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Retrograde intrarenal surgery versus percutaneous nephrolithotomy for renal stones of 1–2 cm: a prospective comparative study with analysis by stone location

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Abstract

Purpose To compare retrograde intrarenal surgery (RIRS) and percutaneous nephrolithotomy (PCNL) for renal stones of 1–2 cm, with attention to stone location.

Methods In this prospective, single-centre, quasi-randomized comparative study, 120 adults with renal stones of 1–2 cm underwent RIRS (n = 60) or PCNL (n = 60); the procedure was chosen alternatively between RIRS and PCNL (systematic allocation). Operative time, postoperative stay, complications, hemoglobin change and residual stones on NCCT KUB at 6 month were compared.

Results Age, sex and previous stone history were similar, but lower-pole stones were more frequent in the PCNL group (50% vs 20%, p = 0.003). Operative time was longer with RIRS (122 ± 22 vs 96.8 ± 18.5 min, p < 0.0001) and postoperative stay was shorter (2.15 ± 0.58 vs 2.83 ± 0.42 days, p < 0.0001). Fever, transfusion, severe pain and hemoglobin fall did not differ significantly. Overall, residual stones at 6 months were present in 13.3% after RIRS and 5.0% after PCNL (p = 0.204). In lower-pole stones, residual stones were more frequent after RIRS (46.2% vs 3.3%, p = 0.002); in upper-pole stones they were less frequent after RIRS (4.0% vs 28.6%, p = 0.047). Longer operative time correlated with more complications in both groups.

Conclusion RIRS shortened hospital stay and PCNL shortened operative time, with similar short-term safety. Clearance differed by stone location, but allocation was not true random and subgroups were small, so these location-specific findings need confirmation in randomized studies.

Introduction

Urolithiasis is a common condition whose incidence has risen over recent decades [1, 2]. For renal stones of 1–2 cm, guidelines of the European Association of Urology allow several treatment options, and both retrograde intrarenal surgery (RIRS) and percutaneous nephrolithotomy (PCNL) are widely used [3]. PCNL generally achieves high stone clearance but carries risks of bleeding and access-related morbidity and usually requires a longer hospital stay. RIRS is less invasive but may take longer and clears stones less reliably in some locations, notably the lower pole [3, 4].

Comparative studies and meta-analyses have not settled which approach is preferable in this size range, and few report outcomes separately for each calyceal group [4, 5]. We therefore compared RIRS and PCNL for renal stones of 1–2 cm, looking at stone clearance, perioperative outcomes and complications, and examining whether stone location influenced the result.

Methods

Study design and participants

This single-centre, prospective, comparative study was conducted in the Department of General Surgery, Jagjivan Ram Railway Hospital, Mumbai, between April 2024 and April 2026, and is reported in line with the STROBE recommendations. [Authors: see Declarations regarding the start of enrolment relative to ethics approval.] Adults (≥ 18 years) with a renal stone of 1–2 cm were eligible. Patients with severe comorbidities, acute renal failure or end-stage renal disease, morbid obesity, a need for multiple access tracts and procedure conversion between RIRS and PCNL during surgery were excluded. Written informed consent was obtained from all participants.

The sample size was based on operative time, using the values of Karakoç et al. [6] (mean 100.26 ± 33.26 min for RIRS and 75.55 ± 21.5 min for PCNL), a two-sided alpha of 0.05 and 80% power. This gave 53 patients per group, increased to 60 per group to allow for 10% attrition.

Assessment and procedures

Baseline assessment comprised history, examination, complete blood count, coagulation profile, renal and liver function tests, serum electrolytes, blood glucose, urine routine microscopy and culture, ECG and chest radiograph. Stone size and location were determined by ultrasonography, radiography and non-contrast CT; stone size was recorded using surface-area calculation according to European Association of Urology guidance. Patients with positive urine cultures received antibiotics before surgery. Patients underwent either RIRS or PCNL, selected by the treating team on the basis of systematic allocation alternating between PCNL and RIRS; allocation was therefore quasi randomized.

