Endourol Bull. 2023;15(2):52-60. doi:10.54233/endouroloji.20231502-1282074

Intraoperative Assessment of Stone Free Status for Percutaneous Nephrolithotomy Surgery: Surgeon's Eye

Perkütan Nefrolitotomi Ameliyatında Taşsızlığın İntraoperatif Değerlendirilmesi: Cerrahın Gözü

Mehmet Yiğit Yalçın[1], Batuhan Ergani[2], Taha Çetin[3], Mustafa Karabıçak[4], Mert Hamza Özbilen[5], Çağdaş Bildirici[5], Erkin Karaca[5], Mehmet Yoldaş[5], Erdem Kısa[6], Tufan Süelözgen[5], Gökhan Koç[5], Özgür Çakmak[6] Hayal Boyacıoğlu[7], Yusuf Özlem İlbey[8]

1 Şanlıurfa Training and Research Hospital, Department of Urology, Şanlıurfa, Turkey
2 Beyhekim Training and Research Hospital, Department of Urology, Konya, Turkey
3 Health Sciences University, İzmir Bozyaka Training and Research Hospital, Department of Urology, İzmir, Turkey
4 Batman Regional State Hospital, Department of Urology, Batman, Turkey
5 Health Sciences University, İzmir Tepecik Training and Research Hospital, Department of Urology, İzmir, Turkey
6 Medicana International Izmir Hospital, Department of Urology, Izmir, Turkey
7 Ege University Faculty of Science, Department of Statistics, İzmir, Turkey
8 Bezmialem Vakif University Faculty of Medicine, Department of Urology, Istanbul, Turkey

ÖZET

Amaç: Perkütan nefrolitotomi (PNL) uygulanan hastalarda cerrahın intraoperatif taşsızlık kanısının doğruluğunu, bunu etkileyen faktörleri, yanlış tahminine sebep olan prediktörleri saptamak ve sonuç olarak "cerrah gözü"'nün güvenilirliğini değerlendirmek amaçlandı.

Gereç ve Yöntemler: PNL uygulanan ve dahil etme kriterlerine uyan 1025 hastanın verileri retrospektif olarak incelendi. Çalışmamızın temeli cerrahın taşşsızlığı değerlendirmesi üzerine olması sebebiyle, cerrahın intraoperatif rezidü taş (RT) kalmadığı kanaatini belirttiği ancak postoperatif bilgisayarlı tomografi görüntülemede RT olan ve olmayan hasta grupları değişkenlere göre karşılaştırıldı.

Bulgular: Cerrah gözü'nün sensitivitesi %67,87, spesifitesi %96,23, pozitif prediktif değeri %91,67 ve negatif prediktif değeri %83,04 bulundu. Çalışmamızda "cerrahın gözü" 'nün %16,9 oranında yanlış taşsızlık tahmin ettiği saptandı. Her iki grup arasında cinsiyet, taşın tarafı, taşın yoğunluğu ve hemoglobin düşüşü arasında istatistiksel anlamlı ilişki saptanmadı. Taş boyutu, operasyon süresi, floroskopi süresi, taşın konumu, kaliks taşlarının sayısı ve GUY's nefrolitometri skoru (GSS) cerrahın gözü ile istatistiksel anlamlı ilişkili saptandı. Cerrahın gözü ile istatistiksel anlamlı ilişki saptanan parametrelerin çok değişkenli (multivariate) lojistik regresyon analizi sonucunda sırasıyla taş boyutu, kaliks taşlarının sayısı ve GSS anlamlı prediktörler olarak bulundu.

Sonuç: PNL' de "cerrah gözü" nün en önemli prediktörleri taş boyutu, kaliks taş sayısı ve GSS idi. Bu prediktörler taşsızlık öngörülen hastaların postoperatif görüntülemelerinde, radyasyon maruziyetini azaltacak yöntemlerin kullanılmasında etkili bir kriter olarak kullanılabilir.

