Retrospective Analysis of Ultrasound-guided Flexible Ureteroscopy in the Management of Calyceal Diverticular Calculi

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Abstract

Background: Percutaneous nephrolithotomy (PCNL) is the most widely recommended treatment for calyceal diverticular calculi, providing excellent stone-free results. However, its invasiveness is not negligible considering its major complication rates. Flexible ureteroscopy (FURS) is currently used to treat calyceal diverticula. However, the greatest drawback of FURS is locating the diverticulum since its neck is narrow and concealed. In such a case, the FURS procedure must be converted to PCNL. The aim of this study was to evaluate ultrasound-guided flexible ureteroscopy (UFURS) identifying diverticulum and the management of calyceal diverticular calculi.
Methods: A retrospective analysis was conducted on 24 patients who had calyceal diverticular calculi. In all 12 patients in the UFURS group, direct FURS failed to find evidence of calyceal diverticula but were confirmed with imaging. The other 12 patients in the PCNL group received PCNL plus fulguration of the diverticular walls.
Results: Puncture of calyceal diverticulum was successful in all 12 UFURS patients. Two patients in this group had postoperative residual calculi and two patients developed fever. In the PCNL group, percutaneous renal access and lithotomy were successful in all 12 patients. One patient in this group had residual calculi, one had perirenal hematoma, and two patients developed fever. No significant difference was found in the operating time (UFURS vs. PCNL, 91.8 ± 24.2 vs. 86.3 ± 18.7 min), stone-free rate (UFURS vs. PCNL, 9/12 vs. 10/12), and rate of successful lithotripsy (UFURS vs. PCNL, 10/12 vs. 11/12) between the two groups (all $P > 0.05$). Postoperative pain scores in the FURS group were significantly lower than that in the PCNL group (2.7 ± 1.2 vs. 6.2 ± 1.5, $P < 0.05$). Hospital stay in the UFURS group was significantly shorter than that in the PCNL group (3.4 ± 0.8 vs. 5.4 ± 1.0 days, $P < 0.05$). All patients were symptom-free following surgery (UFURS vs. PCNL, 10/10 vs. 12/12).
Conclusion: Ultrasound-guided puncture facilitates identification of calyceal diverticula during FURS and improves the success rate of FURS surgery.

Key words: Calyceal Diverticulum; Calyceal Diverticulum Calculi; Flexible Ureteroscope; Percutaneous Nephrolithotomy; Puncture; Ultrasound

Introduction

Calyceal diverticulum is an abnormal cavity in the renal parenchyma. The cavity of the diverticulum is lined with nonsecretory transitional cell epithelium and communicates with the collecting system through a narrow orifice. Diverticular neck stenosis can cause diverticular dilation, urine stasis, stone formation, and infection.[1-3] Calyceal diverticula are mostly asymptomatic and are often diagnosed during imaging examination for other causes. Calyceal diverticulum is seen in 0.21–0.60% of intravenous pyelography (IVP). It is most commonly located at the upper pole of the kidney, with up to 50% of diverticula containing calculi.[3-7] Patients with symptomatic calculi may present with flank pain, repeat urinary tract infection,

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and gross hematuria.[5-7] Surgical intervention is required for symptomatic calculi.[2,6]

After removing the diverticular stone via percutaneous nephrolithotomy (PCNL), dilatation of the calyceal diverticular neck and electrocoagulation of the diverticulum wall are performed.[5-7] However, PCNL is associated with disadvantages of massive trauma, long hospital stay, and multiple complications.[6,7] In recent years, flexible ureteroscopy (FURS) has been used for the treatment of calyceal diverticula. Despite its advantages, many diverticular necks are narrow and concealed with atresia and obstruction, thus warranting PCNL treatment.[2,4-11]

