Validation of S.T.O.N.E nephrolithometry and Guy's stone score for predicting surgical outcome after percutaneous nephrolithotomy

Nasir Khan, Syed Muhammad Nazim, Muhammad Farhan, Basit Salam[1], Muhammad Hammad Ather

Departments of Surgery and [1]Radiology, The Aga Khan University Hospital, Karachi, Pakistan

Abstract

Background: The aim of this study was to validate and compare Guy's and S.T.O.N.E. scoring systems in predicting perioperative and postoperative outcome following percutaneous nephrolithotomy (PCNL).

Materials and Methods: From November 2015 to June 2017, 190 patients with renal stones who underwent single tract unilateral PCNL in the prone position were included in our study. Guy's and S.T.O.N.E. nephrolithometry scores were calculated in each case based on preoperative computed tomography images. The association of these scoring systems with stone-free status, length of hospital stay, operative time, and postoperative complications was studied. Regression analysis was done, and receiver operating characteristic curves were plotted.

Results: Mean S.T.O.N.E. and Guy's stone scores were 8.76 ± 2.29 and 2.70 ± 1.0, respectively. When compared with patients with residual stones, stone-free (SF) patients had significantly lower mean Guy's score (2.58 ± 1.01 vs. 3.23 ± 0.77 [$P < 0.001$]) and S.T.O.N.E. scores (8.44 ± 2.24 and 10.17 ± 2.0 [$P < 0.001$]), respectively. On logistic regression analysis, both Guy's score (odds ratio [OR] = 0.48, $P = 0.001$) and S.T.O.N.E score (OR = 0.78, $P = 0.001$) were found to be significantly associated with SF status. Both of these scoring systems were also significantly associated with longer operative time (>90 min), prolonged hospital stay (>3 days) and overall complications. No significant difference was found in the area under curve for both scoring systems for stone clearance.

Conclusion: Both the S.T.O.N.E and Guy's scoring systems were found to predict the outcome of PCNL, either of these could be used in the routine clinical practice for patients' counseling.

Keywords: Endoscopy, kidney, lithotripsy, nephrolithiasis, outcome, percutaneous, scoring

Address for correspondence: Dr. Syed Muhammad Nazim, CHC Offices, Department of Surgery, The Aga Khan University Hospital, Karachi-74800, Pakistan.
E-mail: muhammad.nazim@aku.edu

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INTRODUCTION

Percutaneous nephrolithotomy (PCNL) is considered the treatment of choice for complex, large, and staghorn calculi due to its high stone-free rate (SFR), minimal complications, and minimal need for auxiliary procedure.[1,2]

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Various factors have been shown to affect the outcome of PCNL including patient-related clinical and anatomical factors, stone-related factors, and technical factors.[3] Multiple attempts have been made to develop an objective

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standardized system for the classification of upper tract stones complexity, which may also help to predict the outcome of PCNL such as SFR and complications.[4,5] Guy's stone score (GSS)[6] and S.T.O.N.E nephrolithometry scores[7] were introduced for objective assessment of renal stones and predicting PCNL outcomes. Both of these scoring systems are based on the parameters derived from preoperative imaging.

The aim of the present study was to validate and compare the Guy's and S.T.O.N.E. nephrolithometry scoring systems in predicting PCNL outcomes in terms of stone-free rate (SFR), operative time (OR), length of hospital stay (LOS), and complications.

MATERIALS AND METHODS

After obtaining institutional review board approval, a prospective cross-sectional study was conducted using nonprobability consecutive sampling. All adult patients (>18 years) who underwent single tract and unilateral PCNL procedure for radio-opaque calculi were included. Patients with renal insufficiency (serum Creatinine >1.3 mg/dL), bilateral renal stones, radiolucent stones, a history of prior surgery on ipsilateral kidney, active urinary tract infection, coagulopathy, and special upper tract anatomy (i.e., horse shoe and ectopic kidneys) were excluded. We also excluded patients with the presence of a nephrostomy tube or ureteral stent on the same side, patients with concurrent ureteral stones or those who underwent additional endoscopic, laparoscopic, or open procedures under the same anesthesia.

