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Comparison of Guy's Stone Score and S.T.O.N.E. Nephrolithometry in Predicting Stone-Free Status After Mini-Percutaneous Nephrolithotomy

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ABSTRACT

Objective: To compare the performance of the Guy's score and the S.T.O.N.E. score in predicting stone-free status (SFS) in Pakistani patients undergoing mini-percutaneous nephrolithotomy (mini-PCNL) including single and multiple tracts at a tertiary care hospital of Pakistan.

Study Design: Prospective comparative study.

Place and Duration of Study: Urology department of Armed Forces Institute of Urology, Rawalpindi, Pakistan, from Nov 2024 to May 2025.

Methodology: Adults (18–80 years) with renal calculi on non-contrast CT-KUB undergoing mini-PCNL were enrolled. Demographics and CT parameters were recorded, and Guy's Stone Score (GSS) and S.T.O.N.E. score were calculated. Stone-free status (SFS) was residual fragments ≤4 mm on postoperative day-1 X-ray KUB.

Results: One hundred-and-ten patients, out of which 79(72.0%) were male, and the mean age was 42.6±11.3 years, underwent mini-PCNL. Lower-pole access was used in 89(81.0%) patients and double-J stents in all. Nephrostomy was placed in 20(18.2%) patients. SFS was achieved in 91(82.7%). Groups were similar in age, sex, creatinine, and laterality. Mean GSS and S.T.O.N.E. were lower in SFS (1.8±0.95 and 5.81±1.14 p<0.001) than non-SFS (3.2±1.03 and 7.11±1.79 p=0.002). GSS showed AUC 0.83 (95% CI 0.72–0.92) versus S.T.O.N.E. 0.72 (0.57–0.86), with a p value of 0.017.

Conclusion: Our results show that both GSS and S.T.O.N.E. meaningfully stratify the likelihood of stone free status (SFS) after mini-PCNL however GSS can better predict SFS as compared to S.T.O.N.E score.

Keywords: Guy's Stone Score, Mini-PCNL, Nephrolithiasis, Percutaneous Nephrolithotomy, S.T.O.N.E Score.

How to Cite This Article: *Akhtar MT, Murtaza B, Ahmed G, Yasir A, Shahid MF, Aslam A. Comparison of Guy's Stone Score and S.T.O.N.E. Nephrolithometry in Predicting Stone-Free Status After Mini-Percutaneous Nephrolithotomy. Pak Armed Forces Med J 2026; 76(Suppl-5): S793-S797. DOI: https://doi.org/10.51253/pafmj.v76iSUPPL-5.13900*

INTRODUCTION

Pakistan is situated in the "Stone Belt" and urolithiasis is very common with a reported prevalence of 16%, with urolithiasis accounting for 12.4% of all CKD patients.[1] Urolithiasis can lead to significant clinical problems, including recurrent pain, urinary tract infections, obstructive uropathy, and even chronic kidney disease or mortality if untreated.[2]

Percutaneous nephrolithotomy (PCNL), particularly its miniaturized form (mini-PCNL), has evolved into the primary recommended treatment for large or complex renal stones, presenting high stone-free rates (SFR) and acceptable complication profiles.[3] However, the wide variation in patient and stone characteristics requires reliable, quantifiable scoring systems to predict surgical outcomes, optimize patient counselling, stratify risks, and promote standardized reporting. Among the prominent scoring systems developed for this purpose are the Guy's Stone Score (GSS), the stone size (S), tract length (T), obstruction (O), number of involved calices (N), and essence or stone density (E) (S.T.O.N.E.), Clinical Research Office of the Endourological Society (CROES), and Seoul National University Renal Stone Complexity (S-ReSC) scores.

