Original Article

Evaluation of the Performance of Stone Management According to Size-Hardness (SMASH) Score in Preoperative Planning for Retrograde Internal Surgery (RIRS) in the Treatment of Renal Stones

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Abstract

Objective: This study aimed to assess the effectiveness of the SMASH score in selecting candidates for Retrograde Intrarenal Surgery (RIRS).

Methodology: This retrospective study was conducted at the the Pakistan Kidney and Liver Institute and Research Center (PKLI & RC) from September 2019 to September 2024. Patients aged >14 years with renal stones sized 1–2.5 cm, undergoing their first RIRS, were included. Exclusion criteria were infected urine, staghorn stones, stones >2.5 cm, or requiring repeat intervention. The SMASH score, derived from Hounsfield units and stone size, was evaluated for its role in predicting stone clearance. Data collected included demographic, clinical, surgical, and postoperative outcomes. Statistical analysis employed Spearman's correlation, logistic regression.

Results: Among 260 patients (mean age: 44.88±15.25 years), complete stone clearance was achieved in 80.4%, with higher success in SMASH scores <15 (67.5%, $p<0.001$). Postoperative complications was seen in 12.7%, including urosepsis (9.2%) and UTIs (3.1%). Median operative and laser times were 80 minutes and 57.5 minutes, respectively, correlating positively with SMASH scores ($\rho=0.194$, $\rho=0.185$, $p<0.01$). Logistic regression identified stone size as a significant predictor of clearance (OR 5.479, $p<0.001$). Operative time increased with stone size ($p<0.001$), emphasizing preoperative complexity. The median hospital stay was one day, indicating rapid recovery.

Conclusion: Lower SMASH scores and smaller stones are associated with higher clearance rates and fewer complications in RIRS. While stone size was a strong predictor, underscoring the importance of preoperative planning

Keywords: Nephrolithiasis, Nephrostomy

Introduction

Renal stone disease is a common urological condition, affecting 2-20% of the adult population worldwide.[1-3] In our country, it is very common; as per the survey, 11.1% of the population is suffering from it.[4] The approaches of management of renal stones encompass ESWL, PNL, RIRS, mini PNL, micro PNL, laparoscopic and open stone surgery.[5, 6] Fluoroscopic systems have gone through improvements that have favored minimal invasive procedures, and flexible ureteroscopy has now become a chief means for accessing the intrarenal system retrogradely via ureters.

EAU guidelines suggest that RIRS is suitable for renal stones under 20 mm in size Stone hardness remains one of the most significant factors in this process, even though it is sometimes disregarded. New grading known as Stone Management According to Size-Hardness (SMASH) score was developed to assist in deciding for renal stones in the 10-20 mm range, aiding the choice between endoscopic and percutaneous approaches.[7]

Recently, RIRS has gained popularity as a method for treating renal stones due to its high efficiency and safety profile. RIRS has been established as an alternative first-line treatment for stones less than 2cm as per urologic guidlines.[8] Some studies have even shown the efficacy of RIRS for stones greater than 2 cm.[9] RIRS is also proved to be effective and safe for a selected group of patients like a solitary kidney, pregnancy, obesity and anatomical renal anomaly.[10]

However, despite its benefits, RIRS is not free from complications. The SMASH score is aimed at enhancing the precision of patient selection for RIRS, especially for stones <20 mm, considering both stone size and hardness. This study aims to evaluate the performance of the SMASH score in preoperative planning, assessing its utility in identifying the most suitable candidates for RIRS treatment of renal stones.

Methodology

Study Design and Setting

This retrospective observational study was conducted in the Urology Department of the Pakistan Kidney & Liver Institute and Research Center (PKLI & RC) after approved by the Institutional Review Board (IRB) of Pakistan Kidney and Liver Institute & Research Center, Lahore, Pakistan, with Ref # PKLI-IRB/AP/00582024. PKLI & RC is a tertiary referral hospital with a dedicated urology unit that manages a high volume of renal stone cases, including patients evaluated for Retrograde Intrarenal Surgery (RIRS). The study followed the STROBE guidelines for reporting observational studies.

Study Population

The study included patients aged over 14 years who were diagnosed with renal stones (confirmed via imaging) and underwent their first RIRS procedure at PKLI & RC between September 2019 and September 2024. The inclusion criteria were:

- Renal stones measuring 1 cm to 2.5 cm in size.
- First-time RIRS procedure.