Retrograde intrarenal surgery (RIRS) is hampered by difficult access to the lower calyx and low lithotripsy efficiency. Nevertheless, the development of FURS and related technology has contributed to the efficacy of RIRS FURS.[2-4,6-9,12-15] FURS combined with Holmium laser facilitate the incision of diverticular infundibulum, stone removal, and relapse prevention.[2,6,8,9,15,16] Because the majority of diverticula are located at the mid and upper portion of the affected kidney, modern ureteroscopy with greater rotating angle allows access to the lower calyx with an infundibulopelvic angle <30°.[17,18] FURS is more advantageous than techniques such as PCNL in particular for anterior diverticula.[4,6,7,9,17,18] Bas *et al*.[6] reported that the success rate of FURS for low calyceal diverticula was up to 60%, but a second PCNL was required if there was difficulty finding the diverticular orifice during FURS.[6-9,17] Auge *et al*.[7] also reported that in four of fourteen patients, they failed to find a diverticular orifice during FURS, which then required PCNL. In 18 of 22 cases undergoing PCNL, access to the renal collecting system could not be established and a new diverticular infundibulum was required because the guidewire failed to pass through the diverticular neck. Therefore, the rapid positioning of the diverticular orifice is the key to successful RIRS treatment of calyceal diverticular calculi.[9,15,16]

In 1995, Gross *et al*.[9] reported the combination of FURS with PCNL in the management of calyceal diverticular calculi. However, the successful positioning and dilation of diverticular orifice via retrograde FURS were a prerequisite. Subsequently, standard PCNL was performed after percutaneous ureteroscope-guided guidewire insertion into the ureter from the diverticulum. In 2006, Matlaga *et al*.[19] reported three cases of fluoroscopy-guided PCNL following preoperative computed tomography (CT) or ultrasound-guided calyceal diverticular puncture with an injection of contrast agent. There are three major defects with this method: (1) prior to surgery, it is unknown whether or not the diverticular neck and orifice can be identified intraoperatively, which might increase the possibility of unnecessary punctures, (2) the operative and puncture procedures are separate, which increases pain and exposure to radiation, and (3) injection of contrast agent is a prerequisite with this method and the procedure duration is short, thus absorption of the contrast results in loss of target during the procedure. PCNL performed in the lateral supine position either ultrasonographically or radiologically is safe and effective.[20,21] Therefore, when ureteroscopy is conducted in an oblique supine lithotomy position, ultrasound-guided percutaneous diverticular puncture enables positioning of the diverticulum. This might increase surgical success, avoid radiologic exposure, obviate the need for radiological protection equipment, and save time. This retrospective analysis was done to evaluate the efficacy and safety of real-time ultrasound-guided diverticular puncture for FURS treatment of calyceal diverticular calculi. To our knowledge, there are rare reports in the literature on this technique.

Methods

From November 2012 to July 2015, we used ultrasound-guided puncture to facilitate FURS treatment of 12 patients with calyceal diverticular calculi complicated by a stenotic or atretic diverticular neck. Twelve patients with PCNL-treated calyceal diverticular calculi during the same period served as the control group. The study was conducted with the approval of Beijing Chaoyang Hospital Ethics Committee.

Clinical materials

Prior to operation, CT or IVP was performed to confirm the location and size of calculi. Patients were divided into ultrasound-guided flexible ureteroscopy (UFURS) group and PCNL group. In the UFURS group (n = 12; eight men and four women), patients treated with UFURS included seven with flank pain, three with urinary tract infection, and two patients who were asymptomatic. Two patients had a history of extracorporeal shock wave lithotripsy (once and three times, respectively). In the PCNL group (n = 12; six men and six women), PCNL was performed including seven with flank pain, two with hematuria, and three with urinary tract infection. Three patients received extracorporeal shock wave lithotripsy (twice, once, and four times, respectively). Data such as the affected side, diverticular distribution, and stone burden in the two groups are summarized in Table 1. Preoperative urinalysis and urine culture were performed. Patients with urinary tract infection received antibiotic treatment for 3 days prior to surgery and underwent repeat urinalysis. When urine white blood cell counts were normalized, surgery was performed.

