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ORIGINAL ARTICLE

Comparison of Stone Scoring Systems as Predictive Tools for Percutaneous Nephrolithotomy Outcome in Kidneys with Anatomical Abnormalities: A Retrospective Study

Gökhan Çil,[1] Mehmet Yılmaz,[1] Yusuf Şahin,[1] Ahmet Yaser Müslümanoğlu[1]

1. Bağcılar Training and Research Hospital, İstanbul, Turkey.

Abstract

Background/Aim: European urology guidelines recommend percutaneous nephrolithotomy (PNL) as a treatment modality to remove complex kidney stones over 2 cm in size. Aim of this study was to compare stone scoring systems in predicting stone-free status and complications rate after percutaneous nephrolithotomy (PNL) in abnormal kidneys.
Methods: Retrospective analysis of data from 94 patients with anatomical abnormalities who underwent PNL for the kidney stones in the Clinic between January 2017 and January 2022 was performed. Sixty-four patients with renal anomalies who underwent PNL were included in the study. Guy, S.T.O.N.E. and CROES nephrolitometry scores were evaluated for each patient by the same researcher using non-contrast computed tomography. The modified Clavien grading system was used to evaluate complications.
Results: The mean age and body mass index (BMI) of the patients were 46 ± 11.7 and 28 ± 6 kg/m^2, respectively. There was no differences between the groups in terms of operative parameters, renal anomaly categorisation and complications. Compared with the residual stone group, GSS (2.49 vs 3.03; p = 0.001) and S.T.O.N.E. scores (7.26 vs 8.38; p = 0.021) in the stone free group were statistically significantly lower, while the CROES score was lower in the group with residual stones (172 vs 245; p < 0.001). In the Chi-square analysis performed between Clavien complication rating and stone scoring systems, no success was found in predicting the presence of complications in any scoring system.
Conclusion: Although nomograms were successful in predicting postoperative stone-free status (SFS) after PNL in abnormal kidneys, they may not predict postoperative complications.

Key words: Renal anomaly; Percutaneous nephrolithotomy; Guy's score; S.T.O.N.E. score; CROES nomogram.

Correspondence:
GÖKHAN ÇİL
T: +905325832037
E: cilgok@gmail.com

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Introduction

European urology guidelines recommend percutaneous nephrolithotomy (PNL) as a treatment modality to remove complex kidney stones > 2 cm size.[1] PNL can be applied in different cases from normal to abnormal kidneys. This procedure may become more difficult due to different kidney locations, anatomically abnormal calyxes, abnormal relationships with neighbouring organs and difficulties in the movements of endoscopic instruments.[2] Renal anatomy, stone burden, stone localisation, stone size and density, skeletal anomalies, comorbidities and surgeon experience affect the success of PNL.[3] Different scoring systems have been designed to evaluate

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complications and the stone free rate (SFR) that may develop after PNL, as well as to inform patients about possible outcomes before the operation. Guy's stone score (GSS), S.T.O.N.E. (stone size (S), tract length (T), obstruction (O), number of involved calyces (N) and essence or stone density (E)) nephrolithometry score and CROES (Clinical Research Office of the Endourological Society) nephrolithometry nomogram are the most widely used scoring systems.[4-6] There is no consensus on the best scoring system for kidneys with renal anomalies. Aim of this study was to compare the value of renal scoring nomograms in predicting PNL outcomes in kidneys with renal anomaly.

Methods

This study was approved by the local Ethics Committee of the Hospital (15 November 2022, Decision No 189) and complied with the principles of the Declaration of Helsinki. All patients provided written informed consent preoperatively.

The data of 94 patients with abnormal kidneys among 494 patients who underwent PNL between January 2017 and January 2022 were retrospectively analysed. Patients under 18 years of age (n = 11), patients with preoperatively ureteral stent or nephrostomy catheter inserted (n = 9), who underwent miniaturised percutaneous surgery (n = 6) and patients whose preoperative computed tomography (CT) images could not be accessed (n = 4) were excluded from the study (Figure 1).