Predicting Stone Free Status (SFS) accurately is crucial for the effective management and follow-up of patients, helping to anticipate the need for ancillary procedures and to identify those at risk of recurrence or complications. Given the increasing reliance on evidence-based management and reporting within contemporary urological practice, local validation of outcome predictors is essential, particularly in Pakistan where stone complexity and comorbidities are observed due to varied sociodemographic profiles.[4] The S.T.O.N.E. Score (STONE) and Guy's Stone score have been compared in predicting SFS in Pakistani population but limited to multiple tract mini-PCNL or standard PCNL.[5,6]

The objective of our study was to compare the performance of the GUY's score and the S.T.O.N.E. score in predicting stone-free status (SFS) in Pakistani patients undergoing mini-percutaneous

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Received: 30 Sep 2025; revision received: 18 Dec 2025; accepted: 23 Dec 2025

nephrolithotomy (mini-PCNL) including single and multiple tracts at a tertiary care hospital of Pakistan.

METHODOLOGY

This comparative prospective study was conducted from Nov 2024 to May 2025 at the Urology Department of Armed Forces Institute of Urology after approval from Institutional Review Board (ERC Trg-1/IRB/2024/022 dated 14 Oct 2024).

Inclusion Criteria: Patients of either gender aged between 18 and 80 years of age who had confirmed renal calculi on non-contrast enhanced CT scan Kidney-Ureter-bladder (KUB) were included.

Exclusion Criteria: Patients who had missing key investigations such as CT-KUB or underwent standard PCNL were excluded.

Sample size was calculated using WHO calculator keeping the stone free status (SFS) at 94%.[7] Non-probability convenience sampling was used to recruit patients, and informed consent was taken.

Data was recorded on printed as well as Google forms. Demographic data including age, gender, comorbidities along with relevant investigation including hemoglobin, creatinine and key CT scan findings were recorded. Guy's score and S.T.O.N.E. score were calculated pre-operatively for all patients by the same senior resident and CT scans were reported by a single consultant to minimize interobserver bias. S.T.O.N.E. score was calculated as shown in Table-I.[8]

Guy's Score was used as Follows:[9]

Grade-1: A solitary stone in the mid/lower pole with simple anatomy or a solitary stone in the pelvis with simple anatomy.

Grade-2: A solitary stone in the upper pole with simple anatomy or multiple stones in a patient with simple anatomy or any solitary stone in a patient with abnormal anatomy.

Grade-3: Multiple stones in a patient with abnormal anatomy or, stones in a calyceal diverticulum or partial staghorn calculus.

Grade-4: Staghorn calculus or any stone in a patient with spina bifida or spinal injury

All included patients underwent mini-PCNL (including single and multi-tract) and printed films or digital video of CT scans were made available in operation theater at the time of surgery. Pre-operative prophylactic antibiotics were given. Stones were fragmented with pneumatic lithotripsy and retrieved with irrigation or graspers. Single or multiple tract access was used as anatomically indicated; nephrostomy placement was selective at case end. Double-J stents were placed in all patients (antegrade or retrograde). All surgical procedures were performed by same surgeon to minimize operator related bias. Post-operatively all patients were admitted and intravenous antibiotics were advised. Patient flow diagram is shown in Figure-1.

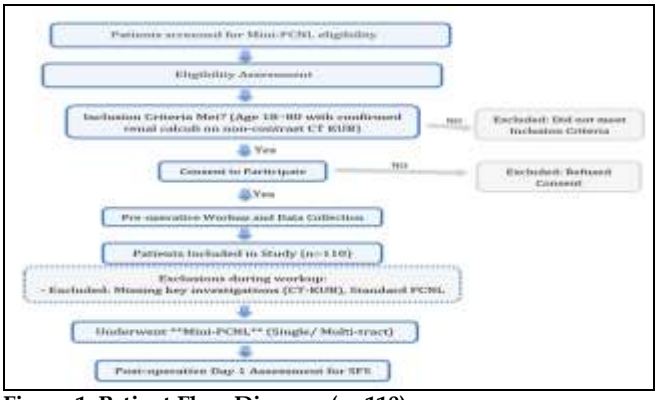

Figure 1: Patient Flow Diagram (n=110)

Stone free status was defined as residual fragments ≤ 4 mm considered stone-free (SFS) as seen on post-op X-Ray KUB done on 1st post-op day (POD). Therefore, X-ray KUB was performed for all on 1st POD or USG scan for radiolucent stones.