Surgical methods

Flexible ureteroscopy

Patients received general anesthesia via laryngeal mask airway or tracheal intubation. The first two patients were placed in lithotomy position and were subsequently altered to oblique supine lithotomy position during puncture. The other ten patients were placed in oblique supine lithotomy position throughout the procedure to expose the affected kidney and facilitate ultrasound examination and puncture. Ureteral access sheath (Boston Scientific Corporation, Massachusetts, USA) was placed after ureteroscopic examination and dilation of the ureter. If the diverticulum

Table 1: Baseline characteristics of UFURS and PCNL groups

Characteristic	UFURS group (n = 12)	PCNL group (n = 12)	Statistics	P
Male/female, n	8/4	6/6	0.686*	0.680
Age (years), mean ± SD	44.8 ± 14.2	39.3 ± 13.7	0.965†	0.345
Stone burden (mm), mean ± SD	12.4 ± 5.1	14.1 ± 5.5	0.758†	0.456
Diverticular maximum diameter (mm), mean ± SD	15.7 ± 6.0	20.3 ± 5.0	2.058†	0.052
Affected side, n				
Left	7	6	0.169*	0.682
Right	5	6		
Location of diverticula, n				
Upper pole	3	4	0.767*	0.761
Mid pole	7	5		
Inferior pole	2	3		

Data are presented as n or mean ± SD. *Chi-square test; †Mann-Whitney U-test. UFURS: Ultrasound-guided flexible ureteroscopy; PCNL: Percutaneous nephrolithotomy; SD: Standard deviation.

was not found under FURS (Olympus, Tokyo, Japan) or the Blue Spritz technique, which involved instillation of methylene blue (Jumpcan, Jiangsu, China) into the collecting system,[4,5,8,10] a G18 puncture needle (Bard, Covington, GA, USA) was used for diverticular puncture under ultrasound guidance. Calyceal diverticula and stones were identified under ultrasound. In patients with small diverticular cavities, puncture needle was forwarded to the stone and the needle core was withdrawn if the needle entered the diverticulum or the stone was moved. Urine outflow or urine withdrawal by a syringe indicated successful puncture. The direction of the puncture needle was maintained and its position continuously monitored. After connecting to an extension tube, the needle sheath was attached to a syringe containing methylene blue solution. The solution was injected into the cavity of the diverticulum via the puncture needle sheath. The diverticulum orifice was observed under FURS and a holmium laser (Shanghai Raykeen Laser Technology Co., Ltd., Shanghai, China) with high frequency and low energy (such as 30 Hz, 0.9 J) was used to fully dilate the orifice. If the orifice was not located, the guidewire (Boston Scientific Corporation, Massachusetts, USA) was introduced via the puncture sheath and oscillated to assist ureteroscopic positioning of the diverticulum. An incision was created at the weakest point on the diverticular wall until the flexible ureteroscope passed through. The stone was crushed and the fragments were washed out under FURS or removed from the diverticulum using an extractor or basket. Larger stone fragments were removed by the basket (Boston Scientific Corporation, Massachusetts, USA). After ensuring patency of the diverticular orifice, a ureteral stent (6.0 Fr) (Boston Scientific Corporation, Massachusetts, USA) was placed with the upper segment within the diverticulum or the calyces.

Percutaneous nephrolithotomy

The ultrasound-guided puncture was performed. Subsequent steps were carried out as described previously.[3,10,22] After stone removal, the diverticular orifice was dilated or incised, the wall was then fulgurated and a ureteral stent (6.0 Fr) was inserted from the diverticulum into the ureter, and a drainage tube placed in the diverticulum.

Postoperative examination and evaluation of outcomes

On postoperative day 1, in the UFURS group, a plain abdominal X-ray was obtained to observe the position of the ureteral stent. Renal ultrasound was conducted to observe perinephric effusion or hematoma in the affected kidney. In the PCNL group, plain abdominal X-ray was performed 1–3 days postoperatively. The drainage tube was removed when no fluid was observed. Stents in both the UFURS and PCNL groups were removed 2–4 weeks after surgery. One month after stent removal, plain abdominal X-ray, ultrasound, and CT were performed for observation of residual calculi. Three months after surgery, treatment outcomes were evaluated. IVP or CT was used to examine change in size of the diverticulum and look for recurrent stones. Asymptomatic stones <4 mm were defined as stones without clinical significance. Absence of residual calculi and nonclinically significant stones indicated successful lithotripsy. Residual stones measuring more than 4 mm were defined as residual calculi with clinical significance.[2,23,24] Visual analog scale (VAS) was used for pain assessment on postoperative day 1. Evaluation and scoring of complications were based on the modified Clavien-Dindo classification.[25] Assessment of symptoms was made 3 months after surgery.

