World J Urol
DOI 10.1007/s00345-015-1503-x

ORIGINAL ARTICLE

Comparison of flexible ureterorenoscopy and micropercutaneous nephrolithotomy in the treatment for moderately size lower-pole stones

Abdullah Armagan · Tuna Karatag · Ibrahim Buldu · Muhammed Tosun · Ismail Basibuyuk · Mustafa Okan Istanbulluoglu · Abdulkadir Tepeler

Received: 24 December 2014 / Accepted: 29 January 2015

Abstract
Purpose To present a retrospective comparative clinical study of micropercutaneous nephrolithotomy (microperc) versus flexible ureterorenoscopy (F-URS) in treatment of moderate-size lower-pole stones (LPSs).
Methods We retrospectively reviewed data on patients with isolated LPSs $\leq$2 cm in diameter treated with F-URS and/or microperc in two referral centers. Patients were divided into two groups by treatment modality: F-URS (Group 1) and microperc (Group 2). Demographics and perioperative parameters were analyzed.
Results A total of 127 patients with isolated LPSs were treated via F-URS (Group 1, $n = 59$) and microperc (Group 2, $n = 68$). Mean patient age in microperc group was slightly lower than in F-URS group ($p = 0.112$). We found no statistically significant difference in terms of either the size or number of stones in two groups ($p = 0.113$ and $p = 0.209$, respectively). Operative time was shorter in microperc, whereas fluoroscopy time was shorter in F-URS (60.1 ± 26.2 vs. 46.2 ± 24.3 min, $p < 0.001$; and 28.3 ± 19.1 vs. 108.9 ± 65.2 s, $p < 0.001$). Mean fall in hemoglobin level was statistically significantly lower in F-URS and hospitalization time was also significantly shorter in F-URS (0.68 ± 0.51 vs. 1.29 ± 0.88 mg/dL, $p < 0.001$; and 23.0 ± 58.1 vs. 33.8 ± 17.2 h, $p < 0.001$, respectively). Stone-free rates (SFRs) were 74.5 % (44/59) in Group 1 and 88.2 % (60/68) in Group 2 ($p < 0.001$).
Conclusions We found that microperc was safe and efficacious when used to treat moderate-size LPSs and may be considered as an alternative to F-URS, affording a higher SFR. Our study supports the notion that microperc should play an increasing role in treatment of LPSs.

Keywords Micropercutaneous nephrolithotomy · Flexible ureterorenoscopy · Lower-pole stones · Comparison

Introduction

Management of lower-pole stones (LPSs) remains controversial because of the spatial anatomy of the lower calyx and variations in stone size. The invasiveness of any procedure must also be considered when selecting the optimal treatment modality. Flexible ureterorenoscopy (F-URS), shock-wave lithotripsy (SWL), and percutaneous nephrolithotomy (PNL) are established treatment options (in selected cases) for the management of LPSs less than 2 cm in diameter, based on guideline recommendations [1]. SWL remains a popular outpatient procedure, being noninvasive and requiring no anesthesia, despite a less-than-complete success rate [2, 3].

Although F-URS was initially introduced as a diagnostic modality, improvements in optical systems and introduction of the Ho/YAG laser have rendered F-URS an acceptable therapeutic option in the management of kidney stones [4]. However, deflection problems encountered when inserting the endoscope into the lower calyx affect the utility of F-URS in the treatment for LPSs [5]. However, F-URS seems to be better than conventional PNL, affording the advantages of decreased levels of postoperative complications and reduced morbidity, but with a comparable success rate [6, 7].

A. Armagan (✉) · M. Tosun · I. Basibuyuk · A. Tepeler
Department of Urology, Faculty of Medicine, Bezmialem Vakif University, Istanbul 34093, Turkey
e-mail: aarmagantr@gmail.com

T. Karatag · I. Buldu · M. O. Istanbulluoglu
Department of Urology, Faculty of Medicine, Mevlana University, Konya, Turkey

Published online: 25 February 2015

Recently, the microperc technique has been introduced to PNL to minimize tract size and associated morbidity; both the optical system and the instrumentation have been improved [8]. Apart from high success rates, several studies have emphasized the feasibility and safety of microperc in the treatment for small and moderately sized kidney stones [9, 10].

We present a retrospective comparative clinical study of microperc versus F-URS in the treatment for isolated LPSs. To our knowledge, this is the first clinical comparison of these two modalities for treating LPSs.

