Comparison of Flexible Ureterorenoscopy and Mini Percutaneous Nephrolithotomy in the Management of Multiple Renal Calculi in 10-30 mm Size

Fatih Yanaral[1]*, Faruk Ozgor[1], Onur Kucuktopcu[1], Omer Sarilar[1], Ali Ayrancı[1], Metin Savun[1], Bahar Yuksel[2], Murat Binbay[1]

Purpose: To evaluate the efficacy and safety of flexible ureterorenoscopy (f-URS) and mini percutaneous nephrolithotomy (mini-perc) in the management of 10-30 millimeter multiple renal stones.

Materials and Methods: The charts of patients who underwent f-URS or mini-perc for multiple kidney stones between January 2011 and July 2015 were retrospectively analyzed. Patients with multiple 10-30–mm-sized renal stones were enrolled in the study. A total of 374 patients underwent mini-perc and 85 patients met the study inclusion criteria. In the same period, f-URS was performed in 562 patients, and 163 had 10-30–mm multiple renal stones. We selected 85 patients to serve as the control group from this cohort using propensity score matching with respect to the patient's age, ASA score, number, size, and location of stones to avoid potential bias between groups.

Results: The mean operation time and fluoroscopy screening time (FST) was significantly longer in the mini-perc group ($P = .001$ and $P = .001$, respectively). The mean hospitalization time was 76.9±38.7 hours in the mini-perc group and 25.0±27.7 hours in the f-URS group ($P = .001$). Post-operative complications, according to the Clavien classification system, were significantly more frequent in the mini-perc group ($P = .003$). The stone-free rate was 87% in the f-URS group and 83.5% in the mini-perc group ($P = .66$).

Conclusion: Our study demonstrated that f-URS and mini-perc were effective treatment options for multiple renal stones 10-30 mm in size. However, f-URS was associated with a significantly lower complication rate, shorter operation time, shorter FST, and shorter hospitalization time.

Keywords: kidney calculi; lithotripsy; nephrolithiasis; nephrolithotomy, percutaneous; ureteroscopy

INTRODUCTION

Shock wave lithotripsy (SWL) has gained popularity because of its acceptable success rates, outpatient nature, minimal anesthesia requirement and superior patient compliance since its introduction in urology practice. Today, SWL is accepted as the first-line treatment for renal stones < 20 mm and as the second-line treatment option for renal stones > 20 mm according to urolithiasis guidelines.[(1)] However, the effectiveness of SWL decreases with lower pole stones, hard stones, multiple stones, and stones of large sizes.[(2)]

With improvements in technology, flexible ureterorenoscopy (f-URS) and mini percutaneous nephrolithotomy (mini-perc) have become important management options for renal stones.[(3)] Modern flexible ureterorenoscopes can access the entire pelvicalyceal system and holmium laser provides effective stone fragmentation, regardless of stone type. With increased surgical experience, f-URS became the preferable option for larger renal stones.[(4)] On the other hand; mini-perc ensures less postoperative morbidity when compared with conventional percutaneous nephrolithotomy (PNL).[(5)]

Although many studies have shown the effectiveness of f-URS and mini-perc on solitary renal stones in the literature, no studies have compared the effectiveness of f-URS and mini-perc in patients with multiple stones. In this study, we aimed to evaluate the efficacy and safety of f-URS and mini-perc in the management of 10-30–millimeter multiple renal stones.

MATERIALS AND METHODS

Study population

In a tertiary academic center, the charts of patients who underwent f-URS or mini-perc for multiple kidney stones between January 2011 and July 2015 were retrospectively analyzed. Patients who had multiple renal stones in different renal locations with 10-30 mm stone sizes were enrolled in the study. Stone sizes were calculated as the sum of maximal diameters of all stones. Exclusion criteria were patients aged below 18 years, patients with renal abnormalities, patients with multiple stones in the same location, and patients with staghorn stone.

[1]Department of Urology, Haseki Teaching and Research Hospital, Istanbul, Turkey.
[2]Department of Obstetrics and Gynecology, Istanbul Medical Faculty, Istanbul, Turkey.
*Correspondence: Department of Urology, Haseki Training and Research Hospital, Millet Street, No: 11, 34096, Fatih, Istanbul, Turkey.
Tel: +90 212 529 44 00. Fax: +90 212 589 62 29. E-mail: fyanaral@yahoo.com.
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Table 1. Patients' demographics and clinical characteristics after propensity score matching.

