Flexible Ureterorenoscopy versus Mini-Percutaneous Nephrolithotomy for the Treatment of Renal Stones

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Purpose: To compare the pain status and stone free rates of flexible ureterorenoscopy (F-URS) versus mini-percutaneous nephrolithotomy (mini-PNL) for the treatment of 1-to 2-cm renal stones.

Materials and Methods: This study was retrospectively designed with match paired method. Between January 2013 and December 2016, 387 patients underwent stone surgery for renal stones, 45 patients underwent FURS and 45 patients underwent mini-PNL. 90 patients were divided into two groups according to the surgical procedures. Group 1 patients underwent F-URS, and Group 2 patients underwent mini-PNL. During the intraoperative and postoperative periods, pain management for all patients was standardized. Pain scores were determined using a visual analogue scale (VAS) completed at 2, 6, 12 and 24 hours postoperatively. The stone free status, hemoglobin levels, fluoroscopy time (FT), operation time (OT), hospitalization time (HT), return to work time (RWT), and complications were noted for each patient.

Results: Of all patients, the mean age was 41.1 ± 12.1 years and the mean stone size was 13.9 ± 2.9 mm. The VAS scores were significantly higher in the mini-PNL group at 2, 6, 12 and 24 hours ($P < .05$). The stone-free status and complication rates were similar between the two groups ($P > .05$); however, the hemoglobin decreases and the fluoroscopy, operation, hospitalization and return to work times were higher in the mini-PNL group than in the F-URS group ($P < .05$).

Conclusion: F-URS is less painful than mini-PNL for the treatment of 1- to 2-cm renal stones. However, the stone free rate is similar between the two procedures while mini-PNL is superior in terms of fluoroscopy, operation, hospitalization and return to work duration. We think that F-URS is more comfortable and less painful than mini-PNL and achieves a similar stone free rate for the treatment of 1- to 2-cm renal stones.

Keywords: Flexible ureterorenoscopy; mini-percutaneous nephrolithotomy; stone treatment; urological surgery.

INTRODUCTION

Since the first placement of a percutaneous nephrostomy tube for a hydronephrotic kidney in 1955[(1)], advancements in endourology have resulted in smaller devices for the percutaneous treatment of renal stones. In 1975, Harris et al. used a bronchoscope to treat renal stones[(2)], and in the following year, Fernstro ̈m and Johansson defined the percutaneous pyelolithotomy technique by using a nephrostomy tract[(3)]. In 1998, Jackman et al. described the mini-percutaneous nephrolithtotomy (mini-PNL) technique using an 11-Fr vascular sheath for infants and preschool-aged children[(4)]. Desai et al. then used the ultra-mini-PNL method in 2011, which had the least amount of access and utilized the 4.8-Fr microperc tract[(5)]. Parallel to these advancements in percutaneous treatment methods, ureterorenoscopy technology provided new approaches to renal stone therapy. In 1990, Fuchs et al. published the first report of a flexible ureterorenoscopy (F-URS) procedure[(6)], after which F-URS became an alternative treatment option for renal stones together with improvements in laser and fiber technologies.

The current EAU guidelines for urolithiasis recommend shock wave lithotripsy (SWL) as the initial treatment for renal stones smaller than 2 cm, except for the lower pole stones with unfavorable risk factors [(7)]. For stones larger than 2 cm, percutaneous nephrolithotomy (PNL) is recommended as the gold standard while cysteine stones, SWL refractory stones, or residual stones following open surgery could be also treated with PNL. Miniperc (< 20 Fr) and ultra-mini-PNL, which use a smaller tract size, expanded the use of the PNL technique for smaller stones in the area of SWL and led to comparable stone-free rates and fewer complications [(8,9)]. For stones smaller than 2 cm, F-URS has recently gained increasing attention for its significantly lower risk of complications and sufficient stone-free rates. Stone-free rates > 80% have been reported for both the mini-PNL and F-URS techniques for renal stones larger than 10 mm[(10)].

In this study, we investigated the effectiveness of the F-URS and mini-PNL techniques to determine which method is less invasive and painful while being more comfortable and suitable for renal stone treatment.

