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Treatment of Complex Renal Calculi by Digital Flexible Ureterorenoscopy Combined with Single-Tract Super-Mini Percutaneous Nephrolithotomy in Prone Position: A Retrospective Cohort Study

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Background: Advances in percutaneous nephrolithotomy (PCNL) have resulted in smaller devices that cause less trauma and bleeding, while flexible ureterorenoscopy (f-URS) allows access to any calyces. These methods are often used in isolation, but used in combination they may improve treatment of complex renal calculi. This study assessed the effectiveness and complications of f-URS combined with super-mini-PCNL (SMP) to treat complex renal calculi.

Material/Methods: A retrospective cohort analysis was made of patients with unilateral complex renal stones treated between March 2013 and December 2016. Patients were grouped according to surgical procedure: SMP (SMP Group), f-URS holmium laser lithotripsy (f-URS Group), and combined SMP and f-URS (Combined Group). The postoperative complications and complete stone-free rate were analyzed and compared among the 3 groups.

Results: A total of 140 patients with complex renal stones were included: 40 patients in the SMP Group, 55 in the f-URS Group, and 45 in the Combined Group. The complete stone-free rate 3 days after the procedure was 77.5% in the SMP Group, 78.2% in the f-URS Group, and 97.8% in the Combined Group (p=0.010). The operation time, intraoperative blood loss, and hospitalization time of the Combined Group were all significantly lower than those in the SMP Group but higher than those in the f-URS Group. The follow-up was 9 months (range, 6–12 months). There were no medium-term complications reported.

Conclusions: SMP combined with f-URS holmium laser lithotripsy in the prone position is an effective treatment for complex renal calculi.

MeSH Keywords: Kidney Calculi • Prone Position • Urology

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Background

Renal stone disease, either urolithiasis or nephrolithiasis, is a common health problem. The global prevalence was estimated to be 1.7–14.8% in 2010, and these rates are apparently increasing [1]. In China, around 5.8% of adults are currently thought to have renal stones [2]. Although many renal stones are asymptomatic for long periods, problems such as pain, infection, and obstruction are occurring at increasing rates, and more than 50% of patients experience a recurrent stone after 5 years [3]. In the long term, renal stones can result in severe problems such as chronic kidney disease (CKD), metabolic bone disease (MBD), and end-stage renal disease (ESRD) [3].

Renal stones of less than 5 mm in diameter can be expected to pass without intervention, so treatment generally involves analgesic relief of symptoms. When stones are between 5 and 10 mm in diameter, intervention is likely to be necessary in up to 50% of cases. Stones that are larger than 10 mm in diameter are unlikely to pass spontaneously [4]. Clinical management of renal stone disease involves metabolic investigation to reveal the likely cause of stone formation, and medical treatment [5]. Surgical techniques have evolved from open surgical lithotomy to minimally invasive endourological approaches. Currently, the most common methods include breaking up the stone with extracorporeal shockwave lithotripsy (SWL), rigid or flexible retrograde ureteroscopic stone fragmentation and retrieval, and stone fragmentation followed by extraction by percutaneous nephrolithotomy (PCNL) [3]. The success rate of these therapies depends on the experience of the treating physician, the size of the stone, its location and composition, and patient characteristics [3]. SWL and ureteroscopic stone fragmentation are most commonly used for smaller stones (less than 20 mm), but recurrence rates are high with larger stones [6]. Since Willard Goodwin first reported on percutaneous renal access in 1955 [7], PCNL is now considered the criterion standard treatment for large and multiple renal calculi [8]. However, while PCNL achieves stone clearance at a high rate, complications often occur, and one of the most serious is bleeding [9]. Bleeding is a dangerous problem, especially during tract dilation, and can increase the risk of mortality and the length of hospital stay [10].

