How to Cite:
Diab, T., El Hamshary, S. A., El-Dakhakhny, A. S., & Fattah, A. A. E. A. (2021). Comparative analysis of RIRS scoring system and Resorlu Unsal Stone Score (RUSS) for predicting stone free rate after retrograde intrarenal surgery: A retrospective study. *International Journal of Health Sciences*, *7*(S1), 1170–1181. https://doi.org/10.53730/ijhs.v7nS1.14353

Comparative analysis of RIRS scoring system and Resorlu Unsal Stone Score (RUSS) for predicting stone free rate after retrograde intrarenal surgery: A retrospective study

Tamer Diab
Lecturer of Urology, Faculty of Medicine, Benha University, Benha, Egypt.
Corresponding author email: Tamer.diab@fmed.bu.edu.eg

Salah A. El Hamshary
Lecturer of Urology, Faculty of Medicine, Benha University, Benha, Egypt.
Email: Salah.abdelhamed@fmed.bu.edu.eg

Amr S. El-Dakhakhny
Assistant Professor of Urology, Faculty of Medicine, Benha University, Benha, Egypt.
Email: amreldakhakhny77@gmail.com

Ahmed Abou Elezz Abdel Fattah
Lecturer of Urology, Faculty of Medicine, Benha University, Benha, Egypt.
Email: ahmed.aboelezz@fmed.bu.edu.eg

***Abstract*---**Objectives: To compare the predictive ability of the RIRS scoring system and the RUSS in predicting stone-free rate (SFR) after retrograde intrarenal surgery (RIRS), and to evaluate the sensitivity and specificity of both scoring systems, as well as their association with complications. Methods: This retrospective study was carried out on patients who underwent RIRS for renal stones between July 2017 and July 2020. Two scoring systems were used to assess the degree of difficulty of the procedure: the RIRS scoring system and the RUSS. The predictive ability of the two scoring systems were compared using receiver operating characteristic (ROC) analysis and calculated the sensitivity and specificity of each system. The association between the scoring systems and complications were determined using logistic regression. Results: A total of 200 patients were included in the study with a mean age of 50.13± 8.98 years and 120 (60%) were males. The results showed a significant AUC of 0.669 for the RIRS score (P<0.001), 95% CI (0.599 to 0.734). The sensitivity and specificity were 76.51 % and 85.7%, respectively. In contrast, the RUSS score revealed

Manuscript submitted: 10 August 2021 Manuscript revised: 21 August 2021, Accepted for publication: 21 Sept 2021

a non-significant unsatisfactory AUC of 0.480 (P = 0.845), with a 95% confidence interval ranging from 0.438 to 0.581. Conclusion: The RIRS scoring system showed a better predictive ability for SFR after RIRS compared to the RUSS. The RIRS scoring system also has higher sensitivity and specificity than the RUSS for predicting SFR. Both scoring systems have similar predictive ability for complications.

***Keywords*---**Scoring System, RIRS, RUSS, Stone Free Rate, retrograde intrarenal surgery.

Introduction

Kidney stones are a common health problem worldwide, with a lifetime prevalence of up to 12% in men and 6% in women. It is estimated that the incidence of kidney stones is increasing, and the disease is becoming a global burden on healthcare systems [1, 2]. Kidney stones can cause severe pain, renal impairment, and complications that may require surgical interventions. Therefore, accurate diagnosis, proper management, and follow-up are crucial for preventing complications and achieving a favorable outcome [3, 4].

Retrograde intrarenal surgery (RIRS) has emerged as a minimally invasive procedure for the management of kidney stones [5]. It involves accessing the kidney through the urethra and using a flexible ureteroscope to visualize and treat stones within the renal collecting system. Accurate prediction of the stone-free rate after RIRS is crucial for optimal patient counseling, treatment planning, and decision-making [6, 7].

The ability to predict the stone-free rate after RIRS allows clinicians to inform patients about the likelihood of complete stone clearance and helps in determining the need for additional interventions or follow-up procedures. Predictive scoring systems have been developed to aid in this process by assessing various factors that can influence stone clearance. These scoring systems aim to provide a standardized approach to predict the likelihood of achieving a stone-free status after RIRS [8].