MATERIALS AND METHODS

Patients and grouping

This study was retrospectively designed and approved by local ethic committee in our country. An Informed consent was obtained from all individual participants

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included in our study. Between January 2013 and December 2016, 387 patients underwent surgery for renal stones. Of 387 patients, 90 were selected and match-paired according to age, stone size (1 to 2 cm) and stone localization. All patients were divided in two groups according to surgical procedures. Group 1 consisted of 45 patients who underwent FURS while group 2 consisted of 45 patients who underwent mini-PNL. The exclusion criteria were age < 18 years or > 65 years, morbid obesity, non-opaque renal stones, or anatomic abnormality. In preoperative period, all patients were evaluated by urinalysis, urine culture, hemoglobin (Hgb), serum urea and creatinine, coagulation tests and radiologic studies, including ultrasonography, radiography of the kidney, ureter, and bladder (KUB) and computerized tomography (CT). The stone sizes were determined by the longest axis of the stones in radiologic test. All patients received a single-dose intravenous prophylactic antibiotic with a first-generation cephalosporin or quinolone during anesthesia induction.

Mini-PNL technique

A retrograde 5-Fr open-ended ureteral catheter was inserted into the patient under general anesthesia with 22-Fr cystoscope in the lithotomy position. A 16-Fr urethral catheter was inserted into the bladder for urine drainage. After ureteral catheter insertion, the patient was moved to a prone position with the appropriate padding placed under the pressure points. The gonads were also protected from X-rays with gonad shields. Percutaneous access was achieved under C-arm fluoroscopic (SIEMENS Arcadis Varic C-arm) guidance with an 18-gauge needle. A j-tipped curved guide wire (0.035 inch) was advanced to place the collecting system preferably in the upper calyx or ureter. The nephrostomy tract was dilated using Teflon Amplatz dilators (Cook Medical®) to establish an adequate tract size for the 14-Fr renal access sheath. A 10-Fr rigid nephroscope (Karl Storz, Berlin GmbH, Germany) was used for stone fragmentation and removal. The irrigation fluids were warmed to avoid hypothermia. Ultrasonic, pneumatic and laser lithotripsy were used for stone fragmentation. Laser lithotripsy was performed using a Holmium:yttrium-aluminum-garnet laser (Dornier© MedTech Laser GmBH, Medilas H, h20-1518, Germany) through a reusable 420 micron FlexiFib fiber (LISA Laser Products OHG). If necessary, the stone fragments were extracted using either grasping forceps or a zero-tip Nitinol stone basket. The operation was complete when no residual fragments could be detected by endoscopic and fluoroscopic imaging.

At the end of the procedure, a 10-Fr percutaneous nephrostomy (PCN) tube was inserted into the collection system. In some patients, the nephrostomy tube was not required. These patients had minimal or no bleeding, no collecting system or pelvic rupture, no stone fragmentation and no need for a secondary PNL procedure. A JJ stent was routinely placed for all patients. The nephrostomy tube was removed when the drainage was clear in the absence of fever or urine leakage around the tube. The JJ catheters were removed 2 weeks after the operation.

F-URS technique

Before flexible ureteroscopy, a 7.5-Fr rigid ureteroscopy (Karl-Storz, Germany) was performed in all patients in the lithotomy position under general anesthesia to detect any previously unseen or nonopaque ureteral stones, place the safety guide-wire and dilate the ureter. All procedures were performed under visual (videoscopic) and fluoroscopic guidance. Fluoroscopy was not routinely used. It was used when stent placement, access sheath insertion and necessary any reason. After the rigid ureteroscopy, a hydrophilic guide-wire was placed into the renal pelvis via rigid ureteroscope. A 9.5-11.5-Fr access sheath (UAS) (Boston Scientific®) was placed into the ureter, if possible. After ureteral access was obtained, a 7.5-Fr flexible ureteroscope (Karl Storz flex X2, Germany) was used for the stone treatment. The stones were fragmented with a holmium laser (Dornier© MedTech Laser GmBH, Medilas H, h20-1518, Germany) using 170-200 µm laser fibers. The holmium laser was used at 0.6–1.2 J and 6–10 Hz. First, we tried to crush the stones into several fragments and then relocate them to the middle or upper calyx by stone basket so the lithotripsy could be performed easily. The stone fragments were extracted using a nitinol basket, if possible (NGage® Nitinol Stone Extractor). At the end of the procedure, a JJ catheter was inserted if there was ureteral injury, ureteral or pelvic edema, an extended operation time or excessive passing of the ureteroscope for renal access. The JJ catheters were removed under brief anesthesia 2 weeks after the operation.