Exclusion criteria included:

- Frank pus or infected urine.
- Staghorn stones.
- Stones greater than 2.5 cm.
- Patients undergoing a second RIRS procedure.
- Patients aged below 14 years.

Data Collection

Data was collected from electronic medical records (EMRs) and included:

1. Demographic data: Age, gender, and body mass index (BMI).
2. Clinical details: Stone size, stone density (Hounsfield units, HU), and preoperative evaluations (history, physical examination, laboratory investigations, and imaging studies).
3. Surgical details: Operative time, laser usage time, and surgical techniques.
4. Outcome measures: Stone clearance rate, postoperative complications (e.g., UTIs, urosepsis), pain scores via Visual Analog Scale (VAS), duration of hospital stay, and any additional interventions (e.g., re-admissions or further procedures).

Study Variables and Measurements

- Stone size: Measured as the maximum diameter on non-contrast CT scans or ultrasound.
- Stone density: Determined using Hounsfield units (HU) on CT imaging.
- SMASH score: Calculated using the formula:

Hounsfield units (HU) x stone maximum size (cm)/100

The SMASH score was used to evaluate its utility in selecting optimal candidates for RIRS.

Surgical Procedure

All RIRS procedures were performed by experienced urologists at . using conventional techniques. The procedure involved:

1. Insertion of a flexible ureteroscope through the urethra into the bladder and renal pelvis.
2. Laser lithotripsy to fragment the stones.
3. Extraction or flushing of stone fragments using a

basket or suction device.

Operative time was recorded from the insertion of the ureteroscope to the completion of stone extraction. Laser usage time (time spent on stone fragmentation) was also documented.

Outcome Measures

- Primary endpoint: Complete stone clearance, defined as no detectable residual fragments on follow-up imaging (primarily CT scans).
- Secondary endpoints: Postoperative complications, pain scores (VAS), duration of hospital stay, and need for additional interventions.

Statistical Analysis

Patient demographics and clinical characteristics were summarized using descriptive statistics. Continuous variables were presented as means with standard deviations (SD) or medians with interquartile ranges (IQR), whereas categorical variables were reported as counts and percentages.

- Correlation analysis: Spearman's rho was used to assess the relationship between the SMASH score and clinical outcomes.
- Group comparisons: Continuous variables were analyzed using the Mann–Whitney U test, while categorical variables were assessed with chi-square tests.
- Predictive analysis: Logistic regression was performed to evaluate the predictive ability of the SMASH score for stone clearance, adjusting for variables such as BMI, operative time, SMASH score group, and stone size.

Statistical significance was set at $p<0.05$, and exact p-values were reported. All analyses were performed using SPSS version 27.

Results

The study included 260 patients with a mean age of 44.88±15.25 years. Gender distribution revealed 143 males (55.0%) and 117 females (45.0%). The median body mass index (BMI) was 23.0 kg/m^2 (IQR: 6.0 kg/m^2). The median stone size was 1.3 cm (IQR: 0.7 cm), with 212 patients (81.5%) having stones <2 cm and 48 patients (18.5%) having stones ≥2 cm. The median operative time was 80 minutes (IQR: 50.0 minutes), while the median laser usage time was 57.5 minutes (IQR: 45.0 minutes). The SMASH score, used to evaluate surgical complexity, had a median value of 12.63 (IQR: 11.97). In 209 patients, complete clearance was achieved (80.4%). Postoperative complications occurred in 33 patients (12.7%), with urinary tract infections (UTI) reported in 8 cases (3.1%) and urosepsis in 24 cases (9.2%). Pain levels were predominantly mild, reported by 252 patients (96.9%), with a median pain score of 2.0 (IQR: 0.0). The median hospital stay was 1 day (IQR: 1.0 day), indicating a short recovery period. Follow-up imaging, primarily CT scans, was performed in 246 patients (94.6%), with one case (0.4%) having an unclear follow-up status. No residual fragments were observed in 168 patients (64.6%), while 86 patients (33.1%) had detectable fragments, and 6 cases (2.3%) had incomplete data. Additional interventions were required in 46 patients (17.7%).