Statistical analysis

Statistical analysis was performed using the Statistical Package for Social Sciences, version 16.0 (IBM, Armonk, NY, USA). A value of $P < 0.05$ was considered significant. Chi-square/Fisher's exact and Mann-Whitney U-tests were used to evaluate association among the different variables.

Results

Preoperative data

No significant difference between the UFURS and PCNL groups was observed in age, maximum stone diameter, maximum diverticular diameter, location of the diverticulum, or distribution of the affected side ($P > 0.05$) [Table 1]. One and two patients were positive for *Escherichia coli* in the UFURS and PCNL groups, respectively.

Perioperative and postoperative results

Successful puncture was achieved in all 12 patients in the UFURS group under ultrasound. Methylene blue was observed flowing from the diverticular orifice in six patients. In the other six patients without imaging evidence of the diverticulum, a guidewire was inserted via the needle sheath and oscillated to assist in positioning the diverticulum, as well as incision and reconstruction of the diverticular infundibulum under FURS. After diverticular wall was incised, guidewire and calculi could be found. Complete incision and drainage were performed on 12 patients. In one patient, bleeding was observed during incision, which affected the visual field. The inner core was inserted into the ureteral access sheath. After approximately 5 min, FURS continued without any blood transfusion. No perinephric effusion or hematoma was detected in the affected side during color Doppler ultrasound a day after surgery. Plain X-ray results showed that in five patients the upper ureteral stent segments were located within the diverticula, and in seven patients, they were located within the renal calyces. In the PCNL group, percutaneous renal access was successfully established in all 12 patients. The stones were removed and the diverticular wall fulgurated.

One month after stent removal, two patients had clinically significant residual calculi in the UFURS group, one of whom was asymptomatic prior to surgery. In the first patient, the diverticulum with residual calculi was located in the mid and lower pole of the kidney. The diverticular infundibulum showed prolonged bleeding during incision, and multiple stones were observed. Flank pain disappeared after surgery. FURS performed 1 month after stent extraction indicated no obvious shrinkage in the reestablished diverticular orifice and an unchanged diverticulum compared with the previous surgery. Holmium laser was used to fragment the 4 mm stone. In the second patient, the diverticulum was located at the lower pole of the kidney. Repeat ureteroscopy indicated a fully patent diverticular orifice and the stone was located at the deepest site away from the orifice. Due to the small angle of the infundibulum and stone location at the bottom of the diverticulum, incision was repeated to remove the stone. No residual calculi were seen in these two patients 1 month after the second surgery. In the PCNL group, one patient had a 4 mm residual stone and another had a 2 mm residual stone. PCNL was repeated to remove the 4 mm stone, without any complications. Surgery was not repeated in the patient with the 2 mm stone due to nonconsent.

No significant difference was observed in surgical time, stone-free rates, rate of successful lithotripsy, and complications between the two groups ($P > 0.05$) [Table 2]. Pain scores in the UFURS group were significantly lower than that in the PCNL group (2.7 ± 1.2 vs. 6.2 ± 1.5, $P < 0.05$). Hospital stay in the UFURS group was significantly shorter than that in the PCNL group (3.4 ± 0.8 vs. 5.4 ± 1.0 days; $P < 0.05$).

