (0–5)	0 (0–5)	0.065
Preoperative serum creatinine (mg/dL) (mean \pm SD)	0.98 \pm 0.30	0.95 \pm 0.37	0.954
Presence of stone surgery (n) (%)			0.590
Primary	14 (50)	13 (61.9)	
Secondary	14 (50)	8 (38.1)	
Presence of hydronephrosis (n) (%)	12 (42.9)	14 (66.7)	0.173
Hydronephrosis degree (median)	0 (0–4)	2 (0–4)	0.063
Stone lateralization (n) (%)			0.432
Right	13 (46.4)	13 (61.9)	
Left	15 (53.6)	8 (39.1)	
Number of stones (mean \pm SD)	1.4 \pm 0.6	1.8 \pm 1.0	0.173
Single (n) (%)	18 (64.3)	13 (61.9)	0.864
Multiple (n) (%)	10 (35.7)	8 (38.1)	
Total stone size (mm) (mean \pm SD)	22.3 \pm 9.1	24.5 \pm 8.1	0.375
Stone localization (n) (%)			0.987
Renal pelvis	9 (32.1)	6 (28.6)	
Upper calyx	3 (10.7)	2 (9.5)	
Middle calyx	3 (10.7)	2 (9.5)	
Lower calyx	7 (25)	5 (23.8)	
Mixed calyces	6 (21.4)	6 (28.6)	

RIRS – retrograde intrarenal surgery, PCNL – percutaneous nephrolithotomy, SD – standard deviation, BMI – Body Mass Index, CCI – Charlson Comorbidity Index

Table 2. Comparison of the stone-free rates, renal functions and operative characteristics based on the applied procedures

	RIRS (n = 28)	PCNL (n = 21)	p-value
Total operative time (min.) (mean \pm SD)	65.7 \pm 29.9	86.6 \pm 40.8	0.044
Total length of hospital stay (day) (mean \pm SD)	2.07 \pm 1.9	4.1 \pm 2.2	0.001
Post-operative serum creatinine (mg/dL) (mean \pm SD)	0.95 \pm 0.32	0.89 \pm 0.33	0.654
Creatinine change (Pre-Post) (mg/dL) (mean \pm SD)	0.02 \pm 0.11	0.05 \pm 0.13	0.819
Single session stone-free rate (n) (%)	20 (71.4)	17 (81)	0.666
Re-treatment (n) (%)	8 (28.5)	1 (4.8)	0.035
Auxiliary procedures (n) (%)	4 (14.3)	4 (19)	0.710
Final stone-free rate (n) (%)	24 (85.7)	19 (90.5)	0.688
Total complication (n) (%)	7 (25)	8 (38.1)	0.502

RIRS – retrograde intrarenal surgery, PCNL – percutaneous nephrolithotomy

to 90.5% following additional procedures. No significant difference was determined between the groups concerning success after a single session and at final status. In the RIRS group, 8 patients required re-treatment and 4 patients required an auxiliary procedure, while 1 patient had retreatment in the PCNL group and 4 auxiliary procedures were performed ($p = 0.035$ and $p = 0.710$). The total operating time and length of hospital stay were statistically significantly shorter in the RIRS group ($p = 0.044$, $p = 0.001$). The study also did not find a difference between the groups concerning complication rates (Table 2). For auxiliary procedures; 3 RIRS patients underwent shock wave lithotripsy (SWL), and 1 had a ureteral stent placed in a separate session, and 3 PCNL patients underwent RIRS, one of which also underwent SWL. One patient in the RIRS group demonstrated success after SWL performed following 2 sessions of RIRS, and 1 patient in the PCNL group showed success following an additional RIRS procedure.

