Efficacy and functional outcome of flexible ureteroscopy for renal stones in patients with a solitary kidney

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Aim: The aim of the present study was to evaluate the efficacy and functional outcome of flexible ureteroscopy (fURS) for renal stones in patients with a solitary kidney.

Patients and Methods: From February 2011 to February 2015, 60 patients with a solitary kidney underwent fURS for the treatment of renal stones. Factors, such as operation duration, complications and stone-free rate (SFR), were analysed. Changes in the renal function were evaluated by comparing preoperative and postoperative glomerular filtration rates (GFR) and serum creatinine. The stage of chronic kidney disease (CKD) was measured to evaluate the influence of fURS on renal function.

Results: The total SFR were 76.67 per cent and 93.33 per cent after the first and final procedures, respectively. Postoperative minor complications, classified as Clavien grade II, were recorded in 4.2 per cent (2/48) and 25 per cent (3/12) of patients with renal stones < 2 cm and > 2 cm, respectively. Serious complications, classified as Clavien grade III, occurred in 8.3 per cent (1/12) with renal stones > 2 cm. For patients with renal stones < 2 cm, the preoperative and postoperative mean GFR, as well as serum creatinine, had statistical difference (P < 0.05). For patients with a solitary kidney with stage 5 CKD, fURS did not improve the renal function regardless of the stone size.

Conclusion: fURS is a more effective and safer procedure, with a higher SFR and a lower rate of complications in treating stones < 2 cm in a solitary kidney than those > 2 cm. For patients with a solitary kidney with stage 5 CKD, fURS did not improve the renal function regardless of the stone size.

Key words: flexible ureteroscopy, renal stone, solitary kidney, treating.

Introduction

Patients with renal stones in anatomically- or functionally-solitary kidneys require safe, planned treatment in order to minimize the risk of complications and prevent kidney impairment. According to the location and size, renal stones in a solitary kidney have traditionally been treated with extracorporeal shockwave lithotripsy (SWL) or percutaneous nephrolithotomy (PCNL). SWL was usually bound up with low stone-free rate (SFR) and repeated treatments.¹ Moreover, in the long-term follow up after SWL, the glomerular filtration rate (GFR) reduced.² PCNL for renal stones in a solitary kidney had a high SFR and provided significant improvement in renal function at long-term follow up, but it was also associated with severe complications.³ Due to these potential drawbacks, it is challenging to treat renal stones in a solitary kidney.

In recent years, flexible ureteroscopy (fURS) has been used to treat renal stones < 2 cm. Currently, fURS is increasingly used for renal stones > 2 cm, with the development of instrumentation and improvement of endoscopic technology.⁴ As far as we know, studies on the safety and efficacy of fURS for renal stones in solitary kidneys are rare. In the present work, we retrospectively studied the efficacy and functional outcome of fURS for renal stones in patients with a solitary kidney.

Methods

In this retrospective study, 60 patients with renal stones in a solitary kidney, who were treated with fURS...
between February 2011 and February 2015 at our hospital were included. Two urologists performed the fURS. The reasons for solitary kidneys and the stone localizations are summarized in Table 1. All patients underwent computed tomography to understand the location and size of the stones preoperatively. Preoperative urine culture was done, and positive patients were treated by sensitive antibiotics. An F7 double-J tube was inserted in all patients to dilate the ureter for 1–2 weeks preoperatively.

**Surgical technique**

After general anaesthesia, the patient was placed in the lithotomy position. A 9.5F rigid ureteroscope was used to pass into the ureter and pull out the presented double-J tube. The guidewire was then placed into the ureter. A ureteral access sheath (UAS) (12F/14F; Cook Medical, Bloomington, IN, USA) was used to access the kidney along the guidewire. fURS was performed with an 8.5F endoscope (FlexXII; Karl Storz, Steinheim, Germany). The stone was then directly fragmented with Ho:YAG laser (200-μm laser fibre) for fURS. Some fragments were removed using a nitinol basket for stone analysis. After the procedure, a 7F double-J stent was placed in the ureter for 2 weeks. SFR was evaluated at 2 weeks postoperatively by computed tomography. Success was defined as stone-free status or fragments less than 3 mm. If a large residual stone was detected, the procedure was repeated and renal ultrasound and plain abdominal radiograph were redone postoperatively. In the follow-up evaluations, serum creatinine, GFR and chronic kidney disease (CKD) stage were obtained 3 months after the procedure.

The statistical analysis of the qualitative data was performed by χ²-test. For the quantitative data, the statistical analysis was performed by t-test. The level of significance was defined as \( P < 0.05 \).