Patients with SMASH scores <15 showed significantly higher stone clearance rates ($p < 0.001$) and fewer postoperative complications ($p = 0.048$) compared to those with SMASH scores ≥15 (Table 1).

Spearman's rho analysis (Table 2) showed a weak positive correlation between SMASH score and operative time ($\rho = 0.194$, $p = 0.002$) and laser time ($\rho = 0.185$, $p = 0.003$). No significant correlation was found between SMASH score and pain scores ($\rho = 0.069$, $p = 0.270$). Operative time and laser time were strongly correlated ($\rho = 0.989$, $p < 0.001$).

Operative time was compared between two SMASH score groups using the independent-samples Mann-Whitney U test., which indicated a statistically significant difference in operative time between the two SMASH score groups (Mann-Whitney U = 9572.5, Wilcoxon W = 14723.5, Z = 2.614, p = 0.009). This finding suggests that operative time differs significantly based on the SMASH score grouping.

The relationship between stone size categories and operative time was analyzed using the Mann-Whitney U test that compared operative time across two stone size categories: Category A (stone size <10 mm) and Category B (stone size ≥10 mm). The Mann-Whitney U test indicated a statistically significant difference in operative time between the two stone size categories (U = 6779.500, Z = 3.600, $p < 0.001$). The results indicate that operative time is significantly different according to stone size, with larger stones requiring more time for the operation. These findings highlight the role of stone size in influencing the complexity and duration of RIRS, emphasizing the need for preoperative planning based on stone size. To determine the association between stone size groups and postoperative complications, a chi-square test for independence was conducted. Among patients with stones <2 cm, 26 (12.3%) had postoperative complications, whereas 186 (87.7%) did not. For patients with stones ≥2 cm, 7 (14.6%) had complications, and 41 (85.4%) did not.

The chi-square test results showed no significant association between stone size categories and postoperative complications ($\chi^2 = 0.190$, df = 1, $p = 0.663$). Similarly, Fisher's Exact Test ($p = 0.636$) confirmed the absence of a significant relationship. These findings suggest that stone size, categorized as <2 cm or ≥2 cm, is not a significant predictor of immediate postoperative complications following retrograde intrarenal surgery (RIRS).

Operative time significantly varied among Combined

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Group Analysis (CGA) categories based on stone size and SMASH score (H = 15.993, df = 3, p = 0.001). Pairwise comparisons showed that patients with larger stones (≥2 cm) and higher SMASH scores (≥15) had significantly longer operative times than those with smaller stones (<2 cm) and lower SMASH scores (<15). Table 3 displays the median operative times (in minutes) and interquartile ranges (IQR) for various combinations of stone size and SMASH scores. Pairwise comparisons between the groups are provided, along with p-values (Bonferroni-adjusted) to indicate the statistical significance of differences.

The logistic regression model analyzed the predictors of stone clearance using five independent variables: BMI, Operative Time, SMASH score group, SMASH score, and Stone Size. The model demonstrated a good fit (Hosmer and Lemeshow test: p = 0.642) and correctly classified 82.7% of cases. Sensitivity (correctly predicting "Yes") was 98.1%, while specificity (correctly predicting "No") was 19.6%. Among the predictors, stone size was the only statistically significant variable (p < 0.001), with an odds ratio of 5.479, indicating a strong positive association with stone clearance. Other predictors, including BMI, Operative Time, SMASH score group, and SMASH score, did not show statistically significant effects Table 4.

Table 1. Association Between SMASH Score Group, Stone Clearance, and Postoperative Complications

Outcome	Category	SMASH Score <15	SMASH Score ≥15	p-value
Stone Clearance	Yes	141 (67.5%)	68 (32.5%)	< 0.001
	No	18 (35.3%)	33 (64.7%)	
Postoperative Complications	Yes	15 (9.4%)	18 (17.8%)	0.048
	No	144 (90.6%)	83 82.2%)	

Table 2. Spearman's rho correlation analysis between SMASH score, pain score, operative time, and laser time.

Variables	SMASH Score	Pain on Pain Analogue Score	Operative Time (Minutes)	Laser Time (Minutes)
SMASH Score	1.000	0.069	0.194**	0.185**
Pain on Pain Analogue Score	0.069	1.000	-0.018	-0.012
Operative Time (Minutes)	0.194**	-0.018	1.000	0.989**
Laser Time (Minutes)	0.185**	-0.012	0.989**	1.000

Note: Correlation is significant at the 0.01 level (2-tailed).

