Comparison of flexible ureterorenoscopy and mini-percutaneous nephrolithotomy in treatment of lower calyceal stones smaller than 2 cm

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ABSTRACT
To compare the outcomes of flexible ureterorenoscopy (F-URS) and mini-percutaneous nephrolithotomy (mini-PNL) in the treatment of lower calyceal stones smaller than 2 cm. Patients who underwent F-URS and mini-PNL for the treatment of lower calyceal stones smaller than 2 cm between March 2009 and December 2014 were retrospectively evaluated. Ninety-four patients were divided into two groups by treatment modality: F-URS (Group 1: 63 patients) and mini-PNL (Group 2: 31 patients). All patients were preoperatively diagnosed with intravenous pyelography or computed tomography. Success rates for F-URS and mini-PNL at postoperative first month were 85.7% and 90.3%, respectively. Operation time, fluoroscopy time, and hospitalization time for F-URS and mini-PNL patients were 44.40 min, 2.9 min, 22.4 h, and 91.9 min, 6.4 min, and 63.8 h, respectively. All three parameters were significantly shorter among the F-URS group (p < 0.001). Postoperative hemoglobin drop was significantly lower in F-URS group compared to mini-PNL group (0.39 mg/dL vs. 1.15 mg/dL, p = 0.001). A comparison of complications according to the Clavien classification demonstrated significant differences between the groups (p = 0.001). More patients in the F-URS groups require antibiotics due to urinary tract infection, and more patients in the mini-PNL group required ureteral double J catheter insertion under general anesthesia. Although both F-URS and mini-PNL have similar success rates for the treatment of lower calyceal stones, F-URS appears to be more favorable due to shorter fluoroscopy and hospitalization times; and lower hemoglobin drops. Multicenter and studies using higher patient volumes are needed to confirm these findings.

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Introduction
For the treatment of lower calyceal stones, current guidelines recommend endourological interventions and extracorporeal shock wave lithotripsy (SWL) as options, though there is no preferred treatment modality.1 Since the end of the 1970s, PNL has played a large role in the treatment of kidney stones.2 However, complications such as hemorrhage and transfusion prevent it from being the preferred choice of treatment.3 Furthermore, PNL requires more analgesia and can result in prolonged hospitalization.4

To mitigate the disadvantages of conventional PNL, instruments with smaller diameters have been developed, and Helal et al. have described a technique for minimally invasive percutaneous nephrolithotomy (mini-PNL), which they first used in the pediatric population in 1997.5 Jackman et al. first performed mini-PNL in adult patients using smaller sheaths and instruments.6,7 and later studies have shown mini-PNL to be a safe treatment choice.8 Today with the development of different size instruments, there is a confusion of terminology used to describe the procedures. However, conventional PNL is done through the tract size ≥24 Fr. Thus, mini-PNL terminology is used for the PNL procedures done through 22-14 Fr-tract size.1

Flexible ureterorenoscopy (F-URS) was first described in 1990 and became the preferred treatment for kidney stones smaller than 2 cm. Improvements in laser and fiber technology improved the success rates of F-URS, and it then became an alternative to PNL.9–11

Few studies in the literature compare F-URS and mini-PNL.12 In this study, we aimed to compare our results using F-URS and mini-PNL for the treatment of lower calyceal stones smaller than 2 cm.

Materials and methods
A retrospective analysis of the 94 patients with medium-sized (<2 cm) lower calyx stone treated with F-URS (Group 1: 63 patients) and mini-PNL (Group 2: 31 patients)
by the same surgical team experienced in endourological procedures at our center between March 2009 and December 2014 was done. Selection of the management methods was primarily based on the patients’ preferences and availability of the instruments. Patients receiving anticoagulant treatment, those younger than 18 years and those with a congenital kidney anomaly (e.g., ectopic kidney, rotation anomaly, horseshoe kidney, etc.) were excluded from the study. Demographics of the patients including age, gender, body mass index (BMI), stone size, laterality, and procedural parameters (operation and fluoroscopy time) and outcomes (success and complication rates and hospitalization time) were retrospectively reviewed and compared.

