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RESEARCH ARTICLE

Outcomes of Percutaneous Nephrolithotomy in Horseshoe Kidneys: A retrospective cohort study from a single centre in South India

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Abstract

Introduction

This study was undertaken to evaluate the outcomes and safety profile of percutaneous nephrolithotomy (PCNL) in HSK patients.

Materials and Methods

Between 2019 and 2024, individuals with stones in HSKs who received PCNL treatment at our institution were retrospectively reviewed.

Results

Between 2019 and 2024, 29 HSKs with stones underwent PCNL treatment at our institution. 39.9 ± 14.95 years was the average age. The mean body mass index (BMI) was 22.9 ± 4.5 kg/m^2. The mean stone size was 25.07 ± 0.8mm. Calyceal access was obtained through the upper pole in 17 patients (58.6%), the inter pole in 10 patients (34.5%), and the lower pole in five patients (17.2%). A flexible nephroscope was done in four patients (13.8%). Postoperative complications occurred in five patients (17.2%) with Clavien Dindo scores less than three and one patient (3.4%) with a

Clavien Dindo score of three.

The success rate following a single session of PCNL was 62%, with seven patients (24.1%) requiring ancillary procedures. After these additional interventions, the overall success rate increased to 86.2%. Analysis of variables affecting stone-free rates after PCNL in HSKs with stones revealed a direct correlation with stone size (p-value 0.04).

Conclusion

Our experience with percutaneous nephrolithotomy in horseshoe kidneys showed a comparable stone-free rate (86.2%) with no occurrence of significant complications. Although stone-free status is less affected by demographic and operative parameters, stone size played an important role in achieving stone-free status in this single-center analysis.

List Of Abbreviations

- HSK – Horseshoe kidney
- PCNL – Percutaneous Nephrolithotomy
- Fr – French
- BMI – Body Mass Index
- SD – Standard deviation
- IQR – Interquartile range
- SWL – Shock Wave Lithotripsy

Introduction

The aberrant fusion of metanephric blastema during the embryologic period is responsible for the development of the horseshoe kidney (HSK).[1] Due to fusion of the lower poles, the inferior mesenteric artery stops the kidneys from moving in their normal anatomical position, which causes malrotation, anterior displacement, and kidney ectopy. According to reports, the likelihood of developing this horseshoe kidney ranges from one in 400 to one in 666.[2] Around 21% to 60% of horseshoe kidney (HSK) cases have kidney stones.[1] Features such as an anteriorly displaced renal pelvis, poor renal drainage, vascular structural variability, malrotation, and ectopic placement make treating urolithiasis in HSKs more difficult. The use of various modalities for the management of stone has been studied in HSK patients.[3] Fletcher and Kettlewell reported the first attempts at percutaneous access to a horseshoe kidney in 1973.[4] For stones larger than 2 cm or for which extracorporeal shock wave lithotripsy is ineffective, percutaneous extraction of horseshoe kidney stones has been the accepted standard of therapy.[5] According to a recent study assessing PCNL success factors, stone characteristics were important in improving PCNL outcomes for this particular patient population; as a result, more research is necessary.[6] The orientation of the calyces and veins makes percutaneous puncture of the horseshoe kidney safe, but the unusual anatomical orientation of the calyces and renal pelvis reduces the likelihood of spontaneous transit of stones, particularly after fragmentation. Because the whole blood supply enters the kidney medially, vascular damage is less likely. Similarly, intestinal damage is less frequent due to the calyces' posterior placement.[7] Earlier, there were a few case series that investigated prone PCNL in patients with HSK.[8,9]

Aim and Objectives

- PCNL Outcomes in horseshoe kidneys: Stone clearance and Complications
- Factors correlating with above outcomes.

Materials and Method

Between 2019 and 2024, individuals with stones in HSKs receiving PCNL treatment at our institution were retrospectively reviewed. Perioperative features and demographics were thoroughly examined to see whether or not they affected the success and complication rates. Under general anaesthesia, after retrograde placement of a five French (Fr) ureteric catheter and a 16 Fr per urethral catheter in lithotomy position, all patients were positioned

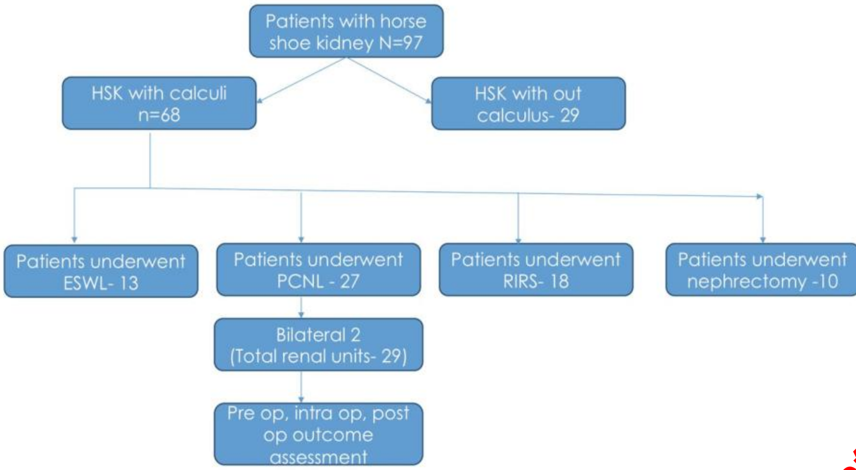

Figure 1 Overview of patients analysed.