Anahtar Kelimeler: *böbrek taşları, perkütan nefrolitotomi, taşsızlık durumu, intraoperatif değerlendirme, cerrahın gözü*

Cite As: *Yalçın MY, Ergani B, Çetin T et al. Intraoperative Assessment of Stone Free Status for Percutaneous Nephrolithotomy Surgery: Surgeon's Eye. Endourol Bull. 2023;15(2):52-60. https://doi.org/10.54233/endouroloji.20231502-1282074*

This study was approved by the University of Health Sciences, İzmir Tepecik Education and Research Hospital Ethical Committee (Approval Number: 2019/14-14, Date: 2019-10-01). All research was performed in accordance with relevant guidelines/regulations, and informed consent was obtained from all participants.

Corresponding Author : Mehmet Yiğit Yalçın, Yenice Mah. Yenice Yolu No:1 35180, Eyyübiye / Şanlıurfa / Turkey
Tel: +90 414 469 69 69 ***Mobile:*** +90 507 346 92 68 ***e-mail:*** yigityalcin@hotmail.com
Received : April 12, 2023 ***Accepted*** : May 23, 2023

ABSTRACT

Objective: In patients who underwent percutaneous nephrolithotomy (PNL),it was aimed to determine the accuracy of the surgeon's intraoperative stone-free status (SFS) prediction, the factors affecting it, the predictors that cause incorrect estimation, and finally to evaluate the reliability of the "surgeon's eye".

Material and Methods: The data of 1025 patients who underwent PNL and met the inclusion criteria were evaluated retrospectively. Since the basis of our study was based on the evaluation of the surgeon's stone-free prediction, patients identified as "absence of residual stone fragment (RF)" by the surgeon were grouped and compared with postoperative computed tomography imaging according to the presence of RF.

Results: Sensitivity, specificity, positive predictive value and negative predictive value were calculated as 67.87%, 96.23%, 91.67% and 83.04%, respectively. In our study, it was found that the "surgeon's eye" predicted SFS incorrectly at a rate of 16.9%. There was no statistically significant relationship between gender,-stone side,stone density and hemoglobin decrease between the two groups. Stone size,operation time, fluoroscopy time, location of the stone,number of stones in the calyces and GUY's stone score (GSS) were found to be statistically significant in relation to the "surgeon's eye". As a result of multivariate logistic regression analysis stone size, number of stones in the calyces and GSS were significant predictors of the parameters that had a statistically significant relationship with the surgeon's eye.

Conclusion: The most important determinants of "surgeon's eye" in PNL were stone size,number of stones in the calyces and GSS. These predictors can be used as an effective criterion in the use of methods to reduce radiation exposure in postoperative imaging of patients who are predicted to be stone-free.

Keywords: *kidney stones, percutaneous nephrolithotomy, stone-free status, intraoperative evaluation, surgeon's eye*

INTRODUCTION

Kidney stones are a common health problem worldwide. Percutaneous nephrolithotomy (PNL) is accepted as the gold standard minimally invasive treatment method in the treatment of complex kidney stones larger than 2 cm (1). PNL gives satisfactory results with low morbidity, acceptable complication, and high success rates. Achieving stone- free status (SFS) or the presence of a residual stone fragment (RF) is an important factor in the success of PNL. Preoperative, and intraoperative estimation of the presence of RF influences the surgeon's decision to perform intraoperative procedures such as nephrostomy or ureteral stent placement.

Although GUY's stone score (GSS), Clinical Research Office of the Endourological Society (CROES) and "stone size, tract length, obstruction, number of involved calyces and essence" (S.T.O.N.E) nephrolithometry scoring systems are used to predict "preoperative" SFS in PNL, there is no scoring system for predicting "intraoperative" SFS yet (2,3).