**Results**

The preoperative and postoperative data are summarized in Table 2. The study included 60 patients

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**Table 1.** Patients and stone characteristics

| Variable                  | Value         |
|---------------------------|---------------|
| Patients (n)              | 60            |
| Stone size (SD; range), cm| 1.68 ± 0.389 (1.0–2.6) |
| Stone localization        |               |
| Upper pole                | 18            |
| Middle calices            | 22            |
| Lower pole                | 16            |
| Renal pelvis              | 12            |
| Cause of solitary kidney  |               |
| Previously nephrectomy    | 32            |
| Nonfunctioning            | 27            |
| Congenital                | 1             |
| Positive preoperative urine culture, no. (per cent) | 27 (45 per cent) |
| *Escherichia coli*        | 12            |
| *Enterococcus faecalis*   | 3             |
| *Pseudomonas aeruginosa*  | 5             |
| *Enterobacter cloacae*    | 3             |
| *Proteus mirabilis*       | 4             |
| Preoperative ureteral stent| 60             |
| Stone analysis            |               |
| Calcium oxalate           | 18 (30 per cent) |
| Calcium oxalate and phosphate| 21 (35 per cent) |
| Uric acid                 | 9 (15 per cent)  |
| Struvite                  | 6 (10 per cent)  |
| Mix                       | 6 (10 per cent)  |

SD, standard deviation.

**Table 2.** Preoperative and postoperative data

| Variable                  | Total            | < 2 cm (n = 48) | ≥ 2 cm (n = 12) | P-value |
|---------------------------|------------------|-----------------|-----------------|---------|
| Age, mean ± SD (range)    | 46.27 ± 4.89 (33–65) | 46.21 ± 4.86 (33–65) | 46.50 ± 1.50 (41–62) | 0.840   |
| Sex                       |                  |                 |                 | 0.947   |
| Male (n)                  | 37               | 30              | 7               |         |
| Female (n)                | 23               | 18              | 5               |         |
| BMI, mean ± SD (range)    | 27.6 ± 5.60 (22–31) | 27.1 ± 5.13 (22–30) | 28.2 ± 6.02 (23–31) | 0.524   |
| Mean operation time (min) | 62.27 ± 30.26 (29–104) | 53.60 ± 25.68 (29–62) | 72.28 ± 33.49 (60–104) | 0.039   |
| SFR                       |                  |                 |                 |         |
| Initial SFR (per cent)    | 76.67 (46/60)    | 83.33 (40/48)   | 50.00 (6/12)    | 0.039   |
| Final SFR (per cent)      | 93.33 (56/60)    | 97.92 (47/48)   | 75.00 (9/12)    | 0.028   |
| Complications of operation (n) | 6             | 2               | 4               | 0.013   |
| Fever (>38.5°C)           | 4                | 2               | 2               |         |
| Sepsis                    | 1                | 0               | 1               |         |
| Anuria                    | 1                | 0               | 1               |         |
| Mean no. procedures       | 1.18 (71/60)     | 1.11 (53/48)    | 1.50 (18/12)    | 0.041   |

BMI, body mass index; SD, standard deviation; SFR, stone-free rate.
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(37 males and 23 females) with a mean age of 46.27 ± 4.89 years (range: 33–65 years) and the body mass index (BMI) of 27.6 ± 5.60 (range: 22–31). The mean stone size was 1.68 ± 0.389 cm (range: 1–2.6 cm). Of the 60 patients, 48 had renal stones < 2 cm; the mean age of the patients was 46.21 ± 4.86 (range: 33–65 years) and their BMI was 27.1 ± 5.13 (range: 22–30). Twelve patients had renal stones ≥ 2 cm; the mean age of the patients was 46.50 ± 1.50 (range: 41–62 years) and their BMI was 28.2 ± 6.02 (range: 23–31). The parameters of the patients in the two groups had no statistical difference in terms of mean age, sex and BMI (P > 0.05).

The total SFR were 76.67 per cent and 93.33 per cent after the first and final procedures, respectively. The initial SFR with renal stones < 2 cm and > 2 cm were 83.33 per cent (40/48) and 50 per cent (6/12), respectively (P < 0.05). The final SFR with renal stones < 2 cm and > 2 cm were 97.92 per cent (47/48) and 75 per cent (9/12), respectively (P < 0.05). The mean number of procedures with renal stones < 2 cm and > 2 cm were 1.11 per patient and 1.50 per patient, respectively (P < 0.05).

