

Safety and efficacy of PNL vs RIRS in the management of stones located in horseshoe kidneys: A critical comparative evaluation

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Summary *Aim: To assess the efficacy and safety of two different techniques (Percutaneous nephrolithotomy (PNL) vs Retrograde intrarenal surgery (RIRS)) in the management of stones in patients with horseshoe kidneys (HSK).*

Patients and methods: Departmental files of 88 cases with radiopaque kidney stones in horseshoe kidneys undergoing two different approaches (PNL vs RIRS) were evaluated with respect to the success and complication rates of in a retrospective manner. In addition to the factors related with the procedures (success and complication rates, additional procedures), patient and stone characteristics were all well evaluated.

Findings obtained in both groups were evaluated in a comparative manner with respect to the statistical significance.

Results: Stone free rates were comparable in both groups after 1-week period (81.6% PNL vs 80% RIRS). As well as 3 months evaluation (84.2% PNL and 82.0% RIRS). The percentage of the cases with residual fragments (> 4 mm) were similar in both groups and while all PNL procedures were completed in one session, mean number of RIRS sessions was higher (1.22 ± 0.05). Mean duration of the procedure was slightly higher in RIRS group and based on Clavien scoring system, despite a higher risk of Hb drop noted in patients treated with PNL, all complication rates were found to be similar in both groups.

Conclusion: Our results demonstrate that of the available minimally invasive treatment alternatives, both PNL and RIRS could be safe and effective alternatives for renal stone removal in patients with HSK.

KEY WORDS: Horseshoe kidney; Percutaneous nephrolithotomy; Retrograde intrarenal surgery; Renal stone; Ureteroscopy.

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INTRODUCTION

Being observed in approximately 1 in 400 to 1 in 666 births, horseshoe kidney (HSK) is the most common renal fusion anomaly (1, 2). Anterior displacement of the renal pelvis and high insertion of the involved ureter cause urinary abnormal drainage with flow hinderance and

urinary stasis in the collecting system which may result in stone formation (1). The reported incidence of urolithiasis in patients with HSK varies between 20% to 60% in different series (3, 4).

On the other hand again, abnormal position of the kidney due to congenital fusion abnormality and unusual course of the ureter over the isthmus bring the management of stones in such kidneys into more challenging position. Although open surgery has been performed commonly in the past, currently all available minimal invasive treatment alternatives such as extracorporeal shock wave lithotripsy (SWL), retrograde intrarenal surgery (RIRS) and percutaneous nephrolithotripsy (PNL) are being performed with varying success rates (4).

Of these alternatives although SWL has been performed as a practical and well tolerated procedure by the majority of cases, success rates in such patients are highly variable and stone free rates (SFR) of 31-100% were reported in the literature (5-8). Although adequate fragmentation can be achieved by SWL, the anatomic abnormalities may prevent fragment passage in a substantial number of these patients.

As a second alternative, PNL has already been found to be efficient in the management of relatively large stones cases with HSK with varying success rates. Due to the relatively lower position of the kidneys most upper as well as mid renal calyces are found to be located below the twelfth rib, thereby making the supracostal puncture relatively safe in these patients. However, despite the higher success rates obtained, the invasive nature of this method and higher risk of major complications (complication rates 14.3-29.2%) led the endourologists to look for more feasible and less invasive options. Stone clearance rates after PNL in series with relatively limited number of renal units have been reported to be 75-87.5% (3, 9, 10).

Last but not least, retrograde intrarenal surgery by using flexible ureterorenoscope has also been shown to be an effective management option; the success rate and associ-

ated complications of this method have not been well documented in such patients. Despite acceptable stone free rates reported in some trials with relatively limited number of cases, due to the anatomical abnormality, a second look is usually required to render the patient completely stone free. A recent review article focusing on the management of renal stones in HSK demonstrated that RIRS may provide acceptable stone free rates (78%) (11). In this present study we aimed to evaluate the clinical efficacy of two different approaches, RIRS combined with holmium laser lithotripter and PNL, in treating renal calculi in horseshoe kidney.

PATIENTS AND METHODS

The medical records of 88 cases with radiopaque renal stones in horseshoe kidneys treated with two different types of procedures (PNL vs RIRS) in 7 different centers between 2007 and 2016 were reviewed. Study protocol was approved by the *Ethics Committee of the Hospital*. All steps of the study were planned and applied carefully according to Helsinki Declaration.

