ORIGINAL RESEARCH

Percutaneous Nephrolithotomy for Staghorn Calculi with Standard 24 Fr Tract: Feasibility and Clearance

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Abstract

Background: Staghorn stones represent branched renal calculi that involve renal pelvis and two or more renal calyces. Various modalities are utilised to treat these complex calculi like PCNL, ECIRS, open surgery, laproscopic/robotic surgery and ESWL. PCNL is considered as the first procedure of the choice to deal with the staghorn stones We here discuss our experience of treating staghorn stones in our tertiary centre for past 10 years.

Material and Methods: This is a retrospective descriptive type of study done at a tertiary center from August 2013 to July 2022. 253 patients of staghorn calculi underwent PCNL. Pre-operative and post-operative x-ray KUB and USG KUB were done to record the stone status. All complications were recorded as per the Clavien-Dindo grading system. The minimum duration of follow-up in the study is 3 months.

Results: The mean age was 41.51 ± 14.75 years with male to female ratio of 2.41. The size of the staghorn calculi ranged from 38-118 mm with a mean of 58.67 ± 16.21 mm. The hemoglobin fell from 12.4 ± 1.21 g/dL pre-operatively to 10.6 ± 1.43 g/dL, post-operatively. There was rise of serum creatinine levels from 1.46 ± 0.56 mg/dL pre-operatively to 1.63 ± 0.66 mg/dL in the post-operative period. 41.10% patients had complications ranging from Calvien-Dindo grade I to III. 89.32% cases were rendered stone free after single session. The success rate at 3 months was 93.67% for complete clearance.

Conclusion: PCNL is a feasible, safe, efficient, and important tool for surgical treatment even with multiple access tracts and remains the gold standard for complex and staghorn renal calculi.

Keywords: PCNL, Staghorn stones, Staghorn calculi, Single step dilatation, Screw dilatation

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Background

The prevalence of renal calculi in India as well as all over the world is around 12%.[1,2] Amongst these, staghorn calculi represent 10 to 20% of cases. Recently, this incidence has been reduced to around 4%, due primarily to the earlier treatment and preventive strategies taken to reduce UTI (urinary tract infection).[3]

Staghorn stones represent branched renal calculi that involve the renal pelvis and two or more renal calyces.[4] These represent the large stone burden, usually more than 2 cm in size. Around 50% of the cases recur in 5 years.[5]

Various modalities are utilized to treat these complex calculi like PCNL (percutaneous nephrolithotomy), ECIRS (endoscopic combined intrarenal surgery), open surgery, laparoscopic/robotic surgery and ESWL (extracorporeal shock wave lithotripsy). Despite the wide variety of options available, complete clearance is achieved with difficulty. More so, by a combination of the above-mentioned procedures.

PCNL is considered the first-choice procedure to deal with staghorn stones because of the minimally invasive nature, good efficiency, better safety, and repeatability if needed. But it is very demanding and complex technical procedure that needs to be mastered. Many times multiple punctures are needed for complete clearance[6] or it can be combined with the flexible ureteroscope (ECIRS) for complete clearance.[7]

However, multiple tracts of access, longer operative times, increased chances of bleeding and infective complications

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are the few concerns that need to be addressed along with the stone-free rates. We here discuss our experience of treating staghorn stones in our tertiary centre for the past 10 years and address and discuss the above-mentioned points.

Material And Methods

Study Design

We did a retrospective descriptive type of study from August 2013 to July 2022 at SMBT IMS & RC, Nashik, Maharashtra, India.

