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Percutaneous Nephrolithotomy versus Retrograde Intrarenal Surgery for Lower Pole Renal Stones in Geriatric Patients: A Comparative Study

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Abstract

Background:

Management of lower pole renal stones in elderly patients requires a balance between effective stone clearance and procedure-related morbidity. This study aimed to compare perioperative outcomes of percutaneous nephrolithotomy (PCNL) and retrograde intrarenal surgery (RIRS) in geriatric patients with isolated lower pole renal stones.

Methods:

This retrospective study included 133 patients aged ≥ 65 years who were treated for isolated lower pole renal stones between January 2024 and January 2026. Sixty-nine patients underwent PCNL, while 64 patients were treated with RIRS. Patients with renal anomalies, ureteropelvic junction obstruction, solitary kidneys, non-lower pole stones, or age below 65 years were excluded. Demographic, clinical, perioperative, and postoperative outcomes were compared between the two groups. Receiver operating characteristic analysis was performed to evaluate the discriminatory ability of stone area in treatment selection.

Results:

Baseline demographic and clinical variables were similar between the PCNL and RIRS groups. Compared with RIRS, PCNL was performed in patients with a larger stone area and was associated with longer operative duration, greater fluoroscopy exposure, more pronounced hemoglobin reduction, and prolonged hospitalization. However, residual stone rates, need for secondary intervention, transfusion requirement, and sepsis rates were comparable between the groups. Receiver operating characteristic analysis showed that stone area had good discriminatory ability in distinguishing patients selected for PCNL from those treated with RIRS.

Conclusions:

In geriatric patients with isolated lower pole renal stones, surgical planning should not rely solely on stone-free expectations. Stone burden, perioperative risk, and the patient's overall clinical condition should be considered together when selecting the optimal treatment modality. PCNL appears to be a suitable option for patients with greater stone burden, whereas RIRS may be preferable when reduced invasiveness and shorter recovery are prioritized.

Background

Urinary stone disease is a multifactorial urological pathology with an increasing prevalence worldwide. According to recent NHANES data, its prevalence in the adult population of the United States has been reported as 9.9% [1]. Lifestyle and metabolic factors, particularly altered dietary habits, obesity, and metabolic syndrome, are considered important contributors to the increasing frequency of urolithiasis. While the disease is encountered throughout adulthood, epidemiological data suggest that its occurrence is most pronounced in individuals aged 50–70 years [2, 3]. With increasing life expectancy, it is estimated that by 2050, individuals older than 65 years will constitute approximately 28% of the general population and 10–12% of all patients with stone disease [4]. In geriatric patients, hypertension, chronic kidney disease and reduced physiological reserve complicate surgical decision-making; therefore, minimizing morbidity has become as important a treatment goal as achieving stone-free status [5].

Management of renal stones is largely guided by stone size, but anatomical and patient-related factors also play an important role. According to the EAU guidelines, PCNL is recommended as the standard approach when the stone burden exceeds 2 cm [6]. For smaller renal stones, RIRS is commonly considered; however, its success depends strongly on stone location, density, and collecting system anatomy. This is especially relevant for lower pole stones, where gravity-dependent positioning and unfavorable infundibular anatomy may impair both endoscopic access and fragment clearance. A steep infundibulopelvic angle is among the best-known anatomical limitations of RIRS in this setting [6, 7]. Overall, recent systematic reviews indicate that PCNL provides superior stone clearance for lower pole stones, while RIRS is generally associated with shorter hospitalization and fewer complications [7, 8].

Although surgical modalities used in stone treatment have been compared at the level of meta-analyses, data specific to the geriatric population remain limited. Recent studies have reported that PCNL achieves higher single-session stone-free rates in geriatric patients; however, RIRS maintains an advantage in terms of lower hemoglobin decrease and reduced perioperative morbidity [9]. Nevertheless, studies directly comparing PCNL and RIRS for lower pole stones in geriatric patients and providing guiding criteria for surgical decision-making are still scarce.

The present analysis focused on elderly patients treated surgically for lower pole renal calculi and examined how PCNL and RIRS differed in terms of perioperative course and early postoperative outcomes. In addition, the role of stone size in predicting which patients may be more suitable candidates for PCNL was evaluated using ROC analysis, with the aim of identifying a clinically applicable cut-off value.