Depending on the type of the procedure applied, cases with horseshoe kidneys were divided into two different groups; in Group 1 (n = 38) cases were treated with PNL and in Group 2 (n = 50) cases were treated with RIRS. All treatment related parameters (stone free rates, number of sessions, treatment duration, hospitalization time, presence of the residual fragments, complications as well as the need for additional interventions) were noted and evaluated between two groups in a comparative manner. Preoperative evaluation

Prior to the above mentioned procedures, in addition to the preoperative laboratory tests including urinalysis, renal functional parameters, complete blood count and prothrombin concentration, urine culture and sensitivity test was performed in all patients with pyuria. Patients with *urinary tract infection* (UTI) were treated before the procedure with an appropriate antibiotic regimen. All patients were given prophylactic antibiotics at the time of anesthesia induction.

In addition to *kidney-ureter-bladder* (KUB) and urinary system *ultrasonography* (USG), a *non-contrast abdominopelvic computed tomography* (NCCT) were performed for radiologic evaluation. NCCT was also applied to assess the final stone free rates after 3-months and/or when there is any suspicion for residual fragments. Both procedures were performed under general anesthesia, a prone position was used for PNL and RIRS procedures were performed in lithotomy position. While the stone disintegration was performed with Ho-YAG laser during RIRS, all stones were fragmented by using pneumatic lithotripter during PNL.

Postoperative evaluation

Success rates in all patients were evaluated one week and 3 months after

the last session of PNL and RIRS with KUB and/or urinary system USG to check the degree of stone fragmentation and the presence of obstruction (hydronephrosis) if present. The ultimate success rates were defined as no stone detectable or the presence of fragments < 4 mm on low dose non-contrast CT imaging for all patients.

Statistical Analysis: The *Prism 5.0* (GraphPad Software, San Diego, CA) was used for the statistical analysis. Data are presented as mean standard error of mean. Student's t test was used for both comparison of descriptive statistical methods and evaluation of quantitative data and chi-square test were used to compare the qualitative data between two groups; p < 0.05 was consider significant.

RESULTS

Departmental files of 88 cases with kidney stones in horseshoe kidneys (56 male and 32 female (M/F: 1.75) undergoing two different approaches (PNL vs RIRS) were evaluated with respect to the success and complication rates of each procedure in a retrospective manner. While the age of the cases ranged from 19 to 60 years (mean 41.161.25); the overall mean size of the stones were 20.590.75 mm (7-42 mm). Patients and stone related factors are summarized in Table 1.

All PNL procedures were completed in one session, but the mean number the sessions for cases undergoing RIRS was 1.220.05 (p = 0.0064). Although mean duration of the procedure was slightly longer in RIRS group (p = 0.9075), mean radiation exposure time was higher in PNL group when compared cases undergoing RIRS (p < 0.0001). On the other hand, while the mean duration of hospital stay was 3.150.24 days (1-10) in patients undergoing PNL procedure; this value was 1.580.20 days (1 to 7) in RIRS group (p < 0.0001) (Table 2). While a nephrostomy tube (14 F) has been placed in 36 cases (94.7%) after the PNL procedure, a double J stent was inserted in 42 of 50 cases undergoing RIRS procedure (84.0%). Evaluation of the degree of hydronephrosis revealed a mean value of 2.050.14 dilatation in Group 1 and 1.460.16 in Group 2, there was a statistically significant difference on this aspect (p = 0.0087).

Table 1. Evaluation of patient and stone characteristics in both groups.

	Overall n = 88	Group 1 (PNL) n = 38	Group 2 (RIRS) n = 50	P*
Age (year)	41.161.25	42.970.87	39.781.68	0.1434
BMI (kg/m ²)	28.270.42	29.150.59	27.600.56	0.0643
Stone size (mm)	20.590.75	21.551.14	19.460.56	0.4638
HU (Hounsfield unit)	97123.46	95734.29	98226.31	0.5496
Degree of hydronephrosis (grade)	1.720.11	2.050.14	1.460.16	0.0087
Stone location; n, (%)				
Renal pelvis	30 (34.1)	12 (31.6)	18 (36.0)	0.8208
Upper calyx	8 (9.1)	3 (7.9)	5 (10.0)	1.0000
Middle calyx	9 (10.2)	3 (7.9)	6 (12.0)	0.7263
Lower calyx	22 (25.0)	9 (23.7)	13 (26.0)	1.0000
Multiple calyces	19 (21.6)	11 (28.9)	8 (16.0)	0.1923

* Comparison between Group 1 and Group 2.

Table 2.

Evaluation of the outcomes of the procedures in terms of success rates as well as early post-operative follow-up data.