Procedure was done by a single experienced surgeon. Holmium laser was used for RIRS along with ureteral sheath access and PCNL needed 24 number percutaneous sheath and nephroscope and pneumatic lithotripter. Antibiotic prophylaxis was given to all patients and DJ stenting was done regardless of the procedure for all patients

Outcomes and statistical analysis

The primary outcome was the presence of residual stones on Non-Contrast CT KUB 6 months after surgery. Secondary outcomes were operative time, postoperative hospital stay, postoperative fever, blood transfusion, severe pain, change in hemoglobin and total leukocyte count (TLC), and the number of postoperative complications.

Categorical variables are given as number (%) and continuous variables as mean ± standard deviation or median (interquartile range). Normality was checked with the Shapiro–Wilk test. Continuous variables were compared with the independent t test (Mann–Whitney U test for non-normal data) and categorical variables with the chi-square test or Fisher's exact test when an expected cell count was below 5. Correlation between operative time and number of complications was assessed with Spearman's rank coefficient. Analysis used IBM SPSS Statistics version 25.0 (IBM Corp., Chicago, USA); $p < 0.05$ was considered significant. No adjustment was made for multiple comparisons.

Results

Patients and baseline characteristics

Of 120 patients enrolled, 60 underwent RIRS and 60 underwent PCNL. Age (mean 55.7 vs 57.6 years), sex distribution and previous stone history were similar between groups, as were baseline hemoglobin and TLC (Table 1). Stone location differed: lower-pole stones accounted for 50% of the PCNL group but 20% of the RIRS group (p = 0.003).

Table 1
Baseline characteristics of patients undergoing RIRS and PCNL

Characteristic	RIRS (n = 60)	PCNL (n = 60)	p value
Age, years, mean ± SD	55.72 ± 7.21	57.55 ± 8.63	0.209[a]
Male sex, n (%)	29 (48.3)	35 (58.3)	0.272[b]
Previous renal stone, n (%)	3 (5.0)	8 (13.3)	0.204[c]
Stone location, n (%)			0.003[b]
Upper pole calyx	24 (40.0)	14 (23.3)	
Middle pole calyx	24 (40.0)	16 (26.7)	
Lower pole calyx	12 (20.0)	30 (50.0)	
Hemoglobin, g/dL, mean ± SD	12.25 ± 1.14	12.03 ± 1.31	0.337[a]
TLC, cells/mm³, mean ± SD	8217 ± 1892	7892 ± 1862	0.345[a]

RIRS retrograde intrarenal surgery, PCNL percutaneous nephrolithotomy, SD standard deviation, TLC total leukocyte count. [a]Independent t test; [b]chi-square test; [c]Fisher's exact test

Perioperative outcomes and complications

Operative time was longer with RIRS (122 ± 22 min) than with PCNL (96.83 ± 18.46 min; p < 0.0001), whereas postoperative stay was shorter with RIRS (2.15 ± 0.58 vs 2.83 ± 0.42 days; p < 0.0001) (Table 2). Postoperative fever (11.7% vs 16.7%), blood transfusion (5.0% vs 11.7%) and severe pain (10.0% vs 15.0%) did not differ significantly. Postoperative hemoglobin, the fall in hemoglobin and postoperative TLC were also similar. Longer operative time was correlated with a greater number of complications in the RIRS group (Spearman ρ = 0.715, p < 0.0001) and in the PCNL group (ρ = 0.442, p = 0.001).