Although the presence of RF is evaluated by the surgeon in the intraoperative period with fluoroscopy-guided radiological and endoscopic methods in PNL, the presence of RF is clarified with non-contrast computed tomography (CT), which is the gold standard imaging in the postoperative period. Today, the absence of RF is accepted as SFS. Millimeter-sized RFs can be easily missed intraoperatively. Therefore, SFS assessment may not always be accurate in the intraoperative period. There are few studies in the literature subjecting the sensitivity and reliability of the surgeon's assessment of the presence of intraoperative RF and its comparison with different postoperative imaging modalities. As a result, the "surgeon's eye" is an important method that can guide the operation in terms of the "intraoperative" SFS assessment and the necessity of different procedures such as nephrostomy and ureteral stent placement.

Unlike other studies, in this study, we aimed to evaluate the accuracy of the surgeon's intraoperative SFS prediction, the factors affecting it, the predictors that caused the wrong estimation, and finally, to evaluate the reliability of the "surgeon's eye".

MATERIAL AND METHODS

The study was carried out retrospectively after the approval of the local ethics committee, dated 09 October 2019, decision numbered 2019/14-14. The data of 1289 patients who underwent PNL in a single center due to kidney stones between November 2008 and July 2019 were collected. Patients who under the age of 18, underwent mini-PNL, had horseshoe kidney anomaly, had non-opaque stones, had missing preoperative/postoperative data, used flexible nephroscopy during the procedure, and had no CT scan for postoperative RF evaluation were excluded from the study. After the exclusion criteria, a total of 1025 patients were included in the study. An informed consent form was obtained from the patients before the procedure.

First of all, demographic data such as age and gender of all patients were recorded. Then, the location, side, number, size, and density (Hounsfield Unit (HU)) of the stones were recorded with the stone protocol CT in the preoperative period. Operation time and fluoroscopy time from the perioperative data, hemoglobin (Hgb) decrease from the postoperative data were collected. In addition, kidney stones of all patients were evaluated according to GSS. In GSS, conditions including the location of the stone, the presence of single or multiple stones, the presence of partial or complete staghorn stones, and the presence of anomaly in the kidney anatomy were evaluated and scored between 1-4 (2). "Calyx" localized stones were defined as stones other than isolated stones in the renal pelvis.

Approximately half of the patients (510 patients) included in the study were operated on by a single surgeon, while other surgeries were performed by different surgeons with at least 50 PNL experience. The operating surgeon performed all percutaneous renal accesses.The time from the beginning of the renal access to the placement of the malecot nephrostomy catheter was accepted as the operation time (min). Fluoroscopy time (sec) was defined as the total duration of exposure during the procedure. The largest stone diameter in the axial and coronal planes was used when calculating the size of the stones in CT The size was recorded in mm^2 by multiplying the lengths in both planes. In the presence of more than one stone, the size of each stone was measured and added separately. SFS was evaluated using non-contrast CT 1 month after surgery. The absence of RF of any size was considered as SFS.

The surgeon stated his opinion on obtaining SFS as " presence of RF" or "absence of RF" in the intraoperative period as a result of his evaluation made by considering both fluoroscopic and nephroscopic examinations. Since the basis of our study was based on the evaluation of the surgeon's stone-free prediction, patients defiined as "absence of RF" by the surgeon were grouped and compared with postoperative CT imaging according to the presence of RF.

Surgical Technique

After general anesthesia, PNL was started with cystoscopy in the lithotomy position. A 6F open-ended ureteral catheter was inserted up to the renal pelvis with the help of a C-arm fluoroscopy machine (Ziehm 8000, Ziehm Imaging GmbH. Nuremberg Germany). The pelvicalyceal system was evaluated by retrograde pyelography by administering contrast media through the ureteral catheter. After this stage, the patient was turned to the prone position. Under fluoroscopy, an 18G percutaneous access needle was inserted into the appropriate calyx using the triangulation technique. Dilatation was performed with a 30F amplatz dilator in accordance with the one-shot dilatation technique. The stones were fragmented with the aid of a 26F nephroscope (Karl Storz GmbH, Tuttlingen, Germany) and pneumatic and/or ultrasonic lithotripter by entering through the amplatz sheath. At the end of the operation, a 14 F malecot nephrostomy catheter was placed. The integrity of the collecting system and the presence of RF were checked with antegrade pyelography by giving contrast media through the catheter.

