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Original Article

Predictive Value of Guy's Stone Score for Stone Clearance and Perioperative Outcomes Following Percutaneous Nephrolithotomy: A Prospective Observational Study

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ABSTRACT

Background: Percutaneous nephrolithotomy (PCNL) is the preferred treatment for large and complex renal calculi. Preoperative assessment of stone complexity is essential for predicting procedural difficulty, stone clearance and postoperative outcomes. Guy's Stone Score (GSS) is an imaging-based classification system that may help predict these outcomes.

Aim: To evaluate the predictive value of Guy's Stone Score in assessing stone clearance, operative complexity and perioperative outcomes in patients undergoing PCNL.

Materials and Methods: This prospective observational study was conducted in the Department of Urology, Chettinad Hospital and Research Institute, Chennai, over 17 months (December 2024 to May 2026). A total of 35 patients undergoing PCNL were included. Preoperative stone complexity was assessed using CT KUB and classified according to Guy's Stone Score (Grades I–IV). Stone-free status was evaluated using postoperative imaging, with residual fragments greater than 4 mm considered failure to achieve stone-free status. Operative duration, intraoperative complications, postoperative complications, ancillary procedures and duration of hospital stay were recorded. Postoperative complications were graded using the Modified Clavien–Dindo Classification. Statistical analysis was performed using SPSS, with $p<0.05$ considered statistically significant.

Results: Among 35 patients, 12 (34.3%) had GSS Grade I, 11 (31.4%) Grade II, 8 (22.9%) Grade III and 4 (11.4%) Grade IV. Complete stone clearance was achieved in 28 patients (80%), while 7 (20%) had residual fragments greater than 4 mm. Stone clearance progressively decreased with increasing GSS grade: 100% in Grades I and II, 62.5% in Grade III and 0% in Grade IV ($\chi^2=23.281$, $p<0.001$). Mean operative duration was 79.26 ± 16.07 minutes and increased significantly with higher GSS

grades (F=4.829, p=0.007). Postoperative fever occurred in 14.3%, urine leak in 5.7%, blood transfusion was required in 8.6%, and urosepsis occurred in 2.9%. No statistically significant association was observed between GSS and postoperative complications or Modified Clavien–Dindo grade (p>0.05). Mean hospital stay was 5.77 ± 1.37 days.

Conclusion: Guy's Stone Score is a useful preoperative tool for assessing stone complexity and predicting stone clearance and operative duration following PCNL. Higher GSS grades were significantly associated with lower stone-free rates and longer operative times. However, no significant association was demonstrated between GSS and postoperative complications in this study. Larger prospective studies are required to validate its predictive value for perioperative morbidity.

Keywords: Guy's Stone Score; Percutaneous Nephrolithotomy; Nephrolithiasis; Stone-free Rate; Residual Fragments; Operative Duration; Postoperative Complications.

INTRODUCTION

Nephrolithiasis is a common urological disorder that can cause renal colic, haematuria, recurrent urinary tract infection, urinary obstruction and, in advanced cases, impairment of renal function. The clinical burden is particularly important in patients with large, multiple or anatomically complex renal calculi, in whom treatment may require technically demanding interventions and more than one procedure. The choice of treatment therefore depends not only on stone size, but also on stone number, distribution within the pelvicalyceal system, renal anatomy, patient-related factors and the likelihood of achieving complete stone clearance.

Percutaneous nephrolithotomy (PCNL) is an established minimally invasive treatment for large and complex renal stones, particularly calculi greater than 2 cm and partial or complete staghorn calculi. [1,2,] By creating a percutaneous tract into the renal collecting system, PCNL permits direct visualisation, fragmentation and extraction of stones. Advances in imaging, access techniques, nephroscopes and lithotripsy devices have improved procedural performance. Nevertheless, PCNL remains associated with clinically relevant risks, including bleeding and transfusion, fever and urinary infection, urine leakage, injury to adjacent structures, residual fragments and the need for ancillary procedures. [1,3,] Outcomes are influenced by stone complexity as well as renal anatomy, access characteristics, comorbidities and operative factors. [3,4,5,]Preoperative assessment of stone complexity is consequently important for operative planning, patient counselling and anticipating the resources that may be required. Stone burden cannot be represented adequately by a single measurement of diameter: the number of calculi, their location and branching pattern, and the anatomy of the collecting system can substantially affect access, instrument manoeuvrability and the feasibility of complete clearance. A reproducible scoring system can support more consistent communication between clinicians, help stratify procedural difficulty and provide a framework for comparing outcomes across patients and studies.

