**Predicting stone free rate after retrograde intrarenal surgery**

**using RIRS scoring system VS (RUSS) Resorlu Unsal stone score.**

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**Abstract**

**Objectives**: To compare the effectiveness of scoring systems in predicting stone-free rates (SFR) following retrograde intrarenal surgery (RIRS) for renal calculi up to 2 cm.

**Methods**: We prospectively analyzed 172 patients who underwent RIRS for kidney stones attending to the urology department Benha university hospital. All Patients will be managed by FURS. All patients had a preoperative CT scan and postoperative imaging for comparison. We collected patient characteristics (sex, age, previous ipsilateral urinary tract surgery, preoperative ureteral stent placement), stone factors (total stone burden, stone number, stone density) and renal factors (anatomical abnormalities, stone location in a lower pole, number of calyceal involvement) and correlated the data against postoperative stone-free status (defined as residual fragment ≤ 4 mm). The Resorlu–Unsal Stone score (RUSS), 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 prediction of SFR and Sensitivity, specificity values and Area under the curve (AUC) using he ROC Curve (Receiver Operating Characteristic). Furthermore, multivariate analysis was done to determine whether the scoring systems associated with SFR and complications.

**Results:** The median patient age was 45 (35–-56). The median RUSS and R.I.R.S scores were 1 (0–1) and 5(4–6) respectively. The overall SFR was 54% after 1 month postoperative. The R.I.R.S. scoring system was found to have a higher predictive value in predicting postoperative SFR than the other RUSS scoring systems (*p* <0.001, AUC = 0,846). Significant differences were found between these cases in terms of stone number, stone location, presence of lower pole calculi and preoperative stent placement. And stone Burden was found to be statistically significant. Complications were not observed in 53% of patients. Stone scoring systems were not statistically associated with complications.

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

**INTRODUCTION**

Kidney stone disease represents a substantial burden on healthcare expenditure. Now, nearly one in 11 are diagnosed with stones during their lifetime. The rising prevalence of kidney stones has been linked to increasing rates of obesity, diabetes and metabolic syndrome. (1)

Common and widely available treatment option for kidney stones include three procedures: extracorporeal shock-wave lithotripsy (SWL), flexible ureteroscopy (URS) and Percutaneous Nephrolithotomy (PCNL)

The role of retrograde intrarenal surgery (RIRS) has broadened in the last decade with improvements in flexible ureteroscopes, instruments and user experience achieving higher stone free rate than SWL and low morbidity than PCNL**).(5)**

Although RIRS is accepted well -established, effective, minimally invasive procedure, neither the AUA nor the EUA guidelines recommends flexible ureteroscopy as a first-line treatment of choice for renal calculi. Because this procedure has some limitations in efficacy and does not always render the patient stone free, it is important that patients with renal calculi be informed of stone-free rates preoperatively. (12)

There is no definitive definition of the stone free rate (SFR) following endourological procedures for renal stones but it is widely accepted to consider residual stone fragments less than 4 mm as clinically insignificance and many studies began adopting this metric when reporting the success of minimally invasive stone treatment. So, we will consider in this study The SFR is less than 4 mm fragments after one month's follow up under CT.

Many parameters were used to predict the outcome of the (SFR) like stone location, burden, association of hydronephrosis, however, when these parameters are used separately, they are not reproducible and do not give precise idea about the outcome. For that reason, scoring systems were developed based on preoperative data like stone size, site, endorenal anatomy and renal anomaly. (17)

Recent scoring systems are used to predict the SFR like RIRS scoring system, Resorlu Unsal stone score, so in our study we evaluate the two scoring systems in predicting the SFR after RIRS