Table 1 Demographic values of the patients

	F-URS (Group 1)	Microperc (Group 2)	*p*
N	59	68	
Male/female	36/23	35/33	
Age* (years)	49.3 ± 15.3	43.6 ± 18.9	0.112
BMI* (kg/m^2)	26.8 ± 7.1	26.3 ± 4.46	0.674
Stone size* (mm)	14.4 ± 3.1	13.7 ± 4.2	0.113
Number of stone*	1.6 ± 0.9	1.4 ± 0.6	0.209

* Mean ± SD

Materials and methods

We retrospectively reviewed data on patients with isolated LPSs ≤2 cm in diameter treated with F-URS and/or microperc nephrolithotomy in two referral centers between March 2012 and June 2014. In one of the center, only microperc procedures were performed for lower-pole stones with failure of SWL because of the unavailability of F-URS. Besides the F-URS, microperc was performed for patients with histories of failed SWL and/or RIRS in the second center. In addition, patients' preferences were considered in a small part of patients in both groups. The patients were divided into two groups by treatment modality: F-URS (Group 1) and microperc (Group 2). Demographics including age; stone size; and perioperative parameters (fluoroscopy and operation times, falls in hemoglobin levels, stone-free status, and complication rates) were analyzed using a database system.

Each patient completed and signed an informed consent form and underwent routine biochemical and microbiological tests preoperatively. Patients with positive urine cultures were treated with appropriate antibiotics. Renal ultrasonography, kidney–ureter–bladder (KUB) radiography, and/or computed tomography (CT) were performed.

Microperc

The microperc procedure was performed in a standard manner with patients in the prone position under general or spinal anesthesia. After insertion of a 6- or 7-Fr open-ended ureteral catheter, percutaneous renal access to the lower calyx was achieved using a 16-G "all-seeing needle" (PolyDiagnost, Pfaffenhofen, Germany) under C-arm fluoroscopic guidance, and the inner puncture shaft was then removed. A three-way connector allowing the insertion of a 0.9-mm-diameter flexible micro-optic cable, a laser fiber, and an irrigation system was attached to the outer tip of the shaft. Stone fragmentation was usually achieved using a 200-μm holmium–yttrium–aluminum–garnet (Ho/YAG) laser fiber in the settings of high frequency–low pulse energy (HiFr–LoPE) at 0.4–0.8 Joules (J) and 10–20 Hertz (Hz). A mechanical pump with foot pedal control was used for irrigation. Saline irrigation supports the maintenance of proper vision and removal of the stone debris during the surgery and provides the flush out of the stone fragments and dust particles through the 6- or 7-Fr open-end ureteral catheter continuously.

After completion of disintegration and confirmation of stone-free status via endoscopic and fluoroscopic imaging, the microshaft was removed and the procedure terminated. The operative time was defined as the duration from the beginning of renal puncture to the removal of the percutaneous system from the kidney.

F-urs

In our clinic, we first performed diagnostic ureteroscopy to eliminate the possibilities of ureteral calculi or other pathological conditions. A guide wire was inserted to the point of the collecting system, and diagnostic ureteroscopy was performed using a 7.2-Fr semirigid ureteroscope. Next, a ureteral access sheath was placed at the location of the proximal ureter, over a guide wire, with fluoroscopic guidance. A 7-Fr flexible ureterorenoscope (Storz Flex X2, Germany) was inserted into the urinary tract through the access sheath. Stone fragmentation was achieved with the aid of a 200-μm holmium–YAG laser fiber operating in the setting of 0.5–0.8 J at 10–20 Hz. In some cases with stones in the step of the infundibulopelvic angle, the stones were initially relocated to the renal pelvis or upper calyx with the aid of a basket. A double-J catheter was placed for 2 weeks and removed in the outpatient clinic. The operative time was the period between the beginning of ureteroscopy and completion of JJ stenting at the end of fragmentation.

If no complication was evident, patients were routinely discharged after removal of the urethral and ureteral catheters, and radiological assessment via plain radiography, on postoperative day 1. The overall success rate was calculated on the basis of absence of any residual fragment on ultrasonography, KUB, and/or CT (if required) images at 1 month of follow-up. Postoperative complications were graded using the Clavien system [11].

Table 2 Comparison of postoperative outcomes

	F-URS	Microperc	p
Operative time* (minutes)	60.1 ± 26.2	46.2 ± 24.3	<0.001
Fluoroscopy time* (seconds)	28.3 ± 19.1	108.9 ± 65.2	<0.001
Hospitalization* (hours)	23.0 ± 58.1	33.8 ± 17.2	<0.001
Hemoglobin drop* (g/dL)	0.68 ± 0.51	1.29 ± 0.88	<0.001
Stone-free rate (*n* %)	44/59 (74.5)	60/68 (88.2)	<0.001
Complications			
Intractable renal colic (Clavien grade IIIa)	6	1	
Acute pyelonephritis (Clavien grade I)	2	1	
Instrument impairments	–	1	

* Mean ± SD

Statistical analysis

Data analysis was performed with the aid of the SPSS statistical package (version 16.0 J; SPSS, Inc., Chicago, IL). Patient and operative parameters were compared between groups using the Mann–Whitney *U* test to analyze numerical variables and the Chi-squared test to explore categorical variables. A p value <0.001 upon Mann–Whitney *U* testing was considered to reflect statistical significance.