Two scoring systems that have gained attention in the literature for predicting stone-free rates after RIRS are the RIRS Scoring System and the Resorlu Unsal Stone Score (RUSS). The RIRS Scoring System incorporates preoperative stone burden, stone location, and other patient-related factors to provide a numerical score that correlates with the predicted stone-free rate. RUSS, on the other hand, evaluates stone burden, stone location, and degree of hydronephrosis to categorize patients into low, intermediate, and high-risk groups based on the likelihood of achieving a stone-free status [9, 10].

Several studies have investigated the use of scoring systems for predicting stone-free rates after RIRS. Previous research has evaluated the RIRS Scoring System, RUSS, and other similar systems in different patient populations [11-13]. Despite the availability of these scoring systems, there remains a need for further research to comprehensively evaluate their predictive performance, strengths, limitations, and clinical utility. Additionally, there is a lack of direct comparative studies between the RIRS Scoring System and RUSS, which hinders the ability to determine the superior predictive ability of these two systems. Therefore, the aim of this study is to compare the predictive ability of the RIRS scoring system and the RUSS in predicting SFR after RIRS.

Patients and Methods

This retrospective study analyzed 200 patients who underwent RIRS for kidney stones attending to the Urology Department Benha University Hospital. The study was done over a period of 3 years from July 2017 to July 2020. The study was performed after being approved by the Research Ethics Committee, Faculty of Medicine, Benha University.

All Patients were managed by FURS. All patients had a preoperative CT scan and postoperative imaging for comparison. 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) were collected 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.

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 the patient was classified 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.

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 the 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 was 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 guidewire under fluoroscopy. For all cases, two guidewires 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 were 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.

Statistical analysis

Data management and statistical analysis were done using SPSS version 28 (IBM, Armonk, New York, United States). Quantitative data were assessed for normality using the Kolmogorov–Smirnov test and direct data visualization methods. According to normality, quantitative data were summarized as means and standard deviations or medians and ranges. Categorical data were summarized as numbers and percentages. Quantitative data were compared between stone-free patients and those with residual stones using the independent t-test or Mann-Whitney U test for normally and non-normally distributed numeric variables, respectively. Categorical data were compared using the Chi-square test. ROC analysis was done for RUSS and RIRS scores to assess their performance in the prediction of the stone-free outcome. Areas Under Curve (AUC) with 95% confidence intervals and diagnostic indices were calculated. Multivariate logistic regression analysis was done to predict the stone-free outcome. Odds ratios with 95% confidence intervals were calculated. All statistical tests were two-sided. P values less than 0.05 were considered significant.

Results

According to stone free rate, 166 (83%) patients had stone free rate and 34(17%) had residual stones. The mean age of the total studied patients was 50.13± 8.98 years. We included 120 (60%) males and 80(40%) females. Regarding ASA, 55(27.50%) had ASA I, 97(48.5%) had ASA II, 48(24%) had ASA III. The mean BMI was 26.45± 1.08Kg/m2. 115(57.5%) of patients had co-morbidities. Previous renal surgery was reported in about 60 (30%. Stone-free patients had significantly lower age (48.42± 7.71vs53.41± 10.48, P < 0.001), BMI (26.44± 1.08vs. 26.94± 0.81, P = 0.011), and co-morbidities (30.12%vs. 88.23%%, P <0.001) compared to those with residual stones. No significant differences were reported regarding sex (P = 0.078) and previous renal surgery (P = 0.784). Table 1

Table 1: General characteristics of the studied patients according to stone-free status

		Stone free		
	Total	Yes (n = 166)	No (n = 34)	P-value
Age (years)	50.13± 8.98	48.42± 7.71	53.41± 10.48	**<0.001***
Sex				
Males	120(60%)	98(59.04%)	22(64.71%)	0.538
Females	80(40%)	68(40.96%)	12(35.29%)	
ASA				
I	55(27.50%)	51(30.72%)	4(11.76%)	0.078
II	97(48.5%)	77(46.33%)	20(58.82%)	
III	48(24%)	38(22.89%)	10(29.41%)	
Body mass index	26.45± 1.08	26.44± 1.08	26.94± 0.81	**0.011***
Other assassinated comorbidities	115(57.5%)	50(30.12%)	30(88.23%)	**<0.001***
Previous renal surgery	60 (30%)	45 (27.16%)	10(29.41%)	0.784

Data are presented as mean ±SD or number (percentage); Atacamenian society of anesthesiology, *: significant as P value <0.05.