	Overall n = 88	Group 1 (PNL) n = 38	Group 2 (RIRS) n = 50	P*
Mean duration of the procedure (min)	77.3 42.71	75.8 42.64	80.2 65.13	0.9075
Mean number of sessions	1.11 0.03	1.00 0.0	1.22 0.07	0.0064
Stone free rate; n, (%)				
1. Week	71 (80.7)	31 (81.6)	40 (80.0)	0.7886
3. Month	73 (82.9)	32 (84.2)	41 (82.0)	0.7820
Residual stone > 4 mm n, (%)	12 (13.6)	5 (13.2)	7 (14.0)	0.7559
Mean fluoroscopy time (sec.)	30.8 05.40	69.2 49.43	20.6 21.81	< 0.0001
Mean drop in hb levels (g/dL)	0.74 0.10	1.55 0.15	0.13 0.07	< 0.0001
Mean hospital stay (day)	2.46 0.12	3.15 0.24	1.58 0.20	< 0.0001
Auxiliary procedures; n, (%)	6 (6.8)	3 (7.9)	3 (6.0)	1.0000

* Comparison between Group 1 and Group 2.

Table 3.

Evaluation of the type and grade of complications according to modified Clavien classification in both groups as early post-operative follow-up data.

Grade/complication	Overall n = 88	Group 1 (PNL) n = 38	Group 2 (RIRS) n = 50	P*
1 Fever > 38 °C; n, (%)	14 (15.9)	6 (15.8)	8 (16.0)	0.2274
Hemorrhage/hematuria not requiring blood transfusion; n, (%)	8 (9.0)	5 (1.8)	3 (3.6)	
2 Hemorrhage/hematuria requiring blood transfusion; n, (%)	4 (4.5)	3 (7.9)	1 (2.0)	0.3113
3a Double J stent placement for ureteral stone; n, (%)	3 (3.4)	2 (5.2)	1 (2.0)	0.4916
3b Endoscopic treatment for ureteral stone; n, (%)	6 (6.8)	3 (7.9)	3 (6.0)	

* Comparison between Group 1 and Group 2.

Evaluation of the results obtained with two different techniques revealed following findings.

Evaluation of the success as well as auxiliary procedure rates

The overall percentage of the cases with no stones detectable or demonstrating fragments < 4 mm after one week period was 80.7% and the stone free rates were comparable in both groups after 1-week period (81.6% for PNL group and 80.0% for RIRS group, $p = 0.7886$). This was also true during post-operative 3 months evaluation period where 84.2% of cases treated with PNL were stone free when compared with the cases undergoing RIRS procedure (82.0%) ($p = 0.7820$).

Evaluation of the residual fragments (RF) sizing > 4 mm demonstrated that 5 cases (13.2%) in PNL group; 7 cases in RIRS group (14.0%) had such larger residual fragments during early (1-week) follow-up evaluation. During the 3-months follow-up period while 1 case in PNL group passed these fragments spontaneously, fragments passed into the ureter in the other 3 cases. A JJ stent have already been inserted in 2 of these 3 cases due to the severe obstruction. Fragments were removed with URS in these 3 cases. 1 case was asymptomatic with RF requiring no intervention. On the other hand, regarding

the larger residual fragments (> 4 mm) in 7 cases of RIRS group, although 1 case did pass the fragment spontaneously, fragments passed into the ureter in 3 cases and were removed again with URS during 3-months follow-up period. A double J stent was again inserted in only 1 of these 3 cases prior to URS due to the obstruction induced by ureteral stones.

PNL was unsuccessful in 2 cases due to the difficulty in accessing the stones (5.3%) and RIRS was performed in these cases. On the other hand, RIRS was unsuccessful in 3 cases (6.0%) because of the difficulty in accessing to the lower pole. A mini-PNL was performed in all these 3 cases with successful stone removal. All these cases were excluded from the study program and were not included in any of these groups (Table 2).

Evaluation of complication rates

All complications observed in both groups were classified by using modified Clavien scoring system (12).

Based on this classification, while 11 cases (28.9%) in PNL group demonstrated grade 1 complications, this number was again 11 (22.0%) in RIRS group ($p = 0.2274$). Regarding these complications, although fever after the procedures were noted in a total of 14 cases in both groups (6 in PNL and 8 in RIRS group) none of these cases demonstrated sepsis during follow-up.