Statistical Analysis

SPSS 25.0 program (I.B.M. Corporation, Armonk, New York, United States) was used in the analysis of the variables. Compliance of the data with normal distribution was evaluated by Kappa analysis. Pearson's

Chi-Square and Fisher's Exact test were used to compare the distribution of categorical variables (gender, side of the stone, location of the stone, number of stones in the calyces, GSS) in the groups. Independent-Samples T-test with Bootstrap results were used to compare the surgeon's eye to RF on CT and fluoroscopy time. Mann-Whitney U test was used with the Monte Carlo simulation technique to compare the stone density (HU), stone size (mm^2), operation time (min), fluoroscopy time (sec), and hemoglobin decrease (g/dl). Multivariate logistic regression analysis was applied to the parameters that had a statistically significant relationship with the surgeon's eye. The sensitivity and specificity of the cut-off value calculated according to the stone size (mm^2), which showed statistical significance with the groups formed, were analyzed and expressed by ROC (Receiver Operating Curve). Quantitative variables were shown in the tables as mean ± std.(standard deviation)(Minimum/Maximum) and median (Minimum/Maximum), while categorical variables were shown as n(%). Variables were analyzed at a 95% confidence interval, and a p-value less than 0.05 was considered statistically significant.

RESULTS

Of 1025 patients included in the study, 627 (61%) were male, and 398 (39%) were female. The mean age was 49.59±13.64 years, and the mean body mass index (BMI) was 28.2 (18– 40.1). Single access was applied to 86.2%, and double access was applied to 11.6% of the patients. 85.5% of the patients had no previous history of stone surgery. History of PNL, open stone surgery, and both PNL and stone surgery were 5.7%, 7.6%, and 1.2%, respectively. The distribution of the presence/absence of RF according to the intraoperative surgeon's eye and postoperative CT is shown in Table 1.

While SFS was achieved in 636 (62.05%) patients, RF remained in 389 (37.95%) patients. 91.6% (264 patients) of the patients who were found to have RF by computed tomography were also considered to have RF by the surgeon's eye. One hundred and twenty- five (16.9%) of the patients with RF were those who were stated to have no RF by the surgeon. Accordingly, there were 264 true positives, 612 true negatives, 125 false negatives, and 24 false positive patients. Kappa analysis showed substantial agreement (κ: 0.675; $p< 0.05$). Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated as 67.87%, 96.23%, 91.67%, and 83.04%, respectively (Table 2).

It was determined that gender, stone side, stone density, and Hgb decrease parameters did not affect the "surgeon's eye" statistically in groups with and without RF on CT. Stone size, operation time, fluoroscopy time, location of the stone, number of stones in the calyces, and GSS were statistically associated with the "surgeon's eye" (Table 3a and Table 3b).

Stone size (OR: 1.001; 95% [CI]: 1- 1.001; p=0.002), number of stones in the calyces (OR: 0.470; 95% [CI])]: 0.255-0.866; p=0.015) and GSS (OR: 0.416; 95% [CI]: 0.198-0.872; p=0.020) were found to be important predictors as a result of multivariate logistic regression analysis of the parameters that had a statistically significant relationship with the surgeon's eye. Stone location, operation time, and fluoroscopy time were not found to be significant predictors as a result of multivariate logistic regression analysis (Table 4).