The mean operative time was 75.52± 13.52, the median pain duration was 7 (4 - 10) months. The mean stone size was 15.2± 3.12 mm. The mean stone density was 1060.48± 188.33 HU. About 30(15%) had multiple stones. The mean RIPA was 85.43± 26.69°, while the mean RIL was 20.25± 10.68mm. About one-third 28(14%) had hydronephrosis. Only 12 (6%) had abnormal renal anatomy. The median RUSS was 1, ranging from 0 to 2, while the mean RIRS was 6.1± 2.67. Complications were reported in 37%.

Stone-free patients had significantly lower pain duration (median = 6 vs. 7.5 months, P < 0.001), stone size (13.56± 2.79vs. 16.29± 3.34mm, P < 0.001), stone density (1044.78± 195.71 vs. 1129.06± 205.63 HU, P < 0.001), Multiple stones (3%vs. 73.50%, P <0.001), and RIRS (mean ± SD = (5.99± 2.63 vs. 7.53± 2, P < 0.001) compared to those with residual stones. In contrast, RIPA was significantly higher in stone-free patients (90.01± 27.74vs. 74.76± 23.19, P < 0.001). No significant differences were reported regarding hydronephrosis (P = 0.070), abnormal renal anatomy (P = 0.464), RUSS (P = 0.435), and complications (P = 0.821). Table 2

Table 2: Perioperative and postoperative outcomes of the studied patients according to stone-free status

		Stone free		
	Total	Yes (n = 166)	No (n = 34)	P-value
Operative time(min)	75.52± 13.52	75.9± 13.47	73.71± 13.86	0.410
Hydronephrosis	28(14%)	24 (14.45%)	4 (11.76%)	0.070
Laterality				
Left	111(55.5%)	92(55.42%)	19(55.88%)	0.96
Right	89(44.5%)	74(44.58%)	15(44.12%)	
Median pain duration (IQR) (months)	7 (4 - 10)	6 (4-9.75)	7.5(4-11.75)	**<0.001***
Stones size (mm)	15.2± 3.12	13.56± 2.79	16.29± 3.34	**<0.001***
Stone density (HU)	1060.48± 188.33	1044.78± 195.71	1129.06± 205.63	**<0.001**
Multiple stones	30(15%)	5 (3%)	25 (73.50)	**<0.001***
RIPA (°)	85.43± 26.69	90.01± 27.74	74.76± 23.19	**<0.00*1**
RIL (mm)	20.25± 10.68	20.74± 10.65	28.26± 5.43	**<0.00*1**
Abnormal renal Anatomy	12 (6%)	9 (5%)	3(8.%8)	0.446
RUSS	1 (0 – 2)	1 (0 – 2)	1 (0 – 3)	0.435
RIRS	6.1± 2.67	5.99± 2.63	7.53± 2	**<0.001**
Complications	74 (37%)	62 (37.35%)	12 (35.29%)	0.821

Data are presented as mean ±SD, median (min-max), or number (percentage); Significant P-values are marked in bold; RIPA: renal infundibulopelvic angle; RIL: renal infundibular length; RUSS: Resorlu Unsal stone score; RIRS: retrograde intrarenal surgery score.

ROC analysis of RUSS and RISS score to predict the stone-free outcome

A ROC analysis was performed to assess the accuracy of RUSS and RIRS scores in predicting stone-free outcome. The results showed a significant AUC of 0.669 for the RIRS score (P < 0.001), 95% CI (0.599 to 0.734). The sensitivity and specificity were 76.51 % and 85.7%, respectively. In contrast, the RUSS score revealed a non-significant unsatisfactory AUC of 0.480 (P = 0.845), with a 95% confidence interval ranging from 0.438 to 0.581. Figure 1