All patients were evaluated preoperatively with intravenous pyelography and/or computed tomography, complete blood count, biochemical parameters, and coagulation parameters. Preoperative urine cultures for all patients were sterile. All patients signed an informed consent form prior to surgery. All patients received prophylactic antibiotics at the induction of anesthesia.

Stone burden was calculated as using the formula described by Tiselius and Andersson (length \( \times \) width \( \times 3.14 \times 0.25 \)).

**Mini-PNL technique**

Under general anesthesia in the lithotomy position, a 5-Fr ureteral catheter was inserted and fixed to the 16-Fr bladder catheter. The calyceal system was visualized using contrast media in the prone position. Access was performed using an 18-G percutaneous access needle under the fluoroscopy. A 0.035-inch hydrophilic guidewire was inserted, and a second guidewire was inserted with a dual lumen catheter. Dilatation was performed using Amplatz dilatators up to 18-Fr. After placement Amplatz sheath to the collecting system over the dilator, nephroscopy was done with 17-Fr nephroscope (Karl Storz, Tuttlingen, Germany) and stone fragmentation was performed using a laser, pneumatic or ultrasonic lithotripter, and stone extraction was performed using a 5-Fr stone extraction device. The surgery was finalized after insertion of a 14-Fr nephrostomy tube under fluoroscopy.

**F-URS technique**

Under general anesthesia, a guidewire was placed into the renal pelvis with a 9.5-Fr semi-rigid ureteroscope while the patient was in the lithotomy position. Visual evaluation of the ureter and the ureteropelvic junction was performed. The dilatation effect facilitates easy placement of the ureteral access sheath. A safety guidewire was placed under fluoroscopic guidance using a 10-Fr dual lumen ureteral catheter. The pelvicalyceal system was assessed with retrograde pyelography. A ureteral access sheath was placed (9.5/11.5 Fr, Cook Medical, Blomington, IN) to decrease the intrarenal pressure, to gain optimal visualization, and to aid mobilization of the flexible ureterorenoscope. A 7.5-Fr fiber-optic flexible ureteroscope (Storz FLEX-X2) and a holmium laser with 273-micron fibers were used for treatment. We usually relocate the stones from lower calyx into more favorable upper calyx with basket catheter. Holmium laser machine was set at an energy of 1.0–1.5 J and a rate of 8–10 Hz. After the laser lithotripsy, stone fragments smaller than 3 mm were left for spontaneous passage, and basket retrieval was performed for fragments larger than 3 mm. At the end of the lithotripsy, a systematic inspection of the renal pelvicalyceal system was performed to confirm sufficient fragmentation. A 4.8-F double J (DJ) ureteral catheter was routinely inserted in all patients and removed 3 weeks after the procedure.

Postoperative complications were classified according to the Clavien Complication Classification System. Patients were routinely evaluated by Kidney, ureter and bladder (KUB) X-ray and ultrasonography to identify stone-free rates at first month. CT was performed for non-opaque stones or when X-ray images are not sufficient to be sure about the stone-free status. Asymptomatic residual fragments smaller than 3 mm were designated as clinically insignificant residual fragments (CIRF). Procedure failure was rendered in the presence of larger residual fragments. Patients with postoperative stone-free status or CIRF were considered to have a successful surgery. Final results were evaluated according to percentages of patients who had a successful operation. Final success rates at first month were given.

**Statistical analyses**

IBM Statistical Package for the Social Sciences (SPSS) version. 16.0 (SPSS, Inc., Chicago, IL) was used for statistical analyses. Data are presented as the number, mean, and standard deviation, and comparisons were performed using the \( \chi^2 \) test, the independent sample \( T \) test, and Mann–Whitney \( U \) test.

