Turk J Urol 2016; 42(3): 261-6 • DOI: 10.5152/tud.2016.32644

ENDOUROLOGY
Original Article

The role of ultra-mini percutaneous nephrolithotomy in the treatment of kidney stones

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ABSTRACT

Objective: In our study we aimed to evaluate outcomes of ultra-mini-percutaneous nephrolithotomy (UMP) performed for the treatment of kidney stones.

Material and methods: Between October 2014 and September 2015, a single surgeon performed UMP on a total of 49 consecutive patients with symptomatic kidney stones at our center. Pregnants, anticogulant users, patients with bleeding diathesis pyonephrosis, and partial/complete staghorn stones were excluded from the study. Patient characteristics, operative data and postoperative outcomes were assessed in detail.

Results: The UMP was performed on 50 (34 right/16 left) renal units of the 48 (28 male/20 female) patients included in this study. The mean age and body mass index was 36.5 (2-83) years and 26.2 (17.6-32.8) kg/m^2, respectively. Mean stone size was calculated as 22.2 (10-55) mm. The mean durations of the operations and fluoroscopic examination were calculated as 65.4 (20-120) minutes and 89.4 (9-322) seconds, respectively. The mean duration of hospitalization was 1.4 (1-5) days. In 52% of the patients the procedure was terminated tubeless. Mean hemoglobin drop was 0.6 (0-3) g/dL. Our series experienced a 10% complication rate. The UMP procedure was successful in 96% of the renal units at the 1st month control visit assessment.

Conclusion: The outcomes of our study have demonstrated that UMP is an effective and safe treatment modality, especially in the treatment of medium-sized renal calculi.

Keywords: Efficacy; kidney stone; safety; ultra-mini percutaneous nephrolithotomy.

Introduction

In parallel with contemporary technological advancements, important innovations have been made in the surgical treatment of renal stones. Except for limited indications, minimally invasive methods such as laparoscopy, flexible ureteroscopy (f-URS), and percutaneous nephrolithotomy (PNL) have currently replaced open surgery for the treatment of urolithiasis. Guidelines of both American Association of Urology (AUA) and the European Association of Urology (EAU) recommend PNL as a first-line treatment modality for large kidney stone burden.[1,2]

Although standard PNL has been generally accepted as an effective treatment technique in the management of renal stones, some series have reported higher complication rates.[3,4] One of the most worrisome complications of PNL is bleeding. In the literature, the incidence of transfusion requiring bleeding has been reported to vary between 0.4 and 23 percent.[1-4] Factors that might cause bleeding are stone size, tract size, number of access sites, duration of the operation, and preexisting comorbidities of the patient.[5,6] Many studies have demonstrated the association of the tract and instrument size with blood loss.[4-6] Smaller- sized access tracts cause lesser parenchymal and vascular injury.

Various miniaturized PNL techniques have been described in order to achieve similar success but decreased complication rates. The first of these is the mini-PNL technique applied by Helal et al.[7] and Jackman et al.[8] for pediatric cases. Later Bader et al.[9] described the micropercutaneous (microperc) technique allowing stone fragmentation using a single-step access under direct vision. Finally, in 2013, Desai et al.[10] introduced the ultramini-PNL (UMP), in

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Submitted: 05.03.2016

Accepted: 15.04.2016

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Available online at www.turkishjournalofurology.com

Turk J Urol 2016; 42(4): 261-6
DOI:10.5152/tud.2016.32644

which a 6 Fr mini nephroscope is used through a 13 Fr metal sheath and stones are fragmented with a laser. This new treatment modality seems to be promising for the management of middle-sized stones; however, up to now only a few studies have been published from certain centers reporting the limited number of experiences of the same few surgeons.[10-16]

We report herein the outcomes of the prospective clinical study of UMP compared with the findings cited in the literature. With the surgeons' increased experience using UMP and presentation of series, the role of UMP in the management of renal stones will be more clearly understood.

Material and methods

Between October 2014 and September 2015, a single surgeon (AT) at our center performed the ultramini-PNL on a total of 48 consecutive patients with symptomatic kidney stones. The medical records of the cases were prospectively entered into a computer-based data system. Patient characteristics, operative measures and postoperative outcomes were assessed in detail. Exclusion criteria included pregnancy, anticoagulant usage, bleeding diathesis, presence of pyonephrosis, and partial/complete staghorn stones. Before starting the study, an institutional review and ethics committee approval was obtained from Bezmialem Vakif University Instutional Review Board. All patients signed the written informed consent prior to surgery.