Methods

Ethical approval

for this study was obtained from the Non-Interventional Clinical Research Ethics Committee of İzmir City Hospital on January 21, 2026, with approval number 2026/26. This study was designed as a retrospective analysis of patients older than 65 years who presented to the Urology outpatient clinic of

İzmir City Hospital between January 2024 and January 2026 with complaints such as flank pain or urinary tract infection, were diagnosed with lower pole renal stones after diagnostic evaluation, and subsequently underwent PCNL or RIRS. Patients with ureteropelvic junction obstruction, anomalous kidneys, age under 65 years, stones located outside the lower pole, or a solitary kidney were excluded from the study. Treatment allocation was not randomized; instead, the operative approach was selected individually by the surgical team after considering stone dimensions, anatomical location, and operator experience. According to the procedure performed, the study cohort consisted of 69 patients treated with PCNL and 64 patients treated with RIRS. Baseline patient characteristics, intraoperative variables, and postoperative findings were then analyzed comparatively between these two cohorts.

Preoperative assessment included non-contrast computed tomography of the abdomen in every patient. Clinical information, including demographic data and perioperative variables, was retrieved from the institutional electronic medical records. Surgical complications occurring after the procedure were graded using the Clavien–Dindo system.

Before intervention, all patients were required to have a negative urine culture. Ceftriaxone was administered as perioperative antibiotic prophylaxis, while subsequent postoperative treatment was adjusted according to each patient's clinical course.

For each case, stone burden was expressed as stone area in mm^2 and calculated using the formula: length × width × π × 0.25, where π was accepted as 3.14.

At the one-month postoperative follow-up, non-contrast abdominal CT was used to determine treatment success. Patients were considered stone-free when no residual calculus was detected or when remaining fragments measured less than 4 mm.

PCNL technique

All PCNL procedures were carried out under general anesthesia. At the beginning of the operation, patients were positioned in lithotomy to allow placement of a 5 or 6 Fr ureteral catheter into the collecting system of the stone-bearing kidney. The catheter was secured to the Foley catheter, after which the patient was turned to the prone position. Percutaneous entry into the collecting system was obtained fluoroscopically with an 18-gauge access needle. Following puncture, the tract was serially enlarged with Amplatz dilators, and dilation was limited to 24 Fr. This tract size was preferred to reduce procedure-related trauma and bleeding risk in elderly patients with limited physiological reserve. Stone fragmentation was performed using a pneumatic lithotripter, and fragments were extracted with forceps. When clinically appropriate, a 14 Fr nephrostomy catheter was left in place at the end of the intervention, followed by antegrade pyelographic control. Foley catheters were generally removed on the first postoperative day. Nephrostomy tubes were withdrawn on postoperative day 1 or 2 in patients without fever or relevant hematuria.

RIRS technique

RIRS was also performed under general anesthesia. Before introducing the flexible ureteroscope, semirigid ureteroscopy was used to inspect the ureter and facilitate active ureteral dilation. A 12/14 Fr ureteral access sheath was then advanced over a guidewire under fluoroscopic monitoring. Disposable flexible ureteroscopes were used in all cases. If sheath placement was not feasible, a double-J stent was inserted to achieve passive ureteral dilation, and definitive RIRS was postponed for approximately 1–2 weeks. Intrarenal stones were fragmented with a Holmium laser using 200 or 273 μm fibers. After removal of the access sheath, the ureter was checked endoscopically for possible trauma. When ureteral injury was suspected or observed, a double-J stent was placed at the surgeon's discretion. In all stented patients, double-J stents were removed within 2–3 weeks after surgery.

Statistical analysis

Data analysis was conducted using IBM SPSS Statistics software (IBM Corp., Armonk, NY, USA). The Kolmogorov–Smirnov test was applied to examine whether continuous variables followed a normal distribution.

Because the distribution of continuous data was non-normal, these variables were summarized as median values with interquartile ranges. Accordingly, non-parametric tests were selected for group comparisons. Categorical variables were reported as frequencies and percentages.

Between-group comparisons of continuous variables were performed using the Mann–Whitney U test. For categorical data, the chi-square test was used when test assumptions were met, and Fisher's exact test was applied when appropriate. The discriminatory ability of stone area for predicting selection of the surgical approach was analyzed by receiver operating characteristic curve analysis. The threshold with the best combined sensitivity and specificity was identified using the Youden index. Statistical significance was defined as a p value below 0.05.