As a result of the ROC analysis performed on the stone size parameter, which is one of the parameters affecting the surgeon's eye statistically, a threshold value of 540 mm^2 was found. True negativity (SFS) increased statistically for stones of this size and below (AUC 0.779; OR: 7.1; 95% [CI]: 4.7 - 10.9; p <0.001) (Figure 1). The sensitivity for stone size was 69.6%, and the specificity was 75.7%.

The overall complication rate was 11.9%. The ureteral catheter was inserted under local anesthesia in 9 patients due to severe colic pain in the early postoperative period (Clavien 3A). Ureterorenoscopy was performed in 26 patients (Clavien 3B).

Table 1. Residual fragment status of the patients according to the surgeon's eye and postoperative CT

		CT		
		Residual fragment (+)	Residual fragment (-)	Total
Surgeon's Eye	Residual fragment (+)	264	24	288
	Residual fragment (-)	125	612	737
	Total	389	636	1025

CT: Computed tomography

Table 2. Sensitivity, specificity, PPV and NPV of the surgeon's eye

		% 95 CI
Sensitivity	% 67.87	% 62.97 - % 72.48
Specificity	% 96.23	% 94.44 - % 97.57
PPV	% 91.67	% 88.07 - % 94.25
NPV	% 83.04	% 80.89 - % 84,99

CI: Confidence interval, ***PPV:*** Positive predictive value, ***NPV:*** Negative predictive value

Table 3a. Factors affecting the surgeon's eye

		Residual fragment status in CT		
		Absent (n=612)	Present (n=125)	P Value
		Mean±SD (Min./Max.)	Mean±SD (Min./Max.)	
Age		49.20 ± 14.22 (18 / 93)	51.34 ± 12.18 (22 / 78)	
		Mean (Min./Max.)	**Mean (Min./Max.)**	
Stone density (HU)		1084.82 (225 / 1626)	1092.43 (330 / 1609)	0.785¥
Stone size (mm²)		441.76 (102 / 4420)	831.35 (156 / 2820)	**<0.001**¥
Operation time (min)		63.89 (19 / 238)	77.41 (19 / 238)	**0.001**¥
Fluoroscopy time (sec)		122.68 (18 / 640)	149.29 (20 / 640)	**0.048**§
		Mean±SD	**Mean±SD**	
Hemoglobin decrease (g/dl)		1.46 ± 1.34	1.78 ± 1.63	0.231¥
		n (%)	**n (%)**	
Gender				
	Male	359 (81.6)	81 (18.4)	0.202*
	Female	253 (85.2)	44 (14.8)	
Side				
	Right	308 (81.3)	71 (18.7)	0.187*
	Left	304 (84.9)	54 (15.1)	
Location of the stone				
	Calyx	183 (80.6)	44 (19.4)	**<0.001***
	Renal pelvis	254 (92.7)	20 (7.3)	
	Calyx and renal pelvis	175 (74.2)	61 (25.8)	

CT: Computed tomography, ***SD:*** Standard Deviation, ***HU:*** Hounsfield Unit

****Chi-Square test, §:*** Independent Samples T Test, ***¥:*** Mann-Whitney U test

Table 3b. Factors affecting the surgeon's eye

		Residual fragment status in CT		P Value
		Absent (n=612) n (%)	Present (n=125) n (%)	
Location of the stone				
	Calyx and renal pelvis	175 (74.2)	61 (25.8)	
	Calyx or renal pelvis	437 (87.2)	64 (12.8)	**<0.001***
Number of stones in the calyces				
	1	236 (87.1)	35 (12.9)	**<0.001***
	2	79 (66.9)	39 (33.1)	
	3	27 (61.4)	17 (38.6)	
	≥4	16 (53.3)	14 (46.7)	
Multiplicity of stone				
	Single	236 (87.1)	35 (12.9)	**<0.001***
	Multiple	122 (63.5)	70 (36.5)	
GSS				
	1	354 (94.4)	21 (5.6)	**<0.001***
	2	187 (78.2)	52 (21.8)	
	3	54 (58.1)	39 (41.9)	
	4	17 (56.7)	13 (43.3)	
GSS				
	1 and 2	541 (88.1)	73 (11.9)	**<0.001***
	3 and 4	71 (57.7)	52 (42.3)	