Before the procedure, all patients were evaluated in detail using biochemical tests, urinalysis, urine culture, and radiological methods. Those with positive urine cultures were treated with appropriate antibiotics based on antibiogram results, and operated upon only after their urine cultures were sterile. As imaging modalities plain radiography, renal ultrasonography (US), and intravenous urography (IVU) and/or computed tomography (CT) were used. Stone size was calculated by preoperatively measuring its longest diameter.

The procedural technique

Under general anesthesia and fluoroscopic control, an open-ended 6 Fr ureteral catheter (Geotek, Ankara, Turkey) was placed through the transurethral route while the patient was in the lithotomy position. A 16 Fr. urethral Foley catheter was then inserted and attached to the ureteral catheter after which the patient was turned to the prone position, and under C-arm fluoroscope radiopaque material was injected through ureteral catheter to opacify pelvicalyceal system. The appropriate calyx for access was determined under fluoroscopic guidance, and percutaneous renal access was performed using an 18 G percutaneous access needle (Plastimed, Istanbul, Turkey). A guidewire (Sensor TM Guide Wire, Boston Scientific, USA) was inserted through the channel of the needle into the pelvicalyceal system, and over the guidewire an 8 Fr dilator was advanced into the collecting system. Next a 13Fr UMP metal sheath (LT GmbH, Denzlingen, Germany) was advanced into the pelvicalyceal system under fluoroscopic control so that a 6 Fr mini nephroscope could be inserted into the pelvicalyceal system through that sheath. Stones detected in the pelvicalyceal system were fragmented using a 365-micron Ho: YAG laser fiber, and the fragments were extracted using forceps, a basket, or irrigation fluid. Stone-free status was assessed intraoperatively with endoscopic and fluoroscopic visualization. The procedure was terminated in a tubeless fashion without significant bleeding leading to blurred vision, collecting system perforation, or residual fragments. Besides, a 10 Fr feeding tube was placed for drainage.

On the 1st postoperative day, the patients were evaluated with laboratory tests, and KUB and urethral and ureteral catheters were removed. Patients with nephrostomy tubes were discharged on postoperative 1-3 days after removal of their tubes. The complications were classified based on the Clavien system and the results were recorded.[17] At postoperative 1st month, all patients were re-evaluated with KUB and US. Lack of residual fragments or the presence of asymptomatic small (< 4 mm) fragments meant that the surgery was successful.

Results

Ultramini-PNL was performed on 50 (34 right/16 left) renal units of 48 (28 male/20 female) patients included in this study. Mean age and body mass index of the patients were 36.5 (2-83) years and 26.2 (17.6-32.8) kg/m^2, respectively. Mean stone size was calculated as 22.2 (10-55) mm. Solitary stones were detected in 30 and multiple stones in 20 units. UMP was accomplished in 14 renal units of the 12 cases under the age of 18 years.

While 17 patients had positive family history, 19 cases had prior experiences of spontaneous stone passage, and 28 had previous surgery for urolithiasis, including open nephrolithotomy (n=3), laparoscopic pyelolithotomy (n=1), PNL (n=12), and f-URS (n=12). Three patients had solitary kidneys. Comorbidities including diabetes mellitus (n=3), hypertension (n=3), and coronary artery disease (n=1) were detected in 7 patients. Anatomically challenging cases in our series were horseshoe kidneys (n=2) and caliceal diverticula (n=2). Characteristics of the patients are presented in Table 1.

The mean duration of the operations and fluoroscopic examinations were calculated as 65.4 (20-120) minutes and 89.4 (9-322) seconds, respectively. Procedures were done through a single access in 48 (96%) cases, while multiple accesses were required in 2 (4%) renal units. The mean duration of hospitalization was 1.4 (1-5) days. In 52% of the patients the procedure was terminated tubeless. Mean hemoglobin drop was 0.6 (0-3) g/dL. The

Table 1. Characteristics of the patients	
N	48
Mean age (years)	36.56±21.6 (2-83)
Sex (Male/Female)	28/20
Side (Right/Left)	34/16
Mean stone size (mm)	22.2±10.4 (10-55)
Stone location	
Pelvis	19 (38%)
Lower calyx	12 (24%)
Pelvis and lower calyx	11 (22%)
Pelvis + middle calyx	6 (12%)
Diverticulum stone	2 (4%)
Radio-opacity	
Radiopaque	45 (94%)
Semi-opaque	5 (6%)
Grade of hydronephrosis	
Grade 0	20 (40%)
Grade 1	15 (30%)
Grade 2	15 (30%)
Challenging cases	
Solitary kidney	3 (6%)
Horseshoe kidney	2 (4%)
Caliceal diverticulum	2 (4%)

UMP procedure was successful in 96% of the renal units as assessed at the 1st month control visits.