Results

A total of 133 geriatric patients met the inclusion criteria and were analyzed according to the surgical procedure performed. The PCNL group included 69 patients, whereas 64 patients underwent RIRS. Baseline variables are presented in Table 1. The two groups showed comparable demographic and clinical profiles with respect to age, body mass index, stone density, previous ESWL treatment, history of stone surgery, and metabolic syndrome, with no statistically significant differences detected for these parameters. Male sex was numerically more frequent among patients treated with PCNL than among those treated with RIRS; however, this finding remained below the threshold for statistical significance (65.2% vs. 48.4%, p=.051).

Table 1
Baseline characteristics of patients undergoing PCNL and RIRS

Variable	PCNL (n = 69)	RIRS (n = 64)	p
Age (years)	70.0 (67.0–72.0)	70.0 (67.8–72.2)	.230
BMI (kg/m²)	27.1 (23.6–29.4)	26.9 (25.0–29.2)	.520
Stone density (HU)	1063 (800–1280)	1015 (830–1160)	.678
Male sex, n (%)	45 (65.2)	31 (48.4)	.051
History of ESWL, n (%)	15 (21.7)	13 (21.0)	.914
Prior stone surgery, n (%)	24 (34.8)	20 (31.2)	.863
Metabolic syndrome, n (%)	6 (8.7)	5 (7.8)	.853

Perioperative and postoperative outcomes are detailed in Table 2. Patients selected for PCNL had a markedly greater stone area than those managed with RIRS (220.0 vs. 113.0 mm², p<.001). In parallel with this larger stone burden, PCNL was associated with longer operative duration and increased fluoroscopy exposure. Hemoglobin reduction and hospitalization time were also significantly greater after PCNL, with all of these comparisons reaching statistical significance (p<.001).

Table 2
Stone-related, operative, and postoperative outcomes

Variable	PCNL (n = 69)	RIRS (n = 64)	p value
Stone area (mm²)	220.0 (157.0–267.0)	113.0 (84.2–180.0)	< 0.001
Operation time (min)	90.0 (60.0–110.0)	45.0 (40.0–60.0)	< 0.001
Fluoroscopy time (min)	69.0 (43.0–102.0)	2.6 (1.4–4.0)	< 0.001
Hemoglobin decrease (g/dL)	1.4 (0.7–2.4)	−0.2 (− 0.2–0.0)	< 0.001
Length of hospital stay (days)	3.0 (2.0–4.0)	1.0 (1.0–2.0)	< 0.001
Right-sided stone, n (%)	33 (47.8)	28 (43.8)	0.637
Preoperative DJ stent, n (%)	0 (0.0)	16 (25.0)	< 0.001
Postoperative DJ stent, n (%)	5 (7.2)	27 (42.2)	< 0.001
Postoperative nephrostomy, n (%)	60 (87.0)	0 (0.0)	< 0.001
Ureteral access sheath use	N/A	33 (51.6)	—
Blood transfusion, n (%)	3 (4.3)	0 (0.0)	0.245
Postoperative SIRS, n (%)	9 (13.0)	2 (3.1)	0.057
Postoperative sepsis, n (%)	1 (1.4)	0 (0.0)	1.000
Residual stone, n (%)	16 (23.2)	16 (25.0)	0.841
Any additional procedure, n (%)	16 (23.2)	16 (25.0)	0.422

Patterns of drainage and stent use differed clearly between the procedures. Double-J stent placement, both before and after surgery, was more frequently required in the RIRS group. In contrast, postoperative nephrostomy placement was mainly observed after PCNL. These differences were statistically significant for all related comparisons (p<.001).

Several postoperative outcomes were similar between the two approaches. Stone laterality, transfusion requirement, postoperative sepsis, residual fragment rate, and the need for an additional intervention did not differ significantly between groups. Although SIRS occurred more often in patients undergoing PCNL, the difference showed only a borderline trend and did not reach statistical significance (p=.057).

Complications graded according to the Clavien–Dindo system are shown in Table 3. Overall, complications tended to be more common after PCNL than after RIRS; nevertheless, the distribution of complication grades was not significantly different between groups (p=.075). Most adverse events were classified as Grade I or II, whereas Grade III complications were uncommon. Grade II events were numerically higher in the PCNL cohort, a finding that may be related to the more invasive nature of the procedure and the greater stone burden in this group.