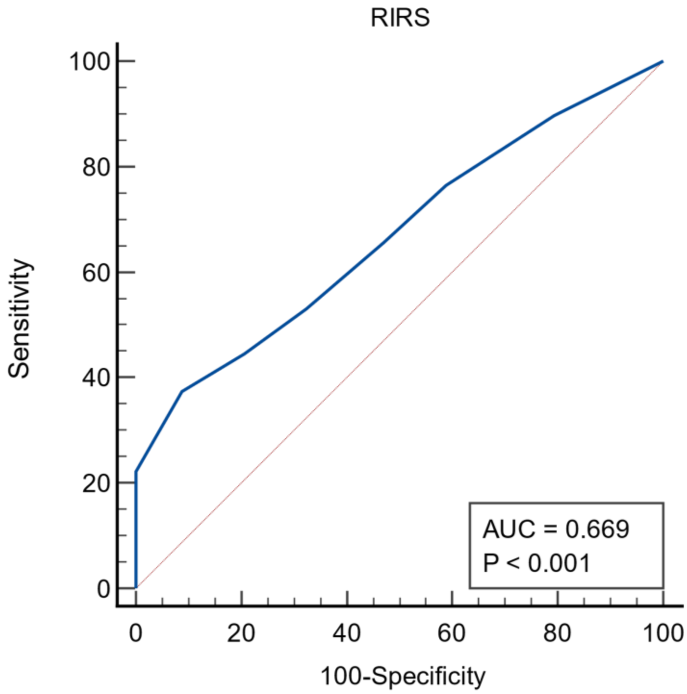

Figure 1: ROC analysis of RUSS and RISS score to predict the stone-free outcome

Prediction of stone-free outcome using RUSS and RIRS

A multivariate logistic regression analysis was done to predict the stone-free outcome. It revealed that stone size, stone density, RIPA, and RIRS were significant predictors for the stone-free outcome, controlling for age, gender, BMI, co-morbidities, and previous renal surgery. Table 3

Table 3: Multivariate logistic regression analysis to predict the stone-free outcome

	OR (95% CI) *	P-value
Stone size (mm)	0.7573(0.6633 to 0.8646)	**<0.001**
Stone density (HU)	0.997 (0.9957 - 0.9999)	**<0.001**
RIPA	1.0217(1.01- 1.037)	**<0.001**
RIRS	1.0221(1.0061 to 1.0382)	**<0.001**

*Adjusted for age, gender, BMI, co-morbidities, and previous renal surgery; OR: Odds ratio; 95% CI: 95% confidence interval; RIPA: renal infundibulopelvic angle; RIRS: retrograde intrarenal surgery score; Significant P-values are marked in bold

Discussion

According to EAU guidelines, PCNL is the standard of treatment for renal stones > 2 cm. Whilst, treatment for renal stones < 2 cm should be performed with either RIRS or ESWL. However, the progressive technological improvements in flexible ureterorenoscopy and new performing lasers have extended the surgical indications for kidney stones reaching a comparable success rate for stones > 2 cm in experienced hands and well selected patients [14, 15]. Notably, several predictive score systems have been recently incorporated in everyday clinical practice in order to predict outcomes following RIRS. Our aim was to externally validate the RUSS score, conceived by Resorlu et al. in 2012, on an Italian cohort of patients.

The present study's findings revealed that age, BMI, co-morbidities, stone size, stone density, multiple stones, lower pole stones, RIPA, and RIRS were significant predictors of the stone-free outcome after FURS for renal stones. Among the demographic factors, age was significantly associated with the stone-free outcome. The stone-free patients demonstrated significantly lower age compared to those with residual stones. This finding is consistent with other studies [16, 17] that have shown that younger age is associated with a higher stone-free rate after FURS.

Regarding the clinical characteristics, the present study found that the stone-free patients had significantly lower loin pain duration, stone size, stone density, multiple stones, lower pole stones, and RIRS compared to those with residual stones. Stone size and location are known to be significant predictors of the stone-free rate after FURS [18]. Additionally, stone-free patients had smaller stone size, lower stone density, and fewer multiple and lower pole stones compared to those with residual stones, which is consistent with the findings of previous studies [19-21].

Interestingly, our study found no significant association between hydronephrosis, abnormal renal anatomy, RUSS score, and complications with the stone-free outcome. This differs from the findings of previous studies that have reported a significant association between these factors and stone-free outcome [22-24]. However, it is worth noting that the sample sizes and patient populations of these studies may have differed from ours, which could explain the discrepancy in results. The present study findings revealed that lower pole stones and multiple stones were significant predictors of the stone-free outcome, consistent with other studies [19, 25].

