



Original Research Article

Prospective study on comparison of outcomes of mini percutaneous nephrolithotomy (mini perc PCNL) versus retrograde intrarenal surgery (RIRS) for renal calculus of size 1-2 cm

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ABSTRACT

Background And Objectives

For renal calculi sized 1-2 cm, Mini Percutaneous Nephrolithotomy (Mini-PCNL) and Retrograde Intrarenal Surgery (RIRS) are prominent surgical options due to their superior clearance rates over traditional methods like ESWL. This study aims to demonstrate comparative clinical outcomes and identify the optimal management modality between RIRS and Mini-PCNL for patients presenting with 1-2 cm renal stones.

Materials And Methods

A single-centre, prospective comparative study was conducted involving 60 patients (>15 years of age) diagnosed with 1-2 cm renal calculi. The study population was divided equally into two cohorts: 30 patients underwent RIRS and 30 patients underwent Mini-PCNL. Data on several perioperative parameters were collected, including operative time, duration of hospital stay, postoperative pain via Visual Analogue Score (VAS), haemoglobin drop, and surgical complications. To evaluate treatment success, the stone-free rate (SFR) was documented using a Non-Contrast CT (NCCT) KUB at a 3-month (90 days) postoperative follow-up.

Results

Demographic profiles, including age and sex, as well as the anatomical locations of the stones, were statistically comparable between the two cohorts. The stone-free rate was significantly higher in the Mini-PCNL group (93.3%) compared to the RIRS group (73.3%) ($P = 0.038$). RIRS demonstrated a significantly shorter mean operative time (79.67 ± 25.83 minutes) in contrast to Mini-PCNL (107.67 ± 49.04 minutes) ($P = 0.008$). The duration of hospital stay was significantly reduced for patients in the RIRS group (3.43 ± 1.07 days) compared to those in the Mini-PCNL group (4.63 ± 0.72 days) ($P < 0.001$). Patients undergoing RIRS experienced significantly less postoperative pain ($P = 0.030$) and a dramatically lower mean haemoglobin drop (0.09 ± 0.17 g/dL) than those undergoing Mini-PCNL (1.20 ± 0.29 g/dL) ($P < 0.001$). Overall complication rates showed no statistically significant difference between the two techniques ($P = 0.305$).

Conclusion

Both RIRS and Mini-PCNL are safe, effective modalities for managing moderate-sized (1-2 cm) renal calculi, with each procedure offering distinct clinical advantages. RIRS is associated with superior perioperative outcomes, specifically reduced operative time, minimal blood loss, decreased postoperative pain, and a faster hospital discharge. Conversely, Mini-PCNL provides superior stone clearance efficacy, making it highly advantageous for complete calculus removal. The choice of surgical modality should ultimately be tailored to patient-specific factors, stone characteristics, and surgeon expertise.

Keywords: RIRS, Mini-PCNL; Stone clearance, Perioperative outcome.

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INTRODUCTION

Nephrolithiasis is a common medical problem in the world. Percutaneous nephrolithotomy (PCNL) was introduced in 1976 to tackle the problem of treating recurrent stone disease and the associated technical difficulties with reoperations.¹ Since then, it has played an important role in the urologists' armamentarium in the management of renal calculus disease. With the invention of extracorporeal shock wave lithotripsy (ESWL) in the late 1980s, it seemed that PCNL would make an early exit but soon became clear that ESWL could not be considered as the only surgical treatment for all stone diseases. For renal calculi sized 1-2cm, there has been steady decline in the use of ESWL with a concomitant increase in the use of PCNL and RIRS, as they are associated with better clearance.^{2,3,4} PCNL is regarded as a second line therapy for several reasons, including procedure related bleeding requiring a blood transfusions or interventions, greater demand for postoperative parenteral analgesics and a longer hospital stay.^{5,6,7,8,9} In order to overcome the disadvantages of PCNL, a mini perc technique was first developed for children and reported by Helal et al.¹⁰ Jackman et al defined mini perc as a PCNL, achieved through a sheath too small to accommodate a standard rigid nephroscope.^{11,12} Marshall performed the first ureteroscopy using a 9 Fr fiberoptic scope in 1964 to visualize an impacted ureteral stone.¹³ Flexible and deflectable ureteroscopy was introduced by Takagi et al from Japan at the 15th SUI congress in 1970. He passed a similar scope through an open ureterotomy into the upper collecting system in a retrograde fashion.¹⁴ Initial scopes were diagnostic scopes, with no channel for irrigation or working instruments and no active deflecting mechanisms. Major advances in the evolution of the flexible ureteroscope spanning over decades have included reliable active deflection, miniaturization of endoscopes, improvement in intracorporeal lithotripsy and the development of 2-3 Fr accessory instrument.^{15,16}

The usage of RIRS is limited to the patients who are contraindicated for PCNL/ESWL such as bleeding diathesis, morbid obesity, mal-rotated or mal-positioned kidney, horseshoe kidney and calculus in unfavourable lower calyx.¹

AIMS AND OBJECTIVES

- The aim of this study is to demonstrate the comparative results of RIRS and mini perc PCNL in the management of 1-2cm renal stones.
- To identify the better modality of management between RIRS and mini perc PCNL in patients with renal stone of size 1-2 cm.

MATERIALS AND METHODS

Study Site: Ruby Hall Clinic, Pune

Study duration: June 23 to June 25

Study Population: All patients who fulfilled inclusion criteria admitted in Ruby Hall Clinic, Pune

Study design: Prospective comparative study.

Sample size: 60

Ethics: Study was initiated after obtaining permission from ethical committee of RUBY HALL CLINIC PUNE

Inclusion criteria:

1. All patients who were admitted with 1-2cm renal calculi between June 2023 to June 2025.
2. Age greater than 15yrs

Exclusion criteria:

1. Stones larger than 2cm and smaller than 1cm
2. More than 3 stones in a pelvicalyceal system
3. Pregnant women

STUDIED PARAMETERS:

1. Operative time (in minutes)
2. Duration of hospital stay (in days)
3. Complications (blood loss, postoperative pain, need of blood transfusions, fever and infection)
4. Hounsfield units (HU) of stone
5. Stone free rate (SFR)
6. Location of stone
7. Number of stones
8. Other rare complications, if any, like perinephric collection, retroperitoneal haematoma, visceral organ injury, ureteric injury (may need further investigations if clinical symptoms are there). Complications were assessed after surgery.

Blood loss was assessed using Haemoglobin estimation method where post operative haemoglobin was tested after 12 hours of surgery. The difference in preoperative haemoglobin and postoperative haemoglobin was used as amount of blood loss for that patient. Post operative pain was assessed using Visual Analogue Score (VAS) 6 hourly till 24 hours after surgery. Blood transfusions, if required, was transfused in units. Highest spike of temperature was noted using axillary thermometer in Fahrenheit, measured 6 hourly till 24 hours of surgery. Infection was documented on the basis of increased total leucocyte counts, done 24 hrs after surgery.