The evaluation of the postoperative complications encountered in the study revealed that more than 50% of the complications encountered in the RIRS group were Grade 1 complications, while this rate was 12.5% for the PCNL group. The PCNL group manifested a higher prevalence of Grade 2 and more severe complications. Complications in the RIRS group were fever that did not require postoperative antibiotics ($n = 4$), urinary tract infections that required antibiotic medication ($n = 2$), and insertion of a ureteral stent on the 2nd postoperative day due to renal colic ($n = 1$). Complications in the PCNL group included blood transfusions ($n = 4$), fever that did not require postoperative antibiotics ($n = 1$), urinoma that resolved under follow-up ($n = 1$), retention and colic due to clot formation ($n = 1$), and urosepsis that required intensive care and was treated with wide-spectrum antibiotics ($n = 1$) (Table 3).

We used a UAS in 20 patients and did not observe any related complications. No access sheaths were used in 8 RIRS patients and none required additional sessions. Multiple accesses were utilized in 3 patients who underwent PCNL and these patients did not require a 2nd PCNL session. 5 patients who underwent PCNL had a nephrostomy created using a foley catheter, while a malecot type was used for other patients.

DISCUSSION

Stone formation is commonly encountered among those with the HSK anomaly and affects 21–60% of these cases [11]. As a result of technological advancements, the treatment of stones in cases of HSK

Table 3. Complications associated with the procedures based on the modified Clavien classification system

	Grade 1	Grade 2	Grade 3a	Grade 3b	Grade 4a	Grade 4b	Grade 5
RIRS (n)	4	2	1	–	–	–	–
PCNL (n)	1	4	2	–	–	1	–

RIRS – retrograde intrarenal surgery, PCNL – percutaneous nephrolithotomy

has begun to favor minimally invasive methods over open surgery [3]. Treatment options include ureteroscopy, PCNL, laparoscopy, and SWL [12].

The high success and low complication rates associated with RIRS in the treatment of stone disease in patients with anatomically normal kidneys have been reported in previous studies [13, 14, 15]. The first study on RIRS of HSK was published in 2005, and stone-free status was achieved in 3 of the 4 patients [16].

Another study reported high success rates in 15 of the 17 patients following an average of 1.5 sessions performed on stones of an average size of 16 mm [17]. In a study conducted by Gokce et al., which compared RIRS and SWL without randomization and presented no statistically significant differences between stone sizes, success rates of 73.9% and 47.7% were reported with RIRS and SWL, respectively [18]. In their study that evaluated RIRS in HSK, Ding et al. reported a stone-free rate of 62.5% following a single session and an 87.5% overall stone-free rate following an average of 1.4 sessions without any major complications, where the mean stone size was 29 ± 8 mm. They emphasized that RIRS had advantages over PCNL in stones <30 mm with lower complication rates and comparable success [10]. One can ascertain from our results that RIRS achieves success rates comparable to PCNL. The RIRS procedure can produce high success rates and cause fewer complication rates in patients with nephrolithiasis with HSK, with a few additional sessions when required. Also, even though RIRS requires more additional sessions, operation time and hospital stay are shorter than for PCNL.

However, the deflection and handling of the flexible ureteroscope are made more difficult as those with HSK have flatter pelvises and narrower intrarenal spaces. The abnormal structure of the kidneys, high insertion of the ureters, long length of the flexible ureteroscope that remains outside of the urethra, and a narrow infundibulopelvic angle make the procedure more difficult, lower stone-free rates, and increase the probability of a 2nd session. Thus, the higher number of RIRS sessions observed in our study was considered normal.

The difficulty of the RIRS procedure compared to one performed on a normal kidney and the consid-

erably high rates of repeated sessions also negatively affect the cost of the treatment. More care must be taken to preserve the device while treating these patients. The advantages of using a UAS, such as facilitating the insertion of the ureteroscope, ensuring the ureteroscope stays straight up to the upper ureter, offering a wider passage for stone fragmentation, protecting the shaft of the device, and reducing pelvic pressure, must be taken into consideration. However, due to the more inferior location of the HSK, care must be taken to prevent mucosal damage and bleeding in these patients.

Another disadvantage associated with RIRS for those with the HSK anomaly is that spontaneous passage is more difficult compared to those with anatomically normal kidneys. The stone must be fragmented as much as possible, and the small fragments must be extracted using a basket. Particularly in the lower calyces, fragmenting the stone after transferring it to an appropriate area is important to preserve the device and facilitate the procedure, since deflection along with laser would become more difficult in these cases.