Table 3
Postoperative complications according to the Clavien–Dindo classification

Clavien–Dindo grade	PCNL (n = 69)	RIRS (n = 64)
Grade 0	54 (78.3%)	59 (92.2%)
Grade I	4 (5.8%)	3 (4.7%)
Grade II	9 (13.0%)	1 (1.6%)
Grade III	2 (2.9%)	1 (1.6%)
Note. Overall comparison was performed using chi-square or Fisher's exact test, as appropriate.		

ROC analysis

The relationship between stone area and selection of PCNL was further assessed using ROC curve analysis. Stone area showed a favorable discriminatory performance for identifying patients treated with PCNL rather than RIRS. The calculated AUC was 0.788, with a 95% confidence interval of 0.705–0.863. Based on the Youden index, the most informative threshold was 126 mm². At this cut-off point, stone area predicted PCNL selection with a sensitivity of 89.9% and a specificity of 56.2%.

Discussion

This study focused on a narrowly defined clinical subgroup: patients aged over 65 years who required surgery for isolated lower pole renal stones. Within this cohort, PCNL and RIRS were compared using perioperative parameters, postoperative outcomes, and the predictive role of stone area in surgical selection. The available literature provides relatively little direct guidance for this subgroup, because lower pole stones in elderly patients are usually discussed within broader series that include different age groups, stone locations, and treatment indications. By restricting the analysis to geriatric patients with isolated lower pole stones, the present study may contribute more targeted evidence for individualized surgical decision-making.

The treatment of lower pole stones may be more challenging than stones located in other parts of the kidney because of stone location and calyceal anatomy. A narrow infundibulum, long infundibular length, and acute infundibulopelvic angle may adversely affect both access to the stone with a flexible ureteroscope and postoperative fragment clearance. Lower pole stones are particularly difficult to manage because both endoscopic access and spontaneous fragment clearance may be limited by unfavorable calyceal anatomy. Previous studies have linked residual fragments and repeat intervention after RIRS to lower pole location, greater stone size, and an infundibulopelvic angle below 90° [10]. In addition, validation studies of the R.I.R.S. score indicate that stone density, total stone burden, lower pole localization, and infundibular length are relevant predictors of stone-free status [11,12]. These anatomical and stone-related factors are especially important in elderly patients, in whom additional

procedures and repeated anesthesia may carry higher clinical risk. These factors become even more important in geriatric patients, as repeated anesthesia, rehospitalization, and additional surgical procedures may impose a higher risk of morbidity in this population.

Available data suggest that PCNL offers stronger stone clearance for lower pole stones, while RIRS provides a less invasive pathway with shorter hospitalization. However, RIRS may still yield acceptable results in carefully selected patients with intermediate-sized lower pole stones [13]. For stones smaller than 2 cm, recent pooled evidence supports both PCNL and RIRS over ESWL, with treatment selection depending on stone burden, collecting system anatomy, comorbidities, and surgeon experience [14]. In our series, residual stone rates were comparable between groups despite the larger stone area in patients undergoing PCNL. This finding suggests that PCNL maintains its effectiveness in patients with higher stone burden, whereas RIRS may provide comparable clinical success with lower invasiveness in geriatric patients with smaller stone areas.

Longer operative and fluoroscopy exposure in the PCNL cohort probably reflects both the larger stones treated in this group and the fluoroscopy-dependent steps inherent to percutaneous access. In addition, the greater need for fluoroscopic control during PCNL may increase radiation exposure. In geriatric patients, prolonged operation time is not merely a surgical parameter but also a clinical factor that may affect anesthesia-related cardiopulmonary risks and postoperative recovery. For patients with limited cardiopulmonary reserve, anticipated operative duration may influence the choice between PCNL and RIRS.

PCNL was associated with a larger hemoglobin drop and longer inpatient stay in our cohort. This pattern is consistent with previous evidence showing that the stone-free advantage of PCNL over RIRS may come at the cost of greater bleeding risk and prolonged hospitalization [15]. In elderly patients, such morbidity is particularly relevant because limited physiological reserve may worsen the impact of bleeding or infection-related complications [16,17]. Although transfusion occurred only in the PCNL group in our study, the between-group difference was not significant, possibly due to sample size, patient selection, and the use of a 24 Fr tract.

