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ORIGINAL ARTICLE

Comparison of scoring systems for predicting stone-free status and complications after retrograde ıntrarenal surgery

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Abstract

Purpose To compare the effectiveness of scoring systems in predicting stone-free rates (SFR) and complications following retrograde intrarenal surgery (RIRS).

Materials and methods We retrospectively analyzed 280 patients who underwent RIRS for kidney stones between 2016 and 2019. The Resorlu–Unsal Stone score (RUSS), Modified Seoul National University Renal Stone Complexity (S-ReSC) score, and R.I.R.S. scoring system score were calculated for each patient who was enrolled in the study. Subsequently, stone scoring systems were compared as to their predictive capability for SFR using receiver-operating characteristic curves. Furthermore, multivariate analysis was done to determine whether the scoring systems associated with SFR and complications.

Results The median patient age was 44 (35-–56). The median RUSS, S-ReSC, and R.I.R.S scores were 0 (0–1), 1(1–2), and 6 (5–7), respectively. The overall SFR was 76.7%. The R.I.R.S. scoring system was found to have a higher predictive value in predicting postoperative SFR than the other two scoring systems ($p<0.001$, AUC = 0,816). RUSS, R.I.R.S. score, and stone size were found to be independent predictive factors for SFR ($p=0.049$, $p=0.024$, $p=0.033$, respectively). Complications were observed in 3.2%(9/280) of patients. Stone scoring systems were not statistically associated with complications. Operation duration was the only independent risk factor for complications ($p=0.010$).

Conclusions The R.I.R.S. scoring system was found to have a higher predictive value than RUSS and S-ReSC to predict SFR following RIRS in our study. However, none of the stone scoring systems was directly proportional to complications of RIRS.

Keywords Renal calculi · Ureteroscopy · Laser lithotripsy · Scoring methods · Treatment outcome

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Introduction

Urinary system stone disease is a health problem which is frequently encountered and has an increasing incidence today [1]. Since the rates of applying to hospitals are high in patients with kidney stones, it causes loss of workforce socioeconomically and high expenditures due to its recurrent nature [2, 3]. Kidney stones could be treated with open surgery, percutaneous nephrolithotomy (PNL), retrograde intrarenal surgery (RIRS), or shock wave lithotripsy (SWL) [4]. Flexible ureterorenoscopy (f-URS), together with the use of high-resolution cameras and auxiliary instrument, have broken ground in the urologic practice from diagnosis to treatment. Following these developments, RIRS has gained more significance in the treatment of kidney stones [5–7].

Scoring systems are developed to select the most appropriate surgical method during the preoperative consultancy and obtain concrete for the success rate of the surgical intervention and the complications that may develop [8, 9]. Recently, scoring systems that can predict the SFR and complications of RIRS have been developed in the literature. When the literature is reviewed, Resorlu et al. developed a scoring system, Resorlu–Unsal Stone score(RUSS), that could determine the SFR for RIRS in 2012 [10]. Then, in 2014, Jung et al. put forward the Modified Seoul National University Renal Stone Complexity (S-ReSC) scoring system, and finally, Xiao et al. set forth an innovative scoring system (R.I.R.S. Scoring System) prediction of SFR after RIRS in their multicenter study in 2017 [11, 12].

To the best of our knowledge, these three RIRS scoring systems had not been previously compared. Therefore, we aimed to determine the predictive value of these scoring systems for SFR and complications after RIRS in this study.

Materials and methods

This study was approved by the ethical committee of Ankara Keciören Traning and Research Hospital, Ministry of Health-University of Health Sciences (approval number 2019–03/1854). Data of 529 patients, who had only kidney stones and above the age of 18 underwent RIRS between January 2016 and July 2019 in a single referred center, were retrospectively analyzed. Patients with missing preoperative imaging data ($n=38$) or had undergone double-j stent catheterization (secondary RIRS, $n=211$) were excluded from the study. In total, 280 patients were enrolled in the study.

The demographic and preoperative data of the patients were recorded. Non-contrast computed tomography (NCCT) was used for the diagnosis of kidney stones. The stone size, density [Hounsfield Unit (HU)], localization (lower pole vs. other), and presence of hydronephrosis were recorded from NCCT. R.I.R.S., RUSS, and Modified S-ReSC were, respectively, calculated and categorized by a urology specialist (RO) who had radiological education in his residency and performing RIRS in routine daily practice.