Several nephrolithometric systems have been developed to characterise renal stone complexity, including the Guy's Stone Score (GSS), the S.T.O.N.E. nephrolithometry score and the Clinical Research Office of the Endourological Society (CROES) nomogram. Guy's Stone Score is a practical imaging-based classification that categorises renal stone disease into four grades according to stone number and location, collecting-system anatomy and relevant anatomical abnormalities. In general, Grade I represents stones in an otherwise normal collecting system; higher grades reflect increasing complexity, including multiple stones, abnormal renal anatomy and partial or complete staghorn calculi. The score is attractive in routine practice because it is relatively straightforward to apply using preoperative imaging and does not require extensive numerical measurements. [1,2,4,6,7,8]

By translating radiological features into an ordinal grade, GSS may help clinicians anticipate the technical demands of PCNL and estimate the likelihood of complete stone clearance. Increasing stone complexity may be associated with longer operating time, more difficult access, a greater likelihood of residual fragments and a need for additional procedures. However, stone clearance is only one dimension of procedural success. Intraoperative events, postoperative complications, duration of hospitalisation and recovery are also important outcomes. Postoperative morbidity can be described systematically using the Modified Clavien–Dindo Classification, which grades complications according to the treatment or intervention required.

Although scoring systems can support clinical judgement, their predictive performance may vary with case mix, surgical expertise, equipment and local practice. [1,2,] Their usefulness should therefore be evaluated against clearly defined clinical outcomes in the population in which they are applied. Prospective assessment of GSS alongside operative findings, stone clearance, ancillary procedures, postoperative complications and length of hospital stay can help clarify its practical value in planning PCNL and counselling patients.

The present prospective observational study evaluated 35 patients with renal calculi undergoing PCNL. Preoperative stone complexity was graded using Guy's Stone Score, and the relationship between the score and intraoperative findings, stone-clearance outcomes and postoperative morbidity was assessed. Postoperative complications were classified using the Modified Clavien–Dindo system. By examining these outcomes together, the study sought to assess whether GSS provides a useful and clinically applicable means of anticipating procedural complexity and stone clearance in patients undergoing PCNL.

AIM AND OBJECTIVES

Aim

To evaluate the utility of Guy's Stone Score in predicting procedural complexity, stone-clearance outcomes, and perioperative outcomes in patients undergoing percutaneous nephrolithotomy.

Objectives

1. To grade preoperative renal stone complexity using Guy's Stone Score in patients undergoing PCNL.
2. To assess the association between Guy's Stone Score and stone-clearance outcomes, including the presence of residual stones.
3. To evaluate the relationship between Guy's Stone Score and intraoperative parameters and complications.
4. To assess postoperative complications according to the Modified Clavien–Dindo Classification and examine their association with Guy's Stone Score.
5. To describe ancillary procedures, duration of hospital stay, and overall recovery following PCNL.

MATERIALS AND METHODS

Study design and setting

This is a prospective observational study conducted in the Department of Urology, Chettinad Hospital and Research Institute, Chennai, a tertiary-care teaching hospital. Patients were observed from preoperative assessment through surgery and postoperative follow-up; treatment decisions and perioperative care followed the treating team's usual clinical practice.

Study period

The study was conducted over 17 months, from December 2024 to May 2026.

Study population and eligibility criteria:

Inclusion criteria

1. Adult patients aged 18 years or older with renal calculi scheduled for percutaneous nephrolithotomy (PCNL).
2. Written informed consent for participation in the study.

Exclusion criteria

1. Patients medically unfit for surgery because of significant anaesthetic or cardiac risk.
2. Patients with uncorrectable coagulopathy or anticoagulant therapy that could not safely be interrupted.
3. Patients with active urinary tract infection or sepsis that had not been adequately controlled before surgery.

Sample Size and Sampling Technique

A consecutive non-probability sampling technique was employed. All eligible patients presenting to the Department of Urology during the study period (December 2024 to May 2026) who fulfilled the inclusion criteria and provided informed consent were recruited sequentially. The final sample consisted of 35 patients. The sample size was determined by the number of eligible patients available during the study period.

