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MANAGEMENT OF UROLITHIASIS IN PATIENTS WITH HORSESHOE KIDNEY

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ABSTRACT

Background: Horseshoe kidney (HSK), the most common congenital renal fusion anomaly, presents unique anatomical challenges that predispose to nephrolithiasis. The altered renal orientation, aberrant vascular supply, and impaired drainage contribute to higher stone risk and complicate surgical management. This study compares surgical outcomes of percutaneous nephrolithotomy (PCNL) in HSK patients versus those with normal renal anatomy.
Method: This prospective, observational study was conducted from January 2021 to December 2024 in a rural South Indian hospital. A total of 110 patients with renal calculi >2 cm were divided into two groups: 55 patients with HSK and 55 age- and stone size-matched controls with normal anatomy. All underwent PCNL under general anesthesia. Intraoperative and postoperative parameters—operative time, access attempts, blood loss, stone-free rate (SFR), complications, hemoglobin drop, and hospital stay—were analyzed using appropriate statistical tests.
Result: HSK patients had significantly longer operative time (87.6 vs 73.8 min, p=0.001), more access attempts (1.6 vs 1.2, p=0.001), higher blood loss (mean Hb drop 1.6 vs 1.2 g/dL, p=0.002), and longer hospital stay (4.1 vs 3.2 days, p=0.001). Postoperative fever (20% vs 7.3%, p=0.04) and need for auxiliary procedures (16.4% vs 5.5%, p=0.04) were also higher in HSK. However, the stone-free rate (80% vs 91%) and complication grades were not significantly different.
Conclusion: Despite increased technical complexity, PCNL remains effective in HSK patients with comparable stone clearance and acceptable complication rates. Individualized surgical planning and experienced hands are key to optimizing outcomes in anatomically challenging cases.

INTRODUCTION

Horseshoe kidneys (HSK) are the most common fusion defect of the kidneys, but this still amounts to only about 0.25% of the population [1]. It was first described by da Carpi in 1522 during various autopsies performed [2]. They are characterized by abnormalities in the position, rotation, and vascular supply of the kidney. Horseshoe kidneys are identified as having functioning renal masses present on both sides of the vertebral column fused together with ureters that remain uncrossed from the renal hilum to the urinary bladder. The developmental fusion of the lower renal poles leads to the formation of an isthmus and abnormal positioning of the collecting system and ureters, which in turn predisposes affected individuals to various complications—most notably Ureteropelvic Junction Obstruction (UPJO), recurrent Urinary Tract Infections (UTIs), vesicoureteral reflux, and urolithiasis [3]. Despite cases of familial clustering, no clear genetic cause has been described for horseshoe kidneys, although several etiological factors may contribute to their development [4]. Nephrolithiasis, commonly referred to as kidney stone disease, is prevalent globally. Bladder stones were more prevalent during older ages, but kidney stones became more prevalent during the past 100 years, at least in the more developed countries. In the general adult population, lifetime prevalence ranges from 7% to 15%, with lifetime recurrence rates reaching up to 30% [5]. In Horse Shoe Kidney (HSK) patients, the risk of stone formation is further exacerbated by a combination of anatomical and metabolic factors. The malrotation and lower location of the kidney, coupled with aberrant ureteral insertion and frequent UJPO, result in urinary stasis—a known independent risk factor for crystal aggregation and stone retention [6]. In the presence of Nephrolithiasis in HSK's, the access to the affected area is often challenging and requires extreme caution while performing the surgery. Appropriate management of urolithiasis within the horseshoe kidney depends not only on stone burden, but also on stone location, calyceal configuration and malrotation. In some cases, a staged clearance might be needed for a stone free life [7]. The objective of this study was to compare the outcomes of surgery for symptomatic Urolithiasis in patients with HSK undergoing percutaneous nephrolithotomy to normal individuals who underwent the same procedure for the same condition.

MATERIALS AND METHODS

Study design and source: This prospective, observational comparative study was conducted at the Department of Urology in a rural Hospital in South India between January 2021 and December 2024 over a period of 4 years. Institutional Ethics Committee approval was obtained prior to study initiation.

Sample size: A total of 110 adult patients diagnosed with renal calculi >2 cm and planned for PCNL were included in the study. Patients were divided into two groups:

Group A (Case group): 55 patients with radiologically confirmed horseshoe kidney.

Group B (Control group): 55 patients with normal renal anatomy matched for age and stone size.

All patients provided informed consent before enrollment.

Inclusion Criteria:

- Age between 21 and 60 years.
- Single or multiple renal calculi >2 cm in diameter.
- Preoperative imaging via Computed Tomography confirming renal anatomy.
- Normal renal function (serum creatinine <1.5 mg/dL).
- No prior renal surgery on the involved side.