The global study published in 2014 by the Clinical Research Office of the Endourological Society states that ureteroscopy could be safely used on patients with high comorbidities [19]. Although the comorbidity rate in the study was high and 4 patients used anticoagulants, only one patient manifested complications more severe than grade 2. Accordingly, literature reviews reveal very low complication rates following RIRS in those with the HSK anomaly, suggesting that RIRS can be preferred in patients under high risk.

While high success rates have been reported with PCNL in patients with a large stone burden, the technique may produce significant complications. Raj et al. have reported a success rate of 87.5% (n = 24) in HSK anomaly, along with a 16.7% minor and 12.5% major complication rate [20]. An 89% success rate was reported in another study following 45 procedures and 12 additional operations at the end of the 3rd month with major complications including blood transfusions in 3 patients due to significant bleeding, sepsis in 1 patient, ureteral obstruction in 1 patient, and colonic injury in 1 patient [21]. In our study, patients who underwent PCNL mani-

fested major complications such as urosepsis, urinoma that resolved spontaneously, and need for blood transfusions. It must be remembered that while high success rates can be obtained with PCNL following a single session, a high risk of complications may also be encountered.

In addition to the disadvantages of the anatomical anomaly for obtaining percutaneous access, aberrant vascularization theoretically increases the risk of bleeding. Similar to several studies in the literature, the rate of transfusion in our study is around 20% [22, 23]. This high rate may be due to abnormal vascularization of HSK anomaly and PCNL not having been experienced much in HSK anomaly. Upper pole access is recommended as it facilitates reaching all calyces and decreases hemorrhage [20]. Twenty-six accesses were made in our study in the PCNL group, and 13 (50%) of these were upper pole accesses. A more inferior location of the kidneys reduces the risk of pleural injury. Moreover, utilizing a medical access tract for calyces with dorsomedial and dorsolateral locations minimizes the risk of colon damage [24]. These complications were not encountered in our series.

One of the limitations of our study is its retrospective design and small sample size even though our clinic is a tertiary treatment center. Another limitation of our study was that randomization could not be performed. But considering that renal stones in HSK

is not common, it is not easy to perform randomization. However, when the data is examined, it can be interpreted that RIRS is more often selected in the cases with comorbidities and that PCNL is preferred in the presence of hydronephrosis. Also, considering the effect of stone composition on the success of treatment modalities, the lack of this data is another limitation. Since there were not enough patients presenting with various stone compositions due to the small sample size, this factor was not evaluated in the study.

CONCLUSIONS

The treatment of stone disease in patients with HSK results in considerable difficulties in urological practice since HSK is quite common, is frequently accompanied by stone disease, and presents anatomical and metabolic disadvantages. Renal stones in the HSK anomaly can be treated with high rates of success using PCNL in a single session, and a similar success rate can be achieved by RIRS with acceptable re-treatment rates. Moreover, RIRS may be chosen to avoid complications associated with PCNL due to the minor character of the associated complications and its safe use on renal stones in the HSK anomaly.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

