

A comparative study of minimally invasive percutaneous nephrolithotomy and retrograde intrarenal surgery for solitary renal stone of 1–2 cm

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Abstract

Background: PCNL is the treatment of choice for renal stones. But wide array of complications due to larger tract size (>20 Fr) has led to development of improved techniques like miniPCNL (<20 Fr) and RIRS (Retrograde intrarenal surgery).

Aim and Objective: To perform a study comparing miniPCNL with RIRS for renal stones 1-2 cm with respect to stone free rate, complications and quality of life.

Materials and Methods: A prospective, randomised study was carried out our tertiary care centre, recruiting 40 patients in each group from Dec 2016 to Oct 2018. Patients demographic characteristics, operative findings, surgical outcomes and quality of life (SF-36 questionnaire) were recorded with 3 months of follow-up.

Results: RIRS has longer operative time (69.75 min > 51.58 min; $p=0.003$), lesser radiation exposure ($p=0.012$), shorter hospital stay ($p=0.15$), lesser blood loss and lesser post operative pain on POD1 and POD2 ($p=0.005$, $p=0.001$ respectively). RIRS group patients suffered more post op complications ($p=0.03$) of which urosepsis was most common. Stone free rate is significantly better ($p=0.003$) in miniPCNL group on POD1, while SFR's at 1 month (miniPCNL-90% and RIRS -85%) and 3 month (miniPCNL- 92.5% and RIRS -87.5%) was better in miniPCNL group, but statistically insignificant. On subgroup analysis SFR in lower pole calculus was better in miniPCNL group at 1 month and 3 month ($p=0.008$). Second intervention for stone clearance was required in 3 patients of miniPCNL and 5 patients of RIRS, out of which 4 had lower pole stone. No significant difference was found in quality of life in both groups at 1 month.

Conclusion: MiniPCNL is a better treatment modality for higher single step stone free rate, shorter operative time and fewer postop complication. RIRS has SFR slightly less than miniPCNL but has less radiation exposure and much less post operative pain. There is no significant difference in quality of life in both groups.

Keywords: Minimally invasive percutaneous nephrolithotomy, retrograde intrarenal surgery, stone-free rate

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INTRODUCTION

Renal calculi are a common urological disorder. Globally, the prevalence and recurrence rates of kidney stones are increasing, probably due to climate or environment change,

and increased diagnosis with limited options for effective medical treatment.^[1] The lifetime prevalence of kidney stone disease is estimated at 1%–15%, varying according to age, gender, race, and geographic location.^[2] Importantly,

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kidney stone is a recurrent disorder, with a 50% incidence of lifetime recurrence. It may lead to end-stage renal disease in around 0.6%–3.2%.^[3]

Table 1: Demographic data

Variables	MiniPCNL	RIRS	P
Renal units	40	40	
Age (years)	35.6	40.45	0.447
Sex (male:female)	25:15	32:8	0.069
BMI	23	25.09	
Laterality (right: left)	15:25	26:14	0.012
Stone size (mm)	12.35	12.90	0.449
Stone distribution			
Upper calyx	2	2	0.042
Mid calyx	8	10	0.147
Lower calyx	8	6	0.589
Pelvis	22	22	0.247
History of DJ stenting	4	40	<0.001

BMI: Body mass index, mini-PCNL: Minimally invasive percutaneous nephrolithotomy, RIRS: Retrograde intrarenal surgery, DJ: Double J

Table 2: Comparison of intraoperative and postoperative surgical outcomes (matched pair analysis)