Exclusion Criteria:

- Anatomical anomalies other than HSK.
- Bleeding diathesis or uncontrolled comorbidities.
- Active urinary tract infection at the time of surgery.
- Pregnancy.

Randomization and Matching: Patients were assigned to Group A or B based on preoperative imaging. Group B patients were selected using **systematic random sampling** from the institutional surgical database and matched 1:1 with Group A for age (±5 years), gender, and stone burden (±1 cm). Matching ensured comparability between groups.

Percutaneous Nephrolithotomy Procedure: All the surgeries were performed under General Anesthesia in the prone position by the same Urologist to prevent bias. Initially, a 5-Fr ureteric catheter was inserted cystoscopically into the affected ureter to opacify the collecting system. Under fluoroscopic guidance, a posterior calyx was punctured using an 18-G access needle, and urine or contrast was aspirated to confirm entry. A guidewire was then advanced into the renal pelvis. Tract dilation was performed using sequential Alken metal dilators up to 24–30 Fr, and an Amplatz sheath was positioned over the guidewire. A 22.5 Fr rigidnephroscope was introduced through the sheath to visualize the stone. Stone fragmentation was achieved using either a pneumatic lithotripter or holmium: YAG laser and fragments were extracted with forceps or irrigation. Intraoperatively, calyceal anatomy, presence of aberrant vessels (particularly in horseshoe kidneys), and infundibular angulation were carefully assessed to avoid injury. A nephrostomy tube was placed at the end of the procedure in most cases, while a double-J stent was inserted selectively based on residual fragments or intraoperative edema.

Parameters for Comparison:

1. Operative time (skin incision to nephrostomy tube placement).

2. Intraoperative complications (bleeding, need for transfusion, visceral injury).
3. Access attempts required.
4. Stone-free rate (SFR) at 1 month (assessed by non-contrast CT).
5. Hospital stay (in days).
6. Postoperative complications (Clavien-Dindo classification).
7. Need for auxiliary procedures (Ureteroscopic Lithotripsy, second-look PCNL).
8. Drop in hemoglobin (pre-operative and post-operative values).

Fever or SIRS within 48 hours postoperatively

Statistical Analysis:

Data were analyzed using **SPSS software version 26**. Quantitative variables were expressed as mean ± standard deviation and analyzed using **unpaired Student's t-test**. Categorical variables were compared using the **Chi-square test or Fisher's exact test**. A p-value of **<0.05** was considered statistically significant.

OBSERVATIONS AND RESULTS

Table 1 - Age distribution between groups

Age Group (years)	HSK Group	Normal Group	p-value
21–30	8 (14.5%)	6 (10.9%)	0.58
31–40	15 (27.3%)	17 (30.9%)	
41–50	20 (36.4%)	21 (38.2%)	
51–60	12 (21.8%)	11 (20%)	

Table 2 - Gender distribution between groups

Gender	HSK Group	Normal Group	p-value
Male	42 (76.4%)	40 (72.7%)	0.66
Female	13 (23.6%)	15 (27.3%)	

Table 3 - Intraoperative and Postoperative parameters between groups

Parameter	HSK Group	Normal Group	p-value
Mean Operative Time (minutes)	87.6 ± 12.5	73.8 ± 10.2	0.001
Access Attempts (mean)	1.6 ± 0.5	1.2 ± 0.4	0.001
Intraoperative Bleeding (≥ Grade 2)	8 (14.5%)	2 (3.6%)	0.04
Mean stone size (mm)	22.1 ± 3.3	21.9 ± 2.8	0.73
Transfusion Required	5 (9.1%)	1 (1.8%)	0.09
Stone-Free Rate (at 1 month)	44 (80%)	50 (91%)	0.08
Mean Drop in Hemoglobin (g/dL)	1.6 ± 0.4	1.2 ± 0.3	0.002
Postoperative Fever (>38.5°C)	11 (20%)	4 (7.3%)	0.04
SIRS within 48 hours	5 (9.09%)	2 (3.6%)	0.11
Hospital Stay (days)	4.1 ± 1.3	3.2 ± 1.1	0.001
Auxiliary Procedures Needed	9 (16.4%)	3 (5.5%)	0.04

Table 4 - Complications noted between groups

Complication Grade	HSK Group	Normal Group	p-value
Grade I	12 (21.8%)	6 (10.9%)	0.11
Grade II	5 (9.1%)	2 (3.6%)	0.23
Grade IIIa	4 (7.3%)	1 (1.8%)	0.17
Grade IIIb or higher	1 (1.8%)	0	0.31