Table 3. Operative Time Comparison Across Combined Groups (CGA)

CGA	Operative Time Median (IQR)	Pairwise Comparison	p-value	Significance
Stone < 2 cm and SMASH < 15	70 (40)	vs. Stone ≥ 2 cm & SMASH ≥ 15	0.001 (Bonferroni-adjusted)	Significant Difference
Stone < 2 cm and SMASH ≥ 15	82.5 (56)	vs. Stone < 2 cm & SMASH < 15, Stone ≥ 2 cm & SMASH < 15, and Stone ≥ 2 cm & SMASH ≥ 15	> 0.05	No Significant Difference
Stone ≥ 2 cm and SMASH < 15	110 (0)	vs. Stone < 2 cm & SMASH < 15, Stone < 2 cm & SMASH ≥ 15, and Stone ≥ 2 cm & SMASH ≥ 15	> 0.05	No Significant Difference
Stone ≥ 2 cm and SMASH ≥ 15	100 (40)	vs. Stone < 2 cm & SMASH < 15	0.001 (Bonferroni-adjusted)	Significant Difference

Table 4. Logistic Regression Analysis

Variable	B (Coefficient)	Wald	p-value	Exp(B) (Odds Ratio)	Interpretation
Body Mass Index (BMI)	0.010	0.068	0.795	1.010	Not significant; minimal effect on outcome.
Operative Time (minutes)	-0.004	0.594	0.441	0.996	Not significant; minimal effect on outcome.
SMASH Score Group	-0.499	0.776	0.378	0.607	Not significant; reduced odds for higher SMASH group.
SMASH Score	0.000	0.000	0.992	1.000	Not significant; no measurable effect.
Stone Size (cm)	1.701	18.478	<0.001	5.479	Significant; larger stones increase clearance odds.
Constant	-3.707	9.618	0.002	0.025	Baseline odds of clearance are very low.

Discussion

Our study is highlighted by the importance of SMASH score in predicting the success of retrograde intrarenal surgery, especially with respect to stone size and hardness. This correlates with Perri et al. (2024), who found that a lower SMASH score (<15) correlated with higher stone-free rates (SFR) in patients undergoing RIRS for stones <20 mm.[11] They found that stone size and hardness were critically important in determining the outcomes of surgery and that an SMASH score can actually be a preoperative determinant in choosing a patient candidate for RIRS.

Perri et al. (2023) have also evaluated the usefulness of the SMASH score in RIRS and mini-PCNL for stones between 10 and 20 mm.[12] Similar to their study, we also found that with the combination of stone size, SMASH score improves preoperative planning and results in better outcomes in stone clearance. They also showed a higher SFR in the group with lower SMASH scores, consistent with our study, in which smaller stones and lower SMASH scores correlated with fewer postoperative complications and shorter operative times.

Moreover, Perri et al. (2024) discussed the bleeding risks between RIRS and mini-PCNL for 10-20 mm renal stones.[13] Although our study primarily focused on RIRS efficiency, their work supports our findings, confirming that RIRS has a comparable safety profile to mini-PCNL, particularly regarding bleeding risks. In both studies, complications were low and manageable, with no major hemorrhagic events reported.

Our findings emphasize the role of preoperative planning using the SMASH score for RIRS in patients with small to medium-sized renal stones. While the SMASH score showed weak predictive ability for stone clearance, stone size emerged as a stronger predictor of surgical success. These results are comparable to the previous studies emphasizing the importance of stone characteristics in optimizing RIRS outcomes. The short operative times and hospital stays observed in our study further support the efficiency of RIRS for smaller stones. Despite providing valuable insights, this study has certain limitations due to its single-center design, lack of long-term follow-up, and non-randomized methodology, all of which limit the generalizability of its findings.

Conclusion

This study underlines the important role of SMASH scores and stone size in determining the success of retrograde intrarenal surgery. The patients with low SMASH scores and small stones had high clearance rates of stones and fewer complications postoperatively. Although stone size emerged as a strong predictor. The results emphasize the value of preoperative planning on the basis of stone characteristics to optimize surgical outcomes. The relatively short operative times and hospital stays reflect the effectiveness and efficiency of RIRS for treating small to medium-sized stones.