Parameter	Mini-PCNL	RIRS	P
Operative time (min)	51.58	69.75	0.003
Fluoroscopy time (s)	56.78	40.20	0.012
Intraoperative complication			
CD Grade I	2	0	
CD Grade II/III/IV/V	0	0	
Total	2	0	
Pain score-POD1	4.45	3.20	0.005
POD2	2.70	1.05	<0.001
Postoperative complication			
CD Grade I	2	4	
CD Grade II	3	7	
CD Grade III	4	5	
CD Grade IV/V	0	0	
Total	9	16	0.03
Drop in hemoglobin	0.88	0.42	<0.001
Hospital stay	2.85	2.45	0.155
Stone free rate (%)			
POD1	77.5	45	0.003
1 month	90	85	0.615
3 months	92.5	87.5	0.338
Second surgery			
DJ stent removal	6	35	
ESWL	2	4	
URSL	1	1	

Mini-PCNL: Minimally invasive percutaneous nephrolithotomy, RIRS: Retrograde intrarenal surgery, POD: Postoperative day, DJ: Double J, ESWL: Extra corporeal Shockwave Lithotripsy, URSL: Ureteroscopic lithotripsy

Table 3: Subgroup analysis as per the location of stone

Location	Number of cases with complete clearance of stone								P
	SFR POD1		P	SFR - 1 month		P	SFR - 3 months		
	Mini-PCNL	RIRS		Mini-PCNL	RIRS		Mini-PCNL	RIRS	
UP	1	1	1	1	2	0.3	1	2	0.3
MP	5	6	0.9	6	8	0.8	6	9	0.4
LP	5	1	0.09	6	1	0.03	8	2	0.008
Pelvis	17	9	0.01	18	19	0.6	22	22	-
Total (complete clearance)	28	17		31	30		37	35	

Mini-PCNL: Minimally invasive percutaneous nephrolithotomy, RIRS: Retrograde intrarenal surgery, POD: Postoperative day, SFR: Stone-free rate

With the recent technological advancements, minimally invasive surgeries such as traditional extracorporeal shock wave lithotripsy (ESWL), percutaneous nephrolithotomy (PCNL), laparoscopic stone surgery, and retrograde intrarenal surgery (RIRS) have become the first line in the treatment of stone disease.^[4] As per the guidelines, PCNL is the gold standard for renal stones >2 cm in size; however, for stone size measuring 1–2 cm, dilemma still persists, for the best and most effective modality.^[5] Hemorrhage, nephron loss, urinary extravasation, sepsis, colonic injury, pleural injury, and higher postoperative pain limit the use of PCNL as the most attractive options despite having good stone-free rates.

The most versatile newer technique is minimally invasive PCNL (also termed mini-PCNL or mini-Perc or mPCNL), devised by Helal *et al.* It comprises using a miniature endoscope via a small percutaneous tract (11–20 Fr).^[6] It is associated with lesser postoperative complications compared to standard PCNL. RIRS (also termed flexible ureterorenoscopy) is another minimally invasive modality for managing the upper tract urinary calculi.^[7] For its characteristics of minimal trauma, faster recovery, easy operability, and lesser contraindication, RIRS has been considered as a reasonable alternative for the percutaneous approaches. RIRS has problems of investment as it requires a laser machine as well as a fragile scope which is definitely costlier than usual nephroscope while mini-PCNL does not necessarily require a laser machine.

Mini-PCNL and RIRS are effective modalities for treating renal stones. The current study is conducted prospectively for comparing stone-free rates, complications, hospital stay, operative time, radiation exposure, and quality of life in both modalities for solitary renal stone of size 1–2 cm.

PATIENTS AND METHODS

A prospective, randomized comparative study was conducted at our tertiary care center from December 2016 to October 2018. A total of 40 patients were randomized to each group on alternate basis. Patients visiting the

outpatient department with solitary renal stone of size 1–2 cm, who are willing to undergo surgery and follow-up, were included in the study.

Patients with prior upper urinary tract surgery, bleeding diathesis, morbid obesity, pregnancy, and renal failure were excluded from the study. All surgeries were performed by an expert urologist in both modalities.

All patients underwent contrast-enhanced computerized tomography-kidney ureter bladder (KUB) and routine blood investigations, including complete blood count, renal function test, and chest X-ray, before undergoing intervention. A sterile urine culture was mandatory before surgery. Written, informed, valid consent was obtained from all the patients. Following demographic data were noted.