prone for PCNL. An Amplatz sheath was placed into the collecting system after the tract was dilated by balloon dilation, single-step dilatation, or sequential dilatation to the required Fr after access was obtained under fluoroscopy. Shock pulse, ultrasonic waves, pneumatic lithotripter, or laser were used to disintegrate the stone utilizing a rigid or flexible nephroscope. Any necessary additional access was created as per the requirement. Nephrostomy tubes were left in situ once the stone-free status was determined by endoscopic and fluoroscopic evaluation.

The following intraoperative characteristics were noted for analysis: intraoperative blood loss, duration of operation, nephroscope utilized (rigid or rigid and flexible), access site (subcostal or supracostal), and access location (upper, interpole, or lower pole calyx). The Clavien Dindo classification system was used to grade the complications. On the first or second postoperative day, nephrostomy tubes were withdrawn. After the nephrostomy tubes had been removed, patients were released in stable condition, unless there was an unresolved complication. Asymptomatic stone fragments less than four millimetres on X-ray KUB during follow-up were documented as stone-free status. Following axillary treatment approaches, final success was assessed. Figure 1. Overview of patients analysed Statistical evaluations were conducted using SPSS version 21.0. The Mann-Whitney U test was applied for univariate analysis of continuous data. For categorical

For categorical variables, statistical significance was decided using either the chi-square test or Fisher's exact test, with a p-value of less than 0.05 considered statistically significant.

Results

Between 2019 and 2024, 29 HSKs with calculi had PCNL treatment at our institute. The mean age was 39.9 ± 14.95 years. The average body mass index (BMI) was 22.9 ± 4.5 kg/m2. The mean stone size was 25.07 ± 0.8 mm. 25 patients (86.2%) had staghorn calculus, with 14 (48.3%) patients having multiple stones, with 58.6 % right lateral preponderance. In Table 1, the demographic profile is presented.

The maximum number of renal punctures for access was three. Access punctures were directed to the upper pole in 17 patients (58.6%), the inter pole in 10 patients (34.5%), and the lower pole in five patients (17.2%). A flexible nephroscopy was employed in four patients (13.8%). On average, the intra-operative blood loss was 181 millilitres, and the average duration of surgery was 112 minutes and 24 seconds. Operating surgeon with surgical experience above five years in 21 patients (72.4%), and below five years in eight patients (27.6%). Intraoperative variables are presented in Table 2.

Table 1. Demographic Profile

• **Variable**	**Data**
Age in years (Mean ± SD)	39.9 ± 14.95
BMI in kg/m² (Mean ± SD)	22.9 ± 4.5
Stone size in mm (Mean ± SD)	25.07 ± 0.8
Stone subtype, n(%)	
Staghorn	4 (13.8%)
Non-staghorn	25 (86.2%)
Stone number, n(%)	
Single	15 (51.7%)
Multiple	14 (48.3%)
Stone laterality, n(%)	
Left	12 (41.2%)
Right	17 (58.6%)

Table 2. Intra-operative variables

Variable	Data
Number of access punctures, median (IQR)	1 (1)
Access puncture location, n(%)	
Upper pole	17 (58.6%)
Inter-pole	10 (34.5%)
Lower pole	5 (17.2%)
Access site, n(%)	
Supracostal	1 (3.5%)
Subcostal	28 (96.5%)
Flexible nephroscope use, n(%)	4 (13.8%)
Estimated blood loss in milliliters, median (IQR)	181.4 (200)
Duration of surgery in minutes, median (IQR)	120 (130)
Operating surgeon experience	
< 5 years	8 (72.4%)
≥ 5 years	21 (27.6%)

Table 3. Postoperative outcomes

Variable	Data
Clavien Dindo grade two complications, n(%)	5 (17.2)
Clavien Dindo grade three complications, n(%)	1 (3.4)
Drop in hemoglobin (g/dl), mean ± SD	1.3 ± 0.8
Duration of hospital stay in days, median (IQR)	2 (1.3)
Ancillary procedures, n(%)	7 (24.1)
Stone free rate, n(%)	25 (86.2)

Table 4. Effects of variables on outcomes of procedures

Variable	Degree of freedom	Effect size	P-value (complication rate)	Degree of freedom	Effect size	P-value (stone-free rate)
Age*	27	0.077	0.84	27	0.46	0.24
Gender#	1	0.177	0.34	1	0.25	0.18
Stone size#	1	0.134	0.47	1	0.38	**0.04**
Access number#	1	0.143	0.44	1	0.093	0.62
Access location#	1	0.14	0.45	1	0.046	0.81
Use of flexible nephroscopy#	1	0.079	0.67	1	0.21	0.26
* - Independent t test and # Pearsons' Chi square test						