	F-URS	Mini-Perc
Number	85	85
Gender (male / female)	53 / 32	52 / 33
Age (years)	42.9 ± 16.9	41.1 ± 15.3
BMI (kg/m^2)	25.8 ± 5.8	27.4 ± 5.5
ASA Score	1.75 ± 1.44	1.66 ± 1.54
Stone size (mm)	23.4 ± 3.8	24.4 ± 5.4
Stone number	2.3 ± 1.4	2.2 ± 1.3
Operation side (Right / Left)	38 / 47	38 / 47
Degree of hydronephrosis Mild (grade 1-2) / severe (grade 3-4)	41 / 5	37 / 7
Stone opacity (opaq / nonopaq)	81 / 4	82 / 3

Abbreviations: BMI, body mass index; ASA, American Society of Anesthesiologists
Data is presented as mean ± SD or number

The patients' medical history was obtained and physical examination was performed for all patients. Preoperatively, renal stone and kidney characteristics were evaluated using intravenous pyelography and/or non-contrast abdominal computed tomography (CT). The patients' demographic parameters including sex, age, ASA score, body mass index (BMI), stone size, stone number, and stone location were recorded. Preoperative laboratory tests were hemoglobin measurements, serum creatinine level, platelet counts, and coagulation screening tests. All patients had sterile urine cultures prior to surgery and each had signed an informed consent form.

Study design
This study was a comparative, retrospective, observational study, which was performed in a referral hospital in Istanbul, Turkey. A total of 374 patients underwent mini-perc, 85 of whom met the study inclusion criteria. In the same period, f-URS was performed in 562 patients, 163 of whom had 10-30 mm multiple renal stones. We selected 85 patients to serve as the control group from this cohort using propensity score matching respect to the patient's age, American Society of Anesthesiologists (ASA) score, number, size, and location of stone. Propensity score matching was utilized to minimize the bias related to the lack of randomization in this observational study by balancing a range of covariate patient and stone-related parameters in the groups. The selection of procedural technique was primarily based on the patients' choice.

Surgical techniques

f-URS technique
Under general anesthesia, a safety guide-wire was placed into the renal pelvis and semi-rigid ureteroscopy was performed for visual assessment of the ureter to facilitate positioning of the ureteral access sheath (9.5/11.5Fr or 11/13 Fr). A 7.5 F fiber-optic flexible ureterorenoscope (Storz FLEX-X 2, Tuttlingen, Germany) with a 200 or 273 µm laser fiber was used for treatment. Stone fragmentation was performed with holmium laser at 0.8-1.5 J and a rate of 5-10 Hz. Stone fragments < 2 mm were left for spontaneous passage and basket retrieval was performed for stone fragments > 2 mm. A 4.8 F JJ stent was routinely placed in each patient at the end of procedures. Operation time (OR) was calculated as the time that passed from anesthesia induction to the completion of the JJ stent placement. The JJ catheter was removed 2 weeks after the operation using a cystoscope.

Mini-perc technique
In the lithotomy position, a 5-Fr ureteral catheter was inserted up to the kidney under general anesthesia. In the prone position, the calyceal system configuration was demonstrated using contrast media and access was gained to the proper calyx using an 18 G needle under the C-arm microscopy unit. After a 0.035-inch hydrophilic guide-wire was placed into the pelvicaliceal system, dilatation was performed using Amplatz dilatators, and an 18- or 20-Fr Amplatz sheath was inserted. With a 17-F rigid nephroscope, stone fragmentation was performed using laser or an ultrasonic lithotripter, and stone removal was performed using stone extraction forceps. At the end of the procedure, a nephrostomy tube was placed under fluoroscopy in the case of pelvicalyceal perforation, the presence of residual fragments, or according to the surgeon's choice. The operation time was defined as the period starting from anesthesia to the placement of the nephrostomy tube.

Outcome assessment
Operation success was evaluated with a kidney-ureter-bladder radiography on the first postoperative day. Afterward, stone-free status was reassessed in an outpatient setting with non-contrast CT between 1 and 3 months, postoperatively. The procedure was accepted as successful if the patient was stone free or if the patients' residual fragments were < 2 mm. The primary outcomes were stone free rate and postoperative complications of f-URS or mini-perc. Secondary outcomes included; OR, fluoroscopy screening time (FST), hospitalization time, haemoglobin drop, and additional procedures. Complications were classified in accordance with the Clavien system.[6]

Statistical Analysis
The Statistical Package of Social Sciences for Windows version 20 was used for statistical analysis. During statistical analyses, values were evaluated as numbers, means, percentages and intervals. Propensity score matching minimized any bias caused by the lack of randomization in this observational study. Numbers and percentages were compared using the Chi-square test. Before the comparison of means, the values were evaluated for normality by Shapiro-Wilk test. Homogeneously distributed values were compared using Student's t-test and heterogeneously distributed values were compared using the Mann-Whitney *U* test.

Table 2. Stone locations in f-URS and mini-perc group.