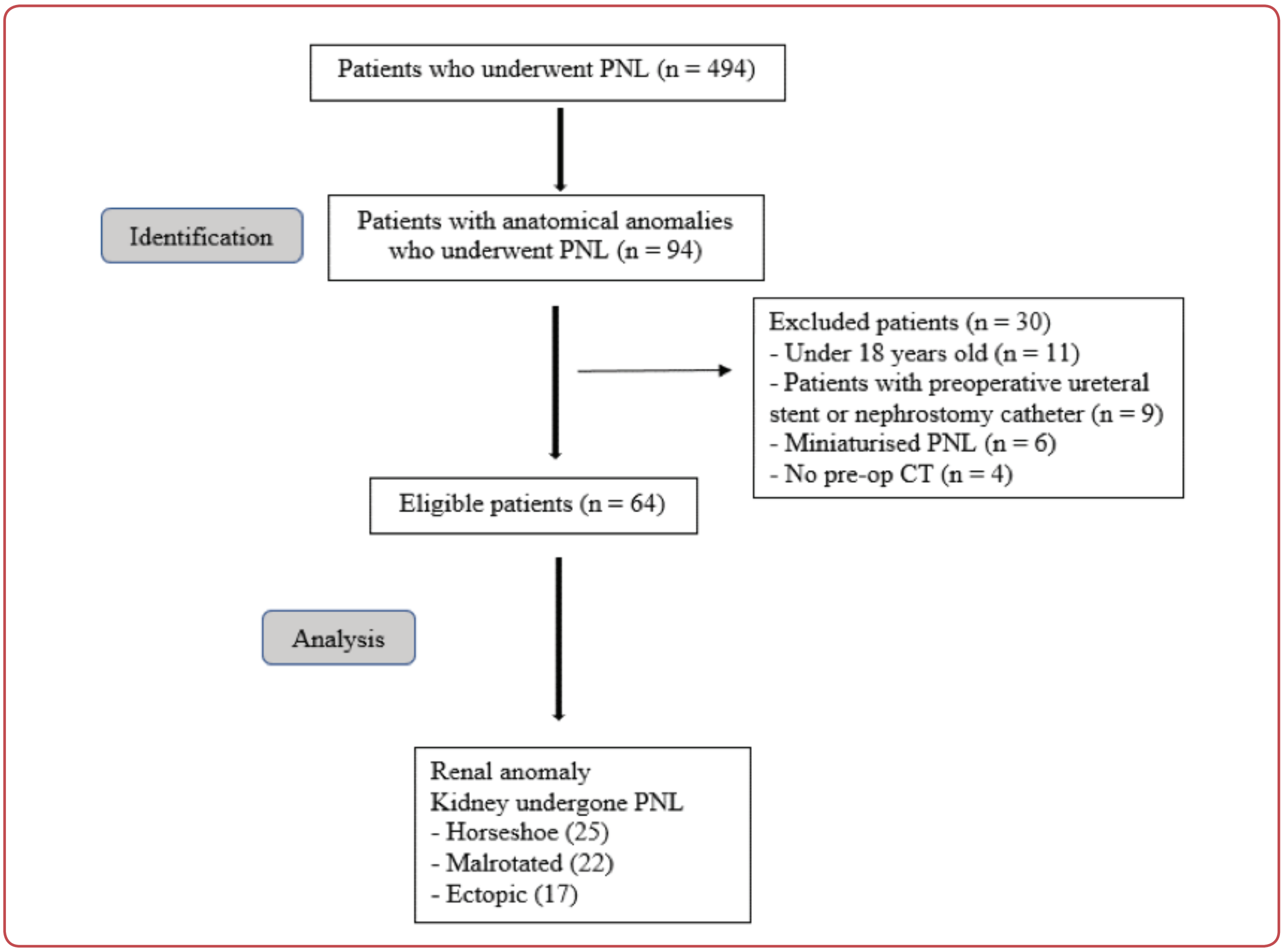

Figure 1: Patient selection and study design flowchart

PNL: percutaneous nephrolithotomy; CT: computed tomography;

Finally 64 patients were included in the study. Patients were divided into the two groups considering to their stone-free status (SFS). Group 1 consisted of 35 stone-free patients, while Group 2 consisted of 29 patients with residual stones. The groups were compared according to their demographic features (age, sex, body mass index - BMI), stone characteristics (stone load, location), anatomical abnormality type and operative parameters (nephrostomy length of stay, location and success, operation time and complications). Clavien grading system was used to evaluate postoperative complications.[7]

Measurements and patient grading

Low-dose non-contrast CT and/or urography, stone size (in mm^2 multiplied by the two longest dimensions), stone density (Hounsfield Unit), renal calyx anatomy in terms of skin-to-stone distance (mm) provided the most appropriate percutaneous access site estimation was performed. GSS, S.T.O.N.E. and CROES scoring systems were calculated by endourologists who mostly perform stone surgery in the daily practice of the Urology Clinic (Bağcılar Training and Research Hospital, İstanbul, Turkey). Patients with anatomical abnormalities for GSS were classified as 2nd, 3rd or 4th grade according to the number and location of stones. S.T.O.N.E. load, tract length, obstruction, relevant calyx number and stone density were noted while nephrolitometry score was used. When calculating the CROES score, the average annual case volume was accepted as 200 for the Clinic.