Inclusion Criteria

1. Age ≥ 16 years, no upper age limit
2. Partial, complete or giant staghorn calculi
3. Written and informed consent for PCNL (single puncture access, multi-puncture access, staged PCNL)

Exclusion Criteria

1. Active urinary tract infection
2. Uncorrectable coagulopathy
3. Pregnancy
4. Severe musculoskeletal deformity

Study Population

A total of 1428 patients underwent surgery for renal calculi, 174 patients underwent anatrophic pyelolithotomy for staghorn calculi and 253 patients of staghorn calculi underwent PCNL and were included in the study after fulfilling the inclusion criteria. The demographic data of all the patients was collected from the in-house records form the medical record department. We collected the pre-operative data in the form of age, sex, comorbid conditions, laterality, staghorn type, grade of hydronephrosis, any previous surgical intervention, status of urine culture & sensitivity, pre-operative hemoglobin and pre-operative serum creatinine levels.

In all the patients, x-ray of the kidney, ureter and bladder (KUB) region (Figure 1), ultrasonography of the KUB region, intravenous pyelography (IVP) and/or computed tomography of the KUB region were done. Functional study, in the form of DTPA/EC scan, was done wherever there was doubt about the renal function.

The intra-operative data collected included the type of anesthesia, number of accesses, point of entry to the pelvicalyceal system, intra-operative complications like bleeding, extravasation, ECG changes requiring termination of the procedure, renal and associated organ injury and operative time. Post-operatively, pyrexia, transfusion of blood, upgradation of antibiotics, haematuria, hemoglobin and creatinine levels and stone-free rates were recorded.

Surgical Technique

Standard prone position PCNL was done in all the patients by the urologist with more than five years of experience in

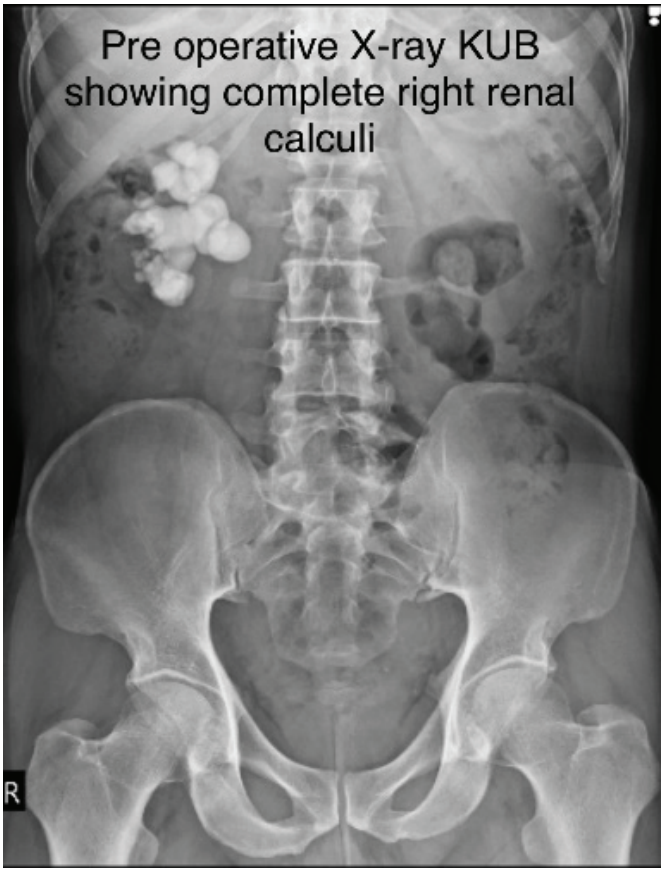

Figure 1: Pre-operative X-ray KUB showing complete right renal calculi

doing prone PCNL. Regional or general anesthesia was given. A prophylactic antibiotic was given at the time of induction. A ureteric catheter was inserted in supine lithotomy position after primary cystoscopy, followed by a prone position for renal access under c-arm guidance. Serial tract dilatation with standard dilatator set and single-step screw dilatation with 24 Fr screw dilator was done, followed by 24 Fr Amplatz sheath placement. We started with serial dilatation and transited to screw dilatation for tract formation. Additional punctures were done if required. All punctures were 24 Fr size. The initial puncture technique varied with the surgeon's comfort, ease and regularity. Three techniques were used for initial puncture, i.e. bull's eye technique, triangulation technique and gradual descent technique. Pneumatic lithoclast was used in all cases. The laser was not used in any case. Double J stent was kept in all the patients and nephrostomy tube was placed in the cases wherever indicated and removed on the next day after surgery. Negative suction was not used and super-perc/mini-perc were not done.