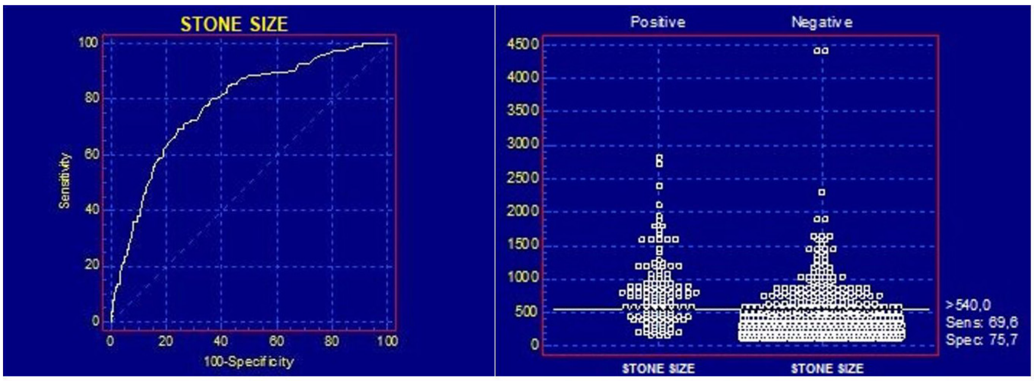
CT: Computed tomography, * Chi-Square test, *GSS:* GUY's stone score

Table 4. Multivariate analyzes of factors that significantly affect the surgeon's eye

	OR	%95 CI	*P* Value
Stone size (mm²)	1.001	1- 1.001	**0.002**
Operation time (min)	1.001	0.994- 1.008	0.822
Fluoroscopy time (sec)	1.002	1- 1.005	0.066
Location of the stone	1.84	0.959- 3.532	0.067
Number of stones in the calyces	0.47	0.255- 0.866	**0.015**
GSS	0.416	0.198- 0.872	**0.02**

OR: Odds Ratio, *CI:* Confidence Interval, *GSS:* GUY's stone score

Figure 1. Stone size (mm2) and ROC curve



ENDOUROLOGY BULLETIN ENDOÜROLOJİ BÜLTENİ

DISCUSSION

PNL is currently accepted as the gold standard minimally invasive treatment method in the treatment of complex and large kidney stones (1). The main goal in the treatment of kidney stones is to ensure complete SFS by minimizing morbidity. CT scan taken in the postoperative period is superior to other imaging methods, with a sensitivity of up to 95% in the evaluation of SFS and the detection of millimeter-sized RFs (4). RF after PNL is important because it may cause new stone formation, symptoms, and additional surgery. Problems associated with RFs after PNL occur at rates of up to 31% and 46% (5-7). The "surgeon's eye" is a criterion that cannot be ignored, as intraoperative evaluation of SFS or RFs may require different types of additional interventions. In our study, based on CT results, the sensitivity, specificity, PPV, and NPV of RFs for the surgeon's eye were 67.87%, 96.2%, 91.67% and 83.04%, respectively. In other words, based on our results, the surgeon was only able to detect SFS in 83.04% of PNL compared to postoperative CT.