METHODOLOGY

After obtaining approval from the ethical committee of ruby hall clinic, Pune, the study was initiated with an informed consent from all the patients. This is a single-centre study, prospective study on patients diagnosed with 1-2cm renal calculi between June 2023 to June 2025. Patients were divided into two groups:

group 1: 30 patients who underwent RIRS group 2: 30 patients who underwent mini perc PCNL. Data was collected to compare above 8 parameters

Follow up protocol:

CT KUB: after 3 months (90 days)

Stone free rate was documented using NCCT-KUB in post-operative period after 90 days. Residual fragments greater than 3mm were considered significant.

STATISCAL ANALYSIS:

Descriptive analysis was used to describe the data, Mean and standard deviation

were used for quantitative variables. Frequency and percentages were used for

categorical variables. Shapiro wilk test was used to assess the normality of the data. Chi2 test was used to see association between the two categorical variables. Two independent sample t test or Mann Whitney u test was used to compare two

independent numeric groups as per normality of data. All analysis were done using SPSS version 25. P value less than 0.05 was considered statistical significance.

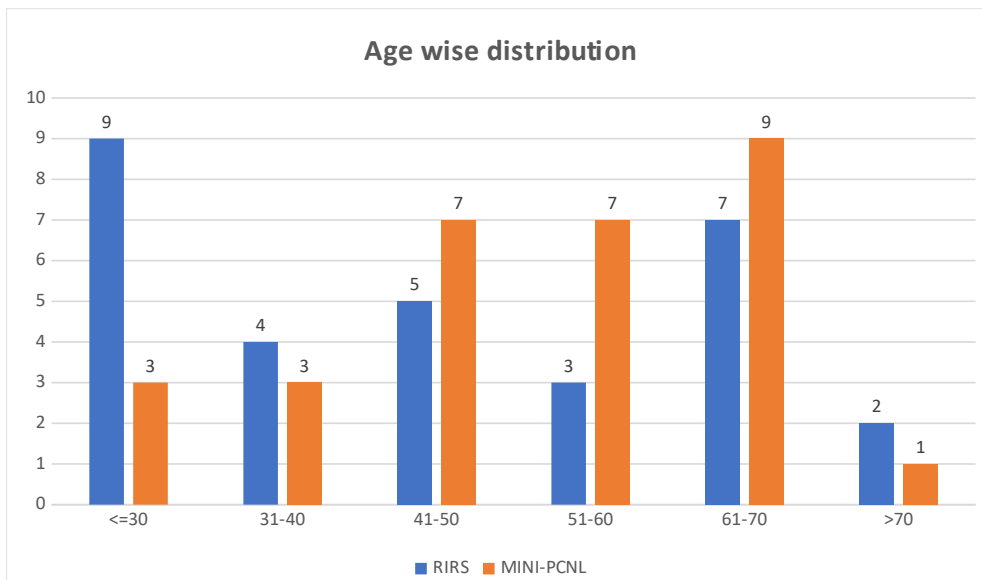
OBSERVATIONS AND RESULT

		Group		Total	P value
		RIRS	MINI-PCNL		
Age	≤30	9	3	12	0.341
	31-40	4	3	7	
	41-50	5	7	12	
	51-60	3	7	10	
	61-70	7	9	16	
	>70	2	1	3	
Total		30	30	60	

The age distribution of patients was compared between the RIRS and MINI-PCNL groups, each comprising 30 patients. Patients were categorized into six age groups: ≤30, 31–40, 41–50, 51–60, 61–70, and >70 years.

In the RIRS group, the distribution was as follows: ≤30 (n=9), 31–40 (n=4), 41–50 (n=5), 51–60 (n=3), 61–70 (n=7), and >70 (n=2). In the MINI-PCNL group, the distribution was: ≤30 (n=3), 31–40 (n=3), 41–50 (n=7), 51–60 (n=7), 61–70 (n=9), and >70 (n=1).

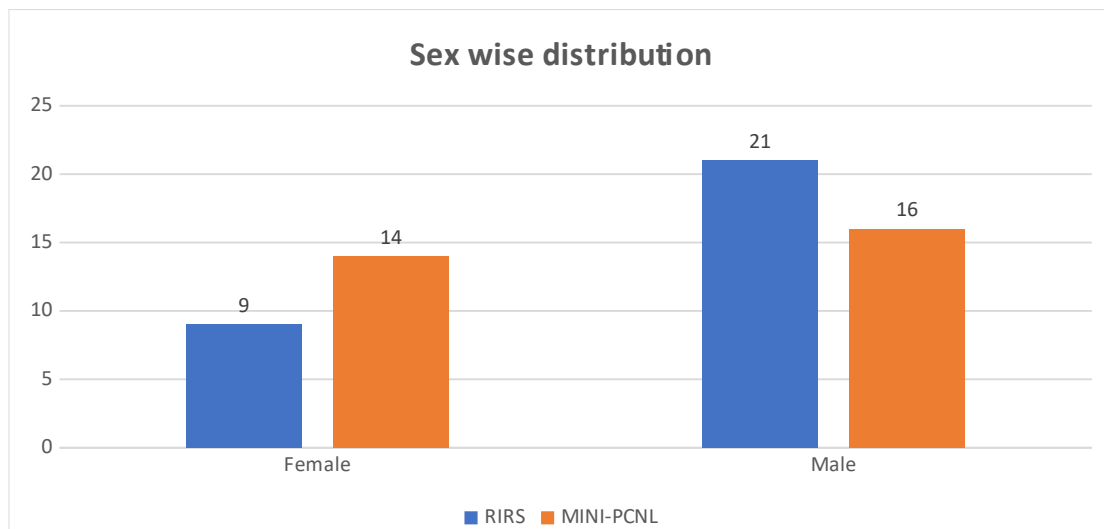
Statistical analysis using the Chi-square test revealed no significant difference in age distribution between the two groups (P = 0.341), indicating that the groups were comparable in terms of patient age.



		Group		Total	P value
		RIRS	MINI-PCNL		
SEX	F	9	14	23	0.184
	M	21	16	37	
Total		30	30	60	

The distribution of sex between the RIRS and MINI-PCNL groups was analyzed. In the RIRS group (n = 30), there were 9 females and 21 males, while the MINI-PCNL group (n = 30) included 14 females and 16 males.

A Chi-square test was performed to assess whether there was a significant difference in sex distribution between the two groups. The result showed no statistically significant difference (P = 0.184), indicating that the groups were comparable in terms of sex.