Data was analyzed using Statistical Package for Social Sciences (SPSS) version 26. Descriptive statistics, including means and standard deviations for continuous variables (e.g., age, creatinine, hemoglobin, GSS and STONE score) and frequencies and percentages for categorical variables (e.g., gender, co-morbids, stone laterality and SFS status), were calculated. Normality of continuous variables was assessed using Shapiro-Wilk test. Independent t test was used to compare means, and Chi-square to check for association. Predictive performance for SFS was evaluated by ROC curves (AUC). Comparisons between the models employed DeLong's method for paired ROC curves. A *p*-value ≤0.05 was considered statistically significant.

RESULTS

A total of 110 patients underwent mini-PCNL: 79 males (72.0%) and 31 females (28.0%) with a mean age of 42.6±11.3 years. Mean creatinine was 94.04±37.64 umol/L and mean hemoglobin was 13.0±1.61. Twenty-six (23.6%) and 16(14.5%) patients had hypertension and diabetes mellitus respectively.

Stone laterality was right in 53(48%), left in 48(44%) and bilateral in 9(8%) cases. Eighty-nine (81%) PCNL punctures were performed via the lower pole, Double-J stents was placed in all patients and a nephrostomy tube was placed in 20(18.2%) cases.

Table-I: Stone (Stone Size, Tract Length, Obstruction, Number of Involved Calices, Essence or Stone Density) Score

Variable	SCORE			
	1	2	3	4
Stone Size (mm2)	0-399	400-799	800-1599	>1600
Tract Length (mm)	<100	>100	-	-
Obstruction	None	Severe	-	-
Calices (n)	1-2	3	Staghorn	-
Essence (HU)	<950	>950	-	-

On post-op day1 X-Ray KUB 91(82.7%) patients achieved SFS, while 19(17%) had residual fragments >4 mm. Patients with stone free status and those with residual stones were compared. There were no significant differences in age (p=0.52), sex (p=0.30), creatinine (p=0.85), or laterality (p=0.84) between them. Mean GSS was lower in SFS (1.80±0.95) than non-SFS (3.21±1.03; p<0.001) patients. S.T.O.N.E. score was similarly lower (5.81±1.14 vs 7.11±1.79; p=0.002). Comparison is shown between these in Table-II.

Table-II: Mean Guy's and S.T.O.N.E. score Comparison for Stone Free Status vs Non-Stone Free Status (n=110)

Variable	SFS Achieved (n=78) Mean±SD	SFS Not Achieved (n=22) Mean±SD	*p*-value
Mean age (years)	41.9±10.8	44.7±12.6	0.21
GUYS score (mean)	1.80±0.95	3.21±1.03	<0.001
S.T.O.N.E. score (mean)	5.80 ±1.14	7.11±1.79	0.002
Creatinine (mg/dL)	1.01±0.24	1.09±0.31	0.18

**S.T.O.N.E.: (Stone Size, Tract Length, Obstruction, Number of Involved Calices, Essence or Stone Density). SFS: stone-free status*

ROC analysis showed AUC 0.83 (95% CI 0.72–0.92) for GSS and 0.72(0.57–0.86) for S.T.O.N.E., the difference favored GSS (DeLong p=0.017). Optimal cut offs were GSS ≤3 (sensitivity 92%, specificity 58%) and S.T.O.N.E. ≤6 (sensitivity 70%, specificity 63%). Predictive performance analysis (ROC Analysis) is shown in Table-III.