Post-operatively, x-ray KUB (Figures 2 and 3) and USG KUB were done to assess the residual fragments. Residual fragments removed by doing re-do PCNL were also recorded. Re-do PCNL was done after 48 of the first surgery. In a few cases, ESWL was done for residual fragments. Stone clearance was evaluated at 4 weeks and 3 months

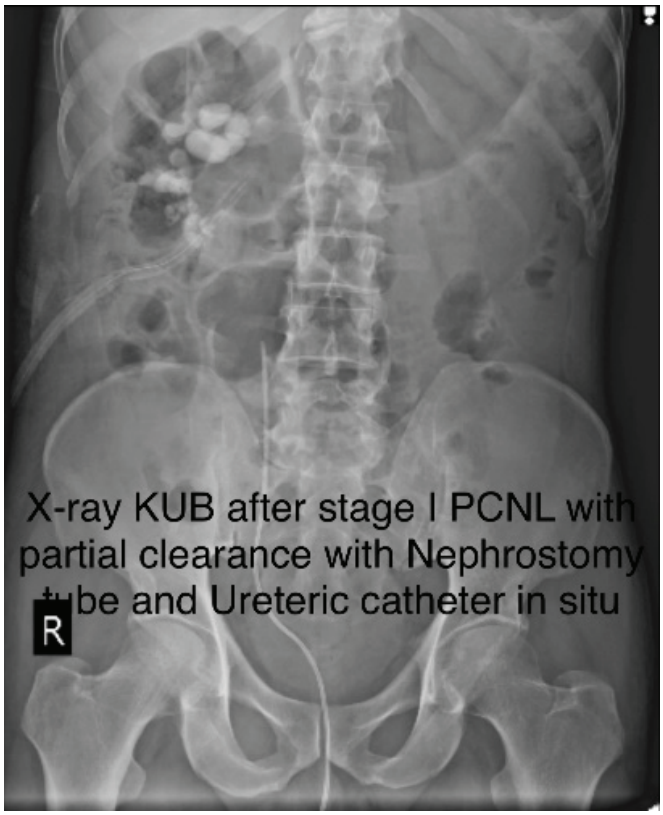

Figure 2: X-ray KUN after stage I PCNL with partial clearance with Nephrostomy tube and Uretric catheter *in situ*