Table 5. Comparative results of previous studies on percutaneous nephrolithotomy in horseshoe kidneys

Author (year)	**Number of HSK**	**Use of flexible nephroscope (%)**	**Complications (%)**	**Stone-free rate (%)**	**Ancillary procedures (%)**
Jones DJ (1991) [10]	18	0.0	22.2	88.8	22.2
Al-Otaibi K (1999) [11]	12	82	42	83.0	33.3
Shokeir AA (2004) [12]	45	0.0	17.6	82.0	35.3
Symons SJ (2008) [13]	60	0.0	18	88.0	40.0
El Ghoneimy MN (2009) [14]	21	0.0	19.0	85.7	0.0
Tepeler A (2014) [15]	54	18.5	16.7	90.7	25.9
Our study (2025)	29	13.8	20.6	86.2	24.1

Post-operative complications observed with Clavien Dindo score less than three were five patients (17.2%); and Clavien Dindo score of three was noted in one patient (3.4%), who underwent angioembolization. After a single PCNL session, the overall success rate was 62%, with seven patients (24.1%) requiring ancillary procedures. The success rate following ancillary procedures rose to 86.2%. The median hospital stay following surgery was two days. Results following surgery are displayed in Table 3.

Effects of variables on stone-free rate post PCNL in HSK with stone showed a direct relation with stone size (p value 0.04), the rest of the variables had no significant correlation with stone-free rate or with complications, as depicted in Table 4.

Discussion

Various modalities have been employed for the management of stones in horseshoe kidneys, including shock wave lithotripsy (SWL), ureteroscopy, percutaneous nephrolithotomy (PCNL), and open surgery. Although SWL can effectively fragment renal calculi, its efficacy is often limited in horseshoe kidneys due to their atypical anatomy, which hampers the spontaneous passage of fragments. Stone-free rates with SWL are modest, with reported success ranging between 50% and 79%, and an average of around 53%. PCNL has emerged as a more effective alternative for treating calculi in horseshoe kidneys. For optimal outcomes, access is generally recommended through the mid-renal or upper pole calyces, while the lower pole calyces, located more posteriorly, are usually avoided. The supracostal approach is considered relatively safe, as the downward displacement of horseshoe kidneys often positions the upper calyces below the 12th rib, allowing safer access. Despite its growing use, limited literature focuses specifically on PCNL in the context of horseshoe kidneys. Table 5 summarizes the outcomes of PCNL from several previously published studies.[10-15]

In those, upper pole access ranged from 62% to 81%, largely due to the broader anatomical access it provides to the proximal ureter, pelviureteric junction, renal pelvis, lower pole calyces, and upper pole calyces. This route also potentially minimizes blood loss, as it aligns the nephroscope with the kidney's natural longitudinal axis, thereby reducing torque-related trauma during instrument manipulation. However, one limitation of upper pole access is the difficulty in reaching the lower and medial calyces, due to the longer and sometimes angulated tract required. In our cohort, upper calyceal access was used in 58.6% of cases, middle calyceal in 34.5%, and lower calyceal punctures in 17.2%. Middle calyceal access was considered advantageous in reducing the tract length to the lower calyx. Nonetheless, in four patients, the rigid nephroscope could not access the lower or isthmic calculi, underscoring the necessity of flexible nephroscopy to achieve complete stone clearance in such anatomically abnormal kidneys. Our overall stone-free rate was 86.2%, which is consistent with prior studies reporting clearance rates between 72% and 87.5%. This supports the notion that PCNL can be both safe and effective in horseshoe kidneys when performed with appropriate technique and instrumentation. The primary limitations of our study include its retrospective design and relatively small sample size. Additionally, data were derived from the experience of a single center, which may limit generalizability. Despite these constraints, we believe our results contribute valuable insights

Despite these constraints, we believe our results contribute valuable insights regarding PCNL outcomes and complications in patients with horseshoe kidneys.

Conclusion

In patients with horseshoe kidneys undergoing percutaneous nephrolithotomy (PCNL), our single-center experience showed a high stone-free rate of 86.2%, comparable to outcomes in anatomically normal kidneys. Importantly, the procedure was associated with a low complication rate, reaffirming the safety and feasibility of PCNL in this anomalous renal anatomy. Among various variables analyzed, stone size appeared as the most significant predictor of stone-free status, underscoring the importance of preoperative imaging and careful surgical planning. In contrast, demographic factors such as age, gender, and BMI, as well as surgical variables including number of tracts and access site, had limited influence on final outcomes. These findings support the tailored use of PCNL as an effective and safe approach in managing nephrolithiasis in horseshoe kidneys, especially when guided by stone burden.

Ethics approval and consent to participate

Not applicable

Consent for publication

Not applicable

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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