The information regarding demographic factors, clinical and operative data were collected prospectively and included age, gender, body mass index (BMI), American Society of Anesthesiology (ASA) score, laterality, operative time (puncture to dressing), length of hospital stay, and number of transfusions.

All patients had a noncontrast computed tomography (CT) scan performed within 4 weeks of surgery on a 64-slice scanner (Aquilion, Toshiba Medical Systems™, Shimoishigami, Otawara-Shi, Japan) using 3-mm axial and reformatted 3-mm coronal sections. The images were evaluated on a picture-archiving computer system (View Pro-X version 4.0.6.2; Rogan-Delft, Veenendaal, Holland).

Both GSS and S.T.O.N.E nephrolithometry score were calculated for each patient on CT scan by a single experienced radiologist. For the Guy's Score, the four grades were assigned based on the elements of location, number, and absence or presence of abnormality in the renal unit.[6] For the S.T.O.N.E score, the variables i.e., (S) tone size, (T) ract length, degree and presence of (O) bstruction (hydronephrosis), (N) umber of involved calyces, and stone (E) ssence (density) were measured on CT scan and were scored according to the predefined scoring. The sum of individual variables was used to calculate S.T.O.N.E nephrolithometry score as proposed by Okhunov *et al*.[7]

All procedures were performed in the prone position under general anesthesia using single tract. Stone localization and tract dilatation with metallic Alken dilators™ was done under fluoroscopy guidance and size 26 Fr. Amplatz sheath was used. We used "Percutaneous Universal Nephroscope" size 24 Fr with 20° angle of view (Richard Wolf GmbH™). We described the technique of PCNL in our earlier publication.[8] Stone fragmentation was achieved using Swiss Lithoclast™ Master (EMS™). The per-operative assessment of stone clearance and hence completion of procedure was done by both nephroscopic and fluoroscopic inspection. A size 12 Fr. Nephrostomy tube was used for temporary drainage.

For the presence of any residual stone(s), a plain KUB X-ray ± ultrasound scan was done on follow-up visit after 1 month and stone-free (SF) status was defined as complete clearance with no residual stone fragment.

The statistical analysis was done on SPSS software version 22 IBM SPSS statistics for windows version 22.0 Armonk, NY; USA. Comparisons were made between stone-free patients and those with residual stones using various variables. Categorical variables were presented with numbers and percentages and compared using the Chi-square test or Fisher's exact test, whereas means and standard deviation were used to present the continuous variables and compared using the independent sample *t*-test and one-way analysis of variance (ANOVA) test. Logistic regression analysis was done to determine the possible association between various demographic and clinical factors and variables in S.T.O.N.E and Guy's scoring systems with SF-status and complications. $P < 0.05$ was considered statistically significant. To assess the predictive role of the two scoring systems on clinical outcomes, receiver operating characteristic (ROC) curves were generated.

The primary outcome of the study was to determine the SFR and compare it with the two scoring systems for clearance. The secondary outcome was to evaluate these scoring systems for predicting longer operative time (>90 min), prolonged hospital stay (>3 days), and peri/postoperative complications within 30 days of procedure using modified Clavian grading system.

RESULTS

A total of 293 PCNL procedures were performed during the study period, out of which 190 (64.8%) patients (114 male and 76 female, respectively) fulfilled the study inclusion criteria and were included in the final analysis. The mean age at presentation was 46.7 ± 11.8 years with a mean BMI of 26.45 ± 3.77 kg/m^2. The distribution of stone on either side was almost equal. Ninety percent of our patients belonged to ASA category 1 or 2. Mean S.T.O.N.E and GSS were 8.76 ± 2.29 and 2.70 ± 1.0, respectively.

