Original Article

STONE score versus Guy's Stone Score - prospective comparative evaluation for success rate and complications in percutaneous nephrolithotomy

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Abstract

Purpose: The aim of the current study was to compare Guy's score and STONE score in predicting the success and complication rate of percutaneous nephrolithotomy (PCNL).

Materials and Methods: A total of 445 patients were included in the study between July 2015 and December 2016. The patients were given STONE score and Guy's Stone Score (GSS) grades based on CT scan done preoperatively and intra- and post-operative complications were graded using the modified Clavien grading system. The PCNL were done by a standard technique in prone positions.

Results: The success rate in our study was 86.29% and both the GSS and STONE score were significantly associated with a success rate of the procedure. Both the scoring systems correlated with operative time and postoperative hospital stay. Of the total cases, 102 patients (22.92%) experienced complications. A correlation between STONE score stratified into low, moderate, and high nephrolithometry score risk groups (low scores 4–5, moderate scores 6–8, high scores 9–13), and complication was also found ($P = 0.04$) but not between the GSS and complication rate ($P = 0.054$).

Conclusion: Both GSS and STONE scores are equally effective in predicting success rate of the procedure.

Keywords: Percutaneous nephrolithotomy, renal, stone

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INTRODUCTION

Renal stone is a major cause of patients' presentation to urology clinics worldwide and Percutaneous nephrolithotomy (PCNL) has emerged as the treatment modality of choice for large and complex renal stones.[1,2] Like any other surgical procedures, this procedure is not without complications. Several preoperative nomograms have been proposed for prediction of success rates of PCNL and also for correlating with the complication rates to standardize the reporting of procedural success, interobserver reliability and aiding in training programs. These include Guy's Stone Score (GSS),[3] Clinical Research Office of the Endourological Society (CROES) nomogram,[4] STONE score,[5] and Seoul National University Renal Stone Complexity.[6,7] Computed tomography (CT) scan has now emerged as a major imaging tool for evaluation of stone disease. Guy's score

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and STONE score based on CT scan have been externally validated, but the superiority of one over the other has not been ascertained yet. We conducted a prospective study to compare Guy's score and STONE score in predicting the success and complication rate of PCNL.

MATERIALS AND METHODS

This prospective study was conducted in the Urology Department, SMS Hospital, Jaipur between July 2015 to December 2016. Ethical clearance was obtained from the institutional ethics committee, and all procedures performed in the study were in accordance with the 1964 Helsinki Declaration and its later amendments. All patients aged >18 years who underwent PCNL were included in the study after taking informed consent. Patients who had radiolucent renal calculi, any renal anomaly, previous history of any renal surgery on the affected side, chronic renal failure, heart disease, or spine abnormality were excluded from the study.

Preoperatively, the patients underwent routine investigations such as complete blood counts (CBCs), renal function tests (RFTs), coagulation profiles, urine culture, and noncontrast CT (NCCT) of kidney ureter bladder (KUB) (NCCT scan). GSS was assigned based on the NCCT images, and STONE Score parameters were reported by a senior radiologist of our Institute. PCNL was done by standard technique in the prone position.

GSS[3] used was as follows:

- Grade I - A solitary stone in the mid/lower pole with simple anatomy or a solitary stone in the pelvis with simple anatomy
- Grade II - 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 III - Multiple stones in a patient with abnormal anatomy or, stones in a calyceal diverticulum or partial staghorn calculus
- Grade IV - Staghorn calculus or any stone in a patient with spina bifida or spinal injury.

The STONE Score5 has been given in Table 1.