Preoperative assessment and Guy's Stone Score

Preoperative evaluation included clinical history and examination, relevant laboratory investigations, urine assessment and imaging. CT KUB was used to assess stone burden and collecting-system anatomy. Each patient's renal stone complexity

was classified before surgery using Guy's Stone Score (GSS), from Grade I to Grade IV. Patients were subsequently analysed according to their recorded GSS grade. [1,4,8]

Procedure and perioperative assessment
PCNL was performed according to the treating surgeon's clinical judgement and institutional practice. Operative details recorded included anaesthesia, puncture/access characteristics, number of punctures, operative duration, double-J (DJ) stent placement and intraoperative complications. The study did not assign patients to different treatment groups or alter routine care for research purposes.

Outcome measures
The principal outcome was stone-free status assessed on postoperative imaging. Residual fragments of greater than 4 mm post operatively is defined as failure to achieve stone-free status. Secondary outcomes included operative duration, intraoperative complications, postoperative complications, need for ancillary procedures, length of hospital stay and overall recovery. Postoperative complications were graded using the Modified Clavien–Dindo Classification. Ancillary procedures and relevant postoperative interventions were documented.

Data collection
Data were collected prospectively using a structured proforma. Recorded variables included demographic characteristics, clinical history, comorbidities, preoperative investigations, GSS grade, operative findings, stone-clearance status, postoperative complications, ancillary procedures and hospital stay. Completed forms were reviewed for completeness and accuracy before data entry into an electronic database.

Statistical Analysis
The data collected were analysed using SPSS. software. Continuous variables were expressed as mean ± standard deviation for normally distributed data and median with interquartile range for non-normally distributed data. Categorical variables were expressed as frequencies and percentages.

The distribution of patients across the four grades of Guy's Stone Score was analysed. The association between Guy's Stone Score and stone-free status following PCNL was assessed using the Chi-square test or Fisher's exact test, as appropriate, depending on the expected cell frequencies. The association between Guy's Stone Score and other categorical postoperative outcomes, including residual stone fragments and the requirement for ancillary procedures, was also evaluated using appropriate categorical tests.

For comparison of continuous variables across the Guy's Stone Score groups, one-way analysis of variance (ANOVA) was used for normally distributed data, while the Kruskal–Wallis test was used for non-normally distributed data. The relationship between Guy's Stone Score and continuous outcome variables, such as operative duration and hospital stay, was assessed using Pearson's or Spearman's correlation, as appropriate.

All statistical tests were two-tailed, and a p-value of less than 0.05 was considered statistically significant

Ethical considerations
The study was conducted after approval from the Institutional Human Ethics Committee of Chettinad Hospital and Research Institute (IHEC-I/3170/24), Chennai. Written informed consent was obtained from participants. Participation was voluntary, confidentiality of patient information was maintained, and no additional invasive procedures were performed solely for research purposes. Clinical treatment and management of complications followed institutional standards.

RESULTS
A total of 35 patients undergoing percutaneous nephrolithotomy (PCNL) were included in the analysis. Results are presented descriptively and according to preoperative Guy's Stone Score (GSS). [1,4,9]

Patient characteristics
The mean age was 45.49 ± 13.49 years. The largest age group was 31–40 years (12/35, 34.3%), followed by 41–50 years (8/35, 22.9%), patients older than 60 years (7/35, 20.0%), those aged 51–60 years (5/35, 14.3%), and those aged 21–30 years (3/35, 8.6%). There were 22 male patients (62.9%) and 13 female patients (37.1%). PCNL was performed on the right side in 22 patients (62.9%) and on the left side in 13 (37.1%). Loin pain was reported in 30 patients (85.7%); five patients (14.3%) presented with loin pain and fever.

Distribution of Guy's Stone Score
Preoperative CT KUB was available for all 35 patients. GSS Grade I was assigned to 12 patients (34.3%), Grade II to 11 (31.4%), Grade III to 8 (22.9%), and Grade IV to 4 (11.4%). All patients had a sterile preoperative urine culture.

Operative findings
Single-puncture access was achieved in 28 patients (80.0%), while double-puncture access was required in 7 (20.0%). The mean operative duration was 79.26 ± 16.07 minutes. Operative duration increased across GSS grades: 68.75 ± 13.02 minutes for Grade I, 79.27 ± 14.36 minutes for Grade II, 87.25 ± 12.29 minutes for Grade III, and 94.75 ± 18.25 minutes for Grade IV. The difference in operative duration across grades was statistically significant ($F = 4.829$, $p = 0.007$). Intraoperative complications occurred in 4 patients (11.4%): significant bleeding in 3 (8.6%) and pelvic perforation in 1 (2.9%). Double-J stents were placed in all 35 patients.

