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Original Article

Efficacy analysis and clinical application of flexible ureteroscope and rigid ureteroscope in the treatment of ureteral calculi

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Abstract: Objective: To compare the therapeutic effects on the clinical application of flexible ureteroscope (FURS) and rigid ureteroscope (RURS) in the treatment of ureteral calculi. Methods: A study population of 307 patients with upper ureteral stones who were admitted in Shanxi Dayi Hospital, Shanxi Academy of Medical Sciences from June 2013 to January 2017 was obtained and retrospectively analyzed. Depending on the type of ureteroscope used, the patients were divided into the FURS group (n=159) and the RURS group (n=148). The therapeutic efficacy of the operation and postoperative complications were compared between the two groups. The prognoses of the patients were followed up for six months, and the rate of calculi recurrence was recorded. Results: The hospitalization time, stone clearance time, operation time and lithotripsy time in the FURS group were shorter than those in the RURS group (all $P<0.05$). The treatment effective rate of the FURS group was 95.60%, which was significantly better than that of the RURS group (83.79%; P=0.01). The incidence of postoperative complications in the FURS group was also significantly lower than that in the RURS group (P=0.01). The recurrence rate of calculi in the FURS group was 3.77%, significantly lower than that in the RURS group which had a recurrence rate of 16.22% (P=0.01). Conclusion: In comparison with those in the RURS group, patients in the FURS group have shorter operation time, more improved therapeutic outcomes, and lesser postoperative complications and relapse rate. Thus, FURS is more highly recommended as an instrument for ureteral lithotripsy in the management of ureteral calculi.

Keywords: Ureteral calculi, flexible ureteroscope, rigid ureteroscope, stone clearance time

Introduction

Ureteral calculi are among the most common urologic diseases in males [1]. Usually, ureteral calculi are originally formed in the kidneys in which they are passed through the ureteropelvic junction and dislodged within the ureters. Ureteral calculi formed primarily within the ureter are quite rare [2]. According to the statistics reported by Hyams et al. there were 860,000 newly diagnosed patients with ureteral calculi in the world in 2015 [3]. Among them, men are affected about 5-fold compared to women. Ureteral calculi do not only affect the excretory renal function of patients, but also cause osteolysis, increase urinary calcium, thereby inducing a series of urinary tract infections, bone atrophy, osteoporosis, osteonecrosis and other malignant diseases [4, 5]. Ureteral calculi have been a popular subject for clinical research. With the rapid development of modern medical science and technology, relatively stable results have been achieved in the management of ureteral calculi [6]. In the clinical practice, ureteroscopic lithotripsy is the most commonly used technique in treating ureteral calculi as it can effectively break down calculi while reducing postoperative complications [7]. However, in the process of lithotripsy, drifting of calculi into the kidneys is a very common problem [8]. According to Cui et al., the probability of calculi drifting into the kidneys during ureteroscopic lithotripsy is as high as 45% [9]. Therefore, it is important to consider whether the ureteroscopic lithotripsy can effectively resolve the calculi drift or not. In clinical practice, flexible ureteroscope (FURS) and rigid ureteroscope (RURS) are commonly used in ureteral lithotripsy, but it is still not yet established which of these specific ureteroscopes is better [10, 11].

Therefore, this study aims to compare the application value of two ureteroscopes in the treatment of ureteral calculi, providing reference and guidance for the future clinical treatment of ureteral calculi.

Materials and methods

General information

This study was approved by the Ethics Committee of the Shanxi Dayi Hospital, Shanxi Academy of Medical Sciences. From June 2013 to January 2017, 307 patients with upper ureteral stones who were admitted in the hospital were retrospectively analyzed. There were 254 males and 53 females, aged 30 to 50 years with an average age of 38.74±8.67 years.

Inclusion criteria: All patients who were diagnosed with upper ureteral calculi by CT scan in Shanxi Dayi Hospital, Shanxi Academy of Medical Sciences; patients whose ureteroscopic lithotripsy was performed in our hospital after diagnosis with clinical manifestations of discontinuous lumbar abdominal pain and hematuria were enrolled; all patients who have complete medical history of the illness.

Exclusion criteria: Patients with other important organ diseases; patients with tumor diseases; patients with surgical tolerance; pregnant women; physically disabled patients; patients with severe hip joint abnormalities; patients who were transferred to other hospital in the middle of the research period.

Each of the patients who had participated in this study signed the informed consent.

Grouping and methods

Depending on the specific type of ureteroscope, the patients were divided into the FURS group (n=159) and the RURS group (n=148). The surgical efficacy and postoperative complications were compared between the two groups, and the patients were followed up for six months by the form of hospital review. The procedure was conducted in strict accordance with the guidelines for ureteroscopic lithotripsy in 2010 [12].

The patients in the FURS group were treated with general anesthesia or combined anesthesia. The zebra guide wire receding mirror was placed to where the stone was positioned. A catheter with a flexible mirror sheath was inserted into the stone's position along with the zebra guide wire. The catheter core was then removed and the flexible ureteroscope was inserted into the flexible ureteroscope sheath. Under direct vision, the ureteroscope was inserted into the upper part of the ureter. After the visualizing the stone, a 200 μm holmium laser fiber was inserted. Holmium laser lithotripsy was then utilized. The energy was set to 1.0-1.5 J/10 Hz, and the stone was gradually crushed. In cases when the stones slid back to the kidney, the flexible ureteroscope was pushed up into the kidney. Then, if necessary, the C-arm X-ray machine fluoroscopy was used to locate the misplaced stones in the kidney, continuing the holmium laser lithotripsy. For larger stone fragments, the net basket was used to catch it. After clearing the stone, the ureteroscope was inserted into the zebra guide wire, passing into the renal collection system under direct vision. Then, with the removal of the lens, the flexible ureteroscope sheath was removed, and a 6F ureteral stent was placed along the guide wire. An indwelling catheter was then inserted after the surgery.