Complications and results 3 months postsurgery

After surgery, two patients each in the UFURS and PCNL groups developed fever. Fever disappeared after antibiotic treatment. Perirenal hematoma was found in one patient in the PCNL group. It was resolved after puncture drainage under local anesthesia; no hemopneumothorax occurred. Ten patients in the UFURS group who had symptoms prior to surgery and 12 patients in the PCNL group became asymptomatic 3 months after surgery. CT or IVP examination performed 3 months after surgery indicated that diverticula disappeared in five of twelve patients, decreased in size in seven patients in the UFURS group (6.1 ± 2.2 vs. 19.3 ± 4.3 mm; $P < 0.05$) and disappeared in eight of twelve patients, decreased in size in four patients in the PCNL group (4.5 ± 1.3 vs. 25.8 ± 3.3 mm; $P < 0.05$). No residual calculi were seen in the two groups except in one patient with a 2 mm residual stone in the PCNL group.

Table 2: Perioperative, postoperative results and operative complications classified according to Clavien-Dindo system

Variables	UFURS group (*n* = 12)	PCNL group (*n* = 12)	Statistics	*P*
Surgery time (min), mean ± SD	91.8 ± 24.2	86.3 ± 18.7	0.624*	0.539
Stone-free rate, *n*	9	10	0.253†	0.615
Rate of successful lithotripsy, *n*	10	11	0.381†	1.000
VAS score postoperative day 1	2.7 ± 1.2	6.2 ± 1.5	2.580*	0.017
Complications, *n*	2	3	0.253†	0.615
Grade II	2	2	0.001†	1.000
Grade IIIa	0	1	1.043†	1.000
Hospital stay (days)	3.4 ± 0.8	5.4 ± 1.0	5.441*	0.001
Diverticular state after 3 months, *n*				
Disappearance	6	10	3.000†	0.193
Decreased in size	6	2		
Symptom-free rate, *n*	10	12		–

Data are presented as *n* or mean ± SD. All *P* values represent comparisons between UFURS group and PCNL group, two-tailed test; *Mann-Whitney *U*-test; †Chi-square test. UFURS: Ultrasound-guided flexible ureteroscopy; PCNL: Percutaneous nephrolithotomy; VAS: Visual analog scale; SD: Standard deviation; –: No data.

Discussion

The goal of the management of calyceal diverticular calculi is the complete removal of stone and dilation of the diverticular infundibulum, resulting in complete drainage (or diverticular fulguration without infundibular dilation).[5-8] Advantages of PCNL include high stone removal rate, diverticular epithelium fulguration, and diverticular neck incision under direct visualization after stone removal. PCNL even enables dilation to establish a new diverticular tunnel through the wall of the diverticulum to the collecting system under fluoroscopic guidance.[4,7,10] In particular, PCNL is the preferred technique for large posterior, mid to lower pole diverticular stones.[4-9] However, PCNL is difficult to master, with frequent channel loss. Loss of channel or hemorrhage might easily occur in small or anterior diverticulum because the diverticular cavity cannot adequately contain the guidewire coil or the guidewire passes through excessive renal parenchyma.[2,5-10,17] In addition to lower pole diverticulum, the main difficulty in finding the diverticular orifice is a small, atretic, or shrunken orifice.[4,6-8,10,19] Atresia or shrinkage of the orifice might result from inflammation or stone impaction.

The greatest advantage of ureteroscopy assisted by a ultrasound-guided calyceal diverticular puncture in treating calyceal diverticula is rapid and accurate positioning or identification of the diverticular orifice via trans-needle injection of methylene blue or guidewire placement. In particular, in patients with diverticular atresia, bulging of the diverticular wall or fluctuation of the diverticular wall caused by movement of the guidewire can be observed under ureteroscopy. In the present study, diverticular orifices were found in six patients by percutaneous injection of methylene blue into the diverticular cavity. In the other six patients without unidentified diverticula, the diverticular walls were located and laser-incised and the infundibula reestablished via the guidewire. Bas *et al*.[6] used FURS with holmium laser to incise the diverticular neck for the treatment of calyceal diverticula, which was similar to our approach. In one patient of the present study, clinically significant residual stone and diverticulum were found at the mid and lower pole of the kidney, which might have been associated with the distant location of the diverticulum from the collecting system: the stone was in the deepest site (bottom) of the diverticulum, which limited the ureteroscope active bending angle when the laser probe was inserted. Another stone was in the lower pole of the kidney. A fistula catheter is often placed in the dilated diverticular infundibulum after PCNL, which is believed to benefit the channel epithelium coverage and maintain channel patency, however, no control experiments have been performed to validate this technique.[1,7] Currently, holmium laser treatment enables adequate stone exposure, diverticular drainage, stone removal, and relapse prevention.[2,8,17] However, because blood vessels, such as interlobar arteries surrounding the diverticulum, might be damaged during diverticular neck incision, the incision should be carefully made at the weakest point, in particular when dealing with the anterior and posterior aspects of the diverticular orifice.[2,5,9,10] After lithotripsy or lithotomy, reexamination should be made to confirm adequate patency of the diverticular orifice. If bleeding occurs, surgery should be stopped and the ureteral access sheath closed to maintain intrapelvic pressure so as to facilitate hemostasis. If reexamination indicates no obvious bleeding, incision of the weak point can be continued or the surgery terminated.

