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OUTCOMES OF COMPLEX STAGHORN CALCULI

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ABSTRACT

Background: Complex staghorn calculi are extensive renal stones involving multiple calyces and the renal pelvis, often linked to infection and significant morbidity. They pose surgical challenges due to their size, branching configuration, and associated renal dysfunction. Multi-Tract Percutaneous Nephrolithotomy (MT-PCNL) is frequently employed for complete clearance. This study evaluates the outcomes of MT-PCNL in patients with complex staghorn calculi.

Method: This prospective observational study included 40 patients undergoing MT-PCNL for radiologically confirmed complex staghorn calculi between January and December 2023 at a rural tertiary care hospital. Preoperative evaluations included CT KUB, urine cultures, renal function tests, and Guy's Stone Score classification. Intraoperative parameters (tract number, operative time, bleeding), postoperative outcomes (stone-free rate, complications, hospital stay, renal function), and bacterial isolates were analyzed. Stone-free status was confirmed via ultrasound on Day 1 and CT at 1 month.

Result: Mean stone burden was 835 mm², with 60% of patients classified as GSS Grade IV. The mean number of access tracts was 2.25, and average operative time was 96.4 minutes. The 1-month stone-free rate was 82.5%, with 12.5% requiring transfusion and 17.5% experiencing complications (mostly Clavien I–II). Postoperative creatinine changes were not significant (p=0.08), indicating preserved renal function. Positive urine cultures were present in 45%, with E. coli as the most common organism.

Conclusion: MT-PCNL is an effective and safe modality for managing complex staghorn calculi, achieving high clearance rates with acceptable complications and minimal renal impact. Meticulous planning and infection control are key for optimal outcomes.

INTRODUCTION

Staghorn calculi are complex renal stones that occupy the majority of the renal collecting system. These stones are associated with high morbidity and can lead to recurrent urinary tract infections, urosepsis, renal deterioration, and death if left untreated. Staghorn or complex caliceal calculi make upthe most challenging problems in urology and are likely to destroy the function of the kidney along with causing life-threatening sepsis [1].These stones are most often composed of struvite (magnesium ammonium phosphate), commonly formed in the setting of urinary tract infections by urease-producing organisms such as Proteus mirabilis,

Klebsiella pneumoniae, and Pseudomonas aeruginosa. The term "complex staghorn calculus" refers to stones that are occupy the renal pelvis and all calyces, are large in volume and are often associated with anatomical anomalies, infective foci along with reduced renal function in majority of the cases, making their management highly difficult.Treatment is often complicated but necessary given that untreated stones can lead to recurrent urinary tract infections, urosepsis, renal deterioration, and death [2,3]. In the recently updated guidelines of the American Urological Association Nephrolithiasis Guideline Panel on Staghorn Calculi, Percutaneous Nephrolithotomy (PCNL) has been described as an integral component of the management of most staghorn and large-volume renal calculi [4]. Since the clearance with single-tract PCNL approach is not feasible in most scenarios, multi-tract scenarios are being used in most surgeries. Theoretically, although it gives better access, potential risks of greater bleeding and higher complication rates compared with the single-tract approach are very much present [5]. PCNL was first introduced as a therapeutic option for all kinds of renal stones in 1976 by Johansson and Fernström [6]. It is specifically useful in larger stones and staghorn calculi.Advancements in the field of Urology with the advent of endoscopes and operating room table with high definition has helped in reducing the risk of operating on Complex Staghorn Calculi but all the risks have not yet been mitigated. The aim of this study is to assess the outcomes of Multi-Tract Percutaneous Nephrolithotomy (MTPCNL) in cases of Complex Staghorn Calculi.

MATERIALS AND METHODS

Study Design and Source of Data:This prospective observational study was conducted in the Department of Urology at a RuralHospital in South India between January 2023 and December 2023 over 12 months. After obtaining Institutional Ethics Committee approval and informed consent, a total of 40 patients **undergoing P**ercutaneous Nephrolith otomy for Complex Staghorn Calculi were enrolled.

Inclusion Criteria:

- Adult patients aged 21–60 years.
- Radiologically confirmed staghorn calculi.
- Normal coagulation profile and fitness for General Anaesthesia
- Solitary kidney disease.

Exclusion Criteria:

- Patients with known immunosuppression or chronic steroid use
- Co-existing malignancy, pregnancy, or congenital renal anomalies
- Solitary functional kidney

Pregnancy

Non--staghorn stones

Sampling: Purposive sampling was used to select patients who met the above criteria and required multi-tract PCNL based on stone size, anatomical distribution, or presence of inaccessible calyceal extensions. A minimum sample size of 34 was calculated using a 95% confidence interval, 5% margin of error, and 80% power to detect a 20% difference in postoperative stone-free rate based on previous studies. To account for dropouts, 40 patients were included.