**Results**

A total of 94 cases with lower calyx stone treated with F-URS (n: 63) and mini-PNL (n: 31). The groups were statistically similar in terms of gender, age, BMI, stone burden, and opacity \( (p = 0.41, \ p = 0.13, \ p = 0.79, \ p = 0.98, \ p = 0.79, \) respectively). F-URS was more
commonly performed on the right side kidney compared to mini-PNL group (p = 0.02). Patient demographics are summarized in Table 1.

Perioperative and postoperative parameters of both groups are shown in Table 2. The mean operation times for the F-URS and mini-PNL groups were 44.4 ± 18.3 and 91.9 ± 37.6, respectively (p < 0.001). The mean fluoroscopy time was longer in the mini-PNL group (p < 0.001), and the mean hospitalization time was shorter in the F-URS group (p < 0.001). Postoperative hemoglobin drop was significantly lower in F-URS group compared to mini-PNL group (0.39 mg/dL vs. 1.15 mg/dL, p = 0.001). There was a significant difference between the groups in complications according to the Clavien classification (p = 0.001). Four patients in the F-URS group required antibiotics due to urinary tract infection (Clavien grade 2). Ureteral DJ catheter insertion under general anesthesia due to leakage from the nephrostomy site because of obstruction of the ureter by stone fragments was performed much more among patients in the mini-PNL group (Clavien grade 3b). In the F-URS group, only one patient needed replacement of the DJ catheter under general anesthesia due to the ureteral migration of DJ catheter (Clavien grade 3b). Final success rates were 85.7% in the F-URS group and 90.3% in the mini-PNL group at first-month follow-up (p = 0.53). In F-URS group, nine patients had residual stones. Four patients were lost to follow-up. Two patients were re-operated (F-URS) and they were stone free in the follow-up period. One patient was undergone right nephrectomy due to the non-functional kidney, which was identified during follow-up imaging. Remaining two patients who had no complaint about residual stones were followed. In a mini-PNL group, three patients had residual stones. Two patients, who had no complaints or symptoms for residual stones, were followed. Evaluation of the last patient was performed after the removal of the stent and this patient did not have any clinically significant residual fragments after evaluation by ultrasonography and KUB X-ray.

**Discussion**

Although SWL is recommended for the treatment of small kidney calculi, its use in the treatment of lower calyceal stones smaller than 2 cm remains controversial. PNL was first described in 1976 and has been used for the treatment of large renal calculi alone or combined with SWL. This allows us to avoid long and unsuccessful treatment periods and the high infection rates that accompany the use of SWL for the treatment of lower calyceal stones. Nevertheless, PNL is not the preferred treatment choice for small renal calculi due to the high rate of hemorrhage-related complications.

With the development of laser and fiber technology, F-URS has been used to treat larger stones. With the development of laser and fiber technology, F-URS has been used to treat larger stones. With the development of laser and fiber technology, F-URS has been used to treat larger stones. With the development of laser and fiber technology, F-URS has been used to treat larger stones. With the development of laser and fiber technology, F-URS has been used to treat larger stones. Despite these developments, postoperative complications and high infection rates are still possible.

Table 1. Preoperative patient demographics are listed.

|                     | Group 1 | Group 2 | p values |
|---------------------|---------|---------|----------|
| Number              | 63      | 31      |          |
| Gender              |         |         | 0.41     |
| Male                | 33      | 19      |          |
| Female              | 30      | 12      |          |
| Age (years)         | 47.7 ± 15.3 | 42.7 ± 15.1 | 0.13     |
| BMI (kg/m²)         | 26.8 ± 5.8  | 27.1 ± 4.1  | 0.79     |
| Stone area (mm²)    | 137.7 ± 40.9 | 137.45 ± 62.5 | 0.98    |
| Opacity             |         |         | 0.79     |
| Opaque              | 58      | 29      |          |
| Non-opaque          | 5       | 2       |          |
| Side of surgery     |         |         | 0.02     |
| Left                | 30      | 21      |          |
| Right               | 33      | 10      |          |

Note: BMI, body mass index.