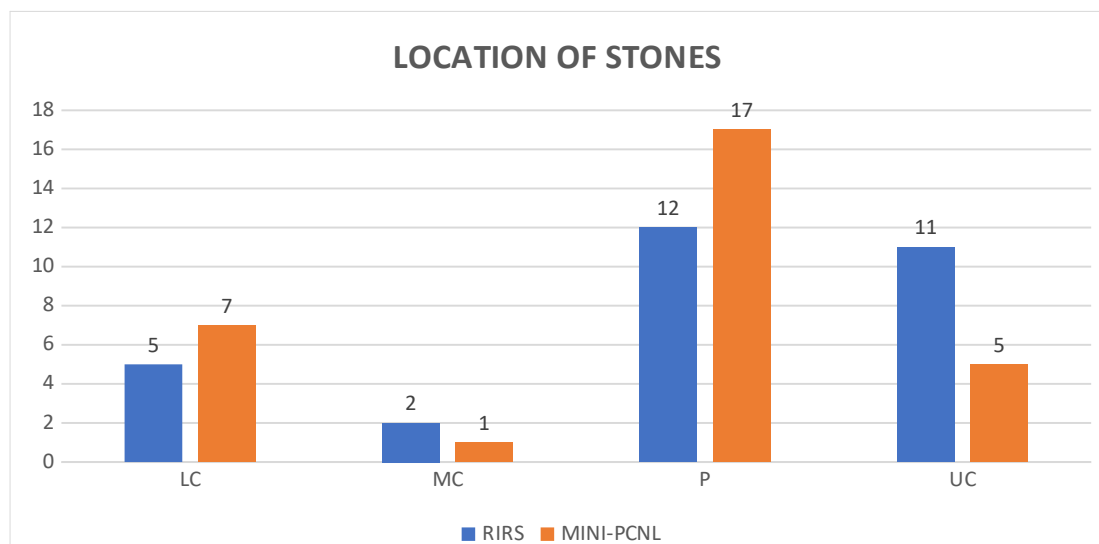
		Group		Total	P value
		RIRS	MINI-PCNL		
LOCATION OF STONES	LC	5	7	12	0.286
	MC	2	1	3	
	P	12	17	29	
	UC	11	5	16	

Total	30	30	60	
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The location of renal stones was assessed and compared between the RIRS and MINI-PCNL groups. Stone locations were categorized as lower calyx (LC), middle calyx (MC), pelvis (P), and upper calyx (UC).

In the RIRS group (n = 30), the distribution was as follows: LC (n = 5), MC (n = 2), P (n = 12), and UC (n = 11). In the MINI-PCNL group (n = 30), the distribution was: LC (n = 7), MC (n = 1), P (n = 17), and UC (n = 5).

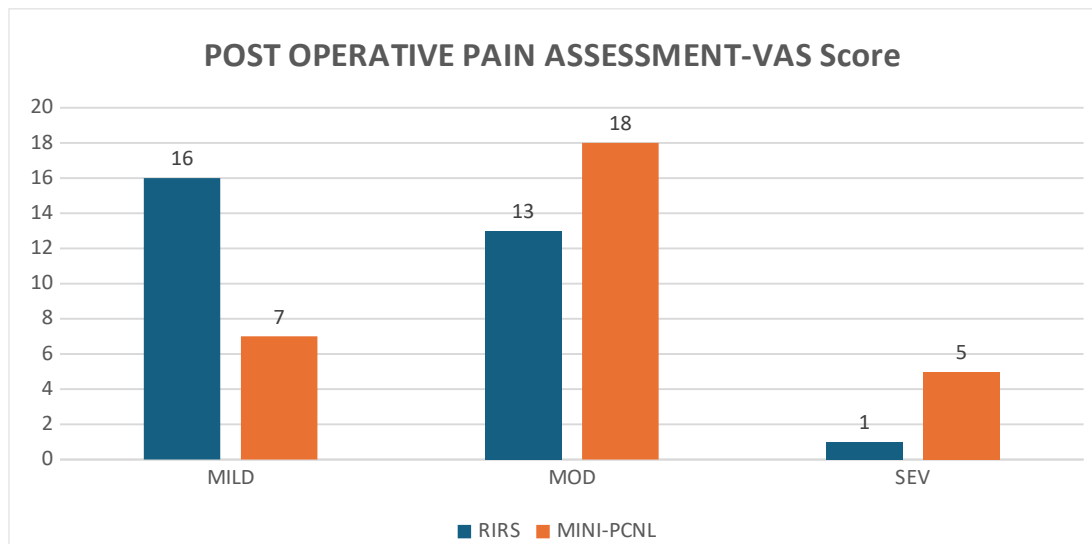
Statistical comparison using the Chi-square test revealed no significant difference in stone location between the two groups (P = 0.286), suggesting that the anatomical distribution of stones was comparable between patients undergoing RIRS and MINI-PCNL.



		Group		Total	P value
		RIRS	MINI-PCNL		
POST OPERATIVE PAIN ASSESSMENT-VAS Score	MILD	16	7	23	0.030
	MOD	13	18	31	
	SEV	1	5	6	
Total		30	30	60	

Postoperative pain was assessed using the Visual Analog Scale (VAS) and categorized as mild, moderate, or severe. In the RIRS group (n = 30), 16 patients reported mild pain, 13 reported moderate pain, and 1 reported severe pain. In contrast, in the MINI-PCNL group (n = 30), 7 patients reported mild pain, 18 reported moderate pain, and 5 reported severe pain.

The difference in postoperative pain levels between the two groups was statistically significant (P = 0.030), indicating that patients who underwent RIRS experienced significantly less postoperative pain compared to those who underwent MINI-PCNL.