All patients received prophylactic or therapeutic culture-guided antibiotics after hospital admission. We used our standard RIRS technique as described previously [13]. All procedures were performed by two surgeons: CS and OFB (> 75 annual cases for each surgeon). Postoperatively, a double-j stent was placed based at the surgeon's discretion and removed within 2–3 weeks. The stone-free condition of the patients was checked in the postoperative first month by NCCT and complete clearance in NCCT was accepted as stone-free.

Scoring systems

RUSS

The parameters of this scoring system are stone size > 20 mm, presence of stone in the lower calyx, and the infundibulopelvic angle of < 45º, more than one stone in different calyces, and presence of abnormal renal anatomy. The total stone score is determined by adding one point for each parameter [10].

Modified S-ReSC score

The modified S-ReSC scoring system is performed according to the anatomical stone location. The locations defined in this system: renal pelvis (#1), upper and lower major calyces (#2–3), anterior and posterior minor calyceal groups [upper group (#4–5), middle group (#6–7), lower group (#8–9)]. One point is given to every defined region. One more point is added to the original score for the stones located in the lower calyx (#3, #8–9) [11].

R.I.R.S. scoring system

It is a scoring system that includes stone density (HU), renal infundibulopelvic length (RIL), renal infundibulopelvic angle (RIPA), and stone burden (mm) [12]. In the scoring system, the calculation is made by adding 1 point: stone diameter ≤ 10 mm, RIL ≤ 25 mm, stone density ≤ 1000 HU and the location of the stone outside the lower pole, 2 points: stone diameter between > 10 mm—≤ 20 mm, RIL > 25 mm, stone density > 1000 HU, presence of a stone in the lower pole and RIPA > 30^0, and 3 points: stone diameter > 20 mm or presence of a stone in the lower pole and RIPA ≤ 30^0. RIL is calculated by measuring the distance from the most distal end of the stone to the midpoint of the renal pelvis. RIPA was defined as the inferior angle of the intersection of the ureteropelvic axis and the lower calyx axis.

Statistical analysis

All statistical analyses were performed using the SPSS 22.0(IBM SPSS Statistics, IBM Corporation, Chicago, IL) software for Windows. The compliance of the numeric variables with the normal distribution was assessed with the Kolmogorov–Smirnov test. Nominal data were compared using the Chi-square test and Mann–Whitney U test was used for the comparison of the medians. The median (interquartile range, IQR) was used to define the nonparametric variables, while frequency and percentage were used for categorical variables. Receiver-operating characteristic (ROC) curves were plotted of scoring systems for SFR. Threshold values were determined using the ROC curves. Multivariate logistic regression analysis was used to determine whether the scoring systems associated with SFR and complications. In all the analyses, the statistical significance level was accepted as 0.05.

Results

The median age and stone size of the patients was 44 years (35–56) and 12.7 mm (9.8–16.1), respectively. The female-to-male ratio was 105/175. The SFR was 76.7%. The median RUSS, S-ReSC, and R.I.R.S scores were 0 (0–1), 1 (1–2), and 6 (5–7), respectively.

A strong correlation was discovered between the stone present in the lower calyx ($p<0.001$), stone size ($p<0.001$), stone density ($p=0.022$), presence of hydronephrosis ($p<0.001$), a score of the R.I.R.S. scoring system ($p<0.001$), RUSS ($p<0.001$) and Modified S-ReSC score ($p<0.001$) and SFR (Table 1).

The R.I.R.S. scoring system was found to have a better predictive value than the other two scoring systems ($p<0.001$, Fig. 1).

In multivariate analysis, RUSS ($p=0.049$), R.I.R.S. scoring system ($p=0.033$), and stone size ($p=0.024$) were found statistically significant (Table 2).

Complications were observed in 9 patients (3.2%). Postoperative fever that required antipyretics (Clavien grade 1) was observed in five patients and postoperative symptomatic urinary tract infection which required treatment by appropriate antibiotics (Clavien grade 2) developed in one patient. Postoperative double-j catheterization placement under local anesthesia (Clavien grade 3a) and ureterorenoscopy under general anesthesia (Clavien grade 3b) were required in two and one patients, respectively, due to renal colic resulting from the residual ureter stone. A strong correlation was determined between RUSS ($p=0.034$), modified S-ReSC score ($p=0.008$), and operation duration ($p=0.010$) and complication rates. In multivariate analysis, operation duration ($p=0.010$) was found to be the only factor associated with postoperative complications (Table 3).