With the intention of preventing hemorrhage during treatment, advanced equipment has been developed [11]. These developments include miniaturized PCNL equipment and flexible ureteroscopes. The new super-mini-PCNL (SMP) system requires a small percutaneous tract for access, so there is less blood loss and there is also effective stone clearance, the visual field is good, and the operation duration is short, with easy operation [12,13]. Flexible ureterorenoscopy (URS) does not require a new tract for access because it can use natural ones such as the urethra, ureter, or renal pelvis. The ureteroscope has a flexible tip allowing easy access to any calyces, so damage is minimized and complications are less frequent [14]. Most urologists tend to use either digital flexible URS or single-tract miniaturized PCNL to treat renal stones, with great success [15,16]. However, these techniques cannot resolve all cases with multiple kidney stones, resulting in a low stone-free rate and complications in some patients [12,14]. Previous reports have demonstrated that miniaturized PCNL combined with digital flexible URS is safe for pediatric [17] and adult patients [18] with multiple kidney stones and for adults with large stones [19,20]. The combination of SMP and flexible URS means the entire procedure from puncture to PCNL can be constantly monitored and limits the size and number of tracts during PCNL. However, there have been few studies on the use of miniaturized PCNL combined with flexible URS in the treatment of large stones and multiple kidney stones [17–20]. Further information is needed to support the use of this technique in suitable patient populations.

The purpose of this study was to retrospectively analyze and compare the treatment effect in patients with complex renal stones who underwent SMP, flexible URS, or both methods in combination. This information will help assess the effectiveness of flexible URS combined with SMP to treat large and multiple kidney stones and to investigate the possible advantages of this technology.

Material and Methods

Patients

This was a retrospective cohort study of patients who were treated for unilateral complex renal stones between March 2013 and December 2016. Complex renal stones were diagnosed by ultrasound and radiological investigation (such as computed tomography [CT] examination). Complex kidney stones were defined as recurrent, multiple, cast kidney stones or kidney stones with calyceal neck stenosis and dilatation, and kidney stones with abnormal renal anatomy.

The exclusion criteria were: 1) patients with cardiopulmonary dysfunction or other important organ dysfunction such as brain, liver, or kidney dysfunction or tumor; 2) patients who could not tolerate surgery; 3) patients with uncontrolled hypertension or diabetes; and 4) patients with coagulopathy.

The Medical Ethics Committee of the Qianfoshan Hospital affiliated to Shandong University, China gave ethics approval for the study (2019-S-302). The need for written consent from the patients was waived by the committee because of the retrospective nature of the study.

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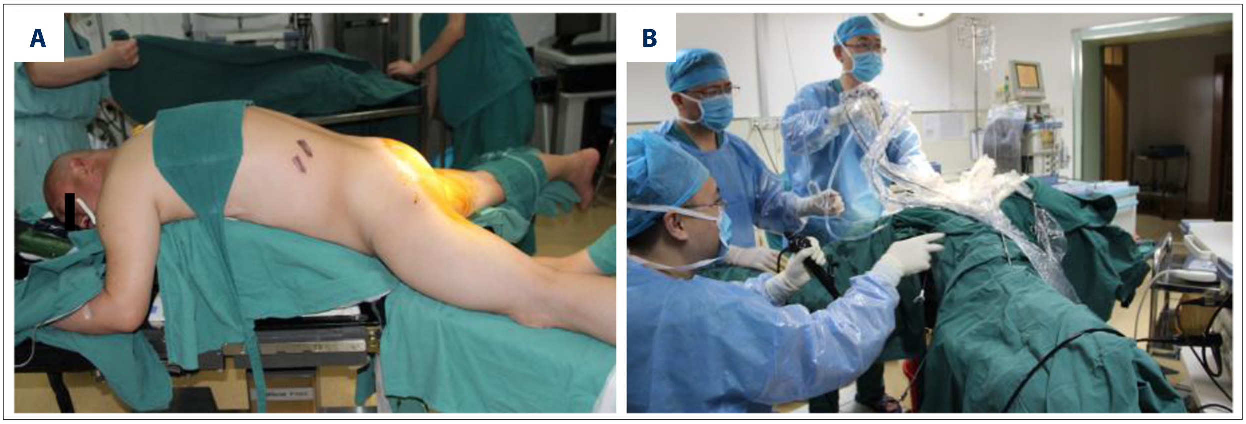

Figure 1. Preoperative position and operative procedure position. A 51-year-old man underwent combined lithotripsy due to complex calculi and hydronephrosis in the left kidney. (**A**) The patient was placed in the prone position. (**B**) The patient while undergoing the combined lithotripsy procedure.

Operative procedures

The patients were grouped according to the procedure they underwent. The SMP Group received SMP alone, the f-URS Group received f-URS holmium laser lithotripsy, and the Combined Group received SMP in combination with f-URS.