The present study found that RIRS score was a significant predictor of the stone-free outcome. The stone-free rate decreased with higher RIRS scores. This finding is consistent with previous studies [11, 12] that have shown that the RIRS score is a significant predictor of the stone-free outcome after FURS. The present study also found that RUSS score did not predict the stone-free outcome, consistent with other studies [26]. In addition, previous studies have reported the usefulness of RIRS score in predicting stone-free outcome [12, 27]. In contrast, RUSS score was found to be a poor predictor of stone-free outcome in our study.

The present study also assessed the accuracy of the RIRS and RUSS scores in predicting the stone-free outcome using ROC analysis. The results revealed that the RIRS score had a significant AUC of 0.868, with a sensitivity of 72% and specificity of 93.7%. In contrast, the RUSS score had an unsatisfactory AUC of 0.480. These findings are consistent with other studies [28, 29] that have shown that the RIRS score is a better predictor of the stone-free outcome after FURS compared to the RUSS score. In contrast, a study reported that RUSS is a user-friendly scoring system that may predict postoperative stone-free rate after RIRS with great efficacy and accuracy [12].

There are several limitations that should be acknowledged in this study. Firstly, it was conducted retrospectively at a single center and had a relatively small sample size, which may restrict the generalizability of the findings to other populations or settings. Secondly, the study did not assess the impact of various surgical techniques on stone-free rates, which could have influenced the outcomes. Thirdly, the study did not examine the effects of patient compliance with follow-up and treatment regimens. Fourthly, factors such as stone composition, location, and number, which could have affected the outcomes, were not evaluated. Fifthly, the study did not investigate the long-term outcomes of patients, and it would be valuable for future research to assess the durability of the stone-free state over time. Additionally, it should be noted that RIRS heavily relies on the operator's skill, introducing the potential risk of bias. Lastly, the study lacked a control group, and future studies should compare the outcomes of different treatment approaches to gain a more comprehensive understanding of the optimal management of renal stones.

Conclusions

In conclusion, our study demonstrated that RIRS and RUSS scores can be used as useful predictors of stone-free outcome in patients with renal stones. Our results showed that the stone-free rate decreased with the higher RIRS scores, while the RUSS score showed a non-significant association with the stone-free outcome. Furthermore, ROC analysis revealed that RIRS score had a high accuracy in predicting stone-free outcome, while the RUSS score was not a significant predictor. These findings support the use of RIRS score as a valuable tool in predicting the success of treatment and can aid in making more informed decisions regarding the management of renal stones. However, further studies are needed to confirm these results and to determine the optimal cutoff values for RIRS and RUSS scores in predicting stone-free outcome.

Acknowledgments: there is none to be declared.

Declaration of interest statement: none to be declared.

References

1. Shoag J, Tasian GE, Goldfarb DS, Eisner BH. The new epidemiology of nephrolithiasis. Adv Chronic Kidney Dis. 2015 Jul;22(4):273-8. PubMed PMID: 26088071. Epub 2015/06/20. eng.
2. Ziemba JB, Matlaga BR. Epidemiology and economics of nephrolithiasis. Investig Clin Urol. 2017 Sep;58(5):299-306. PubMed PMID: 28868500. Pubmed Central PMCID: PMC5577325. Epub 2017/09/05. eng.
3. Alelign T, Petros B. Kidney Stone Disease: An Update on Current Concepts. Adv Urol. 2018;2018:3068365. PubMed PMID: 29515627. Pubmed Central PMCID: PMC5817324. Epub 2018/03/09. eng.