Discussion

The main objective of the surgical treatment of kidney stones is to ensure acceptable complications and high SFR after the operation. Scoring systems that could predict the SFR were needed to obtain concrete information for preoperative consultancy to patients and to determine the most appropriate operation type. For this purpose, three different scoring systems have been developed by Resorlu et al., Jung et al., and Xiao et al. over the last 10 years, and it was shown

Table 1 Patients' demographics and clinical data

	Stone-free $n=215$	Not stone-free $n=65$	Total $n=280$	p
Age, years	43 (35–56)	47 (35–59)	44 (35–56)	0.313 ^{m}
Gender, n (%)				
Male	132 (75.4)	43 (24.6)	175 (62.5)	0.487^{k}
Female	83 (79)	22 (21)	105 (37.5)	
BMI, kg/m^2, (IQR)	26.8 (24–29.8)	25.6 (22.6–29.6)	26.7 (23.6–29.8)	0.113^{m}
Side, n (%)				
Right	109 (80.1)	27 (19.9)	136 (51.4)	0.195^{k}
Left	106 (73.6)	38 (26.4)	144 (48.6)	
Stone size, mm, (IQR)	12 (9–14.4)	20 (13.2–30.2)	12.7 (9.8–16.1)	<0.001^{m}
Stone density, HU, (IQR)	906 (652–1193)	1061 (733–1344)	952 (678.2–1245.2)	0.022^{m}
Hydronephrosis, n (%)				
Yes	57 (91.9)	5 (8.1)	62 (22.1)	0.001^{k}
No	158 (72.5)	60 (27.5)	218 (77.9)	
Lower calyx stone, n (%)				
Yes	42 (53.2)	37 (46.8)	79 (28.2)	<0.001^{k}
No	173 (86.1)	28 (13.9)	201 (71.8)	
R.I.R.S. scoring system, (IQR)	6 (5–6)	7 (6–8)	6 (5–7)	<0.001^{m}
RUSS, (IQR)	0 (0–0)	1 (0–2)	0 (0–1)	<0.001^{m}
Modified S-ReSC score, (IQR)	1 (1–1)	3 (1–4.5)	1 (1–2)	<0.001^{m}
Duration of operation, min, (IQR)	35 (22–45)	51 (32–64)	36,5 (25–52.5)	<0.001^{m}
Length of hospital stay, days, (IQR)	1(1–1)	1 (1–1)	1 (1–1)	0.014^{m}

IQR ınterquantile range, *BMI* body mass index, *HU* hounsfield unit, *RUSS* resorlu–unsal stone score, *S-ReSC* Seoul national university renal stone complexity