Table 2
Perioperative outcomes and complications

Outcome	RIRS (n = 60)	PCNL (n = 60)	p value
Operative time, min, mean ± SD	122 ± 22	96.83 ± 18.46	< 0.0001[a]
Postoperative stay, days, mean ± SD	2.15 ± 0.58	2.83 ± 0.42	< 0.0001[a]
Postoperative fever, n (%)	7 (11.7)	10 (16.7)	0.432[b]
Blood transfusion, n (%)	3 (5.0)	7 (11.7)	0.322[c]
Severe pain, n (%)	6 (10.0)	9 (15.0)	0.408[b]
Postoperative hemoglobin, g/dL, mean ± SD	11.35 ± 1.61	11.03 ± 1.89	0.325[a]
Fall in hemoglobin, g/dL, median (IQR)	1 (0–1)	1 (0–1.25)	0.916[d]
Postoperative TLC, cells/mm³, mean ± SD	9958 ± 2714	9650 ± 2570	0.524[a]

IQR interquartile range. [a]Independent t test; [b]chi-square test; [c]Fisher's exact test; [d]Mann–Whitney U test

Residual stones

At 6 months, residual stones were found in 8 of 60 patients (13.3%) after RIRS and 3 of 60 (5.0%) after PCNL (p = 0.204) (Table 3, Fig. 1). By location, residual stones in the lower pole were more frequent after RIRS (46.2% vs 3.3%, p = 0.002), those in the middle pole were similar (4.3% vs 6.3%, p = 1.0), and those in the upper pole were less frequent after RIRS (4.0% vs 28.6%, p = 0.047).

Table 3
Residual stones on Non-Contrast CT KUB at 6 month, overall and by stone location

Stone location	RIRS, n/N (%)	PCNL, n/N (%)	p value
Overall	8/60 (13.3)	3/60 (5.0)	0.204[a]
Lower pole calyx	6/13 (46.2)	1/30 (3.3)	0.002[a]
Middle pole calyx	1/23 (4.3)	1/16 (6.3)	1.000[a]
Upper pole calyx	1/25 (4.0)	4/14 (28.6)	0.047[a]

RIRS retrograde intrarenal surgery, PCNL percutaneous nephrolithotomy. [a]Fisher's exact test.

Discussion

In this prospective comparison of RIRS and PCNL for renal stones of 1–2 cm, the two procedures showed a consistent trade-off. RIRS took about 25 minutes longer but allowed earlier discharge, while short-term complications, hemoglobin change and leukocyte response were similar. Overall residual stone rates at 6 months did not differ significantly, but the pattern depended on stone location.

Longer operative time and shorter stay with RIRS agree with earlier comparative work and meta-analysis [4, 8, 9]. The much higher residual rate after RIRS for lower-pole stones is also in line with other series, in which PCNL cleared lower-pole stones better than RIRS [7, 9] and lower-pole location predicted failure of RIRS [10]. Unfavorable infundibulopelvic anatomy and gravity-dependent fragments are plausible explanations, although we did not measure them.

The upper-pole result should be read with care. Residual stones were less frequent after RIRS (4.0% vs 28.6%), but the p value (0.047) was borderline, only 14 upper-pole stones were treated by PCNL, three subgroup comparisons were made without correction, and we are not aware of other series reporting this difference. Access to the upper pole by PCNL often requires a supracostal tract, which may affect fragment clearance, but this was not recorded. We therefore regard this finding as hypothesis-generating rather than a basis for choosing RIRS.

Operative time correlated with the number of complications in both groups. This is an association: longer operations may reflect more complex stones or anatomy rather than cause complications.

The main limitation is that allocation was not true random, so the groups differed at baseline (lower-pole stones were more common with PCNL). The study was done at a single centre, subgroup numbers were small, and some subgroup denominators need to be reconciled (Table 3). Strengths are the prospective design, a sample size calculated in advance and the uniform assessment of both groups.

Conclusion

RIRS and PCNL were both safe and effective for renal stones of 1–2 cm in this series, with RIRS giving a shorter hospital stay and PCNL a shorter operative time. Stone location appeared to influence clearance: PCNL left fewer residual stones in the lower pole, whereas the apparent advantage of RIRS in the upper pole needs confirmation. Randomized studies stratified by stone location are needed.

Declarations

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Competing interests The authors have no relevant financial or non-financial interests to disclose.

Ethics approval The study protocol was reviewed by the Scientific Research Committee of Jagjivan Ram Railway Hospital (meetings of 23 and 27 March 2024) and approved by the Institutional Ethics Committee of Jagjivan Ram Railway Hospital (IEC-JRH; registration no. EC/NEW/INST/2023/3824) on 12 May 2024.