Table-III: Receiver Operating Characteristics Analysis to ascertain Sensitivity and Specificity of both Scoring Systems (n=110)

Predictor	AUC (95% CI)	Optimal cutoff	Sensitivity (%)	Specificity (%)
Guy's Stone Score	0.83 (0.72–0.90)	≤3	92	58
S.T.O.N.E. score nephrolithometry	0.72 (0.57–0.86)	≤6	70	63

**S.T.O.N.E.: (Stone Size, Tract Length, Obstruction, Number of Involved Calices, Essence or Stone Density)*

DISCUSSION

The study demonstrates that mini-PCNL is a highly effective procedure (82.7% SFS) and highlights that stone complexity, as measured by the Guy's Stone Score and S.T.O.N.E. score, is a critical determinant of immediate stone clearance, with GSS emerging as the more powerful and reliable predictor of success. The GSS had a significantly higher Area Under the Curve (AUC=0.83) compared to the S.T.O.N.E. score (AUC=0.72) for predicting SFS, as confirmed by the DeLong test (p=0.017). A GSS ≤3 is highly predictive of SFS (Sensitivity 92%), though with moderate specificity (58%). An S.T.O.N.E. score ≤6 is also useful (Sensitivity 70%, Specificity 63%).A high sensitivity means that most patients who do achieve SFS will have a GSS ≤3. In parallel to these score many imaging-based nephrolithometric scores have also developed to standardize case complexity assessment and to counsel patients pre-operatively about their chance of becoming stone-free.[10] These scores—Clinical Research Office of the Endourological Society nomogram, and later Seoul National University Renal Stone Complexity score —allow comparisons across centers and surgeons and are now commonly studied in both standard and mini-PCNL cohorts.[11] Recent multicenter and large cohort analyses further support their clinical usefulness.[12]

Our findings broadly align with prior Pakistani studies, though some differences arise from methodology. Bhatti *et al.*, examined multiple-tract mini-PCNL in Pakistan and reported a stone-free rate (SFR) of 78.2%, slightly below our 82.7%. This difference is likely attributable to their more stringent follow-up imaging – they used a 4-week post-PCNL CT scan to define stone-free status, which is more sensitive for detecting small residual fragments than our pragmatic Day-1 X-ray criterion. Notably, their patients were younger on average (32.90±10.98 years) than ours (41.9±10.8 years), but age itself was a weak determinant of success in both studies. Overall, despite a retrospective design, Bhatti *et al.*, demonstrated that both Guy's Stone Score (GSS) and S.T.O.N.E. score correlated with outcomes in a similar direction to our prospective findings.[6]

Skolarikos *et al.*, studied single-tract PCNL in Karachi and observed an SFR of 74.8% which is lower than our result.[5] A key factor is that Skolarikos's protocol limited each case to one access tract, whereas our mini-PCNL series employed multiple tracts when necessary for complex stones. The single-tract

approach can leave more residual fragments in large stone burden cases, potentially explaining their lower clearance rate. Demographically, their patients' mean age (~45 years) and strong male predominance (79% male) were close to our cohort. Consistent with our results, Skolarikos *et al*., found that higher stone complexity scores (whether GSS, S.T.O.N.E., or others) significantly predicted failure to achieve SFS.[5]

International comparisons further underscore the generalizability of our findings. Biswas *et al*., conducted a large prospective study of standard-caliber PCNL (n=252) and achieved an SFR of 82.1%, virtually identical to our 82.7% despite differences in surgical technique (standard PCNL vs. mini-PCNL) and population. Biswas *et al*., assessed stone clearance with early postoperative ultrasound and X-ray KUB on post-operative day 2, supplemented by CT only if needed, using a >4 mm residual definition. This approach is comparable to our immediate X-ray method and likely contributes to the similar SFRs. Like us, Biswas *et al*. noted that patient gender had no significant impact on stone-free outcomes (SFR ~82% in both males and females). They also reported slightly higher mean ages (~47–50 years) in their cohort, but likewise found age to be a poor discriminator of SFS. In terms of prognostic tools, Biswas *et al*., concluded that GSS, S.T.O.N.E., and the CROES nomogram were all equivalent in predicting SFS.[13]