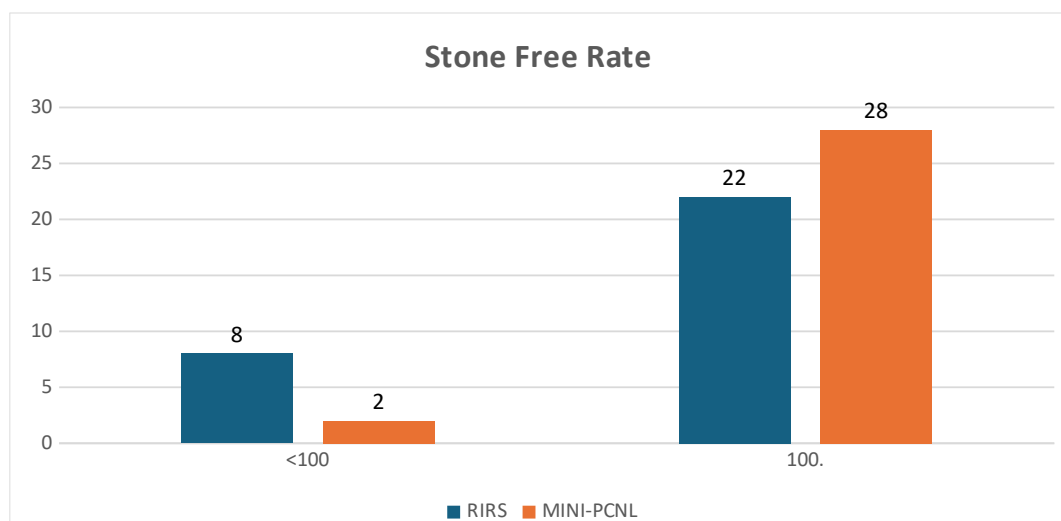


		Group		Total	P value
		RIRS	MINI-PCNL		
Stone Free Rate	<100	8	2	10	0.038
	100	22	28	50	
Total		30	30	60	

The stone-free rate post-procedure was evaluated in both groups. Patients were categorized as either stone-free (100%) or having residual fragments (<100%).

In the RIRS group (n = 30), 22 patients (73.3%) achieved a 100% stone-free rate, while 8 patients (26.7%) had residual fragments. In the MINI-PCNL group (n = 30), 28 patients (93.3%) were stone-free, and 2 patients (6.7%) had residual stones.

The difference in stone-free rates between the groups was statistically significant (P = 0.038), with MINI-PCNL showing a higher rate of complete stone clearance compared to RIRS.



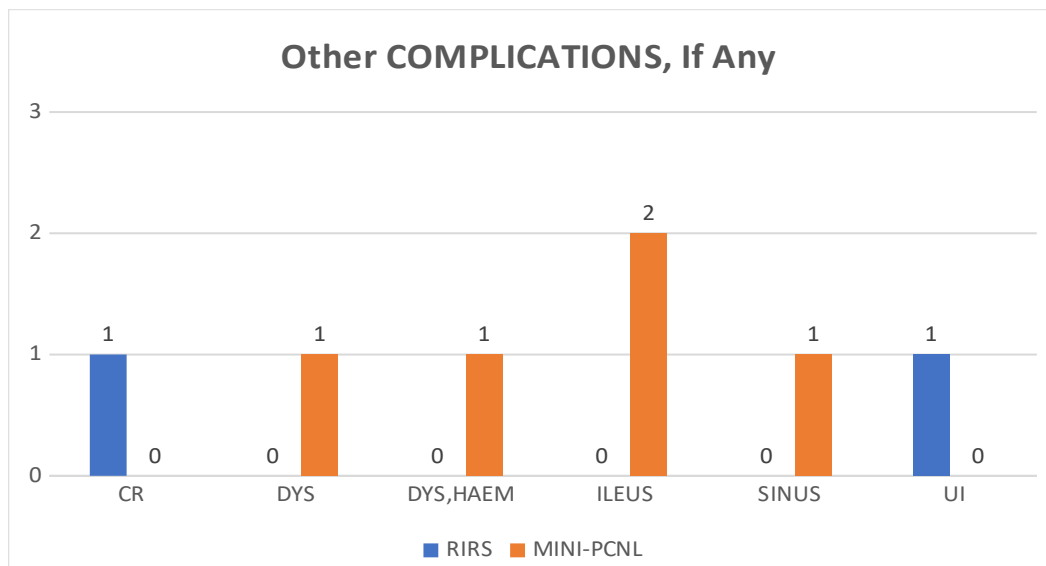
		Group		Total	P value
		RIRS	MINI-PCNL		
Other COMPLICATIONS, If Any	CR	1	0	1	0.305
	DYS	0	1	1	
	DYS, HAEM	0	1	1	

	ILEUS	0	2	2
	SINUS	0	1	1
	UI	1	0	1
Total		2	5	7

Postoperative complications were recorded and classified as calyceal rupture (CR), dysuria (DYS), dysuria with haematuria (DYS, HAEM), ileus, sinus formation (SINUS), and ureteric injury (UI).

In the RIRS group (n = 30), 2 patients experienced complications: one case of calyceal rupture and one case of ureteric injury. In the MINI-PCNL group (n = 30), 5 patients experienced complications: one each of dysuria, dysuria with haematuria, sinus formation, and two cases of ileus for more than 48 hrs.

Statistical analysis showed no significant difference in the overall incidence of complications between the two groups (P = 0.305), suggesting that both procedures had a comparable safety profile in terms of minor and major postoperative complications.

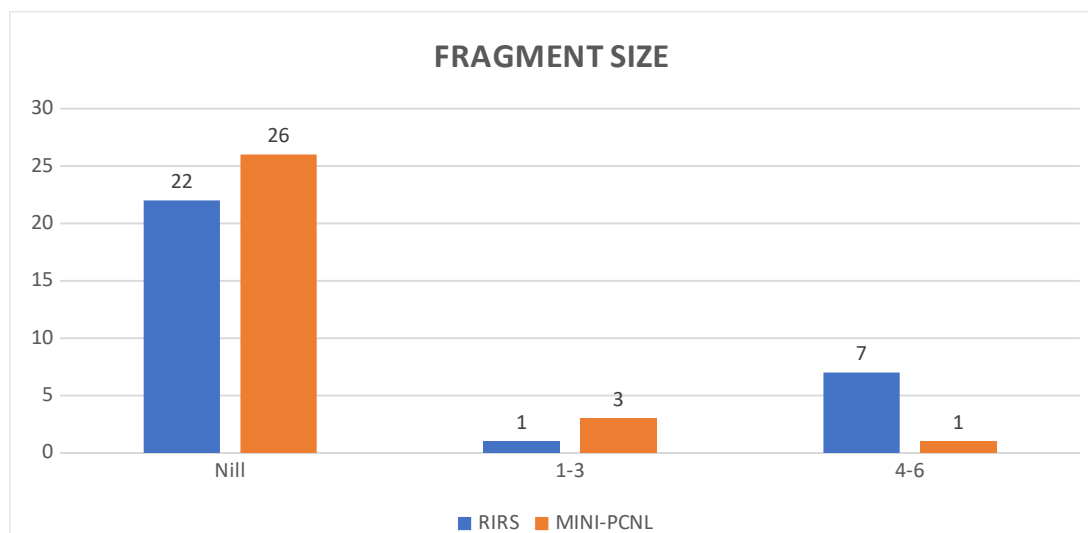


		Group		Total	P value
		RIRS	MINI-PCNL		
FRAGMENT SIZE	Nil	22	26	48	0.045
	1-3	1	3	10	
	4-6	7	1	2	
Total		30	30	60	

A total of 60 patients were included in the study, with 30 patients each undergoing Retrograde Intrarenal Surgery (RIRS) and Mini Percutaneous Nephrolithotomy (MINI-PCNL). Fragment size following the procedure was assessed and categorized as Nil (0 mm), 1–3 mm, and 4–6 mm.