Pain management

The pain management for all patients was standardized. After the operation, all patients received a single dose of intravenous meperidine hydrochloride (pethidin) 1 mg/kg from the anesthesiologist in the operation room. During the postoperative period, 50 mg intramuscular dexketoprofen trometamol and 50 mg intramuscular meperidine hydrochloride were used for pain management. These drugs were used at request of the patients (dexketoprofen trometamol max 150 mg/day and meperidine hydrochloride max 100 mg/day). Meperidine hydrochloride was used only on postoperative day 1. During the following postoperative days, pain was managed with 25 mg dexketoprofen hydrochloride taken orally twice per day. Each analgesic request was noted.

Follow-up

During the postoperative period, pain scoring was assessed using a visual analog scale (VAS)[11]. In our clinic, we routinely perform the VAS measurements in post-operative period. The VAS was used to classify pain severity among ten 1-cm horizontal segments, with no pain indicated at 0 cm and the worst pain at 10 cm. The VASs were completed at 2, 6, 12 and 24 hours postoperatively. The fluoroscopy time (FT), operation time (OT), JJ stent insertion rates, hospitalization time (HT) and return to work time (RWT) were also noted. Complications were classified according to the Clavien Classification system[12]. On the first postoperative day, patients' general condition and pain status were evaluated, and KUB was performed to verify the JJ stent insertion and stone-free status. During the first postoperative month, low dose computed tomography was performed. Stone-free status was defined as no residual fragments on CT evaluation during the first postoperative month. Residual stones □4 mm in size were defined as clinically insignificant residual fragment (CIRF)[13]. After obtaining approval of the local ethics committee, we retrospectively assessed the patients' files and documents in our clinics. An inform consent form including

Table 1. Preoperative Data of All Patients

Demographic Data	F-URS	Mini-PNL	*p* value
The mean age ± SD mean ±S D	40.46 ± 12.4	41.93 ± 11.9	0.137
The mean Stone Size (mm) mean ± SD	13.7 ± 2.5	14.2 ± 3.3	0.251
Gender (male/female)	31/14	29/16	0.421
Side of Surgery (left/right)	22/23	24/21	0.812
Location of stone (%)	0.632		
Upper Pole	10 (22.2)	11 (24.5)	-
Middle Pole	19 (42.2)	16 (35.5)	-
Lower Pole	16 (35.6)	18 (40.0)	-

Abbreviations: F-URS, Flexible Ureterorenoscopy; Mini-PNL, Mini-Percutaneous Nephrolithotomy; SD, Standard deviation

ethical and detailed surgical procedure was given to all patients before the surgery.

Statistical Analysis

Statistical analysis was done using Statistical Package for Social Sciences 20.0 software (SPSS 20.0 for MAC). Descriptive statistics of nominal samples were expressed with numbers and percentiles. Descriptive statistics of scale samples were expressed as mean ± standard deviation (minimum-maximum). Shapiro-Wilk, Kurtosis, and Skewness Tests were used to assess the variables' normalization. The Independent Sample *T* Test was used to compare the pre and post procedure independent scale parameters with normally distribution. The Mann-Whitney *U* Test was used to compare the pre and post procedure independent scale parameters without normally distribution. The Paired Sample T Test was used to compare the pre and post procedure dependent scale parameters with normal distribution. The Wilcoxon Test was used to compare the pre and post procedure dependent scale parameters without normal distribution. Mc Nemar Test was used to compare the pre and post procedure dependent nominal parameters. Chi Square Test was used to compare the pre and post procedure independent nominal parameters. ANOVA test was used to compare the repeated scale parameters with normal distribution. Friedman Test was used to compare the repeated scale parameters without normal distribution. Probability of $p < 0.05$ was accepted as statistically significant.

RESULTS

The demographic data and preoperative parameters of all patients are shown in **Table 1**. The demographic characteristics were similar between the groups ($P < .05$). The mean stone size was 13.7 ± 2.5 mm and 14.2 ± 3.3 mm in the group 1 and group 2, respectively ($P = .251$).