Table 1: 'Comparison of Operative Duration According to Guy's Stone Score Among Study Participants (N = 35)'

Guy's Stone Score	**N**	**Mean ± SD (minutes)**
Grade I	12	68.75 ± 13.018
Grade II	11	79.27 ± 14.360
Grade III	8	87.25 ± 12.291
Grade IV	4	94.75 ± 18.246
Total	**35**	**79.26 ± 16.068**
F = 4.829, p = 0.007		

Stone-clearance outcomes
Complete stone clearance was achieved in 28 patients (80.0%); residual stones were identified in 7 (20.0%). All patients with GSS Grade I (12/12) and Grade II (11/11) achieved complete clearance. Complete clearance was achieved in 5 of 8 patients with Grade III stones, while all 4 patients with Grade IV stones had residual stones. The association between GSS and stone-clearance outcome was statistically significant ($\chi^2 = 23.281$, $df = 3$, $p < 0.001$). Residual fragments greater than 4 mm were reported in 7 patients (20.0%).

Table 2 : Association Between Stone Clearance and Guy's Stone Score Among Study Participants (N =

Stone clearance	**Grade I n (%)**	**Grade II n (%)**	**Grade III n (%)**	**Grade IV n (%)**	**Total n (%)**
Complete Clearance	12 (42.9%)	11 (39.3%)	5 (17.9%)	0 (0.0%)	28 (100.0%)
Residual Stone	0 (0.0%)	0 (0.0%)	3 (42.9%)	4 (57.1%)	7 (100.0%)
Total	**12 (34.3%)**	**11 (31.4%)**	**8 (22.9%)**	**4 (11.4%)**	**35 (100.0%)**
$\chi^2 = 23.281$, df = 3, p < 0.001'					

Ancillary procedures
No ancillary procedure was required in 28 patients (80.0%). Retrograde intrarenal surgery (RIRS) was performed in 3 patients (8.6%), re-look PCNL in 2 (5.7%), ureteroscopic lithotripsy (URSL) in 1 (2.9%), and open surgery in 1 (2.9%).

Postoperative complications and recovery
Postoperative fever occurred in 5 patients (14.3%), urine leak in 2 (5.7%), blood transfusion was required in 3 (8.6%), and urosepsis requiring intensive care unit admission occurred in 1 patient (2.9%). The thesis reported no statistically significant association between GSS and postoperative fever ($p = 0.830$), urine leak ($p = 0.240$), urosepsis/ICU admission ($p = 0.324$), or transfusion requirement ($p = 0.545$). There was also no statistically significant association between GSS and Modified Clavien–Dindo complication grade ($\chi^2 = 6.318$, $df = 9$, $p = 0.708$). The mean hospital stay was 5.77 ± 1.37 days. All 35 patients were reported to have recovered successfully.

DISCUSSION
Principal findings
This prospective observational study evaluated the relationship between Guy's Stone Score (GSS) and outcomes following percutaneous nephrolithotomy (PCNL) in 35 patients. The principal findings were that increasing GSS was associated with longer operative duration and a lower likelihood of complete stone clearance. Complete clearance was achieved in all

patients with GSS grades I and II, in five of eight patients with grade III, and in none of the four patients with grade IV. In contrast, the study did not demonstrate statistically significant associations between GSS and the postoperative complications recorded or the Modified Clavien–Dindo grade. These findings suggest that, in this cohort, GSS was more informative for stone clearance and operative complexity than for perioperative morbidity. [1,2,4,6,8,9]

Guy's Stone Score and stone clearance

Complete stone clearance was documented in 28 of 35 patients (80%), while seven patients (20%) had residual fragments greater than 4 mm. The relationship between GSS and clearance was statistically significant ($\chi^2 = 23.281$, df = 3, $p < 0.001$). The gradient across grades was clinically notable: clearance was 100% in grades I and II, 62.5% in grade III, and 0% in grade IV. The four grade-IV patients all had residual stones, although the small number in this category means that the estimate is imprecise and should not be interpreted as a universal prediction for every patient with grade-IV stones. The observed pattern supports using preoperative GSS to identify patients in whom complete clearance may be more difficult and to inform counselling about the possibility of residual stones or additional treatment. Stone-free rates can also be affected by stone burden and distribution, access strategy, equipment, surgeon experience, and the modality and timing of postoperative imaging; these factors should be considered when interpreting the association.