Surgical technique

The PNL procedure started with the placement of 5F open-ended Hydrophilic Ureteral Catheters (*Plasti-med*) retrograde into the involved kidney under general anaesthesia and 3rd generation cephalosporin prophylaxis and continued with the prone position. With an initial puncture needle (18 G/20 mm/2 parts, *Plasti-med*) retrograde contrast was given under fluoroscopy and posterior calyx access was achieved. Renal access was performed by entering a nephrostomy balloon dilator (*Nephroflex*) after an *Amplatz* dilator up to 12 French (F) and a 24 F nephroscope (*Alken-Hohenfellner, Karl Storz, Germany*) through a 30 F *Amplatz* sheath. Fragmentation of stones was performed using pneumatic and ultrasonic lithotripters. After endoscopic and fluoroscopic stone-freeness was achieved, a 14 F *Malecot* nephrostomy set was placed in the kidney. On the first postoperative day, both stone-free and pleural injury control were performed with direct urinary system radiography (CUB) and chest radiography in intercostal accesses. The discharge of the patients was carried out according to the dryness of the tract after the removal of the nephrostomy catheter. Stone-free control was achieved with CUB and urinary ultrasonography in the first month postoperatively and low-dose CT at the third month. Absence of residual fragments or < 4 mm fragments were considered stone free.

Statistical analysis

Statistical Package for Social Sciences software was used for statistical analysis of study data (IBM SPSS Version 22.0). The Chi-square test or Fisher's exact test was used for categorical variables, while continuous variables were compared with the independent sample t-test and One-way analysis of variance (ANOVA) test. Receiver operating characteristic (ROC) curves were generated to assess the predictive role of stone scoring systems and other significant variables on postoperative SFS. Logistic or linear regression analyses were performed to determine the possible relationship of stone scoring systems, BMI, stone burden and skin to stone distance (SSD) parameters with SFS. $P < 0.05$ was noted as statistically significant.

Results

The mean age and BMI of the patients included in the study were 46 ± 11.7 and 28 ± 6 kg/m^2, respectively and BMI was statistically significantly higher in Group 1 ($p = 0.002$). While 19 out of 64 patients were female, stone-free was achieved in 73 % of them ($p = 0.042$). The mean SSD (mm) was higher in Group 1 and the number of kidneys with staghorn stones was higher in Group 2 (98.54 mm ± 22.88, $p = 0.001$ and 7 (10.9 %) / $p = 0.013$, respectively). Table 1 shows patient demographics, stone characteristics and operative parameters. Compared with the Group 2, GSS (2.49 vs 3.03; $p = 0.001$) and S.T.O.N.E. scores (7.26 vs 8.38; $p = 0.021$) in the Group 1 were lower, while the CROES score was lower in the Group 2 (172 vs 245; $p < 0.001$).
The ROC curves of 3 scoring systems, SSD, stone burden and BMI on prediction of SF status are shown in Figure 2. According to the ROC analy-

Table 1: Patient demographics, stone characteristics and operative parameters

Parameters	Total	SFS: Yes	SFS: No	p-value
Age (years)	46 (11.70)	46.09 (10.08)	45.90 (13.72)	0.930
BMI (kg/m²)	28 (60)	30 (6.00)	26 (4.00)	**0.002**
Male	45 (70.30)	21 (32.81)	24 (37.50)	**0.042***
Female	19 (29.70)	14 (21.88)	5 (7.81)	
The Guy's stone score	2.73 (0.64)	2.49 (0.61)	3.03 (0.56)	**0.001**
The S.T.O.N.E. nephrolithometry score	7.77 (1.64)	7.26 (1.06)	8.38 (1.99)	**0.021**
CROES nomogram score	211.92 (54.37)	245 (48.14)	172 (28.62)	**< 0.001**
Stone burden (mm²)	460.8 (379.80)	313.2 (212.23)	638.92 (458.02)	**< 0.001**
HU	980 (278.75)	978.26 (276.93)	981.97 (285.83)	0.989
SSD (mm)	90.5 (25.66)	98.54 (22.88)	80.79 (25.83)	**0.001**
Staghorn stones	8 (12.50)	1 (1.56)	7 (10.94)	**0.013¥**
Stone side (right/left)	26 (40.6) / 38	14 (21.88) / 21 (32.81)	12 (18.75) / 17 (26.66)	0.556*
Number of hydronephrosis	(59.40)	17 (26.66)	16 (25.00)	0.392*
Renal abnormality	33 (51.60)			0.848
Horseshoe kidney	25 (39.10)	14 (21.90)	11 (17.19)	
Malrotated kidney	22 (34.40)	12 (18.80)	10 (15.63)	
Pelvic kidney	17 (26.60)	9 (14.10)	8 (12.50)	
OTT (min)	101.33 (33.64)	94.43 (27.30)	109.66 (38.86)	0.098
Time with nephrostomy tube (day)	2.17 (1.79)	1.8 (1.23)	2.62 (2.24)	0.088
EBL (gr/dL)	1.94 (1.24)	1.78 (1.35)	2.13 (1.07)	0.069
Complications	24 (37.50)	11 (17.20)	13 (20.30)	0.200*