Statistical analysis was performed using SPSS (V-20) software, with statistical significant $P < 0.05$. Categorical variables

were analyzed using Fisher’s t -test and Chi-square test, and independent t -test was used for comparison between two groups.

Minimally invasive percutaneous nephrolithotomy

Under general anesthesia, a 5 Fr ureteric catheter was placed in the pelvicalyceal system and the patient turned prone. Initial puncture was done using an 18G diamond tip needle under fluoroscopy guidance using Bull’s eye technique. Tract was dilated using facial dilator up to 16 Fr and 16.5/17.5 mini-Perc Amplatz sheath was placed. 12 Fr (Karl Storz) nephroscopy was done; stone fragmentation was done using holmium laser/pneumatic lithotripsy, and fragments were removed and 12 Fr nephrostomy tube was placed.

Retrograde intrarenal surgery

RIRS was performed using Flexible urterorenoscope Olympus (URF P-6, by Olympus America) with Holmium (200 μ fiber) laser. All patients were double J (DJ) stented 2 weeks before surgery for achieving ureteric dilation for easier passage of ureteric access sheath. Intraoperatively, 9.5/11 Fr ureteric access sheath was placed at pelviureteric junction and LASER vaporization of stone was performed. Postoperative 5 Fr DJ stenting was done in all patients, which was removed after 4 weeks after confirming stone clearance.

Intraoperatively, operative time, fluoroscopy time, and complications were noted using Clavein–Dindo (CD) classification.

Postoperatively, stone-free rate (clinically insignificant residual fragment [CIRF] ≤4 mm) was assessed using X-KUB and

Table 4: Comparison of quality of life

Quality of life	miniPCNL	RIRS	P
PF	93.5	93.25	0.903
RL d/t PH	90.62	92.5	0.9
BP	94.08	9.85	0.122
GH	94.95	97.10	0.159
Energy	98.12	100	0.079
Emotional	95.85	95.7	0.916
SF	97	96.75	0.895
Health change	97.5	96.88	0.792
RL d/t MH	100	100	-

Mini-PCNL: Minimally invasive percutaneous nephrolithotomy, RIRS: Retrograde intrarenal surgery, PF: Physical Functioning, RL d/t PH: Role limitation due to physical health. BP: Bodily Pain, GH: General Health, SF: Social Functioning, RL d/t MH: Role limitation due to mental health

Table 5: Comparison with other studies

Variable	Sabnis et al. ^[15]		Knoll et al. ^[11]		Lee et al. ^[19]		Pan et al. ^[18]		Our study		
	Mini-PCNL	RIRS	Mini-PCNL	RIRS	Mini-PCNL	RIRS	Mini-PCNL	RIRS	Mini-PCNL	RIRS	P
Renal units	32	32	25	21	35	33	59	56	40	40	
Age (years)	44.48	49.28	56	53	59.3	55.8	49.32	49.37	35.6	40.45	0.447
Sex (male:female)	19:13	25:7	15:10	9:12	28:7	28:5	37:22	36:20	25:15	32:8	0.069
BMI	-	-	27	31			23.52	23.69	23	25.09	
Stone size (cm)	1.52	1.42	18	19	39.1	28.9	22.37	22.28	12.35	12.9	0.449
OT time (min)	40.81	50.63	59	106	76.1	99.6	62.39	73.07	51.58	69.75	0.003
Fluoroscopy time (s)	-	-	-	-					56.78	40.20	0.012
Intraoperative comp	1	0	1	1					2	0	
Postoperative comp	1	3	3	4			7	9	9	16	
Pain POD1	2.74	2	-	-	2.7	3.1			4.45	3.20	0.005
Pain POD2	1.9	1.22	-	-					2.70	1.05	<0.001
Hb drop	1.43	0.40	-	-	0.69	0.38	0.128	0.04	0.88	0.42	<0.001
Hospital stay	2.07	1.94	-	-	1.6	1.5	4.47	1.95	2.85	2.45	0.155
SFR (%) - POD1	-	-	96	71.5					77.5	45	0.003
1 month	100	96.88	100	85.8			96.6	71.4	90	85	0.615
3 months	-	-	-	-					92.5	87.5	0.338
Second surgery	0	1	-	-					3	5	
DJ stent removal			23	19	33	33			6	35	
QOL									Same	Same	