In the RIRS group, 22 patients (73.3%) had no residual fragments, 1 patient (3.3%) had fragments measuring 1–3 mm, and 7 patients (23.3%) had fragments measuring 4–6 mm. In comparison, the MINI-PCNL group showed 26 patients (86.7%) with no residual fragments, 3 patients (10.0%) with 1–3 mm fragments, and 1 patient (3.3%) with 4–6 mm fragments.

Statistical analysis using the Chi-square test revealed a significant difference in fragment size distribution between the two groups (P = 0.045), indicating that MINI-PCNL associated with a higher rate of complete stone clearance compared to RIRS.



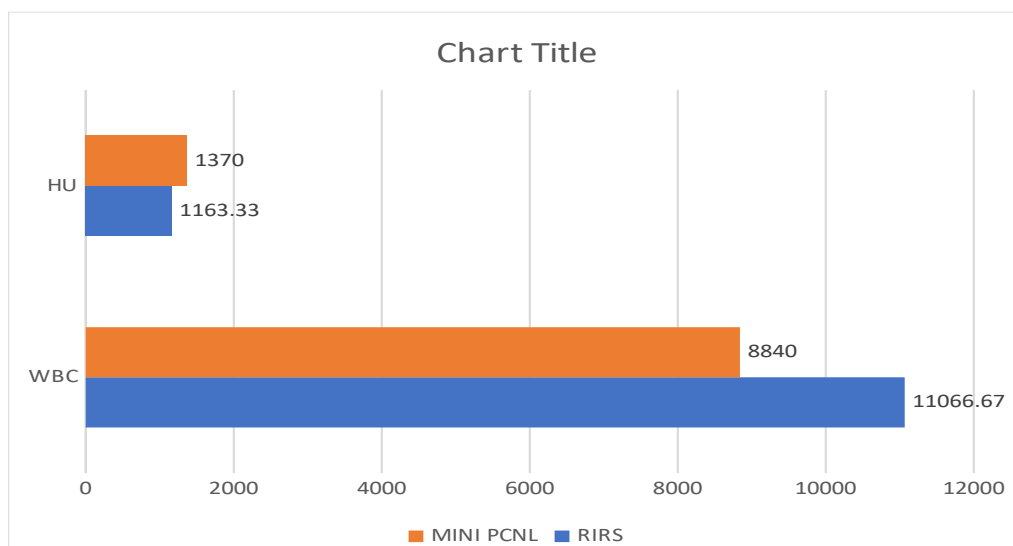
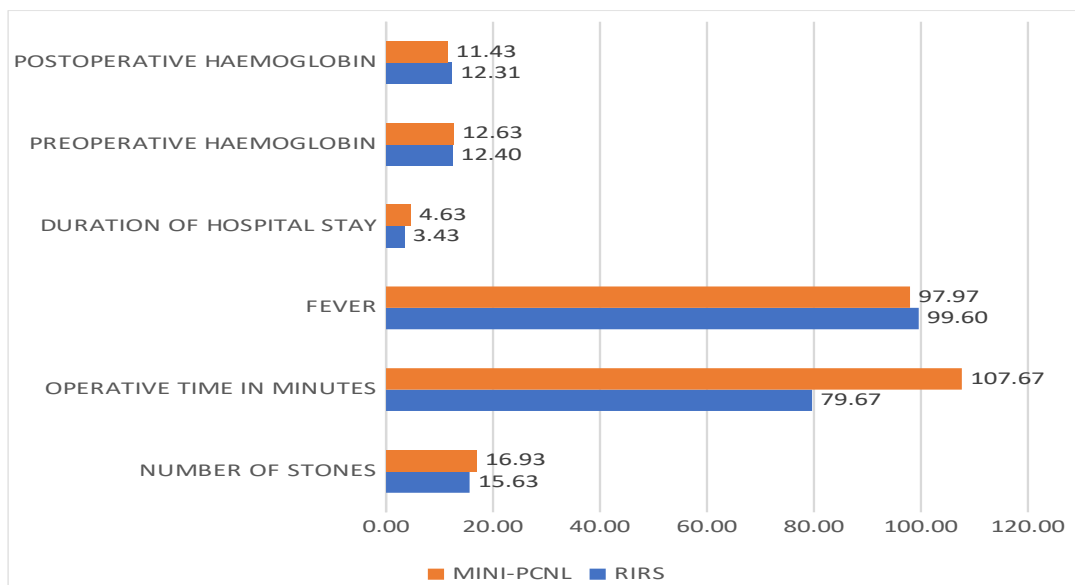
Group		N	Mean	SD	P value
NUMBER OF STONES	RIRS	30	15.63	2.51	0.042
	MINI-PCNL	30	16.93	2.32	
HOUNSFIELD UNITS(HU)	RIRS	30	1163.33	175.15	< 0.001
	MINI-PCNL	30	1370.00	158.44	
OPERATIVE TIME IN MINUTES	RIRS	30	79.67	25.83	0.008
	MINI-PCNL	30	107.67	49.04	
FEVER	RIRS	30	99.60	1.51	< 0.001
	MINI-PCNL	30	97.97	1.30	
WBC count	RIRS	30	11066.67	2891.53	0.046
	MINI-PCNL	30	8840.00	2962.25	
DURATION OF HOSPITAL STAY	RIRS	30	3.43	1.07	< 0.001
	MINI-PCNL	30	4.63	0.72	
PREOPERATIVE HAEMOGLOBIN	RIRS	30	12.40	1.25	0.452
	MINI-PCNL	30	12.63	1.10	
POSTOPERATIVE HAEMOGLOBIN	RIRS	30	12.31	1.30	0.008
	MINI-PCNL	30	11.43	1.18	

Several perioperative parameters were compared between the RIRS and MINI-PCNL groups, as detailed below:

- Number of Stones: The mean number of stones was significantly lower in the RIRS group (15.63 ± 2.51) compared to the MINI-PCNL group (16.93 ± 2.32), with a statistically significant difference ($P = 0.042$).
- Hounsfield Units (HU): The mean stone density, measured in Hounsfield Units, was significantly lower in the RIRS group (1163.33 ± 175.15) compared to the MINI-PCNL group (1370.00 ± 158.44) ($P < 0.001$).
- Operative Time (minutes): The mean operative time was significantly shorter for RIRS (79.67 ± 25.83 minutes) than for MINI-PCNL (107.67 ± 49.04 minutes) ($P = 0.008$).
- Postoperative Fever ($^{\circ}\text{F}$): The mean recorded postoperative body temperature was significantly higher in the RIRS group ($99.60 \pm 1.51^{\circ}\text{F}$) compared to the MINI-PCNL group ($97.97 \pm 1.30^{\circ}\text{F}$) ($P < 0.001$).
- WBC Count: The RIRS group had a significantly higher mean white blood cell count (11066.67 ± 2891.53) than the MINI-PCNL group (8840.00 ± 2962.25) ($P = 0.046$).
- Duration of Hospital Stay (days): Patients in the RIRS group had a significantly shorter hospital stay (3.43 ± 1.07 days) compared to those in the MINI-PCNL group (4.63 ± 0.72 days) ($P < 0.001$).
- Preoperative Haemoglobin (g/dL): There was no significant difference in preoperative haemoglobin levels between the RIRS (12.40 ± 1.25) and MINI-PCNL (12.63 ± 1.10) groups ($P = 0.452$).
- Postoperative Haemoglobin (g/dL): The RIRS group had significantly higher postoperative haemoglobin levels (12.31 ± 1.30) than the MINI-PCNL group (11.43 ± 1.18) ($P = 0.008$).

RIRS was associated with significantly lower stone density, shorter operative time, higher postoperative fever, higher WBC count, shorter hospital stay, better preservation of haemoglobin postoperatively and higher inflammatory response due to closed system.

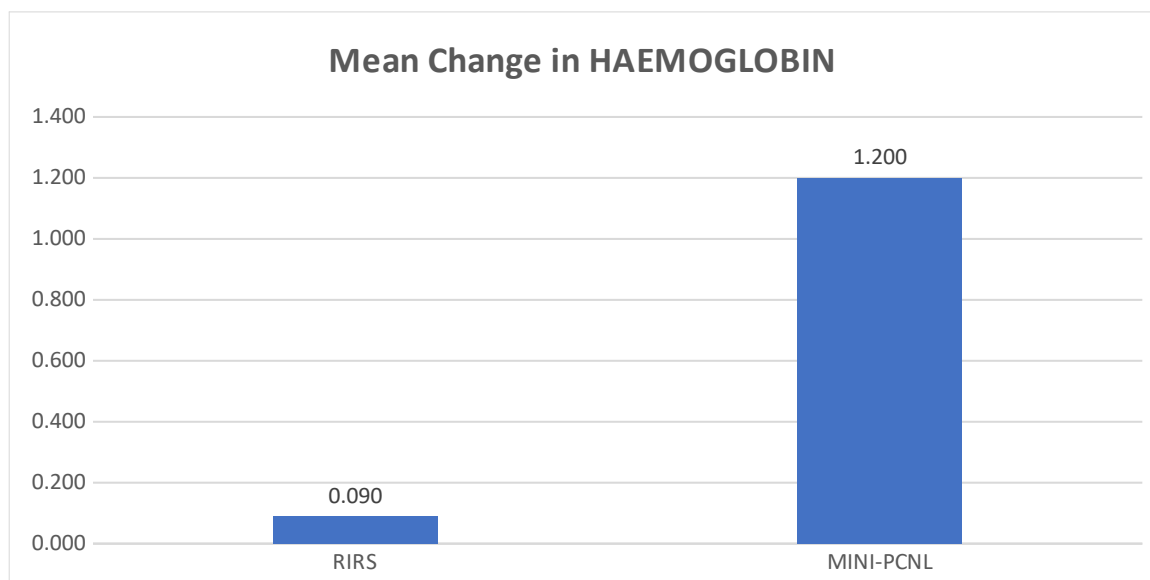
MINI-PCNL was associated with a higher stone-free rate (from previous results) but showed slightly higher operative burden and lesser inflammatory response mainly due to open system.



Group		N	Mean	SD	P value
Change in HAEMOGLOBIN	RIRS	30	0.090	0.169	< 0.001
	MINI-PCNL	30	1.200	0.286	

The mean change in haemoglobin levels postoperatively was significantly different between the two groups. The RIRS group (n = 30) showed a minimal mean decrease in haemoglobin of 0.09 ± 0.17 g/dL, whereas the MINI-PCNL group (n = 30) experienced a substantially greater mean decrease of 1.20 ± 0.29 g/dL.

This difference was statistically significant ($P < 0.001$), indicating that patients undergoing RIRS had significantly less blood loss or haemoglobin drop compared to those undergoing MINI-PCNL.



DISCUSSION

This prospective comparative study was conducted at Ruby Hall Clinic, Pune, between June 2023 and June 2025, to evaluate and compare the outcomes of Mini Percutaneous Nephrolithotomy (Mini-PCNL) and Retrograde Intrarenal Surgery (RIRS) in the management of renal calculi measuring 1–2 cm. A total of 60 patients, aged over 15 years and meeting the inclusion criteria, were enrolled and equally divided into two groups: Group 1 underwent RIRS, and Group 2 underwent Mini-PCNL. The aim of the study was to assess and compare clinical outcomes based on eight predefined parameters, with follow-up imaging (NCCT KUB) performed at 3 months post-procedure. The findings are discussed below in the context of existing literature, with emphasis on efficacy, safety, and suitability of each procedure for the treatment of medium-sized renal calculi.

The age distribution of patients was compared between the RIRS and MINI-PCNL groups, each consisting of 30 patients. Patients were categorized into six age groups: ≤ 30 , 31–40, 41–50, 51–60, 61–70, and >70 years. In the RIRS group, the age distribution was as follows: ≤ 30 years (n=9), 31–40 years (n=4), 41–50 years (n=5), 51–60 years (n=3), 61–70 years (n=7), and >70 years (n=2). In the MINI-PCNL group, the distribution was: ≤ 30 years (n=3), 31–40 years (n=3), 41–50 years (n=7), 51–60 years (n=7), 61–70 years (n=9), and >70 years (n=1). These trends partially align with Bhargava Reddy (2022)³⁶, who observed slightly older patients undergoing RIRS, although the differences were statistically insignificant.

Regarding sex distribution, the RIRS group included 21 males (70%) and 9 females (30%), while the MINI-PCNL group comprised 16 males (53.3%) and 14 females (46.7%). Male predominance was consistent with previous studies such as Rakib (2020)³⁷ and Kanchi Reddy (2022)³⁸, which reflects the known epidemiological pattern of nephrolithiasis being more prevalent in men due to dietary and metabolic factors.