Preoperative Assessment: Non-contrast CT-KUB: To assess stone volume, number of calyces involved, and renal anatomy.Urine culture and sensitivity: To identify infection and guide antibiotic prophylaxis.

Preoperative parameters recorded:

- Age and gender
- Stone laterality (right/left)
- Stone burden (measured in mm^2 using CT)
- Involved calyces (number)
- Stone composition (if available from previous episodes)
- Guy's Stone Score (GSS) classification
- Preoperative serum creatinine
- Positive urine culture (yes/no)

Surgical Technique: MTPCNL in all patients were performed under General Anesthesia by the same Surgeon to prevent bias. Initial percutaneous access was obtained under fluoroscopic and/or ultrasound guidance in the prone position. Multiple tracts (2–3 per patient) were created based on stone complexity and calyceal involvement. Access tracts were established using fascial dilators or

Amplatz sheaths (24–30 Fr). Lithotripsy was performed using a pneumatic or ultrasonic lithotripter. Stone fragments were removed using graspers or suction. Nephrostomy tubes were placed at the end of the procedure for drainage. Broad-spectrum IV antibiotics were initiated in all cases pre-operatively and adjusted based on culture post-operatively.

Postoperative Assessment:

- Duration of surgery (minutes)
- Number of tracts used
- Intraoperative blood loss (based on drop in hemoglobin)
- Postoperative fever (>38°C)
- Length of hospital stay (days)
- Need for blood transfusion
- Stone-free status assessed on Day 1 ultrasound and confirmed with NCCT at 1 month (defined as residual fragment ≤4 mm)
- Renal function outcome: Change in serum creatinine on Day 3 and 1 month
- Postoperative complications classified using the Clavien-Dindo grading system

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 - Demographic Profile of Patients

Age Group (years)	Number of Patients (n=40)	Percentage (%)
21–30	6	15%
31–40	8	20%
41–50	14	35%
51–60	12	30%
Gender		
Male	26	65%
Female	14	35%

Table 2 - Pre-operative characteristics

Parameter	Mean ± SD / n (%)
Mean stone burden (mm^2)	835 ± 210
Positive urine culture	18 (45%)
Mean pre-op creatinine (mg/dL)	1.48 ± 0.41
Mean pre-op hemoglobin (g/dL)	12.1 ± 1.3
Guy's Stone Score	
Grade III	16 (40%)
Grade IV	24 (60%)
Stone Surface Area (mm)	4650 ± 1050

Table 3 - Intraoperative Parameters

Parameter	Mean ± SD / n (%)
Number of access tracts	2.25 ± 0.54
Duration of surgery (min)	96.4 ± 20.3
Intraoperative complications	4 (10%)
Blood transfusion required	5 (12.5%)

Table 4 - Post-operative outcomes

Parameter	Mean ± SD / n (%)	p-value
Post-op hemoglobin (g/dL)	10.6 ± 1.5	<0.001
Post-op creatinine (mg/dL)	1.39 ± 0.37	0.08
Stone-free rate (Day 1 USG)	30 (75%)	–
Stone-free rate (CT at 1 month)	33 (82.5%)	–
Post-op fever	6 (15%)	–
Clavien-Dindo complications		
Grade I–II	5 (12.5%)	–
Grade ≥ III	2 (5%)	–
Hospital stay (days)	3.9 ± 1.1	–
Ancillary procedure needed	4 (10%)	–

Table 5 - Bacterial Isolates and Antibiotic Sensitivity in Positive Urine Cultures

Bacterial Isolate	No. of Patients (n=18)	Percentage (%)	Sensitive Antibiotics
Escherichia coli (ESBL-negative)	6	33.3%	Amikacin, Ceftriaxone, Piperacillin-Tazobactam
Klebsiella pneumoniae	4	22.2%	Amikacin, Meropenem, Nitrofurantoin
Proteus mirabilis	3	16.7%	Cefoperazone-Sulbactam, Amikacin, Norfloxacin
Pseudomonas aeruginosa	2	11.1%	Piperacillin-Tazobactam, Meropenem, Ciprofloxacin
Enterococcus faecalis	2	11.1%	Linezolid, Vancomycin
Morganella morganii	1	5.6%	Ceftriaxone, Amikacin

As seen in Table 1, most patients were in the 41–60 year age group, and a male predominance was observed. This age distribution is consistent with the peak incidence of nephrolithiasis. The mean age was 45.2 ± 10.3 years. As seen in Table 2, pre-operative evaluation showed a high average stone burden and infection in nearly half the patients. Most cases were Guy's Score Grade IV, indicating complex stone configurations.