During the surgical procedure for SMP as provided to the SMP Group, patients were given general anesthesia and placed in the prone position. A F7 ureteral catheter was retrogradely placed into the ipsilateral ureter to establish artificial hydronephrosis. The patient does not change position,with the ipsilateral kidney slightly higher. Routinely, the region from the 11 intercostal area or the 12 subcostal axillary line to the scapular line was selected as the puncture site [21]. The target calyx was punctured under the guidance of B-ultrasound, then the guidewire was inserted into the collection system. After that, a percutaneous renal passage was established, through which a working sheath (F16 expanded to F18) was placed to construct a percutaneous nephrolithotomy passage [22]. Then, a nephroscope was inserted through the working passage to the collection system to locate stones, followed by pneumatic trajectory or holmium laser lithotripsy. Most of the stone fragments came out through the lavage fluid, and small parts were removed using stone pliers. After the operation, a ureteral stent (F4.8 and renal fistula tube F16) was indwelled.

In the surgical procedure for flexible URS as provided for the f-URS Group, patients were given general anesthesia and placed in the lithotomy position. A zebra guide wire was retrogradely inserted through a F8/F9.8 ureteroscope, which was then retracted. Subsequently, the dilator sheath of the flexible ureteroscope was inserted into the outlet of the renal pelvis via the zebra guide wire, the catheter core was removed and a flexible ureteroscope was inserted via the dilator sheath. After the flexible ureteroscope was inserted into the renal pelvis under direct vision and stones were located, and the holmium laser fiber was inserted to break the stones into small pieces with a diameter <3 mm. After the stones were cleaned, the flexible ureteroscope sheath was removed, and a F4.8 ureteral stent was indwelled through the guide wire, followed by catheter indwelling.

In the surgical procedure for SMP+ flexible URS as provided to the Combined Group, patients were given general anesthesia and placed in the prone position, with legs apart (Figure 1A) [23]. Then, intubation was performed in the ipsilateral ureter under an ureteroscope, through which 50 ml of normal saline was injected to generate artificial hydronephrosis. With the patient in the same position, a flexible ureteroscope sheath was placed with the guidance of a zebra guide wire, followed by insertion of the flexible ureteroscope (Figure 1B) [24]. Subsequently, the renal area at the ipsilateral side was elevated, stones were located with the guidance of B-ultrasound, and the distribution of calyceal calculi as observed by the flexible ureteroscope. Then, the vault of the middle renal calyx was punctured in an appropriate location using a 16.0 G renal puncture needle (Figure 2), during which the angle and depth of the needle was monitored, followed by observation of liquid outflow. The flexible ureteroscope was used to observe whether the needle reached the target position. During puncture, attention was paid to the sensation of breakthrough and the sensation of touching the calculi when the needle passed through the renal cortex and the renal pelvis mucosa. After successful puncture, the zebra guide wire was sent into the needle sheath, and a 0.5-cm incision was made. Then, a fascial dilator was used to gradually expand the puncture channel from F16 to F18 along the trajectory of the zebra guide wire, and the working sheath was indwelled. Then, under guidance of the flexible ureteroscope in the ureter, stones located on the upper calyx were removed using a stone basket clip to the orthoscopic field of

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Figure 2. Renal puncture under monitoring with a flexible ureterorenoscope during SMP and f-URS combined surgery.

view of the nephroscope for subsequent processing or were directly pulverized by a holmium laser [25]. Large stones were crushed with an ultrasonic lithotripsy system, and the stone fragments were flushed continuously with normal saline out of the body or were removed with stone forceps [26]. After that, a F4.8 double J tube and F16 renal fistula tube were antegradely inserted and fixed, followed by removal of the ureteral catheter [27].

Postoperatively, an F4.8 double J tube and urethral catheter were routinely placed in patients in all 3 groups, and a F16 renal fistula tube was routinely placed in the Combination Group. Patients in all 3 groups were treated with cephalosporin antibiotics for postoperative anti-infection.

The intraoperative blood loss was estimated by the following equation: intraoperative blood loss (ml)=[hemoglobin concentration (g/L) in the flushing fluid×total flushing fluid volume (ml)]/preoperative hemoglobin concentration (g/L). Postoperative pain was evaluated at 6 h using a visual analog scale (VAS), scored 0–10 [28]. VAS score >0 was considered as pain.

Follow-up and stone clearance rate

Kidney and ureter CT examination were performed at 3 days and at 1 month after surgery to see if there were any residual stones. At 3 days, residual stones with a diameter <4 mm were considered clinically meaningless residual stones, while those with a diameter >4 mm were defined as failure of stone clearance.