References

- Pitts WR, Jr, Muecke EC. Horseshoe kidneys: a 40-year experience. *J Urol.* 1975; 113: 743-746.
- Weizer AZ, Silverstein AD, Auge BK, et al. Determining the incidence of horseshoe kidney from radiographic data at a single institution. *J Urol.* 2003; 170: 1722-1726.
- Yohannes P, Smith AD. The endourological management of complications associated with horseshoe kidney. *J Urol.* 2002; 168: 5-8.
- Raj GV, Auge BK, Assimos D, Preminger GM. Metabolic abnormalities associated with renal calculi in patients with horseshoe kidneys. *J Endourol.* 2004; 18: 157-161.
- Turk C, Petrik A, Sarica K, Seitz C, Skolarikos A, Straub M, Knoll T. EAU Guidelines on Interventional Treatment for Urolithiasis. *Eur Urol.* 2016; 69: 475-482.
- Assimos D, Krambeck A, Miller NL, et al. Pearle MS, Preminger GM, Razvi H, Shah O, Matlaga BR. Surgical Management of Stones: American Urological Association/Endourological Society Guideline, PART II. *J Urol.* 2016; 196: 1161-1169.
- Michel MS, Trojan L, Rassweiler JJ. Complications in percutaneous nephrolithotomy. *Eur Urol.* 2007; 51: 899-906.
- Miller NL, Matlaga BR, Handa SE, Munch LC, Lingeman JE. The presence of horseshoe kidney does not affect the outcome of percutaneous nephrolithotomy. *J Endourol.* 2008; 22: 1219-1225.
- Ozden E, Bilen CY, Mercimek MN, Tan B, Sarikaya S, Sahin A. Horseshoe kidney: does it really have any negative impact on surgical outcomes of percutaneous nephrolithotomy? *Urology.* 2010; 75: 1049-1052.
- Ding J, Huang Y, Gu S, et al. Flexible Ureteroscopic Management of Horseshoe Kidney Renal Calculi. *Int Braz J Urol.* 2015; 41: 683-689.
- Mottola A, Selli C, Carini M, Natali A. Lithiasis in horseshoe kidney. *Acta Urol Belg.* 1984; 52: 355-360.
- Blackburne AT, Rivera ME, Gettman MT, Patterson DE, Krambeck AE. Endoscopic Management of Urolithiasis in the Horseshoe Kidney. *Urology.* 2016; 90: 45-49.
- Bas O, Tuygun C, Dede O, et al. Factors affecting complication rates of retrograde flexible ureterorenoscopy: analysis of 1571 procedures- a single-center experience. *World J Urol.* 2017; 35: 819-826.
- Ghani KR, Wolf JS, Jr. What is the stone-free rate following flexible ureteroscopy for kidney stones? *Nat Rev Urol.* 2015; 12: 363.
- De S, Autorino R, Kim FJ, Zargar H, et al. Percutaneous nephrolithotomy versus retrograde intrarenal surgery: a systematic review and meta-analysis. *Eur Urol.* 2015; 67: 125-137.

16. Weizer AZ, Springhart WP, Ekeruo WO, et al. Ureteroscopic management of renal calculi in anomalous kidneys. *Urology*. 2005; 65: 265-269.
17. Molimard B, Al-Qahtani S, Lakmichi A, et al. Flexible ureterorenoscopy with holmium laser in horseshoe kidneys. *Urology*. 2010; 76: 1334-1337.
18. Gokce MI, Tokatli Z, Suer E, Hajiyev P, Akinci A, Esen. Comparison of shock wave lithotripsy (SWL) and retrograde intrarenal surgery (RIRS) for treatment of stone disease in horseshoe kidney patients. *Int Braz J Urol*. 2016; 42: 96-100.
19. Daels FP, Gaizauskas A, Rioja J, et al. Age-related prevalence of diabetes mellitus, cardiovascular disease and anticoagulation therapy use in a urolithiasis population and their effect on outcomes: the Clinical Research Office of the Endourological Society Ureteroscopy Global Study. *World J Urol*. 2015; 33: 859-864.
20. Raj GV, Auge BK, Weizer AZ, et al. Percutaneous management of calculi within horseshoe kidneys. *J Urol*. 2003; 170: 48-51.
21. Shokeir AA, El-Nahas AR, Shoma AM, et al. Percutaneous nephrolithotomy in treatment of large stones within horseshoe kidneys. *Urology*. 2004; 64: 426-429.
22. Liatsikos EN, Kallidonis P, Stolzenburg JU, et al. Percutaneous management of staghorn calculi in horseshoe kidneys: a multi-institutional experience. *J Endourol*. 2010; 24: 531-536.
23. Majidpour HS, Yousefinejad V. Percutaneous management of urinary calculi in horseshoe kidneys. *Urol J*. 2008; 5: 188-191.
24. Gupta NP, Mishra S, Seth A, Anand A. Percutaneous nephrolithotomy in abnormal kidneys: single-center experience. *Urology*. 2009; 73: 710-714. ■