4. Bird VY, Khan SR. How do stones form? Is unification of theories on stone formation possible? Arch Esp Urol. 2017 Jan;70(1):12-27. PubMed PMID: 28221139. Pubmed Central PMCID: PMC5683182. Epub 2017/02/22. Cómo se forman las piedras? Es posible la unificación de las teorías sobre la formación de las piedras? eng.
5. Van Cleynenbreugel B, Kılıç Ö, Akand M. Retrograde intrarenal surgery for renal stones - Part 1. Turk J Urol. 2017 Jun;43(2):112-21. PubMed PMID: 28717532. Pubmed Central PMCID: PMC5503427. Epub 2017/07/19. eng.
6. Klein I, Gutiérrez-Aceves J. Preoperative imaging in staghorn calculi, planning and decision making in management of staghorn calculi. Asian J Urol. 2020 Apr;7(2):87-93. PubMed PMID: 32257800. Pubmed Central PMCID: PMC7096669. Epub 2020/04/08. eng.
7. Wong C, Leveillee RJ. Single upper-pole percutaneous access for treatment of > or = 5-cm complex branched staghorn calculi: is shockwave lithotripsy necessary? J Endourol. 2002 Sep;16(7):477-81. PubMed PMID: 12396440. Epub 2002/10/25. eng.
8. Xiao Y, Li D, Chen L, Xu Y, Zhang D, Shao Y, et al. The R.I.R.S. scoring system: An innovative scoring system for predicting stone-free rate following retrograde intrarenal surgery. BMC Urology. 2017 2017/11/21;17(1):105.
9. Resorlu B, Unsal A, Gulec H, Oztuna D. A new scoring system for predicting stone-free rate after retrograde intrarenal surgery: the "resorlu-unsal stone score". Urology. 2012 Sep;80(3):512-8. PubMed PMID: 22840867. Epub 2012/07/31. eng.
10. Ozbek R, Senocak C, Haberal HB, Damar E, Sadioglu FE, Bozkurt OF. Comparison of scoring systems for predicting stone-free status and complications after retrograde ıntrarenal surgery. World J Urol. 2021 Jul;39(7):2741-6. PubMed PMID: 33057889. Epub 2020/10/16. eng.
11. Xiao Y, Li D, Chen L, Xu Y, Zhang D, Shao Y, et al. The R.I.R.S. scoring system: An innovative scoring system for predicting stone-free rate following retrograde intrarenal surgery. BMC Urol. 2017 Nov 21;17(1):105. PubMed PMID: 29162070. Pubmed Central PMCID: PMC5696735. Epub 2017/11/23. eng.
12. Wang C, Wang S, Wang X, Lu J. External validation of the R.I.R.S. scoring system to predict stone-free rate after retrograde intrarenal surgery. BMC Urol. 2021 Mar 4;21(1):33. PubMed PMID: 33663459. Pubmed Central PMCID: PMC7934254. Epub 2021/03/06. eng.
13. Selmi V, Sari S, Oztekin U, Caniklioglu M, Isikay L. External Validation and Comparison of Nephrolithometric Scoring Systems Predicting Outcomes of Retrograde Intrarenal Surgery. J Endourol. 2021 Jun;35(6):781-8. PubMed PMID: 33198505. Epub 2020/11/18. eng.
14. Ferakis N, Stavropoulos M. Mini percutaneous nephrolithotomy in the treatment of renal and upper ureteral stones: Lessons learned from a review of the literature. Urol Ann. 2015 Apr-Jun;7(2):141-8. PubMed PMID: 25837662. Pubmed Central PMCID: PMC4374249. Epub 2015/04/04. eng.
15. Kim CH, Chung DY, Rha KH, Lee JY, Lee SH. Effectiveness of Percutaneous Nephrolithotomy, Retrograde Intrarenal Surgery, and Extracorporeal Shock Wave Lithotripsy for Treatment of Renal Stones: A Systematic Review and Meta-Analysis. Medicina (Kaunas). 2020 Dec 30;57(1). PubMed PMID: 33396839. Pubmed Central PMCID: PMC7823824. Epub 2021/01/06. eng.