The stone clearance rate was calculated as follows: Stone clearance rate=(total number of patients–number of patients with stone clearance failure)/total number of patients×100%. Patients with significant stone residuals were treated with oral stone-discharging drugs, with second-stage surgery, or extracorporeal shock wave lithotripsy (ESWL). If patients were determined to have clinically insignificant stones, those in the f-URS and SMP Groups had the renal fistula tube clamped for 1 day, which was routinely removed on the next day. For all 3 groups, the ureteral stent tube (i.e., the double J tube) was removed at 2 to 4 weeks after surgery.

At the postoperative 1-month CT examination, patients with enlarged residual stones with surgical indications and without contraindications underwent a secondary surgery.

Data collection

The patient evaluation undertaken before the procedure included taking the patient's history, clinical examination, urinary tract ultrasound, and CT imaging. Antibiotic therapy was provided if the patient had a positive result from the urinary culture test and the procedure was postponed until further urine examinations were found to be normal.

Statistical analysis

SPSS 16.0 for windows (SPSS, Inc., Chicago, IL, USA) was used for all statistical analyses. Continuous variables were tested for normality using the Kolmogorov-Smirnov test. Normally distributed continuous variables are expressed as means ± standard deviation (SD) and were analyzed by one-way analysis of variance (ANOVA) and post hoc test (SNK-q test). Non-normally distributed continuous variables are presented as median (range) and were compared using the Kruskal-Wallis test. Classification variables are expressed as frequency and percentage and were compared by the chi-square test or Fisher exact test. $p<0.05$ was considered statistically significant.

Results

Baseline characteristics

A total of 140 patients with complex renal stones were included in the study: 40 patients in the SMP Group, 55 in the f-URS Group, and 45 in the Combined Group. The mean age was 52.88±13.08 in the SMP Group, 49.04±14.25 in the f-URS Group, and 52.33±14.24 in the Combined Group ($p=0.335$). A majority of the patients in all 3 groups were male ($p=0.652$) and the average stone size was approximately 2 cm ($p=0.342$). No statistically significant differences in stone location and preoperative hydronephrosis were observed among the 3 groups (Table 1).

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Table 1. Demographic information for the patients (n=140).

Characteristics	SMP	f-URS	Combined group	P
No.	40	55	45	
Age, years (mean ±SD)	52.88±13.08	49.04±14.25	52.33±14.24	0.335
Sex				0.652
Female	17 (42.5%)	19 (34.5%)	19 (42.2%)	
Male	23 (57.5%)	36 (65.5%)	26 (57.8%)	
Stone size, cm (mean ±SD)	2.4±0.8	2.3±1.1	2.6±1.2	0.342
Location of stones				0.495
Left side	21 (52.5%)	24 (43.6%)	18 (40.0%)	
Right side	19 (47.5%)	31 (56.4%)	27 (60.0%)	
Preoperative hydronephrosis				0.900
No or mild level	15 (37.5%)	22 (40.0%)	16 (35.6%)	
Middle or severe level	25 (62.5%)	33 (60.0%)	29 (64.4%)	

Table 2. The intra- and postoperative clinical outcome.

Variables	SMP	f-URS	Combined group	P
Total length of operation (min), mean ±SD	73.83±6.34*	54.87±7.18**,***	63.27±8.60	<0.001
Intraoperative blood loss (ml), mean ±SD	116.30±9.94*	10.31±2.86**,***	67.98±13.52	<0.001
Stone-free (<4 mm) 3 d after operation, n (%)	31 (77.5%)*	43 (78.2%)**	44 (97.8%)	0.010
Hospitalization days (day), mean ±SD	9.95±1.89*	4.33±1.55**,***	7.36±1.77	<0.001
Postoperative complications during hospitalization, n (%)				–
Pain	12 (30.0%)	4 (7.3%)**,***	13 (28.9%)	
Fever (>38.5°C)	3 (7.5%)	13 (23.6%)**,***	4 (8.9%)	
Hematuria	18 (45%)*	2 (3.6%)**,***	9 (20.0%)	

* Combined group *vs.* SMP group P<0.05; ** Combined group *vs.* f-URS group P<0.05; *** SMP group *vs.* f-URS group P<0.05.