Consent to participate Written informed consent was obtained from all participants before inclusion.

Consent to publish Not applicable; no identifying information is presented.

Data availability The datasets generated and analysed during the study are available from the corresponding author on reasonable request.

Prior presentation This article is based on the first author's dissertation submitted to the National Board of Examinations in Medical Sciences, New Delhi (DNB General Surgery, 2026). The work has not been published elsewhere.

Author Contribution

Nijesh S K – conceptualization, investigation, data curation, formal analysis, writing – original draft. Prashant Rishi – conceptualization, supervision . Sreelakshmi – writing , review and editing. All authors read and approved the final manuscript.

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Figures

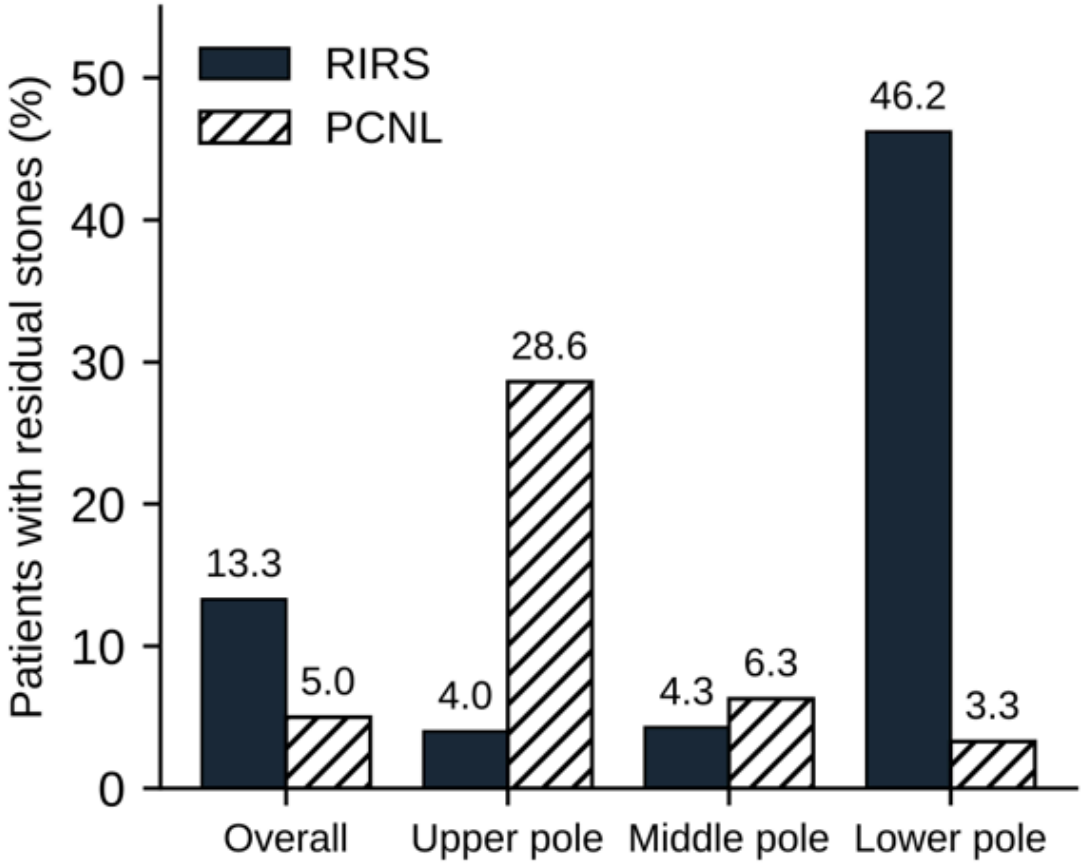

Figure 1

Percentage of patients with residual stones on Non-Contrast CT KUB at 6 month after RIRS and PCNL, overall and by stone location