^{k}:Chi-square test, ^{m}:Mann–Whitney *U* test

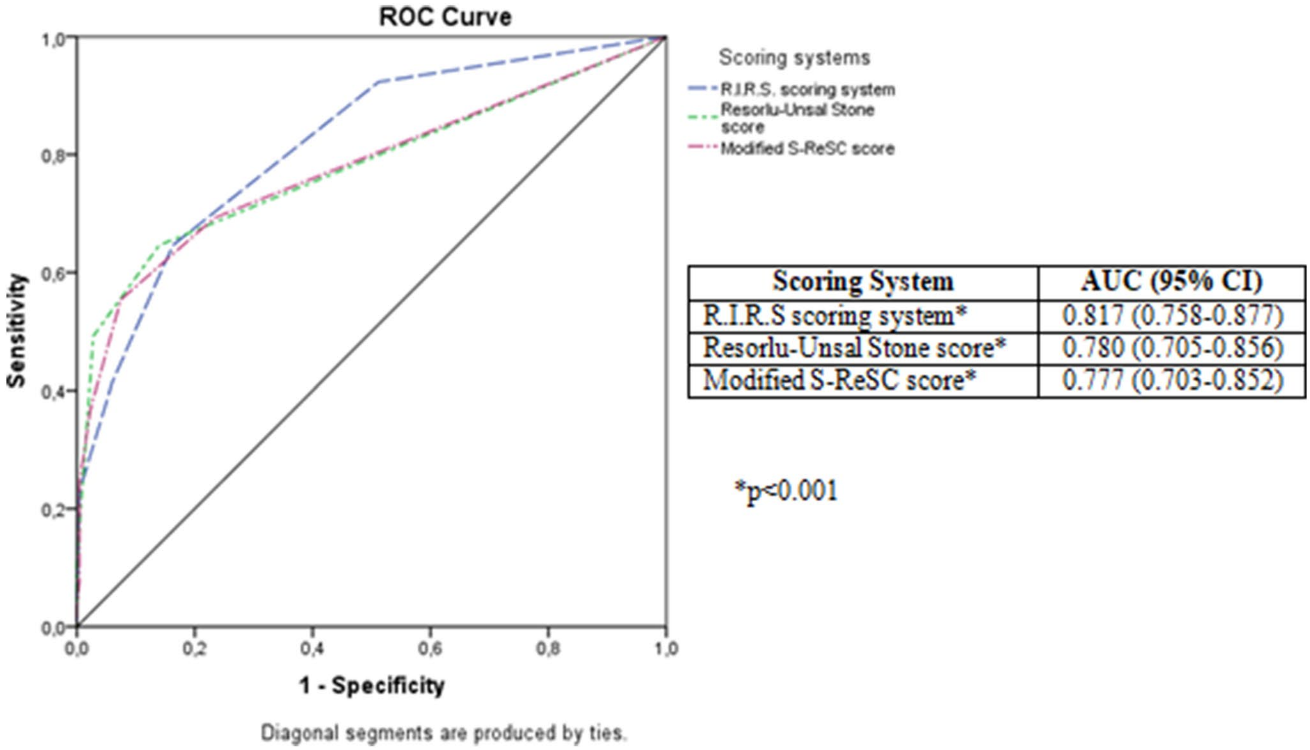

Fig. 1 ROC curve for scoring systems in predicting stone-free status

Table 2 Univariate and multivariate logistic regression analysis for predictors of stone-free status

	Univariate analysis			Multivariate analysis		
	OR	%95 CI	*p*	OR	%95 CI	*p*
Age	1.011	0.991–1.031	0.276			
BMI (kg/m$^{2)}$	0.960	0.899–1.024	0.215			
Stone size (mm)	1.232	1.154–1.315	**< 0.001**	1.093	1.007–1.186	**0.033**
Stone density (HU)	1.002	1.001–1.003	**< 0.001**			
Lower calyx stone	0.184	0.101–0.333	**< 0.001**			
Presence of hydronephrosis	0.231	0.088–0.604	**0.003**			
RUSS	5.481	3.564–8.430	**< 0.001**	1.482	1.022–2.192	**0.049**
Modified S-ReSC score	2.667	2.005–3.584	**< 0.001**			
R.I.R.S. scoring system	2.787	2.110–3.681	**< 0.001**	2.109	1.104–4.028	**0.024**
Operation duration	1.045	1.028–1.062	**< 0.001**			

Values in bold indicate statistically significant results

OR odds ratio, *CI* confidence ınterval, *BMI* body mass index, *HU* hounsfield unit, *RUSS* resorlu–unsal stone score, *S-ReSC* Seoul national university renal stone complexity

that they could predict the results of the f-URS operation [10–12]. However, it is yet unknown which scoring system predicts the SFR and complications better.

The first scoring system is the RUSS system developed by Resorlu et al. in 2012. In this study, a high RUSS was shown to be correlated with the low SFR after RIRS. Furthermore, it was reported in previous studies that PNL might be a more effective treatment method than RIRS in patients with an RUSS ≥ 2 [10]. Following this, in our patient group, we detected the number of patients with an RUSS ≥ 2 was low as we preferred PNL due to the low SFR after RIRS according to our experiences in patients with an RUSS ≥ 2.