The demographic data of the patients, intra- and post-operative records were recorded in Excel Sheet. The complications were graded according to the Modified Clavien grading system[8] for PCNL. Operative time was defined as the time taken from the delineation of the PCS and up to the completion of the procedure. Fluoroscopy time was defined as the total time for which fluoroscopy was used during each procedure. All the patients were given preoperative intravenous antibiotics which were continued postoperatively. Postoperatively, the patients were given analgesics as and when needed. Routine blood investigations including CBC and RFT were done on the 2nd postoperative day along with a digital X-ray of KUB region to look for any residual fragment. The PCN tube was removed if there was no or clinically insignificant residual fragments (CIRFs)[9] on the X-ray. The procedure was considered to be successful if the patient had no residual fragments or had CIRFs which is defined as <4 mm, nonobstructing noninfectious, and asymptomatic residual fragments on X-ray KUB and ultrasonography done at the 4th week of follow up.

The statistical analysis was performed using SPSS version 20 IBM SPSS Statistics windows, Version 20.0. (Armonk, NY:IBM Corp.) and Student's *t*-test and Chi-square test were used. The value of $P < 0.05$ was considered as statistically significant.

RESULTS

The total number of patients who were eligible for final analysis in our study was 445. The demographic data of the patients are been summarized in Table 2. The mean age of the patients in the study was 40.8 ± 8.72 years. Male:female ratio was 2.027, with 298 males and 147 females. The stones on the right accounted for 54.61% of all the cases and the stones on the left was seen in 45.31% of cases. The mean body mass index (BMI) of the patients in the study was 24.53 ± 1.52. The success rate in our study was 86.29%. The mean stone size (mm^2) in this study was 658.87 ± 399.56. The mean GSS was 1.82 ± 0.9 and the mean STONE score was 6.93 ± 2.1.

The STONE score was significantly higher for those with residual calculi (8.81 ± 2.50) as compared to those who were stone free (7.57 ± 1.88) with a $P = 0.0002$, whereas the GSS for those with residual calculi was 2.06 ± 0.94 in comparison to 1.58 ± 0.77 for those with complete clearance with the value of $P < 0.0001$. Thus, both the scoring systems had a good correlation in predicting the stone free rate of

Table 1: STONE score

Variable	1	2	3	4
Stone size (mm^2)	0-399	400-799	800-1599	≥1600
Tract length (mm)	≤100	>100	-	-
Obstruction	None/mild	Moderate/severe	-	-
Calyces	1-2	3	Staghorn	-
Essence (HU)	≤950	>950	-	-

HU: Hounsfield units

PCNL [Table 3]. Patient status and stone free status with both the scoring systems are shown in Table 4. Logistic regression analysis showed odd's ratio (OR) of the STONE score to be 0.77 ($P = 0.001$) and of GSS to be 0.56 (0.001), and both were significantly associated with stone free rates. Moreover, we observed that for every unit of increase in STONE score, the operative time increased by 8.1 min ($P < 0.001$) and for every unit of increase in GSS it increased by 9.9 min ($P < 0.001$). The length of stay increased by 0.58 days ($P = 0.001$) as compared to 0.84 days ($P < 0.001$) for every unit of rise in STONE score and GSS, respectively [Table 5]. On receiver operating characteristic curve, there was no significant difference in the area under the curve (AUC) for the Guy's and STONE scoring systems (0. 739 [95% confidence interval (CI) 0.665–0.813] vs. 0.708 [95% CI 0.631–0.784]; $P > 0.05$) and both the scoring systems have good predictive rate for stone free status [Figure 1].

Intra- and post-operative complications were graded according to modified Clavien grading system.[8] Out of the total cases, 102 patients (22.92%) experienced complications. Grade 1 complication was seen in 44 patients, most common being postoperative nausea and vomiting followed by pain. Grade 2 complication was seen in 53 patients, of which 13 had nephrostomy site leakage for >12 h, 15 needed change of antibiotics due to infection, and 25 needed a blood transfusion. Grade 3a complication was seen in 3 patients of whom 2 needed a double J (DJ) stenting for persistent urinary leakage >24 h and 1 needed DJ stenting intraoperatively for pelvic perforation. Two patients developed Grade 3b complication and needed angioembolization for arteriovenous pseudoaneurysm. We did not come across any case of Grade 4 complication in our study, and there were no deaths among the patients up to 1 month of follow up.