	F-URS	Mini-Perc	P Value
Pelvis + lower calyx	45	39	0.324
Pelvis + middle calyx	2	4	
Pelvis + upper calyx	16	10	
Pelvis + multiple calyx	7	9	
Lower pole + upper calyx	3	7	
Lower pole + middle calyx	8	11	
Middle pole + upper calyx	2	5	
Lower pole + middle calyx + upper calyx	2	0	

RESULTS

In accordance with the design of our study, renal stone characteristics including renal stone number (P = .63), the sum of total stone size (P = .20), stone locations (P = .32), and stone opacity (P = .56) were comparable between groups. Also, age (P = .46), BMI (P = .07), and ASA scores (P = .78) of patients were similar between the f-URS group and mini-perc group. Preoperative parameters are listed in **Tables 1 and 2**.

The mean operation and FST was significantly longer in the mini-perc group (P = .001 and P = .001, respectively). A flexible nephroscope was used in 19 patients (22.4%) during mini-perc. Additional access was required in 22 patients (two access was required in 20 patients and three access in two patients) and the mean access number per patient was 1.28. In the mini-perc group, the mean hemoglobin drop after the procedure was calculated as 1.0 g/dL. Hemoglobin values were not routinely assessed postoperatively in the f-URS group unless any uneventful hemorrhagic complications occurred. Tubeless mini-perc was performed in 36 patients (42.3%). The mean hospitalization time was 25.0 ± 27.7 hours in the f-URS group and 76.9 ± 38.7hours in the mini-perc group (P = .001).

Post-operative complications, according to the Clavien classification system, were significantly more frequent in the mini-perc group (P = .003). Renal colic was treated in two patients in both the f-URS and mini-perc groups, and transient hematuria was observed in two patients of the mini-perc group (Clavien 1). Post-operative fever that required antibiotic therapy was seen in three patients and one patient in f-URS and mini-perc groups, respectively (Clavien 2). A hemoglobin drop that required blood transfusion occurred in three patients in the mini-perc group (Clavien 2). Angioembolization was performed in one patient following mini-perc (Clavien 3b). A JJ stent was inserted in two patients without anesthesia (Clavien 3a) and in four patients under anesthesia (Clavien 3b) following mini-perc because of pain and persistent leakage of urine after the removal of the nephrostomy tube.

The stone-free rate was 78.8% for the f-URS group and 74.1% for the mini-perc group after a single session procedure (P = .58). After additional procedures including, SWL, URS/f-URS, and mini-perc, the success rate increased to 87% in the f-URS group and 83.5% in the mini-perc group, respectively (P = .66) (**Table 3**).

DISCUSSION

In urolithiasis guidelines, the treatment recommendation for kidney stones substantially depends on stone size and location of the stone. However, many authors stated that the number of stones affected procedure outcomes including SWL, f-URS, and PNL. Ackermann et al. found stone number was more related with procedure success than the stone burden.[7] During stone fragmentation in operations or SWL, multiple small stones can easily move up and escape from laser or shock waves. Kanao et al. emphasized that focusing on one large stone was easier than targeting multiple small stones with the same stone burden.[8]

Shock wave lithotripsy was recently recommended as the first-line treatment for 10-20 mm renal stones and a second-line treatment alternative for renal stones > 20 mm. However, the success of SWL is clearly adversely affected by the presence of multiple renal stones. Cass et al. achieved ≤ 50% stone-free rates in the management of multiple renal stones following SWL.[9] Similarly; McAdams et al. investigated the importance of stone number in SWL. The mean stone number was 2.81 in patients in whom SWL failed, and 1.87 in patients who were treated successfully using SWL.[10] Therefore, f-URS and mini-perc have become important treatment alternatives for multiple renal stones in a zone where SWL is not preferred, and the selection of treatment modality and must be clarified.

We obtained 78.8% SFR after f-URS and our success rate increased to 87% following additional procedures.

Table 3. Patients' intraoperative and postoperative data.

	F-URS	Mini-Perc	P Value
Operation time (minutes)	62.6 ± 2.3	117.8 ± 43.7	0.001
Fluoroscopy screening time (minutes)	2.4 ± 1.2	5.6 ± 4.1	0.001
Hospitalization time (hours)	25.0 ± 27.7	76.9 ± 38.7	0.001
Haemoglobin drop (g/dL)	NA	1.0 ± 1.1	
Postoperative complications (Clavien classification system)			0.003
Grade 1	2	4	
Grade 2	3	4	
Grade 3a	0	2	
Grade 3b	0	5	
Success after single session			0.585
Residual fragment	18 (21.2%)	22 (25.9%)	
Stone free	67 (78.8%)	63 (74.1%)	
Additional procedures			0.365
SWL	2	4	
URS/f-URS	6	7	
mini-perc	4	1	
Stone free after additional procedures	74 (87%)	71 (83.5%)	0.660

Data is presented as mean ± SD or number

Similarly, Huang et al. achieved 60.7% and 85.7% SFR following single and second session f-URS in the management of multiple renal stones larger than 20 mm.[11] In another study, Breda et al. treated multiple renal stones with f-URS and reported 92.2% SFR after two sessions.[12] However, all patients in Breda's study had stones < 15 mm in size and the mean stone size was smaller than in the present study (6.6 vs. 23.4 mm).