**Pearson Chi-square; ¥: Fisher's Exact Test; Values are presented as N (%) or mean (SD); BMI: Body mass index; EBL: Estimated blood loss; HU: Hounsfield Unit; OTT: Operation table time; SSD: Skin to stone distance; SFS: Stone free status;*

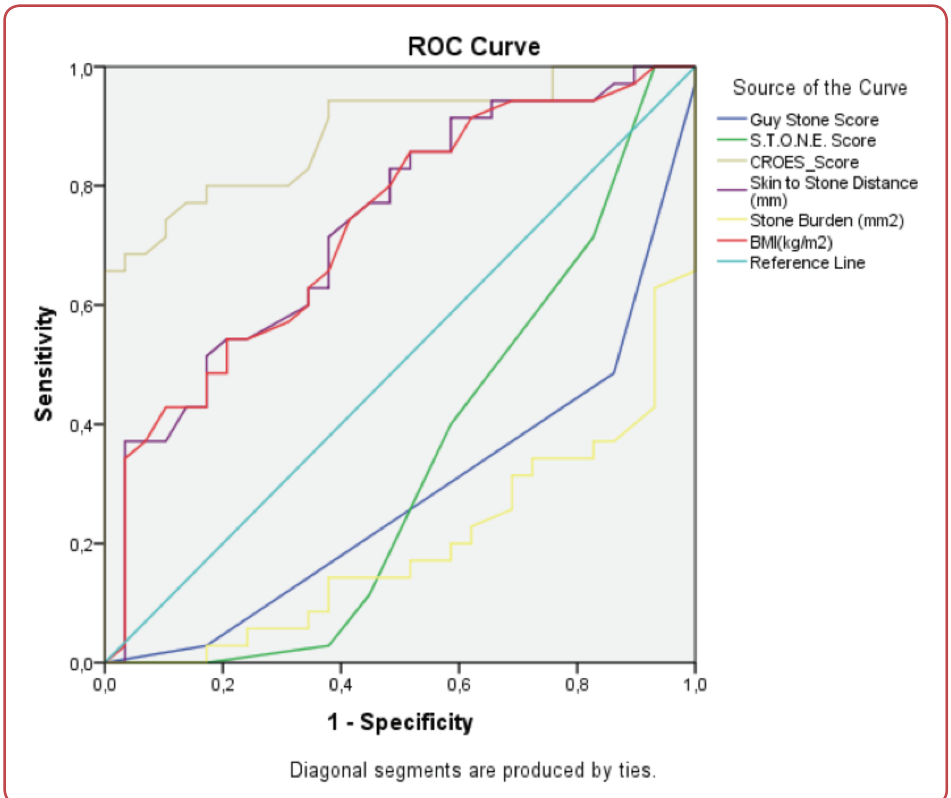

Figure 2: The ROC curves of 3 scoring systems, SSD, stone burden and BMI on prediction of stone-free status (SFS)

BMI: Body mass index; SSD: Skin to stone distance; SFS: Stone free status;

Table 2: ROC curves of variables with significant association with stone-free status (SFS)

Variable(s)	Area	p-value	95 % Confidence interval
Guy stone score	0.280	0.003	0.155 - 0.405
S.T.O.N.E. score	0.335	0.024	0.195 - 0.476
CROES score	**0.891**	**0.000**	0.812 - 0.969
SSD (mm)	0.733	0.001	0.610 - 0.856
Stone burden (mm^2)	**0.197**	**0.000**	0.091 - 0.303
BMI (kg/m^2)	0.731	0.002	0.608 - 0.854

BMI: Body mass index; SFS: Stone free status; SDD: Skin to stone distance;