A correlation between STONE score stratified into low, moderate, and high nephrolithometry score risk groups (low scores 4–5, moderate scores 6–8, high scores 9–13) and complication was also found ($P = 0.04$) but not between the GSS and complication rate ($P = 0.054$) [Tables 6 and 7].

DISCUSSION

Preoperative prediction of success rate and complications for PCNL has drawn the attention of the urologists

Table 2: Baseline demographics and preoperative characteristics

Variables	Mean±SD
Patients age (years)	40.8±8.72
Gender (%)	
Male	298 (66.96)
Female	147 (33.03)
Stone side (%)	
Right side stone	243 (54.61)
Left side stone	202 (45.39)
BMI (kg/m^2)	24.53±1.52
Stone size (mm^2)	658.87±399.56
Tract length (mm)	94.14±11.32
HU	1044.44±203.53
STONE nephrolithometry score	6.93±2.1
Guy's score	1.82±0.9
Number of tracts	1.35±0.57
Operative time	75.51±27.42
Postoperative hospital stay (days)	3.77±0.94
Stone free (%)	384 (86.29)
Nonstone free (%)	61 (13.71)
Modified Clavein grading	
1	44
2	53
3a	3
3b	2

BMI: Body mass index, HU: Hounsfield units, SD: Standard deviation

Table 3: Comparative chart between STONE score and Guy's Stone Score showing stone free and residual calculi

	Stone free	Residual calculi	*P*
STONE score (mean±SD)	8.81±2.50	7.57±1.88	0.0002
GSS (mean±SD)	1.58±0.77	2.06±0.94	<0.0001

GSS: Guy's Stone Score, SD: Standard deviation

Table 4: Patient distribution and stone-free status according to guy's and STONE nephrolithometry scoring systems

Nephrolithometry scoring system	Number of patients (%)	Number of stone-free patients (%)	Number of complications			
			1	2	3a	3b
The Guy's scoring system						
Grade 1	218 (48.89)	185 (84.86)	25	28	0	0
Grade 2	121 (27.19)	108 (89.25)	18	11	0	0
Grade 3	72 (16.18)	63 (87.5)	1	5	1	1
Grade 4	34 (7.64)	28 (82.35)	1	8	2	1
The STONE scoring system						
4	2 (2.7)	12 (100)	1	1	0	0
5	48 (10.79)	48 (100)	9	5	0	0
6	78 (17.53)	72 (92.31)	5	4	0	0
7	78 (17.53)	73 (93.59)	5	3	0	0
8	79 (17.75)	70 (88.61)	5	3	0	0
9	64 (14.38)	56 (87.5)	4	5	0	0
10	31 (6.97)	24 (77.42)	3	5	0	0
11	30 (6.74)	21 (70)	4	6	0	0
12	18 (4.04)	8 (44.44)	4	9	1	1
13	7 (1.57)	0	5	11	2	1

Table 5: Effect of Guy's and STONE nephrolithometry scoring systems on stone-free status, operative time, and length of stay

Nephrolithometry scoring system	B-coefficient	OR	95% CI	*P*
Stone free				
Guy score	-	0.56	0.32-0.65	0.001
Stone score system	-	0.77	0.61–0.89	0.001
Operative time (min)				
Guy score	9.9	-	5.4–14.6	<0.001
Stone score system	8.1	-	5.1–10.9	<0.001
Length of hospital stay (days)				
Guy score	0.84	-	0.31–1.11	<0.001
Stone score system	0.58	-	0.21–0.78	0.001

OR: Odds ratio, CI: Confidence interval

Table 6: Complication rate with STONE score stratified into groups

Complication	Stone score			*P*
	Low	Moderate	High	
Grade 1	15	16	13	0.04
Grade 2	8	18	27	
Grade 3a	0	0	3	
Grade 3b	0	0	2	
Grade 4a	0	0	0	
Grade 4b	0	0	0	
Grade 5	0	0	0	