**Patients and Methods**

We prospectively analyzed 172 patients who underwent RIRS for kidney stones attending to the urology department Benha university hospital. All Patients will be managed by FURS. All patients had a preoperative CT scan and postoperative imaging for comparison. We collected patient characteristics (sex, age, previous ipsilateral urinary tract surgery, and preoperative ureteral stent placement), stone factors (total stone burden, stone number, and stone density) and renal factors (anatomical abnormalities, stone location in a lower pole, number of calyceal involvement) and correlated the data against postoperative stone-free status (defined as residual fragment ≤ 4 mm). NCCT were revised preoperatively and classified each case using the Resorlu Unsal stone score (**RUSS**) which considers four parameters (1 point for each of the four criteria): stone size *>*20 mm; lower pole location with infundibulopelvic angle(IPA)*<*45˚;stone number in different calyces *>*1; abnormal renal anatomy; with a total score ranging from 0 to 4 .

|  |  |
| --- | --- |
| **Weight** | **Clinical condition** |
| 1 | Stone size >20 mm (one point per 10 mm) |
| 1 | Lower pole stone location and IPA < 45 |
| 1 | Stone number in different calyces >1 |
| 1 | Abnormal renal anatomy (horseshoe kidney or pelvic kidney) |

Total score ranges between **0** and **4**.

Stone composition was not added into score as it cannot be identified prior to surgery, however we discovered the composition of stone is related to their density so we classified the patient with (**RIRS Scoring system**) It is a scoring system that includes stone density (HU), renal infundibulopelvic length (RIL), renal infundibulopelvic angle (RIPA), and stone burden (mm). 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**>300**, and **3 points**: stone diameter**>20 mm** or presence of a stone in the lower pole and RIPA**≤300**. 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.

|  |  |  |  |
| --- | --- | --- | --- |
| **Score** | | | |
| **parameters** | 1 | 2 | 3 |
| **Renal stone density (HU)** | ≤1000 | >1000 |  |
| **Inferior pole stone** | Non inferior | Inferior with RIPA >30º | Inferior with RIPA≤30º |
| **RIL (mm)** | ≤25 | >25 |  |
| **Stone burden(mm)** | ≤10 | >10 and ≤20 | >20 |

Total score ranges between **4** and **10**

The Resorlu–Unsal Stone score (RUSS), 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 prediction of SFR and Sensitivity, specificity values and Area under the curve (AUC) using he ROC Curve (Receiver Operating Characteristic). Furthermore, multivariate analysis was done to determine whether the scoring systems associated with SFR and complications.

**Operative Technique**

All RIRS operations will be performed under spinal anesthesia and in a lithotomy position. Before the RIRS procedure, ureteral dilatation will be performed by ureteral dilators up to 12-14 Fr. a 9.5/11.5 Fr ureteral access sheath (Cook Medical Bloomington, IN, USA) will be inserted over the guide wire under fluoroscopy. For all cases, two guide wires will be used but only Safety Wire Will Be Left outside the Access Sheath. Flexible URS will be performed with a 9.5 Fr (The LithoVue™ System-Boston Scientific). Stones will be managed with a holmium: YAG laser. After the procedure a JJ stent will be inserted. Operative time is defined as the time that will be elapsed from the start of introducing the instruments through the urethra until JJ-stent insertion.

**Data management and statistical analysis: -**

The collected data was recorded then presented, and statistically analysed by computer using Statistical Package for the Social Sciences (SPSS) 28.0 for windows (SPSS Inc., Chicago, IL, USA) as follow:

1. Editing and coding.
2. Data entry in computer.
3. Data were summarized and presented in tables and graph.
4. The normality of distribution for the analysed variables was tested using Kolmogorov-Smirnov test. The collected data were summarized in terms of median and Inter Quartile Range (IQR) for nonparametric data as appropriate and as number and percentage for qualitative data. Comparisons between the different study groups were carried out using the Chi-square (χ2) to compare qualitative data (number and percentage) as appropriate, Mann Whitney test to compare non parametric quantitative data.
5. Sensitivity, specificity values and Area under the curve (AUC) of anterior and posterior approach predictability of improvement were calculated using him ROC Curve (Receiver Operating Characteristic).

**ROC curve=** *receiver operator characteristic curve,* it is a graphic presentation of sensitivity against 1- specificity.