Complications were classified according to the Clavien system. On the whole, Intraoperative complications were not found in any of the 60 patients. Postoperative complications were recorded in six patients (10 per cent). Four patients had fevers and one patient had sepsis, but was cured with drug treatment (Clavien grade II). One patient had anuria because of steinstrasse, which occurred after the removal of the double-J stent, necessitating an emergency ureteroscope to remove the obstruction (Clavien grade III). For the patients with renal stones < 2 cm, fever was recorded in two patients (Clavien grade II). For the patients with renal stones ≥ 2 cm, fever was recorded in two patients (Clavien grade II), while sepsis (Clavien grade II) and anuria were respectively recorded in one patient (Clavien grade III). Postoperative complications had a significantly statistical difference in the two groups (P < 0.05).

For the patients with renal stones < 2 cm, the mean preoperative GFR (40.82 ± 22.55 mL/min) was significantly lower than the mean postoperative GFR (52.72 ± 25.64 mL/min) 3 months postoperatively (P < 0.05). The mean preoperative serum creatinine (131.90 ± 32.92 umol/L) was significantly higher than the mean postoperative serum creatinine (109.06 ± 33.75 umol/L) 3 months postoperatively (P = 0.001). For the patients with renal stones ≥ 2 cm, the mean preoperative GFR (43.88 ± 30.96 mL/min) was not statistically lower than the mean postoperative GFR (49.80 ± 27.93 mL/min) 3 months postoperatively (P > 0.05). The mean preoperative serum creatinine (159.16 ± 20.02 umol/L) was not statistically higher than the mean postoperative serum creatinine (145.83 ± 17.89 umol/L) 3 months postoperatively (P = 0.100).

CKD stage was compared in Table 3 before and after the treatment. Among the patients with renal stones < 2 cm, two improved to be CKD stage 1, and 10 patients improved to be CKD stage 2 3 months postoperatively. The stage 2 patients improved and the stage 4 patients decreased statistically 3 months postoperatively (P < 0.05). Among the patients with renal stones ≥ 2 cm, although four patients improved to be CKD stage 3 from stage 4 3 months postoperatively, there was no statistical difference between the stages (P > 0.05). Among the patients who were CKD stage 5 in the two groups, fURS did not improve GFR, regardless of the stone size.

Discussion

For patients with a solitary kidney, the therapeutic method is challenging. According to the European Association of Urology guideline, SWL is the first-line therapy for stones < 2 cm, whereas PCNL is the first-line therapy for stones ≥ 2 cm. Despite being least invasive, SWL has been associated with low SFR and many complications, such as steinstrasse (4–7 per cent), symptomatic renal haematoma (< 1 per cent) and sepsis (1–2.7 per cent). 5–9 Cass reported an average reduction of 22 per cent in GFR after more than 2 years of follow up. 2 Intraoperative and postoperative complications of PCNL were also very common, including colonic injury (0.2–0.8 per cent), postoperative fever (21–32.1 per cent), bleeding necessitating transfusion (11.2–17.5 per cent), urinary extravasation (7.2 per cent) and sepsis (0.3–4.7 per cent). 10 In a study by Bucuras et al., PCNL had lower SFR, a higher level of renal impairment and greater transfusion rates when treating the stones of patients with a solitary kidney than that with bilateral kidneys. 11

fURS has been increasingly developed into an effective therapeutic method for renal stones in recent years. Miernik et al. reported the SFR to be 96.7 per cent with a low complication rate when treating renal stones of a medium of 2.3 cm with fURS. 12 fURS provided an advantage for preventing renal impairment, which might be especially important for the patients with a solitary kidney. When treating renal stones in a solitary kidney, Atis et al. reported the SFR to be 83.3 per cent and 95.8 per cent after the first and second procedures, respectively, with no major complications occurring. 13 Gao et al. reported the SFR to be 64.44 per cent and 93.33 per cent after the first and final
procedures, respectively. In our study group, the SFR were 76.67 per cent and 93.33 per cent after the first and final procedures, respectively. However, for renal stones < 2 cm, the first and final SFR were 83.33 per cent and 97.92 per cent, respectively, after fURS, which was statistically higher than that of renal stones > 2 cm. Although the final SFR reached 75 per cent, the first SFR for stones > 2 cm was only 50 per cent, and the number of procedures, as well as the mean operation time, increased, which would subsequently increase the risk of postoperative complications.