Perioperative data

There were no intraoperative complications in any of the patients. No patients required a blood transfusion. The complete stone-free rate 3 days after the procedure was significantly higher in the Combined Group compared to the other 2 groups (97.8% in the Combined Group, versus 77.5% in the SMP Group and 78.2% in the f-URS Group, p=0.010). In addition, the operation time, intraoperative blood loss, and hospitalization time of the Combined Group were all significantly lower than those in the SMP Group but higher than those in the f-URS Group (Table 2). There were some postoperative complications during hospitalization. There were significantly more cases who experienced pain in the Combined Group and SMP Group than in the f-URS Group (both p<0.05), but all cases were mild pain that was easily tolerated, with visual analog score (VAS) of less than 4, and they did not require further treatment. However, there were significantly more cases with fever (T>38.5°C) in the f-URS Group compared to the Combined Group or the SMP Group (both p<0.05). Further pathogenic examination (routine urine testing and urine culture) confirmed urinary tract infections in these patients. There were more cases of hematuria in the SMP Group (45%) than in the Combined Group (20%, p<0.05) and there were more cases in the Combined Group than in the f-URS Group, where the rate was very low (3.6%) (p<0.05). However, all cases were gross hematuria (mild hematuria) and none needed treatment with transfusion, embolization, or open surgery. The follow-up was a median 9 months (range, 6–12 months). There were no reports of any medium-term complications. Figure 3 shows CT images from a typical case in the Combined Group.

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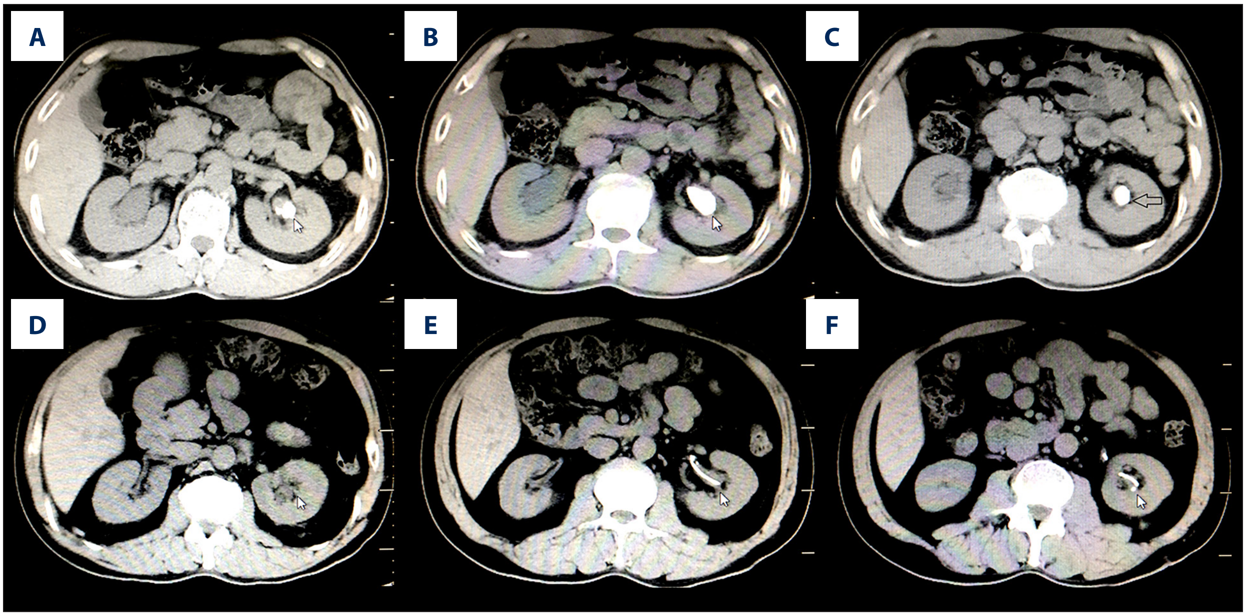

Figure 3. Computed tomography scan of complex renal calculi. Scan images from a 46-year-old man who underwent combined lithotripsy due to complex calculi (white arrow) and hydronephrosis in the left kidney. (**A–C**) CT scan of kidney and ureter showed stones (size of about 2.4×2.2 cm) in the left kidney at 2 days before operation. (**D–F**) CT scan of kidney and ureter showed no obvious residual stones 1 month after operation.