***Sensitivity =*** *ability of the test to detect the true +ve cases with minimal false negatives*

***Specificity =*** *ability of the test to detect the true –ve cases with minimal false positives*

**AUC =** *area under the curve, the greater the area, the more accurate is the curve,*

Total area is 1.0, the red line is the reference line, and it divides the area into 2 halves.

**95% CI of AUC**= confidence interval = it is an interval at which the investigator is 95% confident that the true AUC lies.

6-All tests were two sided. The accepted level of significance in this work was (p <0.05), p ≤ 0.001 was considered highly statistically Significant (HS), and p > 0.05 was considered none statistically Significant (NS).

**Results**

172 patients participated in this study. 81 (74%) achieved stone-free status, and 69 patients (26%) had one or more residual fragments. The median patient age was 45 (35–-56). The median RUSS and R.I.R.S scores were 1 (0–1) and 5(4–6) respectively. The overall **SFR** was 74% after 1 month postoperative. Preoperative patient characteristics and stone parameters are shown in Table 1. The stone characteristics such as stone burden, inferior pole stone, RIL, kidney stone density, and renal infundibulopelvic angle (RIPA) have statistically significant differences whether RIRS achieved stone-free status or not (**P**< 0.001, **P**< 0.001, **P**: 0.001, **P**< 0.001, **P**: 0.001) showed in Table 3. Compared with patients who failed RIRS, patients who successfully applied RIRS had a significantly lower scoring system (**P**< 0.001). The SFR was significantly decreased over getting high score in R.I.R.S. score system (**P**< 0.001), and RUSS (**P** 0.001) in Table 2. The **R.I.R.S.** scoring system was found to have a higher predictive value in predicting postoperative **SFR** than the other **RUSS** scoring systems (*p* <0.001, AUC = 0,846). Complications were not observed in 53% of patients. Stone scoring systems were not statistically associated with complications.

**Table 1 the demographic and clinical data of the 150 patients and the stone characteristics used to calculate the R.I.R.S. & RUSS score: -**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| characteristics | | Total  (N=150) | Stone free  (N=81)  (N. %) | p-value |
| Sex | **Male** | 86 | 53(65.4%) | **.053** |
| **Female** | 64 | 28(34.6%) |
| Age Groups | **≤40 years old** | 66 | 43(53.1%) |  |
| **>40** | 84 | 38(46.9%) |
| Previous Urinary tract surgery | **Yes** | 70 | 34(42%) |  |
| **No** | 80 | 47(58%) |
| Preoperative ureteral stent | **Yes** | 60 | 42 |  |
| **No** | 90 | 39 |
| Stone factors :- | |  |  |  |
| Total stone burden | **≤10 mm** | 70 | 51(63%) | **<.001** |
| **11-20mm** | 50 | 24(30%) |
| **>20 mm** | 30 | 6(7%) |
| Stone density | **≤1000** | 90 | 74 | **.001** |
| **>1000** | 60 | 7 |
| Stone Number | **single** | 95 | 72 |  |
| **Multiple** | 55 | 9 |
| Hydronephrosis | **Yes** | 72 | 37 | **.006** |
| **No** | 78 | 44 |
| Anatomical abnormalities | **Normal position** |  | 74(91.4%) |  |
| **Horseshoe** |  | 1 (1.2%) |
| **Ectopic pelvic** |  | 6 (7.4%) |
| Stone location | **Lower polar stone** | 60 | 45(55.5%) |  |
| **Non lower polar stone** | 90 | 36(44.4) |
| Only lower polar stone | **Infundibulopelvic angle (RIPA)**  **≤45°**  **>45°** |  | **3** | .001 |
|  | **8** |
| **Infundibular length (RIL) mm**  **≤25**  **>25** |  | **5** |
|  | **6** |

Table 2 The SFR after RIRS according to the R.I.R.S. scoring system and RUSS: -

|  |  |  |  |
| --- | --- | --- | --- |
| **RIRS score** | **SFR (%)** | **RUSS** | **SFR (%)** |
| 4 | 98% | 0 | 85% |
| 5 | 86% | 1 | 75% |
| 6 | 82% | 2 | 68% |
| 7 | 72% | 3 | 14% |
| 8 | 61% | p-value 0.001 | |
| 9 | 13% |
| 10 | 9% |
| P-value | <0.001 |