All patients in the RURS group received manually controlled low-pressure perfusion with a 50 mL syringe after anaesthesia. While keeping the visual field clear, the ureteroscope was set under direct vision to avoid causing damage of the mucous membrane of the urethra and bladder neck leading to bleeding that could affect the visual field. After placing the ureteroscope into the bladder, 20 to 40 mg of furosemide was administered into the vein. The mirror was led under the zebra guide wire. With timely replacement of the fine ureteroscope, the inner segment of the bladder wall was blocked, expanding under direct vision and reaching the stone as far as possible to remove the stones. A 550 μm holmium laser fiber was inserted to adjust the holmium laser power at 15-30 W, keeping the fiber and lens body moving simultaneously. From the upper end or lower end of the stone, the "encroachment" method was used. The exploration confirmed there was no significant residue of the remaining stone fragments. The double J tube was placed in the conven-

Table 1. Comparison of clinical data between two groups of patients

	FURS group (n=159)	RURS group (n=148)	χ^2/t	P
Age (years)	42.17±9.68	41.09±8.87	1.02	0.31
Weight (kg)	54.63±12.66	56.09±13.08	0.99	0.32
Disease course (d)	16.33±4.68	17.04±3.24	1.54	0.13
Gender (n, %)			0.22	0.64
Male	130 (81.76)	124 (83.78)		
Female	29 (18.24)	24 (16.22)		
Place of residence (n, %)			0.13	0.72
City	87 (54.72)	78 (52.70)		
Rural	72 (45.28)	70 (47.30)		
Smoking history (n, %)			1.18	0.28
Yes	107 (67.30)	108 (72.97)		
No	52 (32.70)	40 (27.03)		

Note: FURS, flexible ureteroscope; RURS, rigid ureteroscope.

tional autoscope and was observed to be curled in place. The ureteroscope was retracted and catheterization was retained.

Evaluating indicators

The primary observation indicators included the patient's rehabilitation status, therapeutic efficacy, postoperative complications, and calculi recurrence. *The 2013 Guidelines for Rehabilitation of Ureter Calculus* were used as the basis of the criteria for the efficacy which was categorized as "excellent", "good", "general" and "poor" [13]. Excellent: Stones are effectively discharged, and clinical symptoms such as abdominal pain and hematuria are resolved. Good: Stones are basically eliminated, and clinical symptoms of lumbar and abdominal pain and hematuria are significantly improved. General: There are still some remaining stones and clinical symptoms of lumbar abdominal pain and hematuria are still occurring. Poor: A large number of stones are seen, and clinical lumbar abdominal pain and hematuria symptoms have not improved or have even aggravated. Effective rate = Number of (excellent cases + good cases)/total number of cases * 100%. Incidence of complications = Number of cases with complications/total number of cases * 100%. The time was defined from the beginning of the operation to the discharge of the patient.

Secondary observation indicators included operating time (the total time spent by the patient upon entering the operating room until the end of the surgery), crushing stone time (the total time spent in the process of crushing stones), stone clearance time (the total time it took to get rid of the stone fragments completely), and total length of hospital stay (the total time from admission to discharge).

Statistical methods

SPSS22.0 statistical software was used to analyze and process the data. The count data were expressed in rates. Chi square test and Fisher exact probability method were used for the comparisons between groups and represented by χ^2. Measurement data were expressed as mean ± standard deviation ($\bar{x}$ ± sd). The t-test was used to compare the measurement data in relation with the normal distribution between the two groups, expressed as t. P<0.05 is considered statistically significant.

Results

Clinical data comparison

There was no significant difference in age, body weight, course of disease, sex, residence and smoking history between the two groups (all P>0.05), which reflected the comparability between the two groups. See **Table 1**.

Curative effect comparison

The mean length of stay in the FURS group was 14.86±2.17 days, which was significantly shorter than the 17.37±2.88 days in the RURS group (P<0.05). Moreover, the net stone removal time in the FURS group was 11.52±1.07 days, which was also better than the 13.64±1.53 days in the RURS group (P=0.01). The operation time and lithotripsy time of the two groups were compared. The mean operation time of the FURS group and the RURS group were 119.73±13.54 min and 137.66±15.87 min, respectively. The mean lithotripsy time of the FURS group was 44.17±12.65 min while the RURS group generally took 67.57±13.27 min. These results showed that the FURS group was superior in shortening the operation and litho-

Table 2. Comparison of efficacy between two groups of patients

	FURS group (n=159)	RURS group (n=148)	T	P
Hospitalization time (d)	14.86±2.17	17.37±2.88	8.67	0.01
Stone clearance time (d)	11.52±1.07	13.64±1.53	14.15	0.01
Operation time (min)	119.73±13.54	137.66±15.87	10.67	0.01
Lithotripsy time (min)	44.17±12.65	67.57±13.27	15.82	0.01

Note: FURS, flexible ureteroscope; RURS, rigid ureteroscope.

Table 3. Comparison of treatment effects between two groups of patients (n, %)

	FURS group (n=159)	RURS group (n=148)	χ^2	P
Excellent	105 (66.04)	86 (58.11)		
Good	47 (29.56)	38 (25.68)		
General	5 (3.14)	15 (10.14)		
Poor	2 (1.26)	9 (6.08)		
Total efficiency	95.60	83.79	11.78	0.01

Note: FURS, flexible ureteroscope; RURS, rigid ureteroscope.

Table 4. Comparison of complications in the