A smaller study from India reported an SFR of 94% in a prospectively scored PCNL series (n=50). This higher clearance rate likely reflects the selection of relatively less complex cases (their average GSS was low, ~1.7) and the impact of a small sample size. The comparative performance of scoring systems in their analysis is similar to our findings. They found GSS to be a strong predictor of outcome (AUC 0.86) with S.T.O.N.E. nearly as predictive (AUC 0.84), which is consistent with our ROC results (where GSS slightly outperformed S.T.O.N.E.). Sanjaya *et al*. in Indonesia compared GSS and S.T.O.N.E. in predicting PCNL outcomes and noted that GSS was the more reliable predictor of stone-free status when compared to S.T.O.N.E score.[14]

Comparing GSS and S.T.O.N.E. head-to-head clarifies why they sometimes behave differently. The GSS is considerably easier to calculate compared to the S.T.O.N.E. nephrolithometry score. The GSS is based purely on a qualitative assessment of stone number, location, and renal anatomy using basic imaging (often plain CT or intravenous urography). In contrast, the S.T.O.N.E. score demands CT-based measurements such as skin-to-stone distance, stone density (Hounsfield units), degree of hydronephrosis, and number of calyces involved.[15] Interestingly, in the original paper introducing the STONE score, the authors noted that some CT parameters—specifically skin-to-stone distance, stone density, and hydronephrosis—were not independently associated with residual stones however the S.T.O.N.E score was overall significantly associated with residuals stone.[8,16] In practice, GSS may better reflect anatomic complexity and calyceal abnormalities—which can affect access and clearance—while S.T.O.N.E. incorporates density and SSD that influence fragmentation efficiency and tract selection. Our findings that GSS slightly outperformed S.T.O.N.E. (AUC 0.83 vs. 0.72) agrees with the findings of Sanjaya *et al*.[17] Scoring systems—especially the CT-based STONE score—were developed for PCNL but have been adapted to ureteroscopy and are now used to predict ureteral lithotripsy outcomes guiding case selection and treatment planning.[18]

LIMITATIONS OF STUDY

Our study has certain limitations. It is a single-center project with a modest sample size (n=110), which limits generalizability. Early assessment of SFS on day-1 KUB can misclassify small fragments relative to follow-up CT, consequently our SFR may be somewhat over- or under-estimated compared with cohorts that use standardized CT at four weeks or three months. Finally, we did not include CROES or S-ReSC in our head-to-head analyses; future work with larger, prospectively imaged cohorts and uniform CT endpoints could compare all four systems for optimized prediction.

CONCLUSION

PCNL continues to revolutionize the management of complex renal stones, and simple, validated scoring systems help translate pre-operative imaging into realistic expectations of stone-free outcomes. Our results show that both GSS and S.T.O.N.E. meaningfully stratify the likelihood of Stone Free Status after mini-PCNL however GSS can better predict as compared to S.T.O.N.E score. Given the moderate sample size and single-center design further multi-center studies are warranted to refine prediction.

ACKNOWLEDGMENT

The team is greatly indebted to radiology department of AFIU especially Dr Amir Hayat, Consultant Radiologist for reporting CT-KUBs for the urology department.

Conflict of Interest: None.

Funding Source: None.

Authors' Contribution

Following authors have made substantial contributions to the manuscript as under:

MTA & BM: Data acquisition, data analysis, critical review, approval of the final version to be published.

GA & AY: Study design, data interpretation, drafting the manuscript, critical review, approval of the final version to be published.

MFS & AA: Conception, data acquisition, drafting the manuscript, approval of the final version to be published.

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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