In the study, no significant difference was found in surgical time between the two groups. Surgical time for PCNL-treated calyceal diverticula was similar to previous reports.[5,17,19,26] Time for FURS in this study was similar to that reported by Sejiny *et al*.[2] (80–210 min, average 91 min), however, diverticular orifices in their study were in an open state, which enabled identification of the orifices. Based on preoperative imaging, we verified the anatomical relationship intraoperatively and then focused on exploration of the diverticular area. The distal part of ureteroscopy was monitored by ultrasound after ultrasound-guided puncture, which improved ureteroscopic positioning of the diverticula. The longer operating time in the UFURS group compared with the PCNL group ($P > 0.05$) was due to the ultrasound-guided puncture, particularly in the initial two patients. Postural adjustment and logistics for percutaneous puncture were tedious procedural steps. In the remaining patients, oblique lithotomy positioning and technical preparation for percutaneous puncture were done preoperatively, which significantly shortened operating time. In the last six cases of the UFURS group, time for sterilization, draping, and puncture to perform diverticular puncture were 6–9 min (7.5 ± 1.1 min).

In the UFURS group, nine patients showed no residual stone, one had nonclinically significant residual stone, and the rate of successful lithotripsy was 83.3%, which was similar to previous reports (81.6–84%).[2,6] Stone-free rate in the PCNL group was 83.3%, which was similar to that (85.7%) reported by Kim *et al*.[3] Bas *et al*.[6] reported a series of 54 cases of calyceal diverticular stones in which FURS and PCNL were used to treat calyceal diverticular calculi measuring 154 ± 77 mm^2 and 211 ± 97 mm^2, respectively. The results showed no significant difference between FURS and PCNL in the success rate (89.7% vs. 84%), stone-free rate (82.8% vs. 76%), and the rate of nonclinically significant stone (6.9% vs. 8.0%) (all $P > 0.05$). However, the incidence of Clavien III complications in the PCNL group was markedly higher than that in the FURS group. In our study, no significant difference was found in stone burden, successful surgery rate, stone-free rate, and the rate of nonclinically significant stone. No significant difference was observed in the incidence of complications between the two groups (2 vs. 3, $P > 0.05$). Furthermore, UFURS is minimally invasive and has few complications and short hospital stay.[2,6] In the study, postoperative pain in the UFURS group was markedly lower than that in the PCNL group. Pain in the PCNL group was consistent with that reported by Singh *et al*.[27] In the absence of fever or displaced ureteral stent, patients in the UFURS group were discharged on postoperative day 1. Hospital stay was significantly shorter in the UFURS group than that in the PCNL group (3.4 ± 0.8 vs. 5.4 ± 1.0 days, $P < 0.05$), which was in accordance with previous reports.[2,5]