References

1. Smith LH. The medical aspects of urolithiasis: An overview. J Urol 1989;141(4):707-10.
2. Trinchieri A. Epidemiology of urolithiasis. Arch Ital Urol Androl 1996;68(3):203-49.
3. Curhan GC. Epidemiology of stone disease. Urol Clin North Am 2007;34(2):287-93.
4. Muslumanoglu AY, Binbay M, Yuruk E, Akman T, Tepeler A, Esen T, et al. Updated epidemiologic study of urolithiasis in Turkey. I: Changing characteristics of urolithiasis. Urol Res 2011;39(4):309-14.
5. Assimos D, Krambeck A, Miller NL, Monga M, Murad MH, Nelson CP, et al. Surgical management of stones: American Urological Association/Endourological Society guide-

line, part I. J Urol 2016;196(4):1153-60.

6. Yazıcı C, Akgül M, Arda E, Akpınar H. Can urologists perform stone analysis, metabolic evaluation and metaphylaxis in urinary-tract stone disease in Tekirdağ? Dicle Med J 2019;46(3):405-10.
7. Perri D, Besana U, Pacchetti A, Morini E, Mazzoleni F, Calcagnile T, et al. MP29-13: Application of the stone management according to size-hardness (SMASH) score in selecting patients for retrograde intrarenal surgery. J Urol 2024;211(5S):e486. DOI: 10.1097/01.JU.0001008680.67760.37.
8. Parikh KP, Jain RJ, Kandarp AP. Is retrograde intrarenal surgery the game changer in managing upper-tract calculi? A single-center, single-surgeon experience of 131 cases. Urol Ann 2018;10(1):29-34.
9. Turk C, Petrik A, Sarica K, Seitz C, Skolarikos A, Straub M, Knoll T. EAU guidelines on interventional treatment for urolithiasis. Eur Urol 2016;69(3):475-82.
10. Al Busaidy SS, Kurukkal SN, Al Hooti QM, Alsaraf MS, Al Mamari SA, Al Saeedi AK. Is RIRS emerging as the preferred option for 2-4 cm renal stones? Our experience. Can J Urol 2016;23(5):8364-7.
11. Perri D, Besana U, Pacchetti A, Morini E, Mazzoleni F, Calcagnile T, et al. MP29-13 application of the SMASH score in selecting patients for retrograde intrarenal surgery. J Urol 2024;211(5S):e486. DOI: 10.1097/01.JU.0001008680.67760.37.
12. Perri D, Besana U, Berti L, Mazzoleni F, Pacchetti A, Morini E, et al. PD28-11: A mathematical model to plan between RIRS and miniperc for 10-20 mm renal stones using holmium:YAG laser (Cyber HO): The SMASH score. J Urol 2023;209(Suppl 4):e823. DOI: 10.1097/JU.0000000000003313.11.
13. Perri D, Besana U, Maltagliati M, Pacchetti A, Calcagnile T, Pastore AL, et al. Risk of bleeding after retrograde intrarenal surgery versus mini-PCNL for 10-20 mm renal stones: A safety profile comparison. BJU Int 2024;[epub ahead of print]. DOI: 10.1111/BJU.16585.

Authors' Contribution Statement

AR contributed to the conception, design, acquisition, analysis, interpretation of data, drafting of the manuscript, critical review, and final approval of the version to be published. NBN contributed to the design, acquisition, analysis, drafting of the manuscript, and critical review of the manuscript. SM contributed to the acquisition, analysis, interpretation of data, and drafting of the manuscript. NZ contributed to the acquisition, analysis, interpretation of data, and drafting of the manuscript. AA contributed to the acquisition, analysis, interpretation of data, and drafting of the manuscript. SI contributed to the analysis and interpretation of data. HAH contributed to the acquisition and analysis of data. AA contributed to the acquisition, analysis, and interpretation of data. SA contributed to the analysis and interpretation of data. MA contributed to the acquisition and analysis of data. AC contributed to the acquisition and analysis of data. SI contributed to the acquisition, analysis, and interpretation of data. All authors are accountable for their work and ensure the accuracy and integrity of the study.

Confilct of Interest

Authors declared no conflict on interest

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None

Data Sharing Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.