According to our experiences, RUSS can be learned in about ten cases and applied easily. Resorlu et al. reported that stone composition was one of the factors determining the SFR after the operation. As this information could not be reached preoperatively, it was kept out of the scoring system. Given the literature review, there are publications

Table 3 Univariate and multivariate logistic regression analyses for predictors of complications

	Univariate analysis			Multivariate analysis		
	OR	%95 CI	*p*	OR	%95 CI	*p*
Age	0.980	0.931–1.031	0.436			
BMI (kg/m$^{2)}$	0.888	0.750–1.052	0.170			
Stone size(mm)	1.039	0.985–1.095	0.161			
Stone density (HU)	1.000	0.998–1.002	0.966			
Lower calyx stone	0.301	0.079–1.150	0.079			
Presence of hydronephrosis	0.430	0.053–3.508	0.431			
RUSS	1.972	1.052–3.695	**0.034**			
Modified S-ReSC score	1.486	1.107–1.996	**0.008**			
R.I.R.S. scoring system	1.432	0.921–2.227	0.111			
Operation duration	1.038	1.009–1.067	**0.010**	1.038	1.009–1.067	**0.010**

Values in bold indicate statistically significant results

OR odds ratio, *CI* confidence ınterval, *BMI* body mass index, *HU* hounsfield unit, *RUSS* resorlu–unsal stone score, *S-ReSC* Seoul national university renal stone complexity

are presenting an association between the stone density and stone composition, and the stone HU measured in NCCT was correlated with stone-fragment ability and operation duration [14, 15]. Besides, only two renal malformations were defined in the scoring system, and these two defined renal malformations (horseshoe kidney and pelvic kidney) were not presented in our patient groups. Therefore, we think that the addition of the stone density and all other renal malformations to the RUSS system will better predict the postoperative results.

In 2013, Jeong et al. developed the S-ReSC scoring system to predict the SFR after the PNL operation [16]. Jung et al. were inspired by this study and modified the S-ReSC scoring system to predict the SFR following the RIRS [11]. Park et al. stated that the S-ReSC-R scoring system was predictive for SFR in their studies [17]. In line with this study, we found that S-ReSC-R scoring system was predictive for SFR in univariate analysis. However, S-ReSC scoring system was found not superior when compared to the other mentioned scoring systems in our multivariate analysis. In addition to this, this scoring system was evaluated by categorization in this study. These factors may play a role in the difference between the two studies. When the literature was reviewed, many factors that affected the results of the RIRS were determined [18–21]. For this reason, we believe that the modified S-ReSC scoring system, which is only applied according to the stone localization, is inadequate for predicting the results of the RIRS effectively.

Finally, the R.I.R.S. scoring system was developed by Xiao et al. in 2017 [12]. In clinical practice, it is a scoring system with a long-learning curve, because these calculations are difficult to make in NCCT. Since this study was multicentric and had a relatively high number of patients compared to other scoring systems studies, we assume that this scoring system could better at predicting the postoperative SFR. However, the presence of renal malformations among the exclusion criteria in the scoring system prevents the adaptation of this scoring system to the whole patient population. Nevertheless, we discovered in our study that the R.I.R.S. scoring system predicted the SFR better than other scoring systems (AUC = 0.817, $p < 0.001$). When the R.I.R.S. scoring system is compared to other scoring systems, it provides a better opportunity for evaluation with more clinical information. For this reason, we think that the R.I.R.S. scoring system has a higher predictive value for SFR.

The majority of the complications that develop after RIRS are infectious complications. Fan et al. [22] stated that advanced age, gender, presence of any comorbid disease, preoperative urine culture result, stone composition, stone diameter, residual stone presence, and operation duration were shown to be the risk factors for postoperative complication development [21]. In our study, the scoring systems did not associate with complications. We believe that scoring systems are inadequate in predicting the complications, because these factors defined for postoperative complication development were not included in the scoring systems. However, the fact that complications were seen in a small number of patients in our study makes the power of our analysis on this subject low.

There are some potential limitations to this study. The retrospective design and its external validation in a single center constitute the main limitations. Although the low number of patients can be seen as limitation, including only primary RIRS patients in our study makes stronger. Finally, the patients in our study were operated by two different surgeons. This situation may be considered as another limitation. However, the high experience of these surgeons in RIRS minimizes the impact of this limitation. Aside from the aforementioned limitations, we believe that the results of the present study will make a significant contribution to the literature, since no are studies comparing these three scoring systems in the literature.

Conclusion

In our study, it was found out that the R.I.R.S. scoring system had superior predictive values than the other two scoring systems for predicting the SFR after RIRS. However, it was concluded that the scoring systems were inadequate in predicting the complications. Multicenter prospective studies with high patient numbers are needed to confirm our results.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Human rights All procedures performed in studies involving human participants was by the ethical standards of the institutional and/or national research committee and with the Helsinki Declaration and its later amendments or comparable ethical standards.

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