The overall SFR was 81.57% (155/190). Stone clearance was more marked in younger individuals ($P = 0.005$) and on right side ($P = 0.04$). Compared to patients with residual stone, patients who achieved SF status had a significantly lower mean stone size (748.41 ± 422.47 vs. 1230.8 ± 430.3 mm^2, $P < 0.001$), mean operative time (90.11 ± 18.41 vs. 114.71 ± 14.8 min, $P < 0.001$), and mean length of hospital stay (2.88 ± 1.05 vs. 3.51 ± 0.65 days, $P = 0.001$). Similarly, they had lower mean S.T.O.N.E score (8.44 ± 2.24 vs. 10.17 ± 2.0, $P < 0.01$) and Guy's score (2.58 ± 1.01 vs. 3.23 ± 0.77, $P < 0.01$), respectively.

Among individual variables of S.T.O.N.E. nephrolithometry score, larger stone size ($P < 0.001$), and number of involved calices ($P < 0.001$) were the factors associated with residual stones. A larger stone burden (>800 mm^2) was found in 22/35 (63%) of patients among residual stones group compared to 40/155 (26%) of patients in SF group ($P < 0.01$). A significantly larger proportion of patients (30/35 (85.7%) with residual stones had 3 or more calyces involved. The degree of obstruction, tract length, and stone density were not found to be the significant factors for predicting SF status. Regarding complications, age, left side, and presence of severe obstruction were the variables associated with significant complications [Table 1].

Among patients with residual stones, 13/35 (37%) underwent additional treatment. Shock-wave lithotripsy was done in 8 (23%) patients, ureteroscopy in 2 (6%), and JJ stent in 3 (9%) patients. None of our patients required redo-PCNL. The remaining residual stones 22 (62%) were managed conservatively with medical dissolution therapy.

The distribution of stone clearance and peri-operative complications according to individual Guy's and S.T.O.N.E nephrolithometry scores is shown in Table 2.

Logistic regression analysis showed that with each unit increase in Guy's grade, the odd of stone clearance decreased by 0.48 ($P = 0.001$) and with each unit increase in the S.T.O.N.E score, the odd of stone clearance decreased by 0.78 ($P = 0.001$). Younger age and right side were also found to be significant independent variables for stone clearance. Patients with age <50 years had 3.38 greater odds of stone clearance compared to elder ones. Both S.T.O.N.E score and Guy's scores were also found to be the predictive factors for longer operative time (>90 min) and prolonged length of stay (>3 days) on logistic regression analysis [Table 3].

Overall 24 patients (12.6%) had peri/postoperative complications with majority (16/24) Clavian grade 1 or 2. Blood loss requiring transfusion was the most common complication seen in 6 patients. Only 1 patient required angiographic embolization for pseudoaneurysm. There were no 30 days postoperative mortality.

Regarding complications, age, and left side were found to be significant factors on logistic regression analysis [Table 3]. Patients >50 years had 2.9 times the odd of complications compared to younger individuals and odds of complications on the left side were 4.1 times as compared to odds on the right side. Both S.T.O.N.E score ($P = 0.02$) and GSS ($P = 0.018$) showed significant association with complications.

The ROC curves of both scoring systems and their prediction of SF status are shown in Figure 1. No significant difference was found in the areas under the curves (AUC) for STONE (0.72, [95% confidence interval (CI): 0.65–0.78]) and Guy's scoring systems (0.68, [95% CI: 0.60–0.74], $P = 0.19$) for stone clearance [Figure 1].