Results

A total of 127 patients with isolated LPSs were treated via F-URS (Group 1, $n = 59$) and microperc (Group 2, $n = 68$). Although the mean patient age in the microperc group was slightly lower than in the F-URS group, the difference did not attain statistical significance (49.3 ± 15.3 vs. 43.6 ± 18.9 years, respectively, $p = 0.112$). The mean body mass indices (BMIs) of the two groups were also similar (26.8 ± 7.1 vs. 26.3 ± 4.46 kg/m^2, $p = 0.674$). We found no statistically significant difference in terms of either the size or number of stones in the two groups ($p = 0.113$ and $p = 0.209$, respectively). Three abnormalities, including horseshoe kidney (n: 1), pelvic kidney (n: 1), and a rotation anomaly of the kidney (n: 1), were noted in Group 1. In Group 2, a scoliosis deformity was evident in one patient, whereas two had solitary kidneys. The demographic data on all patients are summarized in Table 1.

We found statistically significant differences with respect to operative and fluoroscopy times when we compared the two groups (60.1 ± 26.2 vs. 46.2 ± 24.3 min, $p < 0.001$; 28.3 ± 19.1 vs. 108.9 ± 65.2 s, $p < 0.001$). We also found statistically significant differences between the groups in terms of the mean fall in hemoglobin level and hospitalization time (0.68 ± 0.51 vs. 1.29 ± 0.88 mg/dL, $p < 0.001$; 23.0 ± 58.1 vs. 33.8 ± 17.2 h, $p < 0.001$, respectively). No blood transfusion was required by any patient.

The stone-free rates (SFRs) were 74.5 % (44/59) in Group 1 and 88.2 % (60/68) in Group 2; the difference was statistically significant ($p < 0.001$). In the F-URS group, six patients underwent a further PNL procedure, and SWL was planned for the remaining patients with residual fragments attributable to the failure of F-URS. Mini-PNL was performed in six patients, and SWL was considered for two patients with residual fragments, in failed cases of Group 2. In terms of complications, six patients in Group 1 suffered intractable renal colic pain postoperatively (Clavien grade IIIa), and acute pyelonephritis developed in two. In Group 2, three complications were observed; these were instrument impairment during surgery (n:1), renal colic requiring stent insertion (Clavien grade IIIa, n: 1), and urinary tract infection (Clavien grade I, n: 1). The clinical and operative outcomes are summarized in Table 2.

Discussion

Current treatment options have been revised in line with the increasing incidence of kidney stones over time [12]. F-URS, miniperc, microperc, and ultra-miniperc were developed to improve success rates and reduce morbidities. In the present study, we evaluated two of these treatment modalities in management of LPSs; such management remains very controversial.

For most urologists, the spatial anatomy of the inferior caliceal system creates difficulties during F-URS and for spontaneous passage of stone fragments after SWL or other lithotripsy procedures. Moreover, the effect on and importance of lower-pole spatial anatomical features, including the infundibular width (IW), infundibular length (IL), and lower-pole infundibulopelvic angle (IPA) in the context of stone clearance have been addressed in several studies [13–15]. Resorlu et al. evaluated the influence of pelvicaliceal anatomy on the success rate of retrograde intra-renal surgery (RIRS) used to treat LPSs, to identify factors important in patient selection. This retrospective study reviewed data on 67 patients [16]. The cited authors measured infundibular length (IL), infundibular width (IW), pelvicaliceal height (PCH), and IPA on preoperative images (intravenous urograms, IVUs). It was concluded that lower-pole anatomy, especially the IPA, significantly impacted stone clearance rates, as did stone size after F-URS. Manikandan et al. also evaluated IVUs of 40 consecutive patients presenting with single lower-pole stones to determine whether anatomical factors predisposed to stone formation on one particular side [17]. It was concluded that the IPA might play a role in predisposing one kidney to the formation of lower-pole stones. It was also emphasized that a consensus on precise measurement of the IPA was required. However, in another clinical trial, Jacquemet et al. compared the use of F-URS to treat LPSs in various renal locations in 371 cases [18]. It was found that LPS location did not influence the efficacy of or morbidity from F-URS. However, it was mentioned that multiple stones and a stone diameter larger than 10 mm seemed to significantly decrease SFRs without affecting morbidity. We did not measure anatomical lengths prior to surgery in most patients. Therefore, we did not perform subgroup analysis. However, we accept that anatomy may be important in terms of patient selection for treatment with particular modalities.