Table 3: Clavien complication rating according to stone scoring systems

Scoring System	Clavien grading system					Total	P-value
	Grade 1	Grade 2	Grade 3a	Grade 3b	Grade 4a		
The Guy's scoring system							
2	1	2	1	1	0	5	0.404
3	8	4	4	0	1	17	
4	2	0	0	0	0	2	
The S.T.O.N.E. scoring system							
5-6	2	2	0	0	0	4	0.763
7-8	5	2	4	1	0	12	
9-13	4	2	1	0	1	8	
CROES score							
< 130	2	0	1	0	0	3	0.844
130-169	2	1	0	0	0	3	
170-219	4	3	2	0	1	10	
> 219	3	2	2	1	0	8	

Table 4: Logistic regression analyses of BMI, SSD, stone burden and nephrolithometry scoring systems on stone free status (SFS)

Variables	Stone free status		
	OR	95 % CI	p-value
The S.T.O.N.E. nephrolithometry score	1.222	0.589 - 2.534	0.590
CROES nomogram score	1.055	1.019 - 1.092	**0.002**
Guy's stone score	1.167	0.170 - 8.011	0.875
Stone burden (mm^2)	1	0.996 - 1.004	0.980
BMI (kg/m^2)	0.979	0.524 - 1.829	0.948
SSD (mm)	1.019	0.895 - 1.161	0.772

BMI: Body mass index, SSD: Skin to stone distance; OR: odds ratio; CI: confidence interval;

sis, although all parameters were significant for stone-free, the highest area under the curve (AUC) and significance were observed in the CROES and stone burden parameters (AUC = 0.891 and 0.197, respectively, $p < 0.001$). Parameters showing statistical significance according to ROC analysis and AUC values were summarised in Table 2.

In the Chi-square analysis performed between Clavien complication rating and stone scoring systems, no success was found in predicting the presence of complications in any scoring system (Table 3).

Logistic regression analysis showed that only CROES scoring systems were significantly associated with stone-free status (OR: 1.055, [95 % CI 1.019–1.092]; $p < 0.002$) (Table 4).

Discussion

In presented study, aim was to compare the GSS, S.T.O.N.E. and CROES nomograms in predicting PNL outcomes in abnormal kidneys. It was found that although these nomograms were successful in predicting postoperative SFS, they did not have predictive value in determining the postoperative complications of PNL. In this regard novel scoring systems may come in mind in predicting outcomes of PNL in abnormal kidneys.

Cağlayan et al evaluated 120 paediatric cases who had undergone PNL surgery, compared CROES with GSS and found that only the CROES scoring system was significant in demonstrating SFS. However, both scoring systems did not predict complications after PNL.[8] Karsiyakali et al evaluated 81 patients who underwent Retrograde Intrarenal Surgery and found that S.T.O.N.E. and CROES scoring systems were significant in showing post-op SFS, but GSS was not, but they did not compare the scoring systems in terms of complications.[9] Consistent with these studies, in presented study it was found that CROES, GSS and S.T.O.N.E. scoring systems could predict SFS after PNL. Similar to the study of Caglayan et al, it was found that these scoring systems cannot predict postoperative complications. Recently, Kocaaslan et al demonstrated that only CROES nomogram may predict the SFS of PNL patients with abnormal kidneys.[10] Yarimoglu et al conducted a study on the evaluation of complications with renal scoring systems in the preoperative period in 160 patients who had undergone PNL for staghorn stones and they found that scoring system did not show postoperative complications.[3] All these studies demonstrated that GSS, S.T.O.N.E. or CROES nomograms may predict postoperative SFS and complications of standard PNL performed in the normal kidneys. But while these nomograms were able to predict SFS, they were found to be unsuccessful in predicting post-operative complications for PNL surgeries performed in rare patient groups such as paediatric patients, staghorn kidney stones and abnormal kidneys. The CROES nomogram was found to be more significant in predicting SFS than other nomograms, including the clinical annual number of cases parameter.

It is very important to accurately predict the results and complications of PNL such as bleeding that will require transfusion, injuries to the colon or pleura, postoperative fever, sepsis and inform the patient about these possible complications. None of the nomograms were categorically associated with postoperative complications. There is necessity for new nomograms that include more specific criteria (kidney anomaly, surgeon case volume and stone surgery history, etc) that may predict complications.

Limitations of the study

The study had several limitations. Firstly, the retrospective data of the single centre were used in the study which may have led to biased selection. Secondly, the sample size in the study was small.

Conclusion

Standard PNL surgery may be more difficult for patients with renal anomaly. Aim was to compare the effects of scoring nomograms in kidney anomalies. Although CROES, Guy and S.T.O.N.E. scoring systems were able to detect stone-free status in the postoperative period, they may not detect complications in the preoperative period.

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None.

Conflict of interest

None.

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