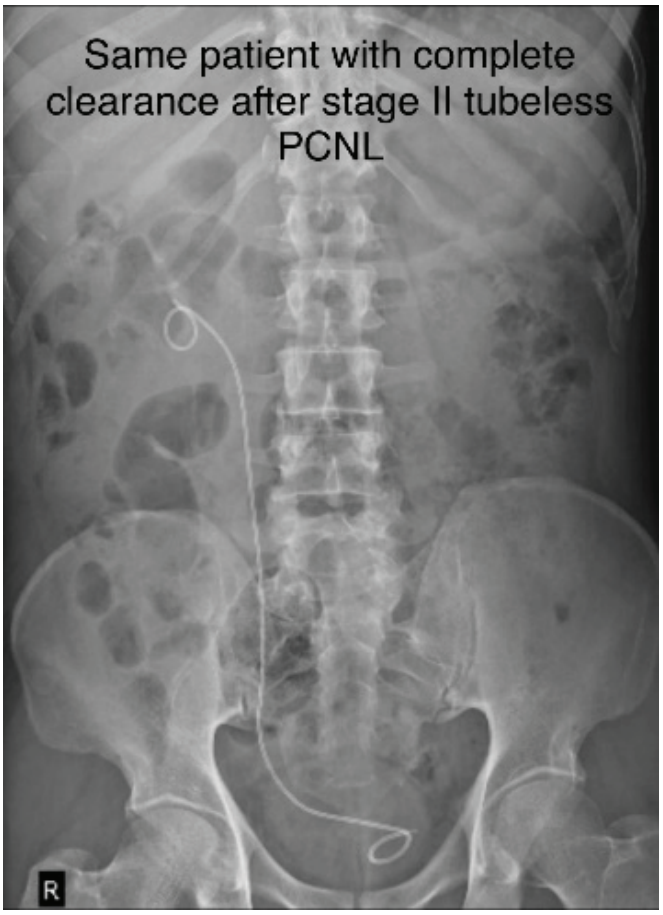

Figure 3: Same patient with complete clearance after stage II tubeless PCNL

post-operatively in all the patients. All complications were recorded as per the Clavien-Dindo grading system. Patients were followed in the post-operative period at 7 days, 1-month, and 3 months. The minimum duration of follow-up in the study is three months.

Statistical Analysis

We used SPSS 20 version to analyze the data. Descriptive statistics was used. We considered a p-value of <0.05 as significant statistically. We utilized chi-square test and t-test for categorical and continuous variables, respectively.

Results

A total of 1428 patients underwent surgery for renal calculi, 174 patients underwent anatrophic pyelolithotomy for staghorn calculi and 253 patients of staghorn calculi underwent PCNL and were included in the study. The mean age was 41.51 ± 14.75 years (range: 18 to 85 years) with male to female ratio of 2.41. The size of the staghorn calculi ranged from 38-118 mm with a mean of 58.67 ± 16.21 mm. 64.42% of patients had positive urine cultures. Severe hydronephrosis was present in 7.11% of cases and no hydronephrosis in 6.71% of patients. 51.38% of patients had stones on right side and 5.13% of patients had bilateral staghorn calculi. 32.8% of patients had a history of previous intervention for stone disease (Table 1).

The mean surgical time was 80.45 ± 25.38 minutes. 82.21% of patients underwent surgery under regional anesthesia. Majority of the patients, 45.59% had two number of access tracts for complete/maximum stone clearance. The number of access tracts varied from one to four on the unilateral side. Overall, a total of 378 tracts were made in 253 kidneys. 4 access tracts were done in only 3.43% of the kidneys. Maximum punctures were done through the lower pole calyces in 63.75% of kidneys, followed by 21.69% in the mid pole calyces and 14.55% in the upper pole calyces respectively (Table 2).

The hemoglobin fell from 12.4 ± 1.21g/dL pre-operatively to 10.6 ± 1.43 g/dL post-operatively. 19 patients require blood transfusion in the post-operative period. This drop was significant statistically. Similarly, there was rise of serum creatinine levels from 1.46 ± 0.56 mg/dL pre-operatively to 1.63 ± 0.66 mg/dL in the post-operative period, but this rise was not statistically significant (Table 2).

We had complications in 41.10% of patients, ranging from Calvien-Dindo grade I to III. Bleeding requiring termination of the procedure happened in 4.34% of cases, while changes in the cardiac rhythm required termination of the procedure in 0.79% of the patients. There were no higher Clavien grade

Table 1: Patients (n=253) and stones demographics.

Characteristics	Number	Percentage (%)
Age, year	41.51 ± 14.75 SD (18–85)	
Gender		
Male	179	70.75
Female	74	29.24
Chronic disease		
Diabetes	49	19.36
Hypertension	46	18.18
Chronic kidney disease	25	9.88
Heart disease		
Hypothyroidism		
Laterality of stones (n=66)		
Right	130	51.38
Left	110	43.47
Bilateral	13	5.13
Urine C/S		
Positive	163	64.42
Negative	90	35.57
Staghorn		
Complete	163	64.4
Partial	90	35.57
Stone size in mm (Mean ± SD)	58.67 ± 16.21	(38–118 mm)
Grade of hydronephrosis		
No	17	6.71
Mild	94	37.15
Moderate	124	49.01
Severe	18	7.11
History of previous stone intervention		
SWL	14	5.53
URS	12	4.74
PCNL	36	14.22
Open	21	8.30