Discussion

The aim of this study was to assess the effectiveness of f-URS combined with SMP to treat complex renal calculi. To do this, 3 cohorts of patients with complex renal calculi treated with f-URS, SMP, or both methods in combination were retrospectively compared. The results show that the combined method was most effective; the complete stone-free rate 3 days after the procedure was 97.8% in the Combined Group, 77.5% in the SMP Group, and 78.2% in the f-URS Group, and operation time, intraoperative blood loss, and hospitalization time were all lower in the Combined Group compared to the SMP Group. Patients were followed for approximately 9 months, with no medium-term complications.

Flexible URS combined with single-tract PCNL has become an important method for treating patients with a large or complex stone burden. Ultrasound-guided puncture of the renal collecting system with subsequent placement of a drainage tube under fluoroscopic guidance is a creative method for PCNL [29]. In this procedure, flexible ureteroscopy provides continuous visualization from puncture to PCNL, including the needle, and this method enhances accuracy during the operation [30]. Compared to SMP and flexible URS in isolation, combining the methods has been shown to have some advantages. The first is that the patient remains in the prone position during the entire operation, which greatly shortens the operation time, has greater comfort for patients, and results in low renal perfusion pressures [31]. Visual discomfort may occur in the initial stage of transurethral ureteroscopy in the prone position, but the surgeon who can perform ureteroscopy skillfully should, with practice, be able to enter the ureteroscope smoothly after a visual flip. In addition, in the complete prone position, the patient's ureter moves under the action of gravity, and there is no obvious abnormality in the position of the ureter compared with the position of lithotomy, which is conducive to performance of ureteroscopy. The second advantage is that the combined surgical method can effectively remove stones from the super-renal and subrenal calyx, which avoids the disadvantages of either single procedure [17]. In the combined operation method, the flexible ureteroscope is located in a natural orifice, which can avoid smaller stone particles resulting from stone pulverization entering the ureter for formation of a "stone street", and it reduces related complications. Larger stone particles can be directly washed out through the nephroscope channel, thereby reducing the number of puncture passages, improving the efficiency of stone removal, and facilitating postoperative recovery. Suction through a percutaneous nephroscopic channel and perfusion with flexible endoscopy ensures double-channel drainage under negative pressure, and effectively guarantees a low intrapelvic pressure. In addition, the combined use of a flexible ureteroscope and B-ultrasound more accurately locates the best puncture site. During the establishment of the nephroscope channel, the ureteroscope allows real-time observation, which, combined with B-ultrasound guidance, ensures a precise puncture, avoids damaging large blood vessels, and improves the safety of surgery. In addition, the placement of a double J tube and renal fistula tube can be visualized to ensure they are placed in the optimal position [17]. However, the combined method has some disadvantages; combined SMP and f-URS surgery requires a high level of skill because the operator must have both percutaneous nephroscopy and flexible ureteroscope surgery experience, more personnel are needed as a double-mirror combined surgery usually needs 2 groups of surgeons, and there is a longer learning curve for the operator.

The results of this study agree with our experience that the combined SMP and flexible URS method shows advantages over either SMP or flexible URS procedures used alone. The comparison of the 3 groups in our study showed more effective stone removal in the Combined Group compared to the other 2 groups, and shorter operation time, lower blood loss, and shorter hospital stay in the combined method [32] compared to SMP alone. This approach may also be more effective than using the 2 methods consecutively. A study that used PCNL to remove complex stones followed by flexible URS to remove residual stones achieved a stone-free rate of 88.9% [33], which is lower than the 97.8% stone-free rate achieved in this study at 3 days after the procedure. These rates are similar to other studies that have used combined methods in treating multiple kidney stones. In pediatric patients, this achieved a stone-free rate of 87% in these difficult-to-treat cases because of the small size of the calyx [17], and in adult patients there was a 92% stone-free rate compared to 80% in patients treated with flexible URS alone [18]. Large stones treated in adults achieved a 81.7% stone-free rate versus 38.9% for mini-PCNL alone [19]; however, the stone-free rates for staghorn stones were similarly high, above 85%, for patients treated with PCNL alone and PCNL and flexible URS in combination, and the combination treatment was longer, with a longer hospitalization time, but this method used traditional PCNL [20]. Other combined methods that used some form of miniaturized PCNL showed shorter operation times than the isolated procedures [18,19]. The differences between the studies are probably because of differences in patient populations and some differences in the technique used.