DISCUSSION

PCNL is an ideal treatment for large and complex upper tract stones. Preoperative imaging is crucial, not only to establish the diagnosis but also to determine the optimal treatment and surgical planning. Noncontrast CT scan (CTKUB) is the gold standard imaging modality for urolithiasis[9] which can determine the complexity of a stone, i.e., size, density, and distribution within the collecting system, the anatomy of pelvi-calyceal system, and the orientation and anatomical relationship of the kidneys.[10,11]

A standardized and reproducible grading system can show correlation with stone clearance and complication rate and is also useful for patient counseling, uniform, and standardized

Table 1: Comparison of categorical variables of 190 patients for stone clearance and peri-operative complications

Variables	Total (*n*=190)	Stone free, *n* (%)	Residual stone, *n* (%)	*P*	Complications, *n* (%)	*P*
Age (years)						
≤50	78	71 (91)	7 (9)	0.005	3 (4)	0.02[a]
>50	112	84 (75)	28 (25)		21 (18.7)	
Gender						
Male	114	92 (80.7)	22 (19.3)	0.84	15 (13)	0.78
Female	76	63 (83)	13 (17)		9 (11.8)	
-					13 (18.3)	
Laterality						
Right	92	83 (90.2)	9 (9.8)	0.04	5 (5.4)	0.04
Left	98	72 (73.5)	26 (26.5)		19 (19.4)	
Stone size (mm²)						
≤799	128	115 (90)	13 (10)	0.001	14 (11)	0.31
≥800	62	40 (64.5)	22 (35.5)		10 (16.1)	
Track (mm)						
Track <100	93	77 (82.8)	16 (17.2)	0.71	12 (12.9)	0.91
Track ≥100	97	78 (80.4)	19 (19.6)		12 (12.3)	
Obstruction						
None	70	60 (85.7)	10 (14.3)	0.33	3 (4.3)	0.008[a]
Severe	120	95 (79.1)	25 (20.9)		21 (17.5)	
Number of calices						
1-2	81	76 (93.8)	5 (6.2)	<0.001	6 (7.4)	0.06
≥3	109	79 (72.5)	30 (27.5)		18 (16.5)	
Essence (H.U)						
≤949	56	47 (84)	19 (16)	0.68	7 (12.5)	0.97
≥950	134	108 (80.6)	26 (19.4)		17 (12.7)	
Complications						
No	166	139 (83.7)	27 (16.3)	0.05	N/A	N/A
Yes	24	16 (66.6)	8 (33.4)		N/A	N/A

Chi square/aFischer's exact test applied. N/A: Not available, HU: Hounsfield unit

Table 2: Patients' distribution, stone clearance and complications according to Guy's and STONE nephrolithometry-scoring systems

Scoring system	Number and percentage of patients (%)	Stone clearance, *n* (%)	No stone clearance, *n* (%)	*P*	Complications, *n* (%)	*P*
The Guy's scoring system						
G1	28 (31.11)	27 (96.42)	1 (3.57)	0.004	1 (3.57)	0.11
G2	49 (25.7)	45 (91.83)	4 (8.16)		4 (8.16)	
G3	65 (34.21)	49 (75.3)	16 (24.61)		9 (13.84)	
G4	48 (25.26)	34 (70.83)	14 (29.16)		10 (20.83)	
Total	190 (100)	155 (81.57)	35 (18.42)		24 (12.63)	
Mean Guy's grade	2.70±1.0	2.58±1.01	3.23±0.77	0.001*		
The STONE nephrolithometry score						
S5	12 (6.31)	12 (100)	0 (0)	0.02	0 (0)	0.22
S6	25 (13.15)	23 (92)	2 (8.0)		2 (8.0)	
S7	26 (13.68)	24 (92.30)	2 (7.69)		4 (15.38)	
S8	32 (16.84)	29 (90.62)	3 (9.37)		3 (9.37)	
S9	24 (12.63)	19 (79.16)	5 (20.83)		2 (8.33)	
S10	24 (12.63)	17 (70.83)	7 (29.16)		3 (12.5)	
S11	18 (9.47)	12 (66.66)	6 (33.33)		2 (11.11)	
S12	15 (7.89)	10 (66.66)	5 (33.33)		3 (20)	
S13	14 (7.3)	9 (64.28)	5 (35.71)		5 (35.71)	
Total	190 (100)	155 (81.57)	35 (18.42)		24 (12.63)	
Mean STONE score	8.76±2.29	8.44±2.24	10.17±2.0	<0.001*		