As seen in Table 1, the age distribution was comparable between the two groups, with most patients falling in the 41–50 age range. There was no statistically significant difference in age distribution (p = 0.58). As seen in Table 2, there was a male predominance in both groups. The gender distribution was statistically comparable between groups with equality in the distribution (p = 0.66). As seen in Table 3, HSK group had significantly longer operative times**,** more access attempts**,** greater hemoglobin drop, and longer hospital stay compared to the normal group. The p-value was significant in these cases (<0.05) indicating better outcomes in normal patients. Although more patients in the HSK group developed Systemic Inflammatory Response Syndrome, this difference was not statistically significant (>0.05) indicating that the antibiotic regimen remained the same among all patients and the microbiologic spectrum was also uniform. Although the stone-free rate was better in the normal patients, it was not statistically significant with a p-value of >0.05. As seen in Table 4 with reference to the Clavien-Dindo Classification [8], majority of complications in both groups were **Grade I or II**, indicating minor and moderate severity. While the HSK group had a slightly higher number of complications overall, none of the differences in individual Clavien-Dindo grades were statistically significant.

DISCUSSION

In this study, percutaneous nephrolithotomy (PCNL) in patients with horseshoe kidney (HSK) required significantly more operative time, access attempts, blood loss, and auxiliary procedures compared to matched controls with normal renal anatomy. However, the stone-free rate (SFR) remained comparable, though non-significantly lower. These findings reinforce the notion that while HSK anatomy complicates PCNL technically, it does not preclude effective outcomes with careful technique. A study conducted in 2016 by Blackburne et al had 69% male and 31% female participants which correlated well with our study where 76% were male in the HSK group indicating a male preponderance [9]. The mean age was in the late 40s and the mean stone size was 16 mm. These parameters also were similar indicating a similar age group where individuals with HSK first experience Urolithiasis. A study performed by Bas et al in 2015 [10] found that the mean operative time of PCNL in HSK was 111 minutes which correlated well with this study where the time was around 100 minutes with the SD. The stone free rate was 71% in their study as compared to 80% in this study. The changes are all comparable which can be attributed to the formulated steps of the surgery which has been in practice for a long time now and also similar aseptic protocols and standardized equipments used in performing the surgery. A study by Satav et al in 2018 [11] noted that the mean stone size was 22.03 ± 10.33 mm in their 24 surgeries. They found that only 8.69% of the cases needed an extra middle calyceal puncture for clearance. In their study, complete clearance was achieved in 21 renal units with PCNL (87.50%). This is very much comparable to this study where the mean access tract used was considerably less than 2 and the clearance and stone free rate was also in the same zone. In this study, HSK cases experienced a significantly greater mean hemoglobin drop (1.6 vs 1.2 g/dL) and higher though non-significant transfusion rate (9.1% vs 1.8%). Major bleeding was uncommon.SIRS occurred in only 9% of the cases. This was comparable to a study done in 2013 by Etemadian et al [12] wherein they found that no major complication occurred during the surgery or in post surgical period. Postoperative minor complications occurred in 3 (14.28%) patients, including transfusion in one (4.76%), fever in one (4.76%), and ileus in one (4.76%) subject. HSK patients had longer hospital stays (4.1 vs 3.2 days, $p < 0.001$) and more auxiliary procedures (16.4% vs 5.5%, $p = 0.04$). These findings reflect the delayed clearance and increased procedural complexity in HSK. As reported in 1988 by Janetschek [13], PCNL has shown the better result with fewer complications to remove calculi from HSKs and is accepted as a routine treatment of large calculi in HSK. In spite of abnormal positional anatomy of HSK, the vascular anatomy of these kidneys is favorable for PCNL. The dorsomedial or dorsolateral orientation of the collecting system offers good access for PCNL. This literature still holds good even after 3 decades since the anatomical assessment remains the same. The amount of complications encountered in HSK patients in this study was around 20% (Clavien Dindo I/II) which is similar to the study by Bas et al [10] wherein only 2 patients had anything Grade III or above. It was reported in 2023 that the expected complications and post-operative course for PCNL in the HSK is similar to that of the anatomically normal kidney. Slightly altered techniques might be needed to get a better clearance but otherwise the surgery can be performed in the same way as other normal cases [14].

CONCLUSION

PCNL in horseshoe kidney, despite anatomical complexity, achieves high efficacy with comparable stone-free outcomes to normal kidneys but requires more operative time, access attempts, and postoperative care. Innovations like supine positioning, ultrasound guidance and meticulous preoperative imaging may reduce morbidity. Tailored strategies balancing effectiveness and safety are essential. There are no significant risks or complications associated with the procedure and a Surgeon's expertise might be the only factor needed for a better outcome.

Limitations: Stone burden quantification, positions for surgery and Body Mass Index were not explicitly stratified which can be done in future studies.

Conflict of interest: The authors report no Conflict of Interest of any kind.

Declaration: The study protocol for medical research involving human subjects was approved by the local ethics committee under the latest Declaration of Helsinki. This article does not contain any studies with animals performed by any of the authors.

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