There were no medium-term complications experienced in any of our patients, but there were some complications reported during hospitalization; fewer patients in the f-URS Group experienced pain and hematuria than in either of the other 2 groups, but cases of fever were highest in this group. Traditional PCNL has a high rate of complications, along with a high stone-free rate; the complications often arise because of percutaneous access and the size of PCNL access tract [34]. The use of SMP addresses these issues [3]. Previous studies have shown low rates of pain and small decreases in hemoglobin with SMP [3,35]. In the present study, in the Combined Group, where patients were punctured with both B-ultrasound and flexible ureteroscope guidance, the probability of puncturing large vessels is small. This might partly explain the low rate of hematuria in this group, but it is not clear why the rate should be so low in the f-URS Group. However, the pain and hematuria experienced by all patients in this study were mild and not serious, and there was no need for further treatment. The cases of fever were all found to be because of urinary tract infection, and this occurred most often with f-URS alone.

There are limitations associated with our study. This was a retrospective cohort study and some bias may have been introduced in the 3 groups. In addition, this was a single-center study, so patient numbers were limited.

Conclusions

Ultrasound-guided SMP combined with flexible URS holmium laser lithotripsy in the prone position is an effective method for treating patients with complex renal calculi. Digital flexible URS combined with single-tract SMP significantly reduced blood loss and improved the stone-free rate after a single procedure. In addition, the length of the operation was significantly shorter. Larger randomized studies are required to support the results of this study.

Conflict of interests

None.

References:

1. Romero V, Akpinar H, Assimos DG: Kidney stones: A global picture of prevalence, incidence, and associated risk factors. Rev Urol, 2010; 12: e86–96
2. Zeng G, Mai Z, Xia S et al: Prevalence of kidney stones in China: An ultrasonography based cross-sectional study. BJU Int, 2017; 120: 109–16
3. Khan SR, Pearle MS, Robertson WG et al: Kidney stones. Nat Rev Dis Primers, 2016; 2: 16008
4. Moran CP, Courtney AE: Managing acute and chronic renal stone disease. Practitioner, 2016; 260: 17–20, 22–23
5. Johri N, Cooper B, Robertson W et al: An update and practical guide to renal stone management. Nephron Clin Pract, 2010; 116: c159–71
6. Vaughan LE, Enders FT, Lieske JC et al: Predictors of symptomatic kidney stone recurrence after the first and subsequent episodes. Mayo Clin Proc, 2019; 94: 202–10
7. Patel SR, Nakada SY: The modern history and evolution of percutaneous nephrolithotomy. J Endourol, 2015; 29: 153–57
8. Skolarikos A, Alivizatos G, de la Rosette JJ: Percutaneous nephrolithotomy and its legacy. Eur Urol, 2005; 47: 22–28
9. Seitz C, Desai M, Hacker A et al: Incidence, prevention, and management of complications following percutaneous nephrolitholapaxy. Eur Urol, 2012; 61: 146–58