16. Alenezi H, Denstedt JD. Flexible ureteroscopy: Technological advancements, current indications and outcomes in the treatment of urolithiasis. Asian J Urol. 2015 Jul;2(3):133-41. PubMed PMID: 29264133. Pubmed Central PMCID: PMC5730717. Epub 2015/07/01. eng.
17. Kılıç Ö, Akand M, Van Cleynenbreugel B. Retrograde intrarenal surgery for renal stones - Part 2. Turk J Urol. 2017 Sep;43(3):252-60. PubMed PMID: 28861294. Pubmed Central PMCID: PMC5562241. Epub 2017/09/02. eng.
18. Tefekli A, Ali Karadag M, Tepeler K, Sari E, Berberoglu Y, Baykal M, et al. Classification of percutaneous nephrolithotomy complications using the modified clavien grading system: looking for a standard. Eur Urol. 2008 Jan;53(1):184-90. PubMed PMID: 17651892. Epub 2007/07/27. eng.
19. McClinton S, Starr K, Thomas R, MacLennan G, Lam T, Hernandez R, et al. The clinical and cost effectiveness of surgical interventions for stones in the lower pole of the kidney: the percutaneous nephrolithotomy, flexible ureterorenoscopy and extracorporeal shockwave lithotripsy for lower pole kidney stones randomised controlled trial (PUrE RCT) protocol. Trials. 2020 Jun 4;21(1):479. PubMed PMID: 32498699. Pubmed Central PMCID: PMC7273687. Epub 2020/06/06. eng.
20. Acar C, Cal C. Impact of Residual Fragments following Endourological Treatments in Renal Stones. Adv Urol. 2012;2012:813523. PubMed PMID: 22829812. Pubmed Central PMCID: PMC3398582. Epub 2012/07/26. eng.
21. Gücük A, Uyetürk U. Usefulness of hounsfield unit and density in the assessment and treatment of urinary stones. World J Nephrol. 2014 Nov 6;3(4):282-6. PubMed PMID: 25374823. Pubmed Central PMCID: PMC4220362. Epub 2014/11/07. eng.
22. Reddy SV, Shaik AB. Outcome and complications of percutaneous nephrolithotomy as primary versus secondary procedure for renal calculi. Int Braz J Urol. 2016 Mar-Apr;42(2):262-9. PubMed PMID: 27256180. Pubmed Central PMCID: PMC4871386. Epub 2016/06/04. eng.
23. Alshoabi SA. Association between grades of Hydronephrosis and detection of urinary stones by ultrasound imaging. Pak J Med Sci. 2018 Jul-Aug;34(4):955-8. PubMed PMID: 30190760. Pubmed Central PMCID: PMC6115544. Epub 2018/09/08. eng.
24. Ergani B, Ozbilen MH, Yalcın MY, Boyacıoglu H, Ilbey YO. The effect of hydronephrosis grade on stone-free rate in retrograde intrarenal stone surgery with flexible ureterorenoscopy. Am J Clin Exp Urol. 2021;9(2):194-201. PubMed PMID: 34079853. Pubmed Central PMCID: PMC8165711. Epub 2021/06/04. eng.
25. Kallidonis P, Ntasiotis P, Somani B, Adamou C, Emiliani E, Knoll T, et al. Systematic Review and Meta-Analysis Comparing Percutaneous Nephrolithotomy, Retrograde Intrarenal Surgery and Shock Wave Lithotripsy for Lower Pole Renal Stones Less Than 2 cm in Maximum Diameter. J Urol. 2020 Sep;204(3):427-33. PubMed PMID: 32150506. Epub 2020/03/10. eng.
26. Erbin A, Tepeler A, Buldu I, Ozdemir H, Tosun M, Binbay M. External Comparison of Recent Predictive Nomograms for Stone-Free Rate Using Retrograde Flexible Ureteroscopy with Laser Lithotripsy. J Endourol. 2016 Nov;30(11):1180-4. PubMed PMID: 27549157. Epub 2016/08/24. eng.
27. Koyuncu H, Yencilek F, Kalkan M, Bastug Y, Yencilek E, Ozdemir AT. Intrarenal Surgery vs Percutaneous Nephrolithotomy in the Management of Lower Pole Stones Greater than 2 cm. Int Braz J Urol. 2015 Mar-

Apr;41(2):245-51. PubMed PMID: 26005965. Pubmed Central PMCID: PMC4752086. Epub 2015/05/26. eng.

28. Sanguedolce F, Bozzini G, Chew B, Kallidonis P, de la Rosette J. The Evolving Role of Retrograde Intrarenal Surgery in the Treatment of Urolithiasis. Eur Urol Focus. 2017 Feb;3(1):46-55. PubMed PMID: 28720366. Epub 2017/07/20. eng.
29. 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 Jan;67(1):125-37. PubMed PMID: 25064687. Epub 2014/07/30. eng.