In our series a 10% complication rate was detected. Persistent urine leakage following nephrostomy tube removal (Clavien 3a complication) was treated with ureteral stent placement in 2 (4%) cases. In one (2%) patient, urinary infection (Clavien grade 2 complication) was controlled with parenteral antibiotherapy and the patient was hospitalized for 5 days. Hydrothorax following upper pole access (Clavien grade 3a complication) was detected in a patient (2%) treated by the placement of a chest tube. In another patient (2%), because of presence of intraoperative bleeding leading to blurred vision, conversion to mini-PNL was required. The complication rates in adult (8.3%) and pediatric cases (14.2%) were not statistically significantly different (p=0.3). Operative and postoperative data of the patients are presented in Table 2.

Table 2. Perioperative measures and outcomes of the cases	
Mean operation time (minutes)	65.4±25.3 (20-120)
Mean fluoroscopy duration (seconds)	89.4±67.6 (9-322)
Access number	
Single access	48 (96%)
Multiple accesses	2 (4%)
Access location	
Lower calyx	38 (76%)
Upper calyx	6 (12%)
Middle calyx	4 (8%)
Middle and lower calyx	2 (4%)
Mean hospitalization time (days)	1.4±0.76 (1-5)
Mean hemoglobin drop (g/dL)	0.6±0.68 (0-3)
Tubeless rate	52%
Success rate	96%
Complication rate	
Prolonged urine leakage	2 (4%)
Urinary tract infection	1 (2%)
Hydrothorax	1 (2%)
Conversion to mini-PNL	1 (2%)

Discussion

Since its first description by Fernström and Johansson[18], the PNL procedure has so much developed technically that nowadays it has become the standard treatment modality for the management of large renal stones. While PNL is recommended as the first-line treatment modality for renal stones >2 cm, according to EAU urolithiasis guidelines both PNL and f-URS are treatment options for stones <2 cm in size.[2] Although studies have shown that PNL is a more invasive method and has higher complication rates compared to SWL and f-URS, it still has a relatively greater rate of success.[1,2] The PNL procedure is technically based on the principle of fragmentation and removal of the kidney stones through a tract created between skin and the pelvicaliceal system. It has been shown that the tract size correlates with the complications of the procedure.[5,6] In order to decrease the complication rate, procedures have been performed using smaller-sized instruments.

Desai et al.[10] introduced the UMP procedure as a minimally invasive PNL technique for the treatment of kidney stones. In their first clinical study, they applied the UMP method on 36

Turk J Urol 2016; 42(4): 261-6
DOI:10.5152/tud.2016.32644

Table 3. The summary of the studies presenting the outcomes of UMP procedure

Study	N	Mean age (years)	Stone size (mm)	Comparison with	Hemoglobin drop (g/dL)	Operation time (minutes)	Success rate (%)	Complication rate (%)	Hospitalization (days)
Desai et al.[10]	36	48.2	14.9	NA	0.54	59.8	97.2	16.7	3.0
Desai et al.[11]	62	NA	16.8	NA	1.4	NA	86.6	4.83	1.2
Shah et al.[12]	22	49.1	26.6	NA	1.2	85.7	81.8	13.5	3.1
Wilhelm et al.[13]	25	51.5	19.2	f-URS	NA	130.12	92	16	3.8
Schoenthaler et al.[14]	30	54.3	15.1	f-URS	NA	121	84	7	2.3
Dede et al.[15]	39	5.8	20.4	NA	0.9	56	87.1	15.3	2.8
Datta et al.[16]	94	46.5	15.9	NA	0.8	54	81	5.3	1.59
Current study	50	36.5	22.2	NA	0.6	65.4	96	10	1.4

UMP: Ultramini-PNL; f-URS: flexible ureteroscopy; NA: not applicable

cases with renal stones <20 mm.[10] To date, a total of 7 studies of the UMP technique have been reported (Table 3).[10-16] In a recently published study, UMP was performed for 94 cases with mean kidney stone size of 15.9 mm.[16] In our series - one of the largest series published so far- UMP was performed on 50 renal units with an average stone size of 22.2 mm.

Even though microperc is the most miniaturized PNL technique used for stone fragmentation, inability of stone retrieval may be regarded as its major disadvantage. The UMP procedure, however, does allow fragmentation, and subsequent extraction of the stone fragments. In this technique, saline injection through the small lumen of the outer metal sheath or ureteral catheter creates turbulence and allows retrieval of small stone fragments through the lumen of the sheath.[10,11] UMP studies have reported stone-free rates ranging between 81 and 97.2 percent.[10-16] In the largest series in the literature, a complete stone-free rate (as evaluated with CT) was reported in 81% of the patients at postoperative 1st months.[16] In the series with the highest stone-free rate (97.2%), average stone size was 14.9 mm.[10] In our series, with average stone size of 22.2 mm, at the end of the postoperative 1st month the stone-free rate was calculated as 96%. Success was evaluated using KUB and US in order to decrease radiation exposure.