In the present study, the location of renal stones was assessed in two surgical groups: RIRS and MINI-PCNL. Stone locations were classified into four anatomical regions—lower calyx (LC), middle calyx (MC), renal pelvis (P), and upper calyx (UC). In the RIRS group, the majority of stones were located in the renal pelvis (n=12) and upper calyx (n=11), whereas in the MINI-PCNL group, a higher proportion of stones were found in the pelvis (n=17) and lower calyx (n=7). This suggests that RIRS is more commonly employed for treating pelvic and upper calyceal stones, likely due to better accessibility with flexible ureteroscopes. In contrast, MINI-PCNL appears to be more suited for stones in the lower calyx and renal pelvis, which may be due to its better reach and higher efficacy in clearing deeper-seated stones.

These findings differ from those of Karthik Meyyappan (2018)⁴⁵, who reported the lower pole (lower calyx) as the most prevalent location for renal calculi. This discrepancy may be attributed to differences in patient selection, regional variations, or evolving surgical preferences. However, our observation aligns more closely with anatomical feasibility—RIRS being technically easier for accessing the pelvis and upper pole, while MINI-PCNL may offer superior outcomes in less accessible locations like the lower pole.

A study by Amr S. Fayad (2016)³⁹ compared RIRS and tubeless MINI-PCNL in patients with lower calyceal stones ≤ 2 cm. The stone-free rate (SFR) was slightly higher in the MINI-PCNL group (92.72%) than in the RIRS group (84.31%), although the difference was not statistically significant ($P = 0.060$). Interestingly, the mean operative time was significantly longer in the RIRS group (109.66 ± 20.75 minutes) compared to MINI-PCNL (71.66 ± 10.36 minutes). The hospital stay was slightly longer in MINI-PCNL patients, though this was not statistically significant. This supports the

notion that while RIRS is less invasive, MINI-PCNL may be more time-efficient and potentially more effective in achieving higher SFRs, especially for stones in more challenging locations.

Similarly, Jiahua Pan (2013)⁴⁰ conducted a comparative study in China evaluating RIRS and mini-percutaneous nephrolithotomy (mPCNL) for single renal stones measuring 2–3 cm. The study reported a significantly higher SFR for mPCNL (96.6%) compared to RIRS (71.4%), and RIRS had a significantly longer operative time. However, RIRS showed advantages in terms of shorter hospital stay and lower costs. Although RIRS was less effective in terms of complete stone clearance (as reflected in the lower effective quotient), it was more cost-effective and had acceptable safety outcomes, making it a viable option in selected cases, particularly when minimal invasiveness and outpatient recovery are priorities.

The findings of the present study resonate with previous literature indicating that RIRS is generally preferred for stones in anatomically accessible regions such as the renal pelvis and upper calyx, while MINI-PCNL offers better outcomes for stones in the lower calyx and for achieving higher stone-free rates. The choice of procedure may ultimately depend on stone location, size, patient anatomy, and the available surgical expertise.

Postoperative pain assessment using the Visual Analog Scale (VAS) revealed a significant difference in pain levels between the RIRS and MINI-PCNL groups, favouring RIRS. In the RIRS group, 53.3% of patients reported mild pain, 43.3% reported moderate pain, and only 3.3% experienced severe pain. In contrast, the MINI-PCNL group had 23.3% of patients reporting mild pain, 60% reporting moderate pain, and 16.7% experiencing severe pain. These findings are consistent with the study by Lee (2015)⁴¹, which demonstrated that RIRS is associated with significantly lower postoperative pain and reduced analgesic requirements compared to PCNL techniques. The reduced postoperative discomfort in RIRS is likely attributable to its less invasive nature, including the avoidance of renal tract dilation and the use of smaller-calibre instruments.

While PCNL has traditionally been the standard for treating large or complex renal stones, it remains the most invasive among minimally invasive stone surgery options. Since its introduction in 1976, significant advancements have been made to reduce the invasiveness of PCNL. As highlighted by Bum Soo Kim (2015)⁴² recent developments in patient positioning, percutaneous access methods, lithotripter technology, miniaturized access tracts (as in MINI-PCNL), and postoperative nephrostomy tube management have contributed to making PCNL safer and more effective. MINI-PCNL, in particular, represents an evolution toward minimizing morbidity while preserving the efficacy of traditional PCNL.

while both RIRS and MINI-PCNL are effective treatments for renal calculi, RIRS appears superior in terms of patient comfort and postoperative recovery. However, MINI-PCNL offers advantages in treating larger stones with relatively less invasiveness compared to standard PCNL, highlighting the complementary roles of these two techniques depending on stone size, location, and patient-specific factor. The stone-free rate (SFR) was higher in the MINI-PCNL group (93.3%) compared to the RIRS group (73.3%). Although RIRS achieved acceptable clearance, the greater efficacy of MINI-PCNL in clearing larger or harder stones is consistent with results from Yang Liu (2024)⁴³ and Shuba De (2016)⁴⁴. These studies showed that PCNL-based techniques often result in higher clearance due to direct access and more effective fragmentation. However, RIRS may be limited by scope flexibility, especially for lower pole stones or high-density calculi.

Our findings showed a higher rate of complications in the MINI-PCNL group (16.7%) than the RIRS group (6.7%). In the MINI-PCNL group, complications included dysuria, haematuria, ileus, and sinus formation. In the RIRS group, two patients experienced complications: one with ureteric injury and one with calyceal rupture. While these complications were not statistically significant, our observations are in line with Karthik Meyyappan (2018)⁴⁵ who found MINI-PCNL associated with more Clavien-Dindo grade 1–4 complications. This highlights the need for cautious selection and postoperative care in MINI-PCNL patient. Our study highlights that RIRS is associated with shorter operative time, less postoperative blood loss, and reduced hospital stay compared to MINI-PCNL. These findings are consistent with Aakash Pai (2019)⁴⁶, who observed a shorter operative time and fewer complications in mini-PCNL, but also noted that umPCNL achieved higher stone-free rates than RIRS. Shawqi George Ghazala (2021)⁴⁷ similarly reported that mini-PCNL provides outcomes comparable to RIRS with high clearance rates and minimal complications. Stefano Paolo Zanetti (2016)⁴⁸ through a European survey, reinforced that RIRS is preferred for stones <2 cm, with shorter hospital stays and less invasiveness, while MINI-PCNL remains a strong option for denser or larger stones. Compared to these studies, our research emphasizes the advantages of RIRS in perioperative safety and recovery, while acknowledging MINI-PCNL's superiority in stone clearance for selected patients.

In our study, follow-up protocols were categorized into fragment size. In the RIRS group (n=30), one patient had fragment size of 1-3 mm, and seven patients had fragment size of 4-6 mm. In the MINI-PCNL group (n=30), three patients had fragment size of 1-3 mm, and one patient had fragment size of 4-6 mm.