Table 7: Complication rate and Guy's Stone Score

Variables	GSS I	GSS II	GSS III	GSS IV	*P*
Number of cases (%)	218 (48.89)	121 (27.19)	72 (16.18)	34 (7.64)	0.054
Complication (%)	53 (24.31)	29 (23.96)	8 (11.11)	12 (35.29)	

GSS: Guy's Stone Score

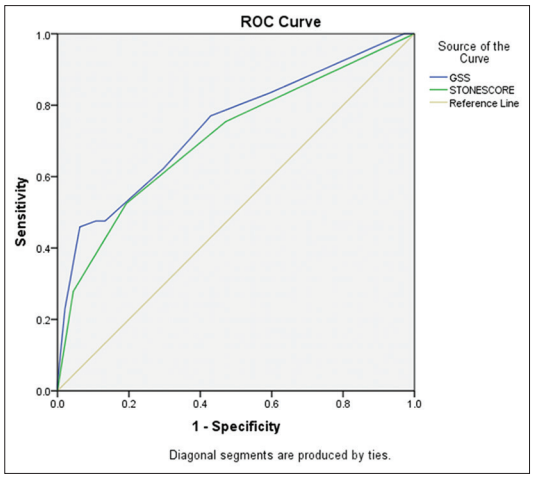

Figure 1: Receiver operating characteristic curve for Guy's Stone Score and STONE score for prediction of success rate of percutaneous nephrolithotomy

Test result variable(s)	AUC			
	Area	SE[a]	Asymptotic 95% CI	
			Lower bound	Upper bound
GSS	0.739	0.038	0.665	0.813
STONE score	0.708	0.039	0.631	0.784

The test result variable(s): GSS, STONE score has at least one tie between the positive actual state group and the negative actual state group. Statistics may be biased. [a]Under the nonparametric assumption. GSS: Guy's Stone Score, SE: Standard error, CI: Confidence interval, AUC: Area under the curve

in the recent years. Prognostic nomograms have been proposed and validated for this purpose. In the year 2008, Tefekli *et al*.[10] did not find any significant relationship between stone complexity and complications of PCNL. de la Rosette *et al*.[11] classified renal calculi based on stone burden (size) and found a significant correlation between stone burden and the duration of surgery. Thomas *et al*.[3] developed Guy's score using intravenous pyelogram and retrograde urethrogram (RGU) findings to classify the patients. Mishra *et al*.[12] came out with staghorn morphometry that requires CT urography along with a CT-based volumetric assessment software. Smith *et al*. introduced the CROES nephrolithometric nomogram[4] based on multivariate analysis of 2806 cases that underwent PCNL at 96 centers worldwide. It includes variables such as case load, prior treatment, BMI, staghorn stones, renal anomalies, and stone burden, location, and count. They concluded that stone burden was the best predictor of the stone-free rate. Other factors associated with the stone-free rate were case volume, prior stone treatment, staghorn stone, stone location, and stone count.

We prospectively compared two of the nomograms Guy's score and STONE score based on preoperative CT scans. There are some differences in these two scoring systems. In Guy's score, the parameters included are a number of stones, the location of the stone (calyces involved), abnormal anatomy, the presence of partial or complete staghorn stones and spinal injury/bifida. However, it does not include stone size, which in itself is a major predictor of the success rate of PCNL. Moreover, partial staghorn definitions are variable among many groups and hence can add to variability in reporting of outcomes of PCNL. The STONE score, on the other hand, includes Stone size (mm^2), tract length (mm), hydronephrosis or obstruction, Number of involved calyces, and stone density or Essence (Hounsfield units). Although a number of calyces involved is included in STONE score, it does not take into consideration the stone location as done by Guy's score. Our study intended to find whether these differences affect the predictive value of these scoring systems.