Table 2. Comparison of surgical results between the operation groups.

|                      | Group 1 | Group 2 | p values |
|----------------------|---------|---------|----------|
| Operation time (min) | 44.4 ± 18.3 | 91.9 ± 37.6 | <0.001   |
| Fluoroscopy time (min)| 2.9 ± 2.8 | 6.4 ± 4.2  | <0.001   |
| Hospitalization time (h)| 22.4 ± 18.2 | 63.8 ± 32.1 | <0.001   |
| Hemoglobin drop (mg/dL)| 0.39 ± 0.39 | 1.15 ± 1.08 | 0.003    |
| Complications (n)    | 5 (8%)  | 9 (29%) | 0.001    |
| Clavien Grade 1      | 0       | 3       |          |
| Clavien Grade 2      | 4       | 0       |          |
| Clavien Grade 3A     | 0       | 0       |          |
| Clavien Grade 3B     | 1       | 6       |          |
| Stone-free status (%)| 85.7%   | 90.3%   | 0.53     |
| CIRF                 | 12 (19%) | 2 (6.5%) |          |
| Residual stone       | 9 (14.3%) | 3 (9.7%) |          |
| Stone-free           | 42 (66.7%) | 26 (83.9%) |          |

Note: CIRF, clinically insignificant residual fragments. Statistically significant p values are shown with bold characters.
reported longer operation times, less hemorrhage and less analgesia with the use of mini-PNL.27 Nagele et al. reported a 92.9% stone-free rate and no major complications following mini-PNL in 57 patients.28 In our study, the success rate for mini-PNL patients was 90.3% at first-month imaging. Six patients (20%) required ureteral DJ stent insertion due to urinary leakage, and three patients (9%) developed a postoperative fever. We think this high percentage (20%) of ureteral DJ stent insertion is due to the false beliefs about the spontaneous passage of stone fragments. Performing more effort for extraction of stone fragments can decrease such kind of complications in mini-PNL.

Few studies have compared F-URS and mini-PNL for the treatment of lower calyceal stones.29 Current guidelines of the European Association of Urology limit the size of the stone to 2 cm when deciding treatment modality.1 To our knowledge, this is the first study comparing F-URS and mini-PNL for the treatment of lower pole stones smaller than 2 cm. Kirac et al. used mini-PNL and F-URS to treat 37 and 36 patients, respectively, for isolated lower calyx stones smaller than 15 mm. The operation time was shorter in the mini-PNL group \( p = 0.01 \), while fluoroscopy and hospitalization time was shorter and the hemoglobin drop was less in the F-URS group \( p < 0.001 \). No major complications were seen, and minor complications did not differ between the groups \( p = 0.386 \). The radiograph on postoperative day 1 revealed no difference in stone-free status among the patients \( p = 0.650 \).29 In our study, we found shorter fluoroscopy and hospitalization times, and lower hemoglobin drops among the F-URS \( p < 0.001, p = 0.003, \) respectively and longer operation times among the mini-PNL group \( p < 0.001 \). Major complications such as DJ stent insertion under general anesthesia occurred more frequently in the mini-PNL group while urinary tract infection was more frequent in the F-URS group \( p = 0.001 \). Postoperative success rates did not differ between groups \( p = 0.53 \).

Despite the high success rates in both groups, this study does have some limitations. The main limitations are the small sample size and retrospective design of the study. Another limitation is our lack of knowledge regarding the stone compositions, which could affect the surgical results in each group. The final limitation of our study was the lack of a pain scale and an assessment of analgesia requirements following surgery.

Treatment of isolated lower calyceal stones remains controversial because the stone clearance is related to the calyx neck anatomy and stone size. Improvements in laser and fiber technology and the use of smaller instruments have led to low rates of complications and high rates of success. Although both F-URS and mini-PNL have similar success rates for the treatment of lower calyceal stones, F-URS appears to be more favorable due to shorter fluoroscopy, operation and hospitalization times, and lower hemoglobin drops. Multicenter and studies using higher patient volumes are needed to confirm these findings.

Declaration of interest
The authors report no conflicts of interest.

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