Guy's Stone Score and operative duration

Mean operative duration was 79.26 ± 16.07 minutes. Mean duration increased across GSS categories, from 68.75 ± 13.02 minutes in grade I to 79.27 ± 14.36 minutes in grade II, 87.25 ± 12.29 minutes in grade III, and 94.75 ± 18.25 minutes in grade IV. The difference across groups was statistically significant ($F = 4.829$, $p = 0.007$). This progressive increase is consistent with the clinical expectation that more complex stone configurations may require more demanding access, fragmentation, and clearance. From a practical standpoint, preoperative grading may help with theatre scheduling, resource planning, and counselling regarding procedural duration.

Intraoperative events and ancillary procedures

Four patients (11.4%) experienced a recorded intraoperative complication: significant bleeding in three (8.6%) and pelvic perforation in one (2.9%). A double puncture was required in seven patients (20%), while 28 (80%) underwent a single puncture. Ancillary procedures were not required in 28 patients (80%); the remaining patients underwent RIRS (3, 8.6%), re-look PCNL (2, 5.7%), URSL (1, 2.9%), or open surgery (1, 2.9%). These observations show that a proportion of patients required further intervention to address residual or additional stone burden. The study data provided do not establish a statistically tested relationship between GSS and each ancillary

procedure, and these procedures should therefore be described as observed treatment requirements rather than as outcomes independently predicted by GSS.

Postoperative complications and hospital stay

Postoperative fever occurred in five patients (14.3%), urine leak in two (5.7%), blood transfusion was required in three (8.6%), and one patient (2.9%) developed urosepsis requiring intensive care. No statistically significant associations were reported between GSS and postoperative fever ($p = 0.830$), urine leak ($p = 0.240$), urosepsis ($p = 0.324$), or transfusion ($p = 0.545$). Similarly, the association between GSS and Modified Clavien–Dindo classification was not statistically significant ($\chi^2 = 6.318$, df = 9, $p = 0.708$). Mean hospital stay was 5.77 ± 1.37 days, and all patients were reported to have recovered. These non-significant findings do not prove that GSS has no relationship with complications. With only 35 participants and relatively few events, the study may have had limited power to detect differences across four score categories. The complication results should therefore be interpreted cautiously and confirmed in a larger cohort.

Clinical implications

The findings support the potential role of GSS as a simple preoperative tool for communicating stone complexity and anticipating two practical outcomes: operative duration and likelihood of complete stone clearance. A higher score may prompt more detailed counselling about residual fragments and the possible need for staged or ancillary treatment, as well as appropriate planning of operating time and resources. GSS should not be used in isolation to determine treatment, predict an individual patient's outcome with certainty, or replace clinical judgement. Decisions should also incorporate the patient's clinical status, stone characteristics, anatomy, infection risk, available expertise, and local practice.

Strengths and limitations

A strength of this study is its prospective design, with preoperative grading and systematic recording of operative and postoperative outcomes. It also reports outcomes across all four GSS categories, allowing the observed gradient in

clearance and operative duration to be described. Several limitations should be acknowledged. First, the sample size was limited (35 patients), with four patients in grade IV, limiting precision and the ability to detect associations with uncommon complications. Second, the study was conducted at a single centre, which may limit generalisability to institutions with different case mix, equipment, and surgical practice. Third, the observational design cannot establish causation, and the available results do not demonstrate that potential confounders were adequately controlled in adjusted analyses.

Future directions

Larger, preferably multi centre prospective studies should validate the observed association between GSS and stone clearance and operative duration. Future analyses should report confidence intervals, prespecify stone-free definitions and imaging time points, and assess whether GSS retains predictive value after adjustment for relevant clinical and procedural factors. A larger sample would also be needed to evaluate associations with specific complications and to compare the predictive performance of GSS with other nephrolithometric scoring systems. Such work would clarify the extent to which GSS can support individualised counselling and perioperative planning.

CONCLUSION

In this prospective observational study of 35 patients undergoing percutaneous nephrolithotomy, Guy's Stone Score was significantly associated with stone clearance and operative duration.

Complete stone clearance decreased with increasing score, from 100% in grades I and II to 62.5% in grade III and 0% in grade IV, while mean operative duration increased from 68.75 minutes in grade I to 94.75 minutes in grade IV. These findings suggest that preoperative GSS may help identify patients likely to require more complex procedures and support counselling and perioperative planning. No statistically significant association was demonstrated between GSS and the postoperative complications or Modified Clavien–Dindo classification assessed in this cohort; the small sample size limits firm conclusions regarding complication prediction.

Larger studies with standardised outcome definitions and postoperative imaging protocols are needed to validate these findings and determine the independent predictive value of GSS. [1,4,6,9]

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