**Table 3 Binary logistic regression analysis of potential independent predictors for postoperative stone-free outcomes: -**

|  |  |
| --- | --- |
|  | **P value** |
| **RIPA** | **0.001** |
| **RIL** | **0.001** |
| **Renal stone Density** | **0.001** |
| **Stone Burden** | **0.001** |
| **RIRS score** | **<0.001** |

**Discussion**

Many parameters were used to predict the outcome of the (**SFR**) after retrograde intrarenal surgeries like stone location, burden, association of hydronephrosis, however, when these parameters are used separately, they are not reproducible and do not give precise idea about the outcome. (1)

For that reason, scoring systems were developed. The 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 (5). Recent scoring systems are used to predict the **SFR** like (**RIRS** scoring system) and (**Resorlu Unsal**) stone score (**RUSS**), so in our prospective study was conducted to compare the effectiveness of scoring systems in predicting stone-free rates (**SFR**) following retrograde intrarenal surgery (RIRS) for renal calculi up to 2 cm.

In our study, the overall stone free rate was (**74 %**) after one month follow up while (26 **%)** of the patients had residual fragments and needed Re-treatment. These results come in agreement with results reported by others **Francois Richard et al, 2020**, **Cong Wong et al. 2021,**and **Ridvan Ozbek** **er al** who reported rates **74.1 %** ,**71.5 %&76.7** respectively.

Other authors reported higher results as **Salih polat et al, 2021** **(84)** (**79.9**%)**, Berkan Resorlu et al. 2012** (**86** %)and lower results as **Suppasek Pattarawong et al (53.3 %) a**nd Stavros et al (**67.1**%)

We believe that the difference between the size (<20mm) and location of the stones in patients in their studies and in patients in the other studies could be an explanation.

In this study, we evaluated the stone free rate in accordance to stone size, location, density and pelvicalyceal anatomy to correlate the data collected in comparison between the two scoring systems (RUSS &RIRS scoring systems).

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 PCNL might be a more effective treatment method than RIRS in patients with an RUSS≥ 2. Resorlu et al. reported that stone composition was one of the factors determining the SFR after the operation and it was found that the stone composition is closely related to SFR during the research process. Because the stone’s composition cannot be known before the operation, this parameter is not included in the RUSS scoring system. However, some scholars discovered that the composition of stones is closely related to their density [13]. Therefore, to render this scoring system more accurate and reasonable, the density  
of stones should be used in scoring systems. Secondly only two renal malformations were defined in the RUSS scoring system, and these two defined renal malformations (horseshoe kidney and pelvic kidney). 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

Finally, the R.I.R.S. scoring system was developed by Xiao et al. in 2017. In clinical practice, it is a scoring system with a long-learning curve include stone burden, Density, lower polar stone with infundibulopelvic angle & infundibular length The patients enrolled in this scoring system had undergone CTU examinations before surgery  
and performed three reconstructions, which can accurately measure all the stones’ data Saskia et al. [16] suggest that CTU is vital before performing an endourologic procedure because CTU can show the anatomy of the renal pyelocaliceal system. We found that the R.I.R.S. scoring system is easy to repeat because the CTU can evaluate all parameters. We assume that this scoring system could better at predicting the postoperative SFR. Our study did not identify enough cases of renal malformation to draw any conclusions 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. An ideal score should be sensitive and available for all patients, but it will be difficult to combine performance and simplicity/efficiency. Nevertheless, we discovered in our study that the R.I.R.S. scoring system predicted the SFR better than other scoring systems (AUC = 0. 846, 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 formation. For this reason, we think that the R.I.R.S. scoring system has a higher predictive value for SFR.

Chart, line chart

Description automatically generated

The practical value of this tool is mainly reflected in two points: patient consultation and research in which doctors can inform patients of the probability of successful treatment and could increase accurate data exchange between researchers.

**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.

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