Table 2: Operative and immediate postoperative outcomes

	Value(n)	Percentage (%), (range)	p-value
Number of accesses (n=)			
1	141	37.30	
2	149	39.41	
3	75	19.84	
4	13	3.43	
Point of entry (n=378)			
Lower calyces	241	63.75	
Mid calyces	82	21.69	
Upper calyces	55	14.55	
Anaesthesia			
Spinal/Epidural	208	82.21	
General	45	17.78	
Mean operating time, mins	80.45 ± 25.38 SD		
Mean preoperative HB g/dL	12.4 ± 1.21 SD	(8.1–15.5)	<0.001
Mean postoperative HB g/dL	10.6 ± 1.43 SD	(8.1–13.3)	
Mean preoperative creatinine mg/dL	1.46 ± 0.56 SD	(0.55–4.1)	0.56
Mean postoperative creatinine mg/dL	1.63 ± 0.66 SD	(0.56–4.1)	
Mean hospital stays (days)	1.8	(1–6)	

Table 3: Complications according to the Calvien-Dindo grading system.

Grade	Number	Percentage (%)
Grade I	49	19.36
Fever	29	11.46
Transient renal function derangement	12	4.74
Increased total leucocyte counts	8	3.16
Post-dural puncture headache		
Grade II	28	11.06
Blood transfusion	19	7.50
Infection requiring upgradation of antibiotics	6	2.37
Leakage from nephrostomy site	3	1.18
Grade III	27	10.67
Bleeding requiring termination of the procedure	11	4.34
ECG changes requiring termination of the procedure	2	0.79
Ureteric calculus after DJ stent removal	14	5.53
Grade IV	None	
Grade V	None	

complications (Table 3). Though complications were more in multiple access tracts than the single access tracts, it was not statistically significant (Table 4).

89.32% of cases were rendered stone-free after single session with and without multiple access tracts. 5.1% of cases needed second look PCNL, 5.92% of patients were managed conservatively, although, 1.97% of patients refused any further treatment for the residual stones. Overall, the success rate at 3 months was 93.67% for complete clearance (Table 5).

Table 4: Comparison of complications between single and multiple access tracts.

Variable	Single access tract		Multiple access tract		p-value
Complications (N/total)	24/141	17.02%	53/237	22.36%	0.201
Mean hemoglobin deficit (gm/dL)	1.5	1.05 (SD)	2.04	1.26 (SD)	0.001

Table 5: Follow-up and adjuvant treatments.

Stone-free after 4 weeks/3 months	226 (89.32%)/237(93.67%)
Second look PCNL	13 (5.1%)
Conservative management	15 (5.92%)
Refused further treatment	5 (1.97%)

Discussion

Renal stones are one of the most common genito-urinary disorders characterized by a high tendency to recur. Among the stones, complex or staghorn renal calculi present a challenging situation to the genito-urinary surgeons. For such stones, PCNL becomes the mainstay as the part of surgical treatment. European Association of Urology guidelines 2023 also suggested that all complex renal calculi including the partial and complete staghorn stones should primarily be approached with PCNL.[8] PCNL can be used as monotherapy with multiple access tracts or combined with flexible ureteroscope (ECIRS) or ESWL for maximal or complete stone clearance to prevent recurrences. For staghorn calculi, the safety and feasibility of PCNL were initially reported by Clayman *et al*. in 1983.[9] Later, and now, PCNL has become the treatment of choice for such large and complex calculi.[10,11] The intention while treating the staghorn stones is to achieve maximum possible clearance with minimal complications.