In comparison, Sorokin (2023)⁴⁹ evaluated RIRS, MINI-PCNL, and micro-PCNL in patients with stones ≤ 2 cm. RIRS had the highest stone-free rate (93.3%) and the shortest operative time (55.7 min) and hospital stay (4.5 days). MINI-PCNL showed slightly lower SFR (80.8%) and longer operative time. Complication rates were lower in RIRS, particularly for minor (grade I–II) complications. While Sorokin did not focus on follow-up timing, our study highlights the importance of consistent post-operative monitoring.

In our present study, we analyzed and compared various perioperative parameters between patients who underwent Retrograde Intrarenal Surgery (RIRS) and those treated with Mini-Percutaneous Nephrolithotomy (MINI-PCNL). We observed that the mean number of renal stones was significantly lower in the RIRS group (15.63 ± 2.51) compared to the MINI-PCNL group (16.93 ± 2.32), with a statistically significant difference ($P = 0.042$). The mean stone density, assessed in Hounsfield Units (HU), was also significantly lower in the RIRS group (1163.33 ± 175.15) than in the MINI-PCNL group (1370.00 ± 158.44), indicating that the RIRS group had relatively softer stones ($P < 0.001$).

In terms of operative time, RIRS was found to be more efficient, with a significantly shorter duration (79.67 ± 25.83 minutes) compared to MINI-PCNL (107.67 ± 49.04 minutes) ($P = 0.008$). Postoperative outcomes also favoured MINI-PCNL, with a significantly lower mean body temperature ($97.97 \pm 1.30^\circ\text{F}$) and white blood cell count (8840.00 ± 2962.25) compared to the RIRS group ($99.60 \pm 1.51^\circ\text{F}$ and 11066.67 ± 2891.53 respectively), suggesting a higher postoperative inflammatory response in the RIRS group. The mean duration of hospital stay was shorter in RIRS patients (3.43 ± 1.07 days) compared to MINI-PCNL patients (4.63 ± 0.72 days), which was also statistically significant ($P < 0.001$). While preoperative haemoglobin levels showed no significant difference ($P = 0.452$), postoperative haemoglobin levels were significantly higher in the RIRS group (12.31 ± 1.30 g/dL) than in the MINI-PCNL group (11.43 ± 1.18 g/dL) ($P = 0.008$), indicating less blood loss in the RIRS procedure.

Our findings are supported by the study conducted by Ahmed Higazy (2025)⁵⁰, which compared flexible MINI-PCNL (F-mPCNL) and RIRS in the management of renal stones. His study found that F-mPCNL had a higher stone-free rate (95.1%) than RIRS (77.8%) with a statistically significant difference ($p < 0.001$). However, F-mPCNL was associated with longer hospital stay, more postoperative pain, and greater need for analgesics, which aligns with our findings where RIRS showed better postoperative outcomes. Higazy also reported shorter operative time for F-mPCNL (47.60 ± 14.54 minutes) compared to RIRS (59.30 ± 20.10 minutes), which differs from our study where RIRS had a shorter operative time.

Similarly, the study by Tolga Akman (2011)⁵¹ showed that the stone-free rate was higher in PCNL (91.2%) than in RIRS (73.5%) after one session. However, the hospital stay was significantly shorter in the RIRS group (30.0 ± 37.4 hours) compared to the PCNL group (61.4 ± 34.0 hours), which is consistent with our findings. The mean operative time was also longer in RIRS in his study, which again differs from our results.

Omer F. Bozkurt (2011)⁵² also reported higher initial stone-free rates in the PCNL group (92.8%), increasing to 97.6% after additional procedures. In contrast, the RIRS group had a first-session stone-free rate of 89.2%, increasing to 94.6% after further treatment. Bozkurt also observed that PCNL patients had a higher risk of haemorrhage requiring transfusion, which supports our finding of greater haemoglobin drop in MINI-PCNL patients. Moreover, hospital stay was significantly longer in the PCNL group, aligning with our observation.

In the present study, the mean postoperative haemoglobin drop was significantly lower in the RIRS group (0.09 ± 0.17 g/dL) compared to the MINI-PCNL group (1.20 ± 0.29 g/dL). This aligns with findings by Dursun Baba (2025)⁵³, who reported greater haemoglobin loss with MINI-PCNL and PCNL than with RIRS. Additionally, Baba noted that RIRS patients had shorter hospital stays and required less analgesia, highlighting the less invasive nature of RIRS. While PCNL had the shortest operative time, it was linked to more blood loss and longer recovery. These findings collectively support RIRS as a safer option with reduced perioperative morbidity.

SUMMARY

This prospective comparative study was conducted to assess the clinical effectiveness and safety of Retrograde Intrarenal Surgery (RIRS) versus Mini Percutaneous Nephrolithotomy (Mini-PCNL) in patients with moderate-sized renal calculi. Both surgical groups were demographically comparable, showing no significant differences in patient age, gender distribution, or the anatomical location of stones. Postoperative outcomes revealed that RIRS was associated with a smoother recovery profile. Patients undergoing RIRS experienced milder postoperative pain, shorter operative times, faster discharge from the hospital, and minimal decline in haemoglobin levels, indicating less intraoperative blood loss. Additionally, Mini-PCNL patients had lower incidences of fever and a reduced inflammatory response, as reflected by lower white blood cell counts postoperatively.

However, when evaluating treatment success, Mini-PCNL demonstrated a higher stone clearance rate, suggesting greater efficacy in achieving complete removal of calculi, particularly in cases with denser or more complex stones. Although

Mini-PCNL was slightly more invasive, the overall complication rates between the two groups did not differ significantly. Follow-up protocols were similar for both groups, further supporting the comparability of the study arms.

CONCLUSION

In this prospective comparative study evaluating RIRS and Mini-PCNL for the management of renal stones measuring 1–2 cm, both techniques were found to be effective and safe, with distinct advantages. RIRS was clearly associated with better perioperative outcomes, including reduced operative time, less postoperative pain, minimal blood loss and shorter hospital stay, making it a more comfortable option for patients and enabling faster recovery. These benefits highlight the minimally invasive nature of RIRS and its suitability for patients where lower morbidity is desired.

On the other hand, Mini-PCNL demonstrated superior stone clearance, making it a more effective option in achieving complete removal, especially in cases of higher stone density or challenging stone locations. While it carried a slightly higher risk of postoperative complications and required longer hospitalization, these were not statistically significant and remained within acceptable clinical limits.

Therefore, both procedures have their place in clinical practice. RIRS may be preferred for patients who are unfit for more invasive surgery or those seeking quicker recovery and minimal discomfort, whereas Mini-PCNL may be favoured in patients with complex or dense stones requiring higher clearance efficiency. The choice between the two should be guided by patient-specific factors, stone characteristics, and surgeon expertise.

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