Moreover, regarding the grade 3 complications while 5 cases in PNL group did show such complications, 4 cases in RIRS group had this kind of complications ($p = 0.4916$) (Table 3). Although evaluation of the rate of hemoglobin drop in both groups showed a statistically significant difference between two groups in ($p < 0.0001$); 3 cases in PNL group and 1 case in RIRS group required blood transfusion ($p = 0.3113$) without any significant difference between two groups. No severe (Grade IV-V) complication was noted in any case. Last but not least stone street formation due to the fragment passage into the ureter has been observed in 1 case undergoing PNL in whom a double J stent placement and ureteroscopic stone removal have been performed.

DISCUSSION

Representing the most common congenital renal fusion anomaly; HSK is mainly associated with the abnormal position of the kidney associated with the unusual course of upper ureter over the isthmus (2). Published data and clinical experience have clearly shown that these anatomical abnormalities cause impaired renal pelvic drainage due to ureteropelvic junction obstruction and resultant hydronephrosis may cause not only with

stone formation but also makes the stone removal procedures more challenging.

Concerning the stone management principles in these patients, all available minimally invasive stone removal procedures namely SWL, PNL and RIRS have been applied as with varying stone-free rates in these patients. Although limited, published data so far has demonstrated that while altered pyelocalyceal system anatomy and high ureteropelvic junction position may lead to relatively poor results of SWL and RIRS; similar to the kidneys with normal anatomy, PNL has been reported as an efficient treatment modality for stones located in HSK (13, 14).

Related with this issue, as a non-invasive and safe alternative, although SWL has been well tolerated by the majority of patients, stone-free rates have been reported to be significantly lower after this procedure. When compared with the patients demonstrating normal kidneys, lower efficiency of this approach could be well explained with some certain factors such as greater skin-to-stone distance (particularly for calyceal stones) value and of more importantly restricted urinary drainage. However, despite the lower stone free rates reported to be changing between 31-100% (5-8), higher risk of complications associated with PNL performed for relatively large stones in HSK (14.3-29.2%) make SWL also RIRS more feasible and safe options in selected cases (3, 9, 10).

On the other hand again, developments in instruments technology and increasing experience in minimally invasive management of stones have changed the treatment concepts of urinary calculi meaningfully over the past two decades. As a result, PNL has become the standard of care for the treatment of large (> 2 cm) stones with its evidently higher stone free rates in a single session (15, 16). However, it is well-known that these higher stone-free rates are being obtained at the expense of some certain severe complications (16).

In the light of the evident lower stone free rates after SWL due to the certain factors mentioned above however, accumulated data so far clearly demonstrate that PNL may constitute a preferred alternative in cases with HSK in experienced hands (3, 17).

Related with this issue, clinical experience showed that while access to the upper pole calyces during PNL often requires a supracostal approach with the associated risk of pleural injury in patients with normal renal anatomy, due to the relatively lower level of the upper pole, a supracostal puncture appears to be relatively safe in these kidneys. Access through the lower pole are not usually recommended due to the posterior location of these calyces. Furthermore, upper-pole access in HSK allows the surgeon to remove all stone burden in one session, as the alignment of the nephroscope with the long axis of the kidney aids manipulation of the scope into the upper calyces, renal pelvis, lower calyces, UPJ (ureteropelvic junction) and proximal ureter in a practical and safe manner. However, as mentined above despite the higher success rates obtained, the complicated nature of this method and higher risk of major complications led the endourologists to look for more feasible and less invasive options (3, 9, 10).

Evaluation of the literature with respect to the success as

well as complications rates of PNL reported in HSK demonstrated varying rates in studies with limited number of cases. In a single session operation using only one tract without any flexible nephroscope, *Etamadjan M. et al.* have reported a stone free rate of 71.4% with a transfusion rate of 4.76% being encountered only in 1 patient (18). In their original study again, *El Ghoneimy MN et al.* treated 21 HSK renal units bearing a single pelvic stone in 52% of the cases and a staghorn calculi in 14% of the cases and 85.7% of the cases were stone free after the procedure with negligible complications (19). In a study of 24 cases with HSK again, *Raj et al.* performed upper-pole access in the majority of the cases (63%) and reported only one pneumothorax formation. They were also able to note that the use of flexible nephroscope was usually required for a satisfactory stone clearance rate, given as 87.5% (3). Last but not least, in relatively larger series of cases *Symons SJ et al.* treated stones in 47 cases with HSK and demonstrated that the number of PNL sessions required for stone free status depended on both the stone configuration and the size as well. PNL was used in 60 renal units of 47 patients with a clearance rate of 77% at one session and while 12 (71%) of the 17 patients demonstrating multiple stones were stone-free in one session; 30 (86%) out of 35 with neither multiple nor staghorn stones were completely stone free (10).