Mini-PCNL: Minimally invasive percutaneous nephrolithotomy, RIRS: Retrograde intrarenal surgery, BMI: Body mass index, POD: Postoperative day, Hb: Hemoglobin, QOL: Quality of life, DJ: Double J, OT- Operative Time. Lee et al.^[17], SFR: Stone-free rate

ultrasonography KUB on postoperative day (POD) 1, 1 month, and 3 months. Stone fragment >4 mm after 1 month of first surgery was defined as failure (incomplete clearance) of surgery and second intervention was planned.

Postoperative complications as per CD Classification^[8] such as hospital stay, pain score (visual analog scale),^[9] fall in hemoglobin, and need for blood transfusion were noted. Patient's quality of life status at 1 month was compared using SF-36^[10] questionnaire in both mini-PCNL and RIRS groups.

Standard hospital antibiotic policy was followed.

RESULTS

Baseline demographics were comparable in both groups. [Table 1].

Age ranges from 4 to 73 years. Mean age of the patients in the mini-PCNL group is 35.6 years and in the RIRS group is 40.45 years.

The RIRS has higher operative time (69.75 > 51.58 min) than mini-PCNL group, which was clinically significant. The mini-PCNL arm has higher fluoroscopy time of 56.78 s with a significant *P* value.

Pain analysis as per visual analog scale demonstrates that patients undergoing RIRS has significantly lesser pain ($P < 0.005$; < 0.001) than mini-PCNL group on both POD1 and POD2. Hospital stay was shorter in the RIRS group, but it was not clinically significant. Both groups have clinically insignificant blood loss during the surgery, and none of the patients required blood transfusion. Blood loss was lesser in the RIRS group, with significant $P < 0.001$. No significant intraoperative complications were noted in the series. Only two patients in mini-PCNL group had pelvic perforation and were managed conservatively. RIRS group patients suffered more postoperative complications, which was statistically significant. Most patients in the RIRS group (7) developed postoperative fever/sepsis and managed conservatively with intravenous antibiotics.

Stone-free rate was significantly better ($P = 0.003$) in mini-PCNL group on POD1. SFR at 1 month (mini-PCNL - 90% and RIRS - 85%) and 3 months (mini-PCNL - 92.5% and RIRS - 87.5%) was also better in mini PCNL group but statistically not significant [Table 2].

On subgroup analysis, mini-PCNL has better SFR for lower pole stone with $P = 0.008$ at 3 months; while there was no

significant difference in both the modalities with respect to stones in the upper pole, mid pole, or pelvis [Table 3].

All patients in the RIRS group compulsorily required second intervention in the form of stent removal, while three patients in the mini-PCNL group and five patients in the RIRS group required second surgery in the form of ESWL or URSL for complete stone clearance. Parameters of physical health and mental health were not statistically significant in both groups as per SF 36 [Table 4].

DISCUSSION

Our study demonstrates significant efficacy profile for both mini-PCNL and RIRS with good stone-free rate after 1 month and 3 months. The SFR here is defined as the absence of CIRF >4 mm. The SFR on POD1 is significantly better ($P < 0.003$) in mini-PCNL group which is in concordance with the study by Knoll *et al.*^[11] [Table 5].