One-way ANOVA test. **t*-test applied

reporting, and hence, comparison between different surgeons, institutes, and techniques (e.g., Supine vs. Prone PCNL).[7] The contemporary predictive scoring systems for PCNL outcome include GSS, S.T.O.N.E nephrolithometry, Staghorn morphometry, and Clinical research office of the endo-urological society (CROES) nephrolithometric nomogram. These objective tools were aimed to incorporate the seminal factors to quantify stone complexity.[12]

Guy's scoring system[6] is more of a qualitative tool while S.T.O.N.E nephrolithometry[7] is a quantitative scoring system. These two scoring systems use parameters that are easy to calculate on a noncontrast enhanced CT (CT KUB) scan and do not require any specialized software. These 2 scoring systems share only two variables i.e., presence of staghorn stone and stone location. Other variables (stone size and number, stone density, renal anatomy, renal pelvic obstruction, tract length, and the presence of spina bifida or spinal injury) are included separately in each scoring system. The CROES nephrolithometry nomogram also takes into account other factors which can predict success of PCNL, i.e., prior surgeries and case volumes of the operating surgeons.[13] Vicentini *et al.* in a recent study found GSS to be the quickest to measure among scoring systems with mean application time of 27.5 s only.[14]

We previously analyzed and validated S.T.O.N.E score in a different cohort of patients and found it to be significantly associated with SFR. Larger stone size and involvement of multiple calyces were also found, among the individual variable to be associated with residual stones.[15]

The patients in the current study were different from the cohort of Thomas *et al.*[6] (GSS) and Okhunov *et al.* (S.T.O.N.E).[7] Patients in our series were younger compared to patients in both the studies. Mean S.T.O.N.E score (8.76) in our series was higher compared to Okhunov *et al.* study (7.7).[7] In our SF group, the mean score was 8.44 compared to 6.8 in their SF group. Our patients had higher stone density in both SF group and for those with residual stones compared to Okhunov *et al.* cohort.

Thomas *et al.*[6] originally described the GSS and showed it to be significantly associated with SFR ($P = 0.01$). The mean Guy's score in our cohort was 2.7, and we had more Grade 3 and 4 complexity patients, i.e., 34% and 25%, respectively, compared to 21% and 17% in Thomas *et al.*[6] cohort. Our overall SFR 81.6% was much higher, compared to 62%. The mean operative time in SF group was comparable to Thomas *et al.* and Okhunov cohort, as was the mean length of stay. In none of our patients, the procedures were abandoned. We did not calculate estimated blood loss and found it difficult to calculate for PCNL procedure.

It is evident from our and other reported works that both the systems were able to predict SF status, length of stay and operating time. As both the scoring systems predicted well for the measured outcomes, they can serve as "stratification tools" providing complexity of each procedure to both the treating surgeon and patient by giving an idea of a potentially "easy" or "difficult" case.

Noureldin *et al.*[16] also compared both Guy's and S.T.O.N.E nephrolithometry scoring systems for predicting SF status in a retrospective cohort of 185 patients with overall SFR of 72%. They found both systems to predict for SF status, blood loss, operative time, and length of stay, but no significant association was found in the scoring systems and complications. In another study,

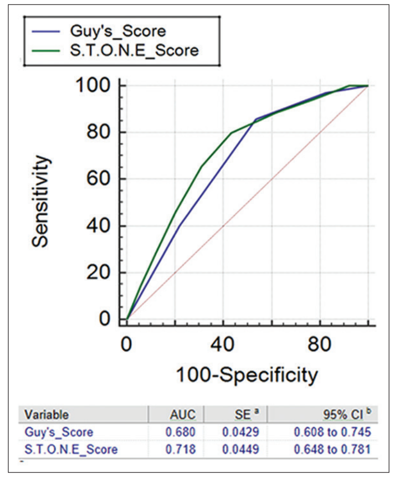

Figure 1: Receiver operating curves for Guy's and S.T.O.N.E nephrolithometry scoring systems for predicting stone-free status