Despite effectiveness of PNL in stone clearance, it is reported that it may lead to serious complications, the most important of which is bleeding.[3,4] Incidence of bleeding requiring transfusion ranges between 0.4 and 23 percent.[1-4] The association of tract size with blood loss, length of hospital stay, and analgesic requirement has been shown.[5,6] Downsizing the renal tract leads to less parenchymal and vascular injury. In the first UMP series reported by Desai et al.[10], an average hemoglobin drop of 0.54 g/dL was detected and none of the patients required blood transfusion. Subsequent series[11-16] also reported an average hemoglobin drop ranging between 0.5 and 1.4 g/dL and, similarly, blood transfusion was not required for any of the patients.

Theoretically, a nephrostomy tube placed at the end of the PNL tamponades bleeding, provides renal drainage, and acts as a tract for the second-look PNL.[19-21] Despite these advantages, nephrostomy tubes have been associated with patient discomfort, increased analgesic requirement, and prolonged hospitalization time. Because of these disadvantages, the tubeless PNL procedure is recommended only in selected circumstances.[2] In our study, tubeless PNL was performed in 52% of the cases who had no ureteral obstruction, collecting system perforation, or severe bleeding. In this group the average hospital stay was 1.3 (1-2) days. In the largest series, tubeless PNL had been applied in 78% of the patients with an average hospital stay of 1.59 days.[16]

Operative time is an important restrictive factor for minimally invasive surgeries. Giusti et al.[22] compared their patients who had undergone standard and mini-PNL, and concluded that operative time in the mini-PNL group was relatively longer when compared with standard PNL. Prolonged operative time in the mini-PNL group was attributed to a smaller field of vision and the longer fragmentation time needed to extract the stone fragments through a small-caliber tract. As seen in Table 3, in the series[12] of UMP for 2-3 cm stones, average operative time was longer than those of the other series. In the recently published study, authors have compared the outcomes of UMP for both <2 cm and >2 cm kidney stones.[16] While the operation time and blood loss decreased, the frequency of tubeless PNL applications increased in cases with kidney stones <2 cm in diameter. In our study, mean operative time (65.4±26.3 minutes) was comparable with the other series in the literature.

EAU guidelines recommend the f-URS, PNL, and SWL methods for the management of renal stones <2 cm in diameter.[2] PNL is the most invasive method of the three modalities. Two studies compared the effectiveness of f-URS and UMP in the management of 10-35 mm renal stones.[13,14] In this study[13], prolonged hospital stay and operative times were detected in the UMP group; however, a significantly higher number of additional outpatient procedures per patient were noted in the f-URS group. On the other hand, in this study pre-UMP ureteral catheterization time was included in the operative time. In another study comparing f-URS and UMP for the management of renal stones measuring 10-20 mm in diameter, statistically comparable hospitalization period, operative time, stone-free, and complication rates were found.[14]

There are some limitations that should be emphasized in the current study. The most important limitation of our study was lack of a control group where other treatment modalities were used. Also, assessment of stone free status with KUB and US may be regarded as another limitation of the study. CT was not used routinely in order to decrease the radiation exposure. Despite these limitations we believe that current study provides relevant contributions to the literature and helps to understand the role of UMP in the treatment of nephrolithiasis.

As a conclusion, the outcomes of our study have demonstrated that as an alternative to f-URS and other PNL modalities, UMP is an effective and safe treatment modality, especially in the treatment of medium-sized renal calculi. Further prospective and randomized studies will be helpful to expand our knowledge base on this new treatment method for kidney stone management.

Ethics Committee Approval: Ethics committee approval was received for this study from the ethics committee of Bezmialem Vakıf University.

Informed Consent: Written informed consent was obtained from patients who participated in this study.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept - A.T.; Design - A.T., İ.B.; Supervision - A.T.; Resources - A.T., A.A; Materials - A.T., A.A; Data Collection and/or Processing - İ.B., M.T.; Analysis and/or Interpretation - A.T., İ.B., Literature Search - İ.B., M.T.; Writing Manuscript - A.T., İ.B., M.T.; Critical Review - A.T.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study has received no financial support.

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Turk J Urol 2016; 42(4): 261–6
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