After 1 month stone-free rates were similar between groups, but the hemoglobin decreases, FT, OT, HT and RWT were higher in the group 2 ($P = .023$, .002, .004, .001, and .001, respectively). The perioperative and postoperative parameters are reported in **Table 2**. The mean VAS scores were significantly higher in the group 2 at 2, 6, 12 and 24 hours ($P < .05$). The mean VAS for all patients are shown in **Table 3**.

During the study period, there was no any major complication. Clavien grade 1 complication were detected in two patients in group 1 and three patients in group 2. In group 2, 1 patient have a Clavien 2 complication such as received transfusions. There was no statistically significant result in two groups in terms of complication rate (CR) ($P = .054$)

In the post-operative period, total meperidine hydrochloride requirements were not different in two groups, however, amount of dexketoprofen trometamol needed were significantly less in group 1 ($P = .001$) (**Table 2**).

Table 2. Preoperative and Postoperative Parameters of All Patients

Data	F-URS	Mini-PNL	*p* value
Fluoroscopy Time (sec.) mean ± SD	3.1 ± 0.9	123 ± 14.3	0.002
Operation time (min.) mean ± SD	37.5 ± 6.6	57.3 ± 7.5	0.004
Hemoglobin Drop (mg/dl)	0.44	2.15	0.023
Complications rate (%)			0.054
Clavien 1	2 (4.4)	3 (6.6)	-
Clavien 2	-	1 (2.2)	-
Clavien 3	-	-	-
Clavien 4	-	-	-
JJ stent insertion rate (%)	45 (100.0)	45 (100.0)	-
Nephrostomy tube insertion rate (%)	0 (0.0)	37 (82.2)	-
Mean Hospitalization Time (hour) mean ± SD	16.8 ± 3.2	43.9 ± 8.6	0.001
Stone-free rate (1. month)	40/45 (88.8)	42 (93.3)	0.453
CIRF rate (%)	2/45 (4.4)	1/45 (2.2)	
Return to Work Time (day) mean ± SD	2.53 ±1.0	8.93 ± 2.2	0.001
The total mean analgesic requirement's			
Meperidine hydrochloride (mg) mean ± SD	76.5±14.3	78.7 ± 15.2	0.15
Dexketoprofen trometamol (mg) mean ± SD	166.0±45.4	214 ± 39.5	0.001

Abbreviations: F-URS, Flexible Ureterorenoscopy; Mini-PNL, Mini-Percutaneous Nephrolithotomy; CIRF, Clinical insignificant Residual Stone; sec, Second; min, Minute

Table 3. The mean VAS of patients during the postoperative period

Postoperative period	F-URS	Mini-PNL	*p* value
2. hours mean ± SD	1.8 ± 0.3	6.3 ± 1.1	0.001
6. hours mean ± SD	1.9 ± 0.3	5.0 ± 1.2	0.001
12. hours mean ± SD	1.1 ± 0.2	4.1 ± 0.6	0.002
24. hours mean ± SD	0.6 ± 0.1	2.5 ± 0.8	0.001

Abbreviations: F-URS, Flexible Ureterorenoscopy; Mini-PNL, Mini-Percutaneous Nephrolithotomy

DISCUSSION

Managing renal stone disease with the highest possible success rate in a single setting is the aim of all endourologists worldwide. For this purpose, we reported our results in an effort to reach a consensus about the best method for a urinary system stone. However, what is the real measure of success after stone disease surgery: is it the stone-free rate, the cost, the resolution of pain, or the complication rate?

Following the invention of the mini-PNL method, many investigators reported less hemorrhage, less analgesia and reduced hospitalization time[12-14]. In addition, use of the mini-PNL approach achieved a similar stone-free rate and no major complications compared with PNL[14,15].