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10. El-Nahas AR, Shokeir AA, El-Assmy AM et al: Post-percutaneous nephrolithotomy extensive hemorrhage: a study of risk factors. J Urol, 2007; 177: 576–79
11. Wagh MS, Merrifield BF, Thompson CC: Survival studies after endoscopic transgastric oophorectomy and tubectomy in a porcine model. Gastrointest Endosc, 2006; 63: 473–78
12. Zeng G, Zhu W, Liu Y et al: The new generation super-mini percutaneous nephrolithotomy (SMP) system: A step-by-step guide. BJU Int, 2017; 120: 735–38
13. Zeng G, Zhu W, Liu Y et al: Prospective comparative study of the efficacy and safety of new-generation versus first-generation system for super-mini-percutaneous nephrolithotomy: A revolutionary approach to improve endoscopic vision and stone removal. J Endourol, 2017; 31: 1157–63
14. Ghani KR, Wolf JS Jr.: What is the stone-free rate following flexible ureteroscopy for kidney stones? Nat Rev Urol, 2015; 12: 363
15. Knoll T, Jessen JP, Honeck P, Wendt-Nordahl G: Flexible ureterorenoscopy versus miniaturized PNL for solitary renal calculi of 10-30 mm size. World J Urol, 2011; 29: 755–59
16. Ozgor F, Yanaral F, Savun M et al: Comparison of miniaturized percutaneous nephrolithotomy and flexible ureterorenoscopy for moderate size renal stones in elderly patients. Kaohsiung J Med Sci, 2018; 34(6): 352–56
17. Guo J, Yang WZ, Zhang Y et al: Ultramini nephrostomy tract combined with flexible ureterorenoscopy for the treatment of multiple renal calculi in paediatric patients. Korean J Urol, 2015; 56: 519–24
18. Mishra DK, Agrawal MS: Use of a novel flexible mini-nephroscope in minimally invasive percutaneous nephrolithotomy. Urology, 2017; 103: 59–62
19. Hamamoto S, Yasui T, Okada A et al: Endoscopic combined intrarenal surgery for large calculi: simultaneous use of flexible ureteroscopy and mini-percutaneous nephrolithotomy overcomes the disadvantageous of percutaneous nephrolithotomy monotherapy. J Endourol, 2014; 28: 28–33
20. Goktug G, Karakoyunlu N, Sener NC et al: Standard percutaneous nephrolithotomy alone versus in combination with intraoperative anterograde flexible nephroscopy for staghorn stones: A retrospective study. Kaohsiung J Med Sci, 2015; 31: 568–71
21. Zegel HG, Pollack HM, Banner MC et al: Percutaneous nephrostomy: Comparison of sonographic and fluoroscopic guidance. Am J Roentgenol, 1981; 137: 925–27
22. Sharma GR, Maheshwari PN, Sharma AG et al: Fluoroscopy guided percutaneous renal access in prone position. World J Clin Cases, 2015; 3: 245–64
23. Edgcombe H, Carter K, Yarrow S: Anaesthesia in the prone position. Br J Anaesth, 2008; 100: 165–83
24. Lyon ES, Huffman JL, Bagley DH: Ureteroscopy and ureteropyeloscopy. Urology, 1984; 23: 29–36
25. Song L, Chen Z, Liu T et al: The application of a patented system to minimally invasive percutaneous nephrolithotomy. J Endourol, 2011; 25: 1281–86
26. Schuster TK, Smaldone MC, Averch TD, Ost MC: Percutaneous nephrolithotomy in children. J Endourol, 2009; 23: 1699–705
27. Korth K: Percutaneous surgery of kidney stones. Berlin, Springer-Verlag, 2012
28. Hawker GA, Mian S, Kendzerska T, French M: Measures of adult pain: Visual Analog Scale for Pain (VAS Pain), Numeric Rating Scale for Pain (NRS Pain), McGill Pain Questionnaire (MPQ), Short-Form McGill Pain Questionnaire (SF-MPQ), Chronic Pain Grade Scale (CPGS), Short Form-36 Bodily Pain Scale (SF-36 BPS), and Measure of Intermittent and Constant Osteoarthritis Pain (ICOAP). Arthritis Care Res (Hoboken), 2011; 63(Suppl. 11): S240–52
29. Sood G, Sood A, Jindal A et al: Ultrasound guided percutaneous nephrostomy for obstructive uropathy in benign and malignant diseases. Int Braz J Urol, 2006; 32: 281–86
30. Sabnis RB, Ganesamoni R, Doshi A et al: Micropercutaneous nephrolithotomy (microperc) vs retrograde intrarenal surgery for the management of small renal calculi: A randomized controlled trial. BJU Int, 2013; 112: 355–61
31. Falahatkar S, Moghaddam AA, Salehi M et al: Complete supine percutaneous nephrolithotripsy comparison with the prone standard technique. J Endourol, 2008; 22: 2513–17
32. Yan X, Al-Hayek S, Gan W et al: Minimally invasive percutaneous nephrolithotomy in preschool age children with kidney calculi (including stones induced by melamine-contaminated milk powder). Pediatr Surg Int, 2012; 28: 1021–24
33. Chen L, Sha ML, Li D et al: Treatment for residual stones using flexible ureteroscopy and holmium laser lithotripsy after the management of complex calculi with single-tract percutaneous nephrolithotomy. Lasers Med Sci, 2017; 32: 649–54
34. Liu Y, AlSmadi J, Zhu W et al: Comparison of super-mini PCNL (SMP) versus Miniperc for stones larger than 2 cm: A propensity score-matching study. World J Urol, 2018; 36: 955–61
35. Simayi A, Liu Y, Yiming M et al: Clinical application of super-mini PCNL (SMP) in the treatment of upper urinary tract stones under ultrasound guidance. World J Urol, 2018 [Epub ahead of print]

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