An alternative to the percutaneous approaches in these cases is flexible ureteroscopy, also referred to as RIRS that has been basically used to treat the lower pole stones resistant to SWL (20). As a result of increasing experience, relatively larger renal stones have also been treated with this approach and first serie of RIRS in HSK patients was published in 2005 where a stone clearance was achieved in 3 of the 4 patients (21). Following this publication, in their original study *Molimard et al.* treated 17 patients with HSK and 15 patients (88.2%) with mean stone size of 16 mm were stone free in one session.

The success rate was comparable to PNL and better than SWL studies with no major complications and 7 (41.2%) patients required more than one session of RIRS (22).

In another study, 25 renal stones in 20 patients were treated with RIRS and a SFR of 70% was reported. The authors found the success rates comparable with PCNL and better than SWL with the advantage of lower complication rates (23).

Currently RIRS and holmium - YAG laser lithotripsy is being increasingly used in the treatment of stone disease particularly in HSK patients. SFR of RIRS in the management of HSK patients were reported to be 70% and 88.2% in the two recently published studies (22, 23). As mentioned above altered orientation of the calyces and high insertion of the ureter coupled with the increased likelihood of UPJ obstruction, endourologists may face evident technical difficulties during RIRS procedure in these cases.

In a relatively higher number of cases with HSK patients (32 stones in 23 patients) undergoing RIRS, *Gokce IM et al.* reported a SFR of 73.9% with acceptable and comparable complication rates (4 of the 23 patients) with previously published series (24).

With the advancement of technology, smaller actively-deflectable *flexible ureteroscopy* (f-URS), equipped with

holmium laser lithotripter and nitinol baskets or graspers increased the effectiveness of RIRS in terms of stone-free rates.

In this present study we mainly aimed to assess the efficacy and safety of two different techniques (PNL vs RIRS) in the management of renal stones in patients with horseshoe kidneys. To our knowledge our study is the first one comparing the efficacy of two different valuable alternatives in the management of renal stones in HSK cases.

Evaluation of our results clearly showed that SFR's were comparable in both groups during 1-week (81.6% vs 80.0%) as well as post-operative 3 months evaluation period. The rate of larger residual fragments (> 4 mm) were again similar in both groups. However, while all PNL procedures were completed in a single session, mean number the sessions for cases undergoing RIRS was higher than PCNL group (1.220.05). Mean duration of the procedure was slightly longer in RIRS group when compared with PNL group. Regarding the mean degree of hydronephrosis in both groups, there was a statistically significant difference in favour of cases undergoing PNL and this could be best explained by the preference of the surgeons for PNL in kidneys with relatively higher degree of dilatation. Last but not least regarding the complications as evaluated on the basis of modified Clavien scoring system although they were similar in both groups; evaluation of mean fluoroscopy time as well as mean Hb drop rate in both groups clearly revealed them to be higher in cases undergoing PNL procedure.

In the light of our findings and the reported literature data as well, we may say that both PNL and RIRS procedures are equally effective treatment alternatives in the management of renal stones in patients with HSK. Although majority of the patients were stone free after a single session of PNL, taking the more invasive nature of this approach with certain complications (bleeding, extravasation), we believe that RIRS may prove itself a valuable alternative with comparable stone free rates despite possible repeated sessions. Moreover, higher risk of radiation exposure as demonstrated in our cases may be another disadvantage of PNL. Depending on the experience of the surgeon and the availability of these systems, best management plan could be made in an individualized basis by considering the patient as well as stone related factors.

The major limitation of the current study may be the retrospective nature of our trial and the lack of randomization. Additionally management of the cases by 7 different surgeons with variable level of experience could constitute another drawback. However, taking the limited number of studies in small series of cases available in the literature, we believe that as the first trial on this subject comparing RIRS vs PCNL in renal stone cases with HSK into account, our findings will be contributive enough to the existing literature.

CONCLUSIONS

Management of renal stones could be challenging depending on the anatomy as well as stone related fac-

tors. Of the available minimally invasive treatment alternatives, in the light of the lower stone free rates with SWL reported in the published data; both PNL and RIRS could be safe and effective alternatives for renal stone removal in patients with HSK. However, we believe that a proper plan could be instituted by considering the experience of the surgeon and availability of the technical equipment. Further studies with larger series of cases focusing on the comparative evaluation of both procedures are certainly needed.

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