1-month SFR was 90% in mini-PCNL and 85% in RIRS group as seen in the studies by Mishra *et al.*^[12] and Knoll *et al.*^[11] At 3 months, mini-PCNL had better SFR of 92.5% compared to 87.5% in RIRS group. Better SFR in mini-PCNL group for lower pole stones with $P = 0.008$ (at 3 months) is attributed to poor accessibility of lower calyx with unfavorable anatomy of lower pole (more acute infundibulo-pelvic angle and narrow and longer infundibulum) which was encountered while performing RIRS. Similar findings were seen in meta-analysis by Junbo *et al.*^[13]

Operative time and fluoroscopy time in our study were similar to the study by Akman *et al.*^[14] The mean operative time is significantly less in mini-PCNL group (51.58 vs. 69.75 min; $P < 0.003$), probably due to longer time required for stone vaporization in RIRS group. In our study, the radiation exposure was more in mini-PCNL group (56.78 vs. 40.20 s; $P = 0.012$) due to C-arm-guided initial puncture of calyx.

Mean hospital stay was almost the same in both arms (2.85 days in mini-PCNL vs. 2.45 days in RIRS; $P = 0.155$). It is in contrast to series by Sabnis *et al.*^[15] and Pelit *et al.* which showed significantly lesser hospital stay; 1.9 days in mini-PCNL and 1.2 days in RIRS.^[16] Patients in RIRS arm were kept longer in hospital to monitor for the development of early fever/urosepsis in the initial 48 h.

There was no significant drop in hemoglobin (>1 gm/dL) in either group. The difference between two groups is statistically significant with $P < 0.001$, but not clinically significant, as none of the patients required blood transfusion.

Pain score as demonstrated by visual analog scale showed statistically significant difference on POD1 and POD2, with patients in RIRS group experiencing significantly lesser pain. The $P = 0.005$ on POD1 and <0.001 on POD2, which turn down into lesser analgesic requirement in RIRS group. These findings are in harmony with outcomes of Sabnis *et al.*^[15] and Lee *et al.*^[17] No significant intraoperative complication was noted in both groups except two patients who had pelvic perforation in mini-PCNL group (CD Grade I). However, significant postoperative complications were noted in both groups. As per CD classification, mini-PCNL group had 2 Grade I, 3 Grade II, and 4 Grade III complications; while RIRS group had 4 Grade 1, 7 Grade II, and 5 Grade III complications. The outcome was statistically significant ($P = 0.03$), with RIRS group encountering more complications. Most of the patients had postoperative fever/urosepsis within 48 h of surgery. Raised intrarenal pressure, infective stone, and intravasation lead to sepsis. Similar findings were seen in the studies by Sabnis *et al.* and Pan *et al.*, [Table 5] while contradictory results were encountered by Zengin *et al.*^[15,18,19]

The patients who had CD Grade III complications had to undergo second intervention for stone clearance, indicating the failure of primary surgery. Four patients in RIRS group and 2 in mini-PCNL group underwent ESWL and one patient in each group required URSL before being declared stone free. Thirty-five patients in RIRS and six in mini-PCNL required one more intervention for stent removal.

Finally, the two groups are compared with respect to their quality of life after each intervention using SF-36 questionnaire at 1 month. Physical and mental health parameters are found no significantly different in two groups. To the best of our knowledge, this is the first study comparing “quality of life” in both subgroups in the Indian scenario.

The main limitation of the study was smaller sample size, more than one operating surgeons, nonusage of screening CT KUB after surgery for demonstrating stone clearance, and use of both pneumatic and holmium LASER as energy sources. Further studies with larger sample size and longer follow-up will consolidate our findings.

CONCLUSION

Both mini-PCNL and RIRS have excellent outcomes for renal stones 1–2 cm in size. Mini-PCNL has a better single step stone-free rate, lesser operative time, and lesser postoperative complication. RIRS has SFR slightly less

than mini-PCNL but less radiation exposure and much less postoperative pain. RIRS requires more auxiliary procedures for stone clearance and stent removal. Both procedures are equally efficacious with respect to stone clearance; however, before deciding the surgical procedure, either mini-PCNL or RIRS, patient factors, expectations, and preferences must be considered.

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Conflicts of interest

There are no conflicts of interest.

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