Table 3: Logistic regression analysis for effect of different variables on stone clearance, operative time, length of stay, and complications

Variable	OR	95% CI		*P*
		Lower	Upper	
Stone clearance				
Guy's score	0.48	0.31	0.74	0.001
STONE score	0.78	0.59	0.84	<0.01
Age				
≤50 (ref)	-	-	-	
>50	3.38	1.39	8.20	0.007
Laterality				
Left (ref)	-	-	-	
Right	3.33	1.46	7.57	0.004
Operative time (> 90 min)				
Guy's score	2.44	1.74	3.42	<0.001
STONE score	1.54	1.32	1.80	<0.001
Age				
≤50 (ref)	-	-	-	0.02
>50	1.97	1.10	3.51	
Laterality				
Left (ref)	-	-	-	
Right	0.847	0.479	1.497	Not significant
Length of stay (>3 days)				
Guy's score	1.80	1.20	2.70	0.004
STONE score	1.30	1.10	1.54	0.001
Age				
≤50 (ref)	-	-	-	
>50	1.539	0.737	3.213	Not significant
Laterality				
Left (ref)	-	-	-	
Right	0.772	0.374	1.591	Not significant
Complications				
Guy's score	1.801	1.107	2.93	0.018
STONE score	1.25	1.04	1.51	0.02
Age				
<50 (ref)	-	-	-	
>50	2.93	1.10	7.74	0.03
Laterality				
Left (ref)	-	-	-	
Right	0.23	0.085	0.67	0.007

OR: Odds ratio, CI: Confidence interval

Labadie *et al.*[12] evaluated urolithiasis-scoring systems in PCNL and found both GSS and stone scores to be significantly associated with SFR (P = 0.002 and P = 0.004, respectively) and length of stay (P = 0.03 and P = 0.009, respectively).

We noted that both GSS and S.T.O.N.E nephrolithometry scoring systems to be equally effective with AUC of 0.68 versus 0.72, respectively, for predicting SF status. Our study showed that both S.T.O.N.E score and GSS show positive association with peri-operative complications. Our study had a lower overall complication measured by modified Clavian grade compared to Thomas *et al*.[6] with overall complication rate of 52% and Okhunov *et al*.[7] with 21% overall complication. The outcomes determined from CROES PCNL global study[15] showed overall SFR of 75.5% and a complication rate of 20.5%. Bleeding requiring blood transfusion is the most common complication observed in our study and was seen in 3.1% of patients, which is lower than 5.7% reported transfusion rate observed in CROES study.

Our study has the strength of being prospective in nature and using rigorous endpoints i.e., complete stone clearance. We had complex stones in our series but we included only single tract. Carrying out PCNL procedures using multiple tracts might render more patients SF. We excluded mini-PCNL cases using smaller sheath size. We did not assess the stone composition in all of our patients neither did we check for interobserver agreement and inter observer reliability of S.T.O.N.E and Guy's scores which were calculated by only a singly experienced radiologist on radiology workstation. However, studies have shown good interobserver reliability and concordance for both the scoring system.[7,17] One of the major limitation in the current work is the use of ultrasound and plain X-ray to assess the SF status. Indeed use of CT may show a lower SF rate. The second important issue is the relatively smaller number of patients.

CONCLUSION

We found both GSS and S.T.O.N.E scoring systems to be simple and easy to apply. As both of these scoring systems were found to predict the outcome of PCNL, either of these could be used in the routine clinical practice to preoperatively counsel the patients regarding stone complexity and hence stone clearance.

Ethical approval

This cross-sectional study was carried out at Aga Khan University Hospital (AKUH) after approval from University's Ethical Committee (Ethics Review Committee)-AKUH.