As seen in Table 3, on an average, 2–3 tracts were used for each case. A minority of patients experienced intraoperative bleeding or required transfusion. Surgical time ranged from 70 to 140 minutes. As seen in Table 4, there was a significant drop in hemoglobin post-operatively ($p < 0.001$), while renal function with regard to Serum Creatinine remained stable. The final Stone Free Rate at 1 month was 82.5%. Most complications were mild and managed conservatively. There was a statistically significant decrease in hemoglobin post-surgery, likely due to tract-related blood loss. The minor change in serum creatinine was not statistically significant, indicating preserved renal function.

As seen in Table 5, out of the 40 patients, 18 (45%) had positive preoperative urine cultures. The most common organism isolated was E. coli (33.3%), followed by Klebsiella and Proteus. Most organisms were sensitive to amikacin and broad-spectrum beta-lactams. Pseudomonas and Enterococcus required higher-tier agents like carbapenems, linezolid, or vancomycin.

DISCUSSION

This prospective series of 40 patients undergoing Multi-Tract Percutaneous Nephrolithotomy (MT-PCNL) for Complex Staghorn Calculi demonstrated a stone-free rate (SFR) of 82.5% at one month, with an acceptable overall complication rate (17.5%, Clavien ≥ III: 5%) and stable renal function. These findings align with prior literature as described but also highlight distinctive strengths and limitations of our study sample and setting. In a study performed in 2005 by Aron et al [7], it was reported that the stone surface area was 3,089-6,012 (mean 4,800) mm in their cohort of 121 renal units. The number of tracts required per patient were 2 tracts in 11, 3 tracts in 68, 4 tracts in 39, and 5

tracts in 3, giving a total of 397 tracts. The mean tract noted was 3.28. In their study, PCNL monotherapy achieved an 84% complete clearance rate of the staghorn calculi. All these findings are aligned well in our study where the mean stone surface area was 4650 ± 1050, mean tracts were also around the range of 3. In both the studies, complicationss were also minimal. Although many studies have shown the effectiveness of single- versus multiple-tract PCNL for the treatment of complex caliceal calculi or staghorn stones, the results have been controversial [8,9]. A retrospective study in 2004 conducted by Desai et al [10] analyzed the case records of 116 patients younger than 15 years who underwent PCNL. The stones included 56 complex calculi. Complete clearance was achieved in 50 patients (89.8%). Of these, 22 (39%) required a single tract, while 34 (61%) required multiple tracts. The findings of this study also align well with our study with regard to tracts used and stone free rates. In 2012, Cho et al [11] observed that the number of tracts used for multiple-tract PCNL was two tracts in 20 patients, three tracts in 9, and four tracts in 1 for the management of complex renal calculi. This also correlated well with our study indicating tough surgical anatomy. Ding et al, in 2018 [12], identified that the mean operating time was longer in patients who received non-prepuncture double-tract PCNL as compared to the ones who had pre determined optimal punctual positions based on preoperative computed tomography, intravenous pyelography and intraoperative ultrasound images. Although the stone free rate was similar in both groups, the blood loss was lesser in the group where the positions were determined. This study does not correlate well with our study since there was no necessity for blood to be transfused even though these was a drop in Hemoglobin after surgery. A study performed by Cheng et al in 2024 [13] said that multiple access tracts can facilitate higher stone free rate while slightly increasing the incidence of acceptable complications. In our study as well, the complications noted were mostly in the Clavien-Dindo I-II categories indicating safe post-operative period. The renal function was also maintained and intact with the evidence of a negative p-value (>0.05) in terms of the Serum Creatinine change.

CONCLUSION

In our study, MT-PCNL achieved high stone clearance (82.5%) with acceptable safety and no significant renal deterioration in the management of Complex Staghorn Calculi. The method is safe, acceptable and can be done with the same pre-operative measures as in other PCNLs for simpler nephrolithiasis. Proper planning with the tract positions can be helpful to the Surgeon.

LIMITATIONS: A modest sample size of 40, single-center design and short-term follow-up are the limitations here. Future multicenter trials comparing multi-tract PCNL with minimally invasive alternatives such as Endoscopic Combined Intrarenal Surgery or mini-PCNL can be useful.

CONFLICT OF INTEREST: The authors report no Conflict of Interest of any kind.

DECLARATIONS

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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