In our study, none of the patients had intraoperative complications. Postoperative complications included fever (6.7 per cent), sepsis (1.7 per cent) and anuria (1.7 per cent). Atis et al. reported postoperative urinary tract infections of 16.6 per cent. Gao et al. reported postoperative sepsis of 4.4 per cent and anuria of 2.2 per cent. In our study, it was worth noting that postoperative complications for patients with stones > 2 cm were statistically higher than that for patients with stones < 2 cm. Of the patients with stones < 2 cm, two had fevers (4.2 per cent), and another patient had postoperative complications. However, in the patients with stones > 2 cm, the postoperative complications included fever (16.7 per cent), sepsis (8.3 per cent) and anuria (8.3 per cent).

When treating stones > 2 cm with fURS, postoperative complications would increase statistically.

As known, obstruction is one of the most important factors causing renal function deterioration in a solitary kidney. So removing the obstruction as early as possible is important to protect renal function. In the present study, for patients who had CKD stage 5 renal stones, fURS did not improve renal function, regardless of the stone size.

Whether the double-J tube being presented to dilate the ureter before the operation is controversial. Until now, no data have shown a failure rate when inserting a UAS before fURS. However, the failure rates of rigid ureteroscopy to pass the ureter have been reported to be between 8 and 10 per cent. In most cases, ureteroscopy has a smaller diameter than fURS, so the failure rate when inserting a 14 Fr UAS is probably higher. Some authors have advocated routine stent placement before fURS to dilate the ureter passively. However, it was necessary to conduct a two-stage procedure for all patients, although this strategy was efficient and safe. Mogilevkin et al. found that patients with presenting were 21 times more likely to accommodate a 14 Fr UAS. In the present study, the double-J tube was routinely presented in all the patients for 1–2 weeks to dilate the ureter and facilitate the UAS to

Table 3. Preoperative and postoperative outcomes of renal function

| Variable                  | Preoperative | Postoperative (3 month) | P-value |
|---------------------------|--------------|-------------------------|---------|
| GFR mean ± SD, range (mL/min) |              |                         |         |
| < 2 cm                    | 40.82 ± 22.55 (10.50–97.50) | 52.72 ± 25.64 (11.50–97.50) | 0.018   |
| ≥ 2 cm                    | 43.88 ± 30.96 (12.70–90.00) | 49.80 ± 27.93 (13.40–92.00) | 0.628   |
| Serum creatinine ±SD, range (umol/L) |               |                         |         |
| < 2 cm                    | 131.90 ± 32.92 (135.00–212.00) | 109.06 ± 33.75 (139.00–199.00) | 0.001   |
| ≥ 2 cm                    | 159.16 ± 20.02 (65.000–187.00) | 145.83 ± 17.89 (65.00–175.00) | 0.100   |
| CKD stage, no.            |              |                         |         |
| < 2 cm                    | 1            | 3                       | 5       | 0.712   |
|                            | 2            | 4                       | 14      | 0.009   |
|                            | 3            | 26                      | 17      | 0.065   |
|                            | 4            | 11                      | 8       | 0.442   |
|                            | 5            | 4                       | 4       | 0.712   |
| ≥ 2 cm                    | 1            | 1                       | 1       | 1.000   |
|                            | 2            | 3                       | 3       | 1.000   |
|                            | 3            | 1                       | 5       | 0.155   |
|                            | 4            | 6                       | 2       | 0.193   |
|                            | 5            | 1                       | 1       | 1.000   |

CKD, chronic kidney disease; GFR, glomerular filtration rates; SD, standard deviation.

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access the ureter; no patients had ureteral injury when inserting the UAS. UAS can facilitate multiple passages of the fURS with lower intrarenal pressure.\textsuperscript{17} However, this was likely related to ureteral injuries and ureteral strictures, thus it is especially important for patients with a solitary kidney to passively dilate the ureteral by presenting stenting preoperatively to avoid ureteral injuries.

Our study had some limitations. First, this is a retrospective study with a small sample. We could not avoid the potential selection bias, which could have influenced the reliability of the statistical results. To lower the bias as much as possible, the procedures were finished by two experienced urologists in our department. To overcome these drawbacks, a prospective trial with a large sample is probably necessary. Second, the follow-up duration was short and it was difficult to evaluate the long-term postoperative complications and effects of fURS on renal function. The long-term outcome of fURS in treating renal stones in a solitary kidney is probably necessary.

Conclusions

In the present study, we found that fURS is an effective and safe procedure in treating stones <2 cm in a solitary kidney, with a high SFR and low rate of complications. However, when treating stones >2 cm with fURS in a solitary kidney, SFR is low, and procedures are likely to increase, accompanied by the increased incidence of postoperative complications. For CKD stage 5 renal stone patients with a solitary kidney, fURS did not improve renal function, regardless of the stone size.

Declaration of conflict of interest

All authors declare that they have no conflicts of interest.

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