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Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Rosa M, Usai P, Miano R, Kim FJ, Finazzi Agrò E, Bove P, *et al.* Recent finding and new technologies in nephrolitiasis: A review of the recent literature. BMC Urol 2013;13:10.
2. Demirbas A, Yazar VM, Ersoy E, Demir DO, Ozcan S, Karakan T, *et al.* Comparision of percutaneous nephrolithotomy and retrograde intrarenal surgery for the treatment of multicalyceal and multiple renal stones. Urol J 2018;15:318-22.
3. Smith A, Averch TD, Shahrour K, Opondo D, Daels FP, Labate G, *et al.* A nephrolithometric nomogram to predict treatment success of percutaneous nephrolithotomy. J Urol 2013;190:149-56.
4. El-Nahas AR, Eraky I, Shokeir AA, Shoma AM, El-Assmy AM, El-Tabey NA, *et al.* Factors affecting stone-free rate and complications of percutaneous nephrolithotomy for treatment of staghorn stone. Urology 2012;79:1236-41.
5. Shahrour K, Tomaszewski J, Ortiz T, Scott E, Sternberg KM, Jackman SV, *et al.* Predictors of immediate postoperative outcome of single-tract percutaneous nephrolithotomy. Urology 2012;80:19-25.
6. Thomas K, Smith NC, Hegarty N, Glass JM. The Guy's stone score – Grading the complexity of percutaneous nephrolithotomy procedures. Urology 2011;78:277-81.
7. Okhunov Z, Friedlander JI, George AK, Duty BD, Moreira DM, Srinivasan AK, *et al.* S.T.O.N.E. nephrolithometry: Novel surgical classification system for kidney calculi. Urology 2013;81:1154-9.
8. Haroon N, Nazim SM, Ather MH. Optimal management of lower polar calyceal stone 15 to 20 mm. Korean J Urol 2013;54:258-62.
9. Maghsoudi R, Etemadian M, Kashi AH, Ranjbaran A. The association of stone opacity in plain radiography with percutaneous nephrolithotomy outcomes and complications. Urol J 2016;13:2899-902.
10. Magrill D, Patel U, Anson K. Impact of imaging in urolithiasis treatment planning. Curr Opin Urol 2013;23:158-63.
11. De S, Autorino R, Kim FJ, Zargar H, Laydner H, Balsamo R, *et al.* Percutaneous nephrolithotomy versus retrograde intrarenal surgery: A systematic review and meta-analysis. Eur Urol 2015;67:125-37.
12. Labadie K, Okhunov Z, Akhavein A, Moreira DM, Moreno-Palacios J, Del Junco M, *et al.* Evaluation and comparison of urolithiasis scoring systems used in percutaneous kidney stone surgery. J Urol 2015;193:154-9.
13. de la Rosette J, Assimos D, Desai M, Gutierrez J, Lingeman J, Scarpa R, *et al.* The clinical research office of the endourological society percutaneous nephrolithotomy global study: Indications, complications, and outcomes in 5803 patients. J Endourol 2011;25:11-7.
14. Vicentini FC, Serzedello FR, Thomas K, Marchini GS, Torricelli FCM, Srougi M, *et al.* What is the quickest scoring system to predict percutaneous nephrolithotomy outcomes? A comparative study among S.T.O.N.E score, guy's stone score and croes nomogram. Int Braz J Urol 2017;43:1102-9.
15. Farhan M, Nazim SM, Salam B, Ather MH. Prospective evaluation of outcome of percutaneous nephrolithotomy using the 'STONE' nephrolithometry score: A single-centre experience. Arab J Urol 2015;13:264-9.

16. Noureldin YA, Elkoushy MA, Andonian S. Which is better? Guy's versus S.T.O.N.E. nephrolithometry scoring systems in predicting stone-free status post-percutaneous nephrolithotomy. World J Urol 2015;33:1821-5.
17. Ingimarsson JP, Dagrosa LM, Hyams ES, Pais VM Jr. External validation of a preoperative renal stone grading system: Reproducibility and inter-rater concordance of the Guy's stone score using preoperative computed tomography and rigorous postoperative stone-free criteria. Urology 2014;83:45-9.