The rate of asymptomatic patients 3 months after surgery was 100% in the PCNL group, which was consistent with previous reports (84–100%).[5,6,22] Ten patients in the UFURS group with preoperative symptoms became asymptomatic, which was similar to the results (92%) of Bas *et al*.[6] The rate of diverticular disappearance in the PCNL group was 83.3%, which was similar to previous reports (87.5–100%).[3,22] Diverticula in both groups decreased in size or disappeared, with no significant difference between the groups ($P > 0.05$). Half of the diverticula disappeared in the UFURS group, which was higher than that (18%) reported by Auge *et al*.[7] Our result might be related to reduced intradiverticular pressure and diverticular collapse after incising the high-pressure diverticula caused by diverticular neck atresia.[10]

Patient selection for FURS is the key to successful treatment of calyceal diverticula.[4-7,10,15] Preoperative IVP and CT examinations were important for choosing patients who would benefit most from this procedure. IVP and CT also facilitate evaluation of diverticular position, degree of hydronephrosis, distance between the diverticular wall and the collecting system, length of the calyceal infundibulum, and renal pelvic infundibulopelvic angle.[1,5-8,10,15,17,19,27,28] Long *et al.*[1] recommend that this approach is best suited for mid and upper pole calyceal diverticula located posterior to and near the renal collecting system (endogenous growth type). The infundibulum or the diverticular wall might be cut during the treatment of calyceal diverticula. Therefore, the distance between the diverticulum and the collecting system should be carefully measured preoperatively. Some investigators have considered UFURS as the first-line treatment, particularly for mid and upper pole and anterior diverticula since a successful UFURS avoids subsequent interventions such as PCNL.[1,2,6-10,17] The advantages of ultrasound-guided puncture-assisted UFURS in treating calyceal diverticula include: (1) avoidance of radiation exposure to patients and medical staff, (2) far less damage caused by UFURS compared with PCNL, in particular, for stones <1 cm as a stone-filled diverticulum is not easily amenable to PCNL,[2,7-10] (3) simultaneous treatment of the diverticular infundibulum leads to better drainage and infundibular reconstruction via adequate incision of the diverticular orifice or wall, (4) monitoring by ultrasound shortens the time to locate the diverticulum and has great advantage over plain radiology in screening for radiologically invisible stones.[19,21]

In addition, FURS is suited for patients who are unwilling to undergo invasive procedures such as PCNL. FURS is specifically indicated for professionals including airline and air force pilots, young women who do not wish to manifest surgical scars, and even pregnant women.[7,10,16,29,30] Traditional PCNL in the prone position has a higher surgical risk for some patients, such as those with severe kyphosis, cardiopulmonary dysfunction, obesity, or spinal cord injury. The oblique supine lithotomy position, on the other hand, is more comfortable and better tolerated by patients and is a familiar position for surgical staff, thus minimizing anesthetic and operative risks.[7,8,10,20,21,30] Therefore, the beneficial implications for FURS treatment for calyceal diverticular stone in the oblique supine lithotomy position are broader than for PCNL. In the present study, two asymptomatic patients included a pilot and an astronaut with diverticular stones found during the physical examination. The stones were successfully removed and the diverticular orifices opened. In an 83-year-old patient with chronic obstructive pulmonary disease, no postoperative complication occurred after UFURS.

There are some limitations to this study. This was a retrospective study and not a randomized controlled study. The follow-up period was short and the sample size was small. Although UFURS can successfully identify calyceal diverticuli, larger multicenter studies with long-term follow-up are needed to confirm our preliminary results. In addition, compared with previous studies, we performed only incision of the calyceal diverticular wall and infundibulum and did not undertake diverticular wall fulguration, balloon dilation, or fistula catheter placement. Diverticular wall fulguration can lead to tissue damage,[9,10] and restenosis might still occur after balloon dilation and fistula catheter placement.[3,8,13,17] Therefore, adequate diverticular drainage may be the key to attenuation of symptoms and prevention of stone relapse.[2,17] Long-term outcomes of the diverticular wall and infundibulum incision need to be determined.

In summary, ureteroscopy can be performed for calyceal diverticular stones, in particular, those located posterior and at mid and upper pole. Ultrasound-guided puncture-assisted ureteroscopy enables rapid and accurate location of the diverticulum, and might improve the success rate of ureteroscopic treatment of calyceal diverticula.

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Conflicts of interest

There are no conflicts of interest.

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