The success rate in our study was 86.29%. The success rate correlated with Guy's score ($P < 0.0001$) and STONE score overall ($P = 0.0002$). Moreover, the success rate also correlated significantly with the stone size ($P = 0.0003$) and the number of calyces ($P < 0.00001$) involved.

Thomas *et al*.[3] found GSS to have good reproducibility, with the good inter-rater agreement. Several investigators have found a good correlation between GSS and stone-free rate.[8,12] Thomas *et al*. who had proposed GSS reported 81%, 72.4%, 35%, and 29% success rate for GSS 1, 2, 3, and 4, respectively. Other authors have reported 93.9%–100%[8,13,14] stone-free rates for GSS1, 85.71% to 97%[8,13-15] for GSS 2, 90.17%–100%[8,13-15] for GSS 3, and 60%–77.77%[8,13-15] for GSS 4. Overall success rate has been given as 62%–97.73%[8,13-15] in different studies while validating GSS. In a retrospective study by Kumsar *et al*.[16] to compare GSS and STONE score the stone-free

rate was 90%, 96%, and 34% in GSS 1, 2, and 3 groups, respectively. Few authors have also found GSS based on CT scan to be effective in predicting success rate of PCNL.[14,15] Okhunov *et al*. gave the STONE score very recently, and retrospective studies[17,18] have validated it for predicting success rate of PCNL. Only one prospective study has also supported this.[19]

Labadie *et al*.[20] in their retrospective comparative study has found both the low GSS and STONE score to be significantly associated with stone-free rate (P = 0.002 and 0.004), and also both the systems to have a correlation with blood loss and length of stay. The AUC in their study was 0.634 (95% CI 0.566–0.702) for GSS and 0.670 (95% CI 0.602–0.738) for STONE score. In another retrospective study,[20] the AUC was 0.74 (95% CI 0.66–0.82) for GSS and 0.63 (95% CI 0.54–0.72) for STONE score, and good correlation was found between the scoring systems and stone free rate. The AUC for the Guy's and STONE scoring systems in our study was 0. 739 [95% CI 0.665–0.813] vs. 0.708 [95% CI 0.631–0.784]; $P > 0.05$) and both the scoring systems have a good predictive rate for stone free status.

We applied NCCT KUB for the calculation of both STONE score and GSS and found both to be good predictors of the success rate of PCNL. In addition, both the scores are good predictors of operative time and length of postoperative hospital stay. STONE score in our study correlated with complication rate when the scores were grouped as mild, moderate, and severe, whereas the GSS did not correlate significantly with the complication rate. Vicentini *et al*.[14] and Mandal *et al*.[8] found a correlation between GSS and complication rate, but Thomas *et al*.[3] and Noureldin *et al*.[21] did not find so.

Preoperative nomograms can prove to be very helpful tools meant for preoperative prediction of success rate and complication rate of any procedure. For a nomogram to be ideal it should be easy to apply, should have good interobserver reproducibility and should correlate with the success and complication rate of the procedure. The best scoring system would be one which would help in unifying reporting for research, training purposes and also for proper patient counseling. PCNL though a very novel technique, is not free of complications,[22] so a proper nomogram is always a requirement. GSS can be equally be applied based on a simple X-ray and RGU or an IVU beside CT scan whereas STONE score is based only on CT scan. CT scan though expensive and is associated with much higher radiation exposure but the advantages of CT scan in stone disease needs no mention. GSS can be helpful at places where CT scan facility is not available, for example, in developing and underdeveloped countries.

The strength of our study was it is a prospective study with a good number of patients. The limitation of our study was that it was a single center study.

CONCLUSION

Preoperative nomograms can prove as a valuable tool for proper patient counseling about the stone-free rate and complications associated with PCNL. Both GSS and STONE scores are equally effective in predicting success rate of the procedure. Further, large scale multicenter prospective studies can help in determining the role of these nomograms in predicting complication rates and whether there is need to develop new nomogram combining these scores for better stone characterisation.

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Conflicts of interest

There are no conflicts of interest.

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