In the geriatric population, surgical success should not be evaluated solely by stone-free rates. Cardiovascular disease, diabetes, chronic kidney disease, anticoagulant or antiplatelet use, and reduced physiological reserve may increase perioperative risk in these patients. In addition, susceptibility to infectious complications may increase due to immunosenescence. The statistical similarity in infectious complications does not eliminate the potential clinical relevance of the higher SIRS tendency observed after PCNL.

The less invasive profile of RIRS makes it particularly attractive for elderly patients. Since the procedure avoids renal parenchymal puncture and uses a natural access route, bleeding risk and recovery burden may be reduced compared with PCNL. Previous geriatric series have suggested that RIRS can be performed with acceptable safety in selected older patients, whereas PCNL may offer better stone clearance at the expense of higher complication rates [9,18]. Our results are consistent with this balance.

In the RIRS group, hemoglobin loss was lower and hospitalization was shorter, supporting its potential role in patients in whom bleeding avoidance or early mobilization is a priority. Nevertheless, it should be remembered that RIRS is not completely free of morbidity. The need for DJ stenting, stent-related symptoms, and the potential risk of infection should be considered in treatment planning, especially in elderly patients.

One of the distinguishing aspects of this study is that stone burden was evaluated not only by maximum stone diameter but also by stone area. Stone area may better reflect stone burden than a single-dimensional measurement, particularly in irregularly shaped or multidimensional stones. The good discriminatory performance of stone area in predicting PCNL selection on ROC analysis and the identification of a cut-off value of 126 mm^2 are clinically important. The high sensitivity of this threshold indicates that the likelihood of selecting PCNL increases in geriatric patients with lower pole stones and larger stone areas. However, the moderate specificity suggests that this value should not be used as a stand-alone criterion for decision-making. Therefore, the 126 mm^2 cut-off value should be regarded as an auxiliary decision-making parameter that needs to be evaluated together with stone anatomy, patient comorbidities, anticoagulant use, anesthetic risk, patient preference, and surgeon experience.

The findings of this study should be interpreted within certain methodological boundaries. Its retrospective and single-center design may have influenced both patient allocation and treatment preference, particularly because patients undergoing PCNL had a larger stone area at baseline. In addition, outcomes may reflect local surgical experience, available equipment, and institutional perioperative practices. Another limitation is the lack of detailed lower pole anatomical measurements, including infundibulopelvic angle and infundibular dimensions, which may affect both access and fragment clearance. Geriatric-specific variables such as frailty status, ASA score, comorbidity burden, antiplatelet or anticoagulant use, renal functional changes, and quality-of-life outcomes were also not included in the analysis. Finally, the sample size limits the strength of subgroup interpretation.

Conclusion

This study provides focused comparative data on PCNL and RIRS in elderly patients treated for isolated lower pole renal stones. The results suggest that the choice of procedure in this population should extend beyond a simple expectation of stone clearance. Although PCNL was applied to patients with a greater stone area and remains a reliable option when stone burden is high, it was also associated with longer operation and fluoroscopy times, greater hemoglobin decrease, and prolonged hospitalization. In contrast, RIRS offered a less invasive treatment pathway with lower bleeding-related impact and shorter hospital stay, making it a relevant alternative for selected older patients, especially when rapid recovery or reduced procedural trauma is prioritized.

Stone area may also assist treatment planning in this setting. The identified cut-off value of 126 mm^2 showed high sensitivity for predicting PCNL selection, suggesting that stone burden can contribute to preoperative decision-making. However, because specificity was moderate, this threshold should not be

used alone. Instead, it should be combined with lower pole anatomy, comorbidity status, bleeding risk, anesthetic tolerance, and patient preference. Future studies should prospectively evaluate these factors together with geriatric-specific parameters to develop more individualized treatment algorithms for lower pole stones in older adults.

Abbreviations

PCNL
Percutaneous Nephrolithotomy
RIRS
Retrograde Intrarenal Surgery
CT
Computed tomography

Declarations

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Competing interests

The authors declare that they have no competing interests.

Ethics approval

This study was approved by the Non-Interventional Clinical Research Ethics Committee of İzmir City Hospital on January 21, 2026, with approval number 2026/26.

Informed consent

Because of the retrospective design of the study, the requirement for informed consent was waived by the ethics committee. Clinical trial number: not applicable.