The mean stone size in our study was 58.67 mm with a standard deviation of 16.21 mm. Rashid *et al*. had a mean size burden of 60 mm with a standard deviation of 18 mm.[12] We had no hydronephrosis pre-operatively in 6.71% of cases while Rashid *et al*. had hydronephrosis in 14% of the cases.[12]

Soucy F *et al*.[13] had 78% stone-free rate in their study with PCNL monotherapy for partial and complete staghorn calculi, Singla *et al*.[14] had 70.7% stone-free rate with single session PCNL and Liatsokos *et al*.[15] had 87% stone-free rate in a single session. We had a stone-free rate of 89.32% in our study with PCNL monotherapy. This happened due to improvement of the technique of PCNL, advancement in the technology, miniaturization of instrumentation and better fragmentation devices.

The stone clearance rate increased after second look PCNL from 89.32% to 93.67% in our study. Singla *et al*.[14] reported 89% stone clearance after a second look PCNL.

5.92% of the patients in our study were managed conservatively with expectant management with double J stent in situ. Ganpule A P *et al*.[16] in their study said that stones fragments less than 5mm get expelled out of their own when double J stent was *in situ*.

Rashid *et al*. had a mean stay of 1.5 days for their patients, but we had a mean hospital stay of 1.8 days in our study. This could be because we had more than 2 tracts in 23.28% of the cases out of the total 378 tracts. Rashid *et al*. had two tracts in most of their patients.[12]

Ultrasonography and x-ray KUB are routinely used in developing countries like India to asses the residual stones after surgery, even though, we get a fair idea about the residual fragments with the c-arm that we use intra-operatively. This mode of investigation overestimates the residual fragment status by about 17-35%.[17] Non-contrast CT scan gives better accuracy of the stone-free status.[18] We used ultrasonography and x-ray KUB to assess the residual fragments post-operatively.

We used single-step PCNL tract dilatation with the help of screw dilator. This saved time in giving the renal access with lesser radiation exposure. Gupta N K *et al*. in their comparative study of one-step and serial dilatation in PCNL concluded that single-step dilatation saves time in getting renal access and decreases radiation exposure.[19]

We did multi-puncture PCNL in most of our patients safely without many problems. Clayman *et al*.[9] indicated that multiple access tracts for staghorn stones are feasible as well as safe. Hegarty and Desai showed no significant change in the serum creatinine levels of single and multiple access tract patients, respectively.[20] We had a mild rise in serum creatinine levels, but it was not statistically significant.

We needed a blood transfusion in 7.50% of cases. El-Nahas *et al*. had a 14% rate of blood transfusion in their study.[21] It is limited to the 18% transfusion rate as stated in the AUA nephrolithiasis guidelines for staghorn stones.[4]

The complication rate in our study was 40.10%. Though the complication rate looks high, most of them were grade I, which correlates to the complication rate of other authors.[22] The complications do not correlate with the technique of puncture or puncture of a particular calyx in our study.

The study had many limitations. Firstly, the retrospective nature of the study followed by the small number of cases. Thirdly, we used ultrasonography and x-ray KUB to confirm the stone-free status, which over-estimates it. Fourthly, only short-term outcomes were evaluated, long long-term complication and stone recurrence parameters were not evaluated. Lastly, metabolic evaluation was not done which helps in deciding the future strategies to prevent the stone formation.

The positive aspects of the study are the feasibility of treating complex and staghorn renal stones by minimal approach with PCNL, with good success rate and comparable complication rate. The use of single-step tract dilatation was the learning for the authors. It saves time and decreases the radiation exposure.

Conclusion

Advancements in the technology in endourological management of stones, especially the staghorn stones have made PCNL a feasible, safe, efficient, and important tool for surgical treatment even with multiple access tracts. As the complexity of the stone increases, the chances of multiple access tracts increase. Single-step dilatation of the PCNL tract is safe. PCNL must be done at centres equipped with a complete endourological armamentarium and by an experienced endo-urologist. All patients must be counseled pre-operatively for multiple access tracts as well as multiple sessions and the chances of ancillary procedures. PCNL remains the gold standard for complex and staghorn renal calculi.

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