Apart from trials focusing on the importance of spatial anatomical measurements, F-URS and PNL have been clinically compared in several studies. Sabnis et al. were the first to compare microperc and F-URS for the management of renal calculi <15 mm in diameter in a randomized prospective trial featuring 70 patients [19]. It was reported that microperc afforded stone-free and complication rates similar to those of F-URS. Moreover, it was stressed that microperc was associated with higher-level hemoglobin loss, increased pain, and greater analgesic requirements, whereas F-URS was associated with a higher rate of JJ stenting. However, our data differ, based on our assessment of LPSs.

Bozkurt et al. [20] retrospectively compared the outcomes of conventional PNL and F-URS used to treat the LPSs of 79 patients. No statistically significant difference was found in either SFRs or complication rates, but the F-URS operative time was longer and hospitalization after PNL was more prolonged. Although the complication rates were similar, we found, in our work, that the use of the microperc system facilitated access to the lower calyx under direct vision, and avoided major injury to the kidney because the sheaths used are larger than those employed during conventional PNL. Our clinical trial differs from studies comparing conventional PNL with F-URS; we compared microperc with F-URS.

We found that the outcomes after microperc were in agreement with those of other clinical reports on microperc success and complication rates [9, 19]. The microperc SFR was higher and the operative time was shorter than for F-URS. Our SFR after F-URS seems to be lower than noted in previous F-URS reports [16, 18]. However, we would state that our SFRs are based exclusively on LPSs. As mentioned previously, active deflection during F-URS may compromise convenient removal of LPSs because of spatial anatomical factors [15, 16], thereby we converted to PNL in six patients with stone diameters 15–20 mm. We did not exclude such converted cases when calculating SFRs. We also found a clear difference between the two groups in terms of fluoroscopy time.

We would highlight that F-URS should be considered for adolescent and child patients for whom radiation exposure should be minimized. Also, the microperc operative time was significantly shorter than that of F-URS. This may be associated with the need to perform a diagnostic evaluation via ureteroscopy prior to F-URS, and/or difficulties with deflecting the lower calyx. However, the puncture required by the microperc system seems to render it easier to reach the lower calyx. Also, we did not measure the duration of preparation prior to microperc, which included ureteral catheter insertion and turning to the prone position. The difference in operative times may also be associated with this fact.

Although the mean fall in hemoglobin level during microperc differed significantly from that during F-URS, no patient in either group required a blood transfusion. Microperc has the advantages that it is a single-step procedure and that the tract dilatation required is not extensive, as described above. Thus, as might be expected, major hemorrhage seems to be rare because of the sheaths used in conventional PNL. However, some hemorrhage may occur during microperc because the procedure features puncture. On the other hand, six microperc cases were converted to mini-PNL because of a need to remove stones from the upper caliceal system and/or an inability to achieve clear vision on the monitor. One patient also had a urinary tract infection that was managed via appropriate intravenous antibiotics. Six patients developed renal colic despite the placement of a double-J stent in the ureter. Acute pyelonephritis developed in two patients who were re-hospitalized for treatment with intravenous antibiotics.

The effectiveness of stone fragmentation can be influenced by laser settings such as applied energy, pulse duration, and frequency as well as the fiber diameter [21]. We should also underline that commonly we have used Ho/YAG laser with a small caliber fiber such as 200 µm commonly in the settings of high frequency–low pulse energy. We consider that Ho/YAG laser with smaller-diameter fiber may provide an ability to reach difficult point of collecting system such as lower calices and allows using working channel more functional as mentioned previously [22].

As a standard manner, microperc procedures are performed in prone position in both two centers. However, we may stress that complications such as brachial plexus and tongue injuries, and ventilation disorders, may occur when patient's position is changed from supine to prone, due to the displacement of the endotracheal tube [23]. According to our best knowledge, only one published clinical trial is available in the literature regarding supine microperc procedure [24]. On the other hand, we should highlight that F-URS requires no changing position. Moreover, the duration of initiative preparation stages of PNL procedures might be increased in prone position due to positioning difficulties such as trying to keep the endotracheal tube in place and/or putting bumper pads for the patients who received general anesthesia [25].

The retrospective nature of the work is the principal limitation of the present study. In addition, CT controls at first month, did not comprise all of the patients due to concerns in radiation exposure. Despite these facts, we suggest that we have contributed to the kidney stone literature; this is the first comparative study of F-URS and microperc in the treatment for LPSs.

Conclusions

We found that microperc was safe and efficacious when used to treat moderately sized LPSs and may be considered as an alternative to F-URS, affording a higher SFR. Microperc was associated with a greater fall in hemoglobin level, and F-URS was superior to microperc in terms of both hospitalization and fluoroscopy durations. Our study supports the notion that microperc should play an increasing role in treatment for LPSs. Furthermore, these procedures may be considered even as a complementary procedures.

Conflict of interest The authors declare that they have no competing interest.

Ethical standard The study was approved by the local ethics committee and performed in accordance with the Declaration of Helsinki and its amendments. All patients provided written informed consent.

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