Author contributions

Furkan Yildiz contributed to study conception, data collection, statistical analysis, and manuscript drafting. Serkan Yarimoglu, Murat Sahan, Tansu Degirmenci, Ibrahim Halil Bozkurt, and Ahmet Alper Özdeş contributed to study design, interpretation of data, critical revision of the manuscript, and final approval of the submitted version.

Data availability

The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

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Figures

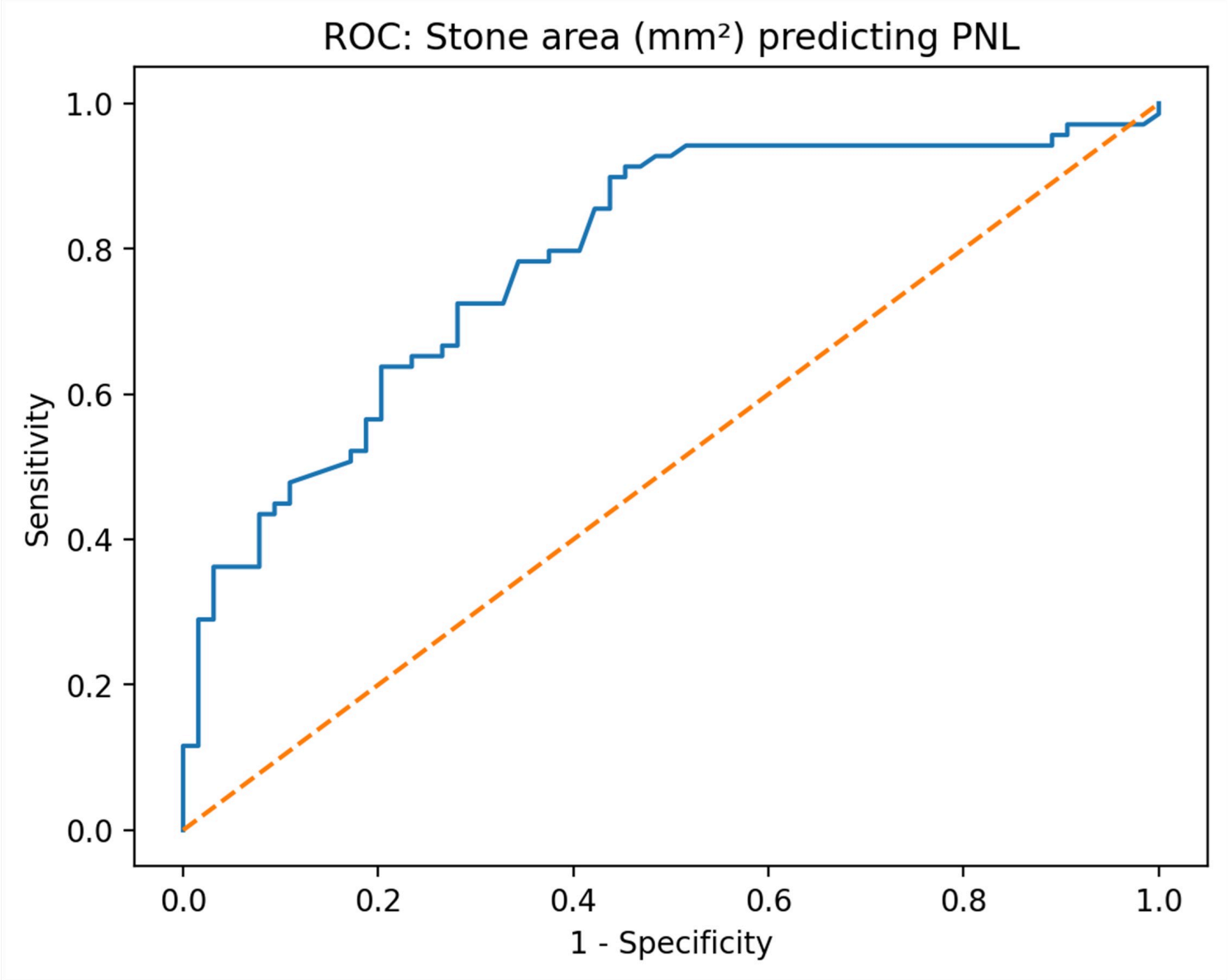


Figure 1

Receiver operating characteristic (ROC) curve of stone area for predicting the selection of percutaneous nephrolithotomy (PCNL).

Supplementary Files

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