When we look at the literature, there are few studies investigating the role of the intraoperative surgeon's opinion in different operations. In a study involving 306 patients regarding the surgeon's intraoperative RF evaluation, it was considered that 236 (77%) procedures were achieved intraoperative SFS. In this study, the sensitivity, specificity, PPV, and NPV of intraoperative surgeon's opinions about SFS were 49.6%, 97.1%, 92.8%, and 72%, respectively (8). Although specificity and PPV were similar, sensitivity and NPV were found to be higher in our study. This may be because non-opaque stones were also included in this study. Portis et al. evaluated the surgeon's opinion about SFS using flexible nephroscopy in their study involving 39 renal units. In their study, SFS was obtained in 26 (66%) cases in PNL. Defining SFS as the absence of any RFs, they found a PPV of 67% and a NPV of 73% (9). They stated that the use of flexible nephroscopy in addition to fluoroscopy could significantly contribute to the accuracy of the surgeon's evaluation and thus reduce additional secondary interventions. However, in our study, although SFS was defined as the absence of RFs, it was shown that high NPV could be achieved without the use of flexible nephroscopy. In the study of Gökçe et al., which included 167 patients who underwent retrograde flexible nephroscopy simultaneously with PNL, the stone-free rate was found to be 92.7%. According to the surgeon's SFS opinion, PPV was 83.3%, and NPV was 96.2% (10). However, in order to perform retrograde flexible nephroscopy, the patient must be in the supine position. Since only prone PNL was performed on the patients in our study, we may not have been able to reach these rates.

The factors affecting SFS after PNL have been evaluated in various studies in the literature. In the study of Perez-Fentes et al., stone size and the presence of multiple stones were stated as the most important determinants of stone-free rate in PNL In addition, an increase in stone size and number was found to be associated with missing RFs (11). Also in the multivariate analyzes of Nevo et al.'s study, stone size (OR = 1.07, 95% CI: 1.03–1.11, p = 0,005) and presence of multiple stones (OR = 4.95, %95 CI: 2.52–9.71, p < 0,001) were found to be independent predictors for missing RFs (12). According to our results, stone size and the number of stones in the calyces, which are parameters affecting the surgeon's eye in PNL, were found to be statistically significant in multivariate analysis. In addition, a statistically significant difference was found when the number of stones was grouped as single and multiple. Thus, it was determined that the most important predictor of the surgeon's eye was the stone size and the number of stones in the calyces. An exact cut-off value that would make the surgeon's eye important for stone size, which is the strongest predictor, was an intriguing question. In our analysis for this question, the threshold value was 540 mm^2. True negativity (SFS) increases statistically significantly for stones of this size and smaller.

Another parameter that had a significant relationship with the surgeon's eye was GSS (p <0.001). As in our study, Noureldin et al. reported GSS as a predictor of SFS after PNL (13). Harraz et al. reported a 43% stone-free rate in GSS 4. They found only GSS as an independent predictor in the model 1 subgroup which they considered the absence of any residual fragments (8). Similarly, in another study, the stone-free rate was found to be 95.2% for GSS 1 and 40.7% for GSS 4, and GSS was found to be an independent predictor (p<0.001) (14). In our study, we found that GSS was an effective factor in predicting SFS, consistent with the literature. In addition, our stone-free rates in high GSS were found to be relatively high compared to other studies. The presence of low GSS provides a better estimation of the surgeon's eye. In our multivariate analysis, larger stone size, increased number of stones in the calyces, and high GSS were found to be independent predictors of missing RFs. In addition to our predictors of stone size and the number of stones in the calyces, GSS should also be used as an effective parameter that can be evaluated in the "surgeon's eye".

The scarcity of similar studies and the fact that it has the highest number of patients compared to similar studies in the literature are the strengths of our study. The retrospective design of the study is one of the limitations. The fact that the operations were performed by more than one surgeon is another limitation as the "surgeon's eye" is a subjective assessment. In addition, our definition of SFS as the absence of RFs may have negatively affected our ratios between the surgeon's eye and CT. Failure to use a flexible nephroscope during the operation may also have affected the surgeon's eye.

CONCLUSION

According to our study, the most important determinants of the surgeon's eye in PNL were stone size, number of stones in the calyces, and GSS. It may be considered that additional intervention or the use of a drainage catheter may be required in patients who are predicted to have RF. It can be used as an effective criterion in the use of methods to reduce radiation exposure in postoperative imaging of patients who are predicted to be stone-free.