For the stones < 2 cm, another technique named F-URS was first described by Fuchs et al[6]. and was speculated to have even lower complication rates than mini-PNL. Following the developments in laser and flexible endoscopic technologies, F-URS is also an acceptable treatment method for larger kidney stones (10-20 mm in size). According to the 2016 guidelines of the European Association of Urology, F-URS is third-line treatment option for 10-20 mm kidney stones [7] . Moreover, some recent reports have suggested F-URS for stones >2 cm with lower complication rates than those observed for the gold standard treatment modality, PNL[16]. In the terms of stone-free rates (SFR), Kruck et al. encouraged the use of mini-PNL or F-URS rather than SWL for stones > 1 cm. They reported that mini-PNL, F-URS and SWL had 77.3%, 72.7%, and 14.8% SFRs for lower pole stones and 80.4%, 69.2%, and 39.3% for non-lower pole stones, respectively (17). A multicenter study reported 83.6%, 86.1%, and 77.2% SFRs in mini-PNL, F-URS, and SWL, respectively[18]. In another prospective study, mini-PNL and F-URS were reported to have 100% and 96.88% SFRs, respectively [19]. Akbulut et al. reported 85.7% and 90.3% SFRs for mini-PNL and F-URS, respectively[20]. Schoenthaler et al. used the 14-Fr dilatation, as in our study, and reported 84% and 87% SFRs for the ultra-mini-PNL and F-URS groups, respectively[21]. Ozgur et al. compared the miniaturized PNL (with 20-F dilatation and a 17-F nephroscope) and F-URS in obese patients and reported 80.4% and 76.7% SFRs, respectively[22]. According to these studies, although mini-PNL seems to be superior to F-URS, no studies have reported a statistically significant difference between the techniques. In a meta-analysis by Gao XS and colleagues, it was reported that stone-free rates of mini-PNL were higher than RIRS[23].They reported that in the meta-analysis mini-PNL provided a significantly higher stone free rate, especially for lover pole renal stones. In our study, we found 93.3 % and 88.8 % SFRs in the mini-PNL and F-URS groups on the first postoperative month. These results are not significantly different from each other, and our SFR results are similar to those obtained in most studies in the literature. At the 3-month follow up, there was only 1 patient in each group with significant residual stones (SRS), and a second F-URS made these patients stone-free.

In the study by Lee et al., the mean VAS scores at 1 hour and 1 day postoperatively in the mini-PNL and F-URS groups were reported to be 4.2 and 5.7 and 2.7 and 3.1, respectively. Within the first postoperative hour, mini-PNL caused significantly lower pain than did F-URS, but at postoperative day 1, there was no difference[10]. In the study by Sabnis et al., F-URS reportedly caused less pain than mini-PNL did at 6, 24, and 48 hours postoperatively[19]. In our research, F-URS caused less pain at 2, 6, 12, and 24 hours postoperatively.

In our study, Hgb decrease, OT and FT were reported to be less in the F-URS group than in the mini-PNL group. The complication rates were not different between the groups. According to Gao XS and their colleagues' meta-analysis, Hgb decrease and hospitalization time were longer in mini-PNL group. They reported that OT and complication rates were no statistical differences between mini-PNL and F-URS[23]. Pan et al. reported the mean OT to be 73.07 ± 13.5 and 62.39 ± 10.6 min in the F-URS and mini-PNL groups, respectively[24]. Contrary to the results from the studies above, Akbulut et al. reported a shorter OT but similar Hgb decreases and FT for F-URS [20]. In our study, we found significantly less Hgb decreases and shorter FT and OT, thus favoring the use of F-URS. The diminished field visibility and the need for prolonged lithotripsy to obtain small fragments suitable for extraction through the small sheath were the major factors for the long operative time in the mini-PNL group. The CRs were not significantly different between the groups, but 1 patients did require blood transfusions (Clavien 2) in the mini-PNL group. Hospitalization time (HT) and return to work time (RWT) are the other hints as to the usefulness of these techniques. Kıraç and Akbulut et al. reported a shorter HT for F-URS[20,25]. Schoenthaler et al. reported a HT of 2.3 and 2.0 days for ultra-mini-PNL and F-URS groups, respectively[21]. Ozgor et al. reported HTs of 22.4 and 63.8 hours for miniaturized PNL and F-URS groups, respectively[22]. Our research supports the previous studies. In our study, we found significantly lower HT in F-URS group. However, we think that RWT is more important than HT for selecting a technique for 1-2 cm stones. With this in mind, we examined the RWT and determined that F-URS was a more useful technique than mini-PNL.

Our study has some limitations. Patient size is the main limitation. Additionally, the retrospective and multicenter nature of the study is another limitation. Studies with more patients in a single center will reveal better results about this subject.

CONCLUSIONS

F-URS and mini-PNL are effective treatment modalities for 1- to 2-cm renal stones with a similar stone-free rate. F-URS is less painful compared with mini-PNL We concluded that F-URS results in shorter hospitalization and return to work times than mini-PNL. Further studies are needed to confirm these results.

CONFLICT OF INTEREST

The authors report no conflict of interest.

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