In the mini-perc group, stone-free status was achieved in 74.1% of patients and increased to 83.5% after additional procedures. Knoll et al. reported 96% SFR after mini-perc; however, all their patients had a solitary kidney stone.[13]) A different study by Kırac et al. demonstrated 91.9% SFR, but the mean stone size in their study was smaller than that study (10.5 vs 24.4 mm) and only 32.4% of patients had multiple renal stones in Kırac's study.14 Additionally, unlike our study, patients with 3 mm stone fragments were accepted as stone free in Kırac's study, which may explain the lower success rates in the present study. Lastly, our study emphasized that SFR following f-URS and mini-perc in the management of multiple renal stones 10-30 mm size did not show a significant difference (*P* = .66).

In the present study, the mean operation time was found significantly longer in the mini-perc group compared with the f-URS group. Different from our study, both Knoll et al. (106 min vs. 59 min) and Kırac et al. (66.4 min vs. 53.7 min) reported significantly longer operation times in f-URS group.[13,14] However, in both studies, the definition of operation time was not well clarified for both f-URS and mini-perc procedures. We accepted OR from the induction of anesthesia to the completion of JJ stent placement in the f-URS group, and placement of the nephrostomy tube in the mini-perc group, which is why we had significantly longer OR in the mini-perc group. It is clear that changing patients from lithotomy position to the prone position requires special attention and is a time-consuming process. Also, obtaining multiple accesses and changing of instruments (rigid nephroscope to flexible nephroscope) may contribute to longer operation times during mini-perc. Previous studies that investigated f-URS in the management of multiple renal calculi have not reported FST.[11,12] Additionally, Knoll et al. and Kırac et al. did not discuss FST between f-URS and mini-perc.[13,14] Our study demonstrated that FST was significantly longer in the mini-perc group when compared with the f-URS group. Similarly, when we analyzed the studies separately, we noticed that FST was longer with mini-perc than f-URS, as in our study.[15,16] Additionally, the mean access number was 1.28, which may have contributed to the longer FST in the mini-perc group. We believe further studies should investigate FST in f-URS and mini-perc to clarify this subject.

Complications following f-URS were not serious and were mostly treated without surgical intervention when compared with mini-perc.[17] Fever requiring antibiotic therapy was more common in the f-URS group, which may be a consequence of working with high intrarenal pressure during f-URS. Although transfusion rates decreased with miniaturized instruments in PNL, three (3.5%) patients and one (1.2%) patient required blood transfusion and angioembolization in the mini-perc group, respectively. Cheng et al. reported a 1.4% blood transfusion rate following mini-perc, but they excluded patients with multiple accesses, which may explain their lower transfusion rates.[5] In contrast, flexible ureteroscopes pass from natural orifices while reaching kidney; therefore, renal parenchyma and vascular structures are protected against procedure-related damage. As such, we do not routinely evaluate hemoglobin levels after f-URS.

Urine leakage from the nephrostomy tract and ureteral obstruction due to stone fragments are major problems following PNL and treated with JJ stent insertion.[18] The JJ stent insertion was a routine part of our f-URS procedure and we experienced no stent migration. In the mini-perc group, we inserted a JJ stent in six patients due to renal colic and urine leakage after nephrostomy withdrawal. In the mini-perc group, in our first cases, we left particles for spontaneous passage after fragmentation of the stones into 2 mm stone particles with a laser lithotripter. After we realized the high JJ stent insertion rate in mini-perc cases, we started to retrieve all fragments using a basket to reduce our JJ stent insertion rates, which may explain our higher JJ stent insertion rate. Fragmentation type in endoscopic procedures may be a subject of another study.

There are some weaknesses to the present study. Although the present study is the first to research this subject, we are aware of the retrospective nature of the study. However, the preoperative characteristics were similar between the groups and we believe that the study scheme prevented potential bias between the groups. In addition, different surgeons including specialists and residents performed operations in both the f-URS and mini-perc groups; however, all procedures conducted by residents were performed under the supervision of an experienced specialist. Also, we did not evaluate analgesic requirement after procedures and the effects of f-URS and mini-perc on patients' quality of life. Finally, we did not compare the stone type between groups due to the insufficient data.

CONCLUSIONS

Our study demonstrated that both f-URS and mini-perc were effective treatment options in the management of multiple renal stones 10-30 mm in size. However, f-URS was associated with a significantly lower complication rate, shorter operation time, shorter FST, and shorter hospitalization time. However, our findings must be supported by further prospective, randomized studies with larger patient volumes.

CONFLICT OF INTEREST

The authors report no conflict of interest.

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