Conflict of Interest: The authors declare to have no conflicts of interest.

Financial Disclosure: The authors declared that this study has received no financial support.

Ethical Approval: The study was approved by the Ethics Committee of University of Health Sciences, İzmir Tepecik Training and Research Hospital (Approval No: 2019/14-14, Date: 2019/09/10). The study protocol conformed to the ethical guidelines of the Helsinki Declaration.

Author Contributions: Conception and design; Yalçın MY, Süelözgen T, Data acquisition; Çetin T, Özbilen MH, Bildirici Ç, Karabıçak M, Yoldaş M, Data analysis and interpretation; Ergani B, Karaca E, Drafting the manuscript; Yalçın MY, Critical revision of the manuscript for scientific and factual content; Süelözgen T, Çakmak Ö, Kısa E, Statistical analysis; Boyacıoğlu H, Supervision; Süelözgen T, Çakmak Ö, Koç G, İlbey YÖ.

REFERENCES

1. Turk C, Petřik A, Sarica K, et al. EAU Guidelines on Interventional Treatment for Urolithiasis. Eur Urol 2016;69:475-82
2. 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. ***[Crossref]***
3. Smith A, Averch TD, Shahrour K, et al. A nephrolithometric nomogram to predict treatment success of percutaneous nephrolithotomy. Journal of Urology 2013;190: 149–56. ***[Crossref]***
4. Lehtoranta K, Mankinen P, Taari K, et al. Residual stones after percutaneous nephrolithotomy: sensitivities of different imaging methods in renal stone detection. Ann Chir Gynaecol 1995;84: 43–49.
5. Gokce MI, Ozden E, Suer E, et al. Comparison of imaging modalities for detection of residual fragments and prediction of stone related events following percutaneous nephrolitotomy. Int Braz J Urol 2015;41: 86-90. ***[Crossref]***
6. Emmott AS, Brotherhood HL, Paterson RF, Lange D, Chew B.H. Complications, Re- Intervention Rates, and Natural History of Residual Stone Fragments After Percutaneous Nephrolithotomy. J Endourol 2018;32:28-32. ***[Crossref]***
7. Wong, VKF, Que J, Kong EK, et al. The Fate of Residual Fragments after PCNL: Results from the EDGE Research Consortium. Journal of Endourology ja. (2023). ***[Crossref]***
8. Harraz AM, Osman Y, El-Nahas AR, et al. Residual stones after percutaneous nephrolithotomy: Comparison of intraoperative assessment and postoperative non- contrast computerized tomography. World J Urol

2017;35:1241–46. *[Crossref]*

9. Portis AJ, Laliberte MA, Holtz C, et al. Confident intraoperative decision making during percutaneous nephrolithotomy: Does this patient need a second look? Urology 2008;71: 218–22. *[Crossref]*
10. Gokce MI, Gulpınar O, İbisA, et al. Retrograde vs. antegrade fl exible nephroscopy for detection of residual fragments following PnL: A prospective study with computerized tomography control. Int Braz J Urol 2019;45: 581-7. *[Crossref]*
11. Perez-Fentes DA, Gude F, Blanco M, Novoa R, Freire CG. Predictive analysis of factors associated with percutaneous stone surgery outcomes. Can J Urol 2013;20: 7050–59. ***PMID:*** 24331348
12. Nevo A, Holland R, Schreter E, et al. How Reliable Is the Intraoperative Assessment of Residual Fragments During Percutaneous Nephrolithotomy? A Prospective Study. J Endourol 2018;32:471-75. *[Crossref]*
13. 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: 1821-25. *[Crossref]*
14. Vicentini FC, Marchini GS, Mazzucchi E, Claro JF, Srougi M. Utility of the Guy's stone score based on computed tomographic scan findings for predicting percutaneous nephrolithotomy outcomes. Urology 2014;83: 1248–53. *[Crossref]*