

# Comparison of the outcomes of flexible ureteroscopy and mini-percutaneous nephrolithotomy for the treatment of kidney stones: a matched-pair analysis

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## SUMMARY

**OBJECTIVE:** Mini-percutaneous nephrolithotomy is a recent advancement in the field of kidney stone treatment; however, its role has not been completely established. We aimed to compare the outcomes of initial Mini-percutaneous nephrolithotomy and flexible ureteroscopy.

**METHODS:** A retrospective review of consecutive mini-percutaneous procedures was performed. Inclusion criteria were as follows: all percutaneous nephrolithotomy procedures performed with an access sheath up to 24Fr, kidney stone burdens up to 1550 mm<sup>3</sup>; and the presence of postoperative computed tomography (for control). The data collected for Mini-percutaneous nephrolithotomy procedures were paired 1:2 with patients treated with flexible ureteroscopy for stones between 100 and 1550 mm<sup>3</sup>, and with postoperative computed tomography for control. A 14Fr Mini-percutaneous nephrolithotomy set was used. The stone-free rate was defined as the absence of fragments on the control computed tomography, whereas success was limited to 2-mm residual fragments. Statistical analysis was performed using SPSS version 19.

**RESULTS:** A total of 63 patients met the inclusion criteria (42 with flexible ureteroscopy and 21 with mini-percutaneous nephrolithotomy). Demographic data were comparable. The stone-free rate and success were similar between the groups (76.2 vs. 66.7%,  $p=0.42$  and 90.5 vs. 85.7%,  $p=0.57$ ). The complication rate was also similar (26.1 vs. 9.6%,  $p=0.188$ ), but Mini-percutaneous nephrolithotomy had longer hospitalization and fluoroscopy time ( $p=0.001$  in both).

**CONCLUSIONS:** Our initial study of Mini-percutaneous nephrolithotomy showed that it is a promising procedure, with outcomes similar to flexible ureteroscopy, but with higher inpatient numbers and fluoroscopy times. A larger study population size and better equipment may improve the outcomes of mini-percutaneous nephrolithotomy.

**KEYWORDS:** Kidney stone. Percutaneous ultrasonic lithotripsy. Nephrolithotomy, percutaneous. Ureteroscopy. Lithotripsy, laser.

## INTRODUCTION

Percutaneous nephrolithotomy (PNL) is the gold-standard treatment for kidney stones >20 mm, according to the most recent guidelines. Smaller stones may be treated by external shockwave lithotripsy (ESWL) or by flexible ureteroscopy (FURS), despite suboptimal results for stones between 15 and 20 mm<sup>1,2</sup>.

Recently, mini-percutaneous nephrolithotomy (MiniPNL), a modification of the regular PNL, has been introduced. Routine kidney stone procedures use catheters between 24 and 30Fr; however, the MiniPNL utilizes a smaller sheath, 22Fr or less, with the aim that a smaller tract could inflict less parenchymal damage and bleeding. Furthermore, the MiniPNL could potentially improve clinical outcomes when compared to FURS

owing to its higher capacity for aspiration and fragment removal. However, the reduction in the diameter of the access sheath used for MiniPNL, compared to that of the PNL, could result in a lower success rate. Even though the technique of MiniPNL is similar to PNL, the diameter of access is not standardized, and there are divergences in the literature regarding the size of the access sheath and the instrument to be utilized<sup>3,4</sup>.

As MiniPNL is a relatively new procedure, there is no consensus in the literature about the best application for this technique, as currently stones <20 mm are commonly treated with FURS, and stones >20 mm with PNL. Thus, our aim was to evaluate the initial results obtained with this technique and compare them with similar cases that underwent FURS.

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Conflicts of interest: the authors declare there is no conflicts of interest. Funding: none.

Received on September 06, 2022. Accepted on September 09, 2022.

## METHODS

After ethics committee approval, we retrospectively reviewed the electronic database of all MiniPNL cases performed between May 2015 and April 2020. In this group, the inclusion criteria were all patients who underwent a MiniPNL (<24Fr) in the supine position. The exclusion criteria were incomplete data and the absence of preoperative and postoperative CT scans. The registry protocol was 34540620.3.0000.0068 at the National Registry site.

Data collected for MiniPNL cases were as follows: demographic: age, sex, BMI, and American Society of Anesthesiologists (ASA) score; and perioperative information: volume, localization, density of the stone, preoperative and postoperative creatinine, surgery and fluoroscopy time, total radiation in mGy, access sheath diameter, site and number of punctures, method of fragmentation, nephrostomy placement, surgeon, hospitalization time, residual stone size, and complications (classified according to the Clavien-Dindo score).

After defining the MiniPNL group, cases were chosen from a prospective database of FURS<sup>5</sup> performed by the same group between August 2016 and August 2017, in a proportion of 2 FURS:1 MiniPNL. The cases were paired according to the size and stone burden. The inclusion criteria for the FURS group were patients with stone burden between 100 and 1550 mm<sup>3</sup> (calculated, the same as in MiniPNL group, using a formula to ellipsoids = (Diameter 1) (Diameter 2) (Diameter 3)  $\pi$  0.166666667) treated with FURS, with preoperative and postoperative CT scans. Exclusion criteria were stone burden less than 100 mm<sup>3</sup> or larger than 1550 mm<sup>3</sup>, kidney malformation, ureteral stenosis, previous ipsilateral surgery (endoscopically or

open), large hydronephrosis, double-J stent placement, or any contraindication for endoscopic flexible surgery.

The data collected in the FURS group were age, body mass index (BMI), ASA score, and perioperative information (i.e., volume, localization, stone density, preoperative and postoperative creatinine, surgery and fluoroscopy time, radiation used in mGy, hospitalization time, residual stone size, ureteral lesions, and complications).

Regarding outcomes, stone-free rate (SFR) was defined as the absence of any stone fragment on the control CT, realized up to 3 months, while success rate (SUC) was defined as the presence of stone fragments up to 2 mm in the CT.

The primary objective of this study was to evaluate the MiniPNL outcomes. The secondary objective was to compare MiniPNL with FURS in terms of results and complication rates.

The surgical technique of MiniPNL was described by Lipsky et al.<sup>3</sup> and FURS technique by Danilovic et al.<sup>5</sup>

Statistical analysis was performed using SPSS version 19 (Chicago, IL, USA). Continuous variables were analyzed using the two-sample t-test assuming nonequal variances, and for noncontinuous samples, the Pearson's  $\chi^2$  test was used. The data were analyzed using the median (min–max) value due to the small number of cases and a non-normal distribution.

## RESULTS

Overall, 21 cases met the criteria for the MiniPNL group and were paired with 42 FURS cases (Figure 1). The demographic data and the stone characteristics are presented in Table 1.

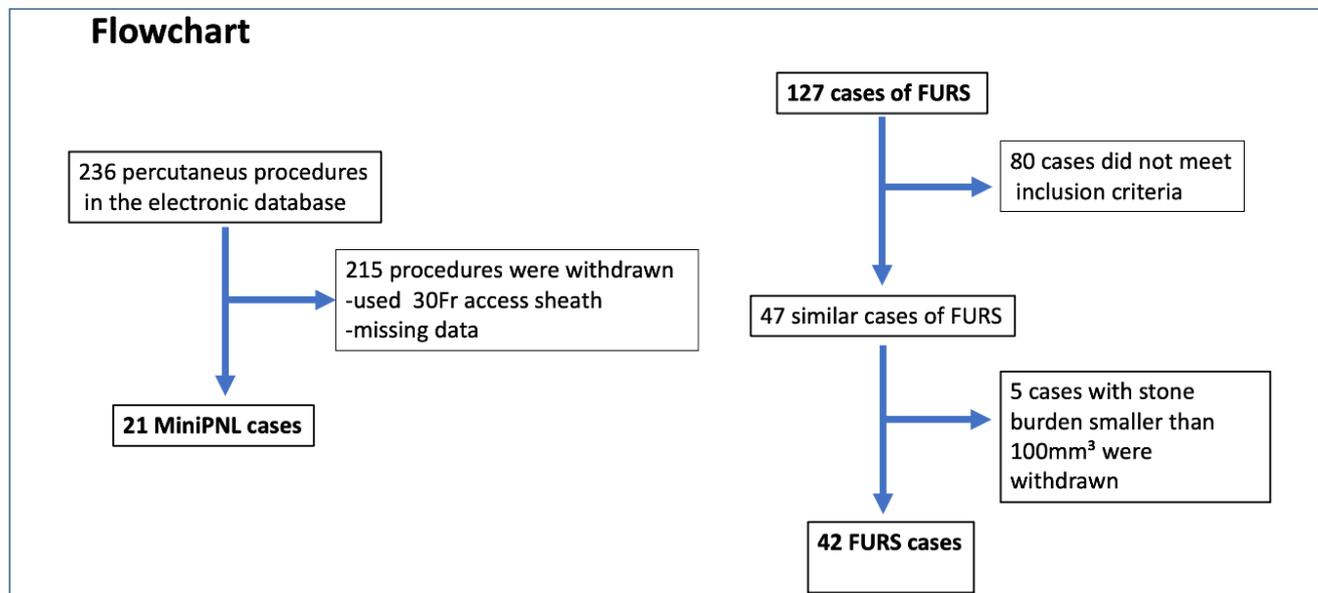


Figure 1. Flowchart of cases selected.

Patients in the FURS group had a significantly higher BMI (28.6 vs. 25.25%,  $p=0.003$ ). The groups were similar in terms of stone burden and density.

The stone location in the FURS group was 21.4% (9) in the upper pole, 9.5% (4) in the middle pole, 50% (21) in the lower pole, and 19.1% (8) in the renal pelvis; in the MiniPNL group, stone location was 0% in the upper pole, 4.8% (1) in the middle, 28.6% (6) in the lower pole, and 66.6% (14) in the renal pelvis ( $p=0.001$ ; Table 1).

With regard to the outcomes, the median residual stone diameter on postoperative CT was 0 mm (0–6.3) in the FURS group and 0 mm (0–5) in the MiniPNL group ( $p=0.682$ ). The SFR was 76.2% (32) in the FURS group and 66.7% (14) in the MiniPNL group ( $p=0.422$ ), while the SUC was 90.5% (38) in the FURS group and 85.7% (18) in the MiniPNL group ( $p=0.571$ ). The complication rate was 26.1% for FURS and 9.6% for MiniPNL ( $p=0.188$ ). No Clavien-Dindo score  $>3$  was observed. Complications are described in Table 2.

The median fluoroscopy time and radiation dosage was, respectively, 0.43 min (0.13–2.6) and 0.83 mGy (0.14–8.16) for the FURS group and 4.12 min (0.46–21.35) and 27.1 mGy (1.61–175) for the MiniPNL group, both with  $p<0.001$ . The median inpatient time was 16 h (12–168) in the FURS group and 44 h (18.49–79.33) in the MiniPNL group ( $p<0.001$ ). Other perioperative parameters are shown in Table 2.

## DISCUSSION

The MiniPNL technique was developed with the aim to reduce the complication rates associated with treatment of renal stones. The concept behind this novel procedure is that by using a smaller access sheath, there would be less dilation required and therefore lower morbidity than when using the standard PNL size access sheath. Moreover, when compared to FURS, the MiniPNL utilizes a larger working channel compared to ureteral diameter, which facilitates the fragmentation and extraction of renal stone remnants.

Thus far, MiniPNL does not have a definitive indication for its use. Some studies have attempted to clarify the capacities and limitations of this procedure; however, the results are still controversial. Li et al.<sup>6</sup> concluded that the SUCs of MiniPNL and FURS were not significantly different; however, FURS incurs lower costs and hospitalization time than MiniPNL. Other studies have reported similar results<sup>7-9</sup>.

In this study, the initial MiniPNL outcomes were demonstrated to be a safe and effective procedure, with good SFR and lower complication rates, which is in agreement with other studies<sup>6,10</sup>. Moreover, we found a comparable SFR and SUC between initial MiniPNL results and FURS performed by an expert, with similar residual stone size, showing that MiniPNL may be as effective as FURS for a similar stone burden, but with the potential for better outcomes.

**Table 1.** Pre-op data.

	FURS	MiniPNL	p
Number of cases	42	21	
Age - median (min-max)	56 (19-72)	46 (25-83)	0.114
Gender - female % (n)	57.1 (24)	76.1 (16)	0.12
BMI (median)	28.6 (19-45.4)	25.25 (19.9-32.3)	0.003
ASA %			
I	33.3 (14)	30 (6)	0.826
II	52.4 (22)	60 (12)	
III	14.3 (6)	10 (3)	
Largest stone diameter (mm)	11.4 (5.9-17.7)	16 (9-23)	0.001
Stone volume, mm <sup>3</sup> (median)	508 (68-2653)	710 (292-2725)	0.233
Stone density (median)	1007 (260-1409)	1200 (400-1500)	0.028
Laterality (%)	Left (16-38.1) Right (26-61.9)	Left (18-85.7) Right (2-9.5) Transplanted kidney (1-4.8)	0.001
Stone location (%)	Upper pole (9-21.4) Middle pole (4-9.5) Lower pole (21-50) Renal pelvis (8-19.1)	Upper pole (0) Middle pole (1-4.8) Lower pole (6-28.6) Renal pelvis (14-66.6)	0.001

Pre-op: preoperative, FURS: flexible ureteroscopy, Mini-PNL: mini-percutaneous nephrolithotomy, BMI: body mass index, ASA: American Society of Anaesthesiologists score.

**Table 2.** Intra- and postoperative information.

	FURS	MiniPNL	p
Pre-op creatinine (mg/dL)	0.73 (0.47–1.56)	0.91 (0.67–1.36)	0.028
Minutes of fluoroscopy (median)	0.3 (0.13–2.6)	4.12 (0.46–21.35)	0.001
Emitted radiation, mGy (median)	0.83 (0.14–8.16)	27.1 (1.61–175)	0.001
Post-op creatinine (mg/dL)	0.83 (0.54–2.2)	0.9 (0.66–1.66)	0.244
Hospitalization time (median)	12 (12–168)	43 (18.49–79.33)	0.001
Residual stone size in mm (median)	0 (0–6.3)	0 (0–5)	0.682
Stone-free rate %	76.2 (32)	66.7 (14)	0.422
Success % (residual <2 mm)	90.5 (38)	85.7 (18)	0.571
Complications, n (%)	11 (26.1)	2 (9.6)	0.188
Clavien-Dindo score %			
0	73.9 (31)	90.4 (19)	
1	7.1 (3)	4.8 (1)	
2	11.9 (5)	0 (0)	
3	7.1 (3)	4.8 (1)	0.158
Surgical complications	2 – Analgesia	1 – Moderate bleeding 1 – Conversion PNL	
	5 – Antibiotic		
	2 – PULS 3		
	3 – Placement JJ post-op		
Blood transfusion	0	0	

FURS: flexible ureteroscopy, Mini-PNL: mini-percutaneous nephrolithotomy, mGy: unidade de medida de radiação-miligray, PULS: post ureteroscopy lesion scale, PNL: percutaneous nephrolithotomy.

The hospitalization time and amount of radiation used in fluoroscopy were significantly higher in the MiniPNL group, which was also observed in other studies<sup>6–9</sup>. However, technical improvements such as a higher ultrasound frequency for performing the puncture and more studies with proper patient selection may transform MiniPNL in an outpatient procedure, as well as FURS. This study used a 270-nm laser fiber for MiniPNL, but potentially a larger fiber of 400 or 600 nm could improve success. In addition, the 7Fr mini-nephroscope used for MiniPNL in this study, provided limited visualization when bleeding occurred due to reduced irrigation. Newer 12Fr nephroscopes are available, which could enhance visualization in order to improve outcomes. The best setting is still a matter of debate.

The safety profile is an important aspect in deciding between two similar procedures. A higher rate of infection-associated complications was observed for FURS than MiniPNL (26.1 vs. 9.6%,  $p=0.188$ ). This may be due to higher intrarenal pressure in FURS than in MiniPNL, which may be more significant in a larger study population and could also be clinically important as most mortality cases in FURS are due to uncontrolled sepsis<sup>11</sup>. Bleeding is a potentially serious complication when

the kidney is punctured. During the initial phase, there was an isolated MiniPNL case where significant bleeding that obscured the vision occurred and regular PNL had to be substituted for MiniPNL. These data contradict the concept that endoscopic procedures such as FURS would be less harmful than percutaneous procedures such as MiniPNL. There is no consensus in the literature regarding this issue, since in some studies the complication rates were lower for FURS<sup>12,13</sup>, some were not different<sup>6,14</sup>, and some were higher<sup>15</sup>. Different MiniPNL sets and surgical techniques may also impact the outcomes.

In both procedures, all patients were considered to be stone-free by the surgeon at the end of the procedure. This was found to be incorrect since 23.8% of FURS cases and 33.3% of MiniPNL cases displayed residual fragments on the control CT scan. This indicates that technical refinement may be required in order to render the patient stone free and suggests that the use of a retrograde flexible ureteroscope at the end of the procedure may improve the outcomes, as was demonstrated by Gökce et al.<sup>16</sup>

Despite this, the current study had several limitations. First, the retrospective study design restricted the potential for comparison, and the limited number of procedures reduced

the precision of the statistical analysis. Second, there was variation in the clinical presentation of certain variables between groups. BMI was higher in FURS cases, which possibly highlights a selection bias toward lower BMI patients being treated with MiniPNL, as they would typically be treated with PNL; in MiniPNL, cases were typically situated in the lower and middle poles and renal pelvis, while in FURS cases, there was no pattern. Conversely, MiniPNL cases had larger kidney stone diameters, which was not reflected in the volume that presented; therefore, the significance of the lower SFR and SUC was potentially underestimated. Larger studies could clarify the best use of MiniPNL in the treatment of renal stones and the rate of surgical complications associated with this procedure.

Regardless of this, the initial MiniPNL outcomes are promising and encouraging. A cost analysis of MiniPNL is recommended, since the use of disposable materials appears to be lower in MiniPNL, when compared to other procedures. Technical improvements may also improve outcomes and inpatient time may be reduced with the implantation of an ambulatory surgery

program, similar to FURS protocols. Further studies may help define the role of MiniPNL in kidney stone treatment.

## CONCLUSIONS

Our initial series study showed that MiniPNL was safe and effective for treating kidney stones, with similar outcomes to FURS but with a longer inpatient time.

## AUTHORS' CONTRIBUTIONS

**JECMR:** Conceptualization, Data curation, Formal analysis, Investigation, Writing – original draft. **FCV:** Conceptualization, Formal analysis, Investigation, Visualization, Writing – original draft, Writing – review & editing. **AD:** Data curation, Formal analysis, Investigation. **GSM:** Formal analysis. **EM:** Writing – review & editing. **FCMT:** Visualization, Writing – review & editing. **CAB:** Visualization, Writing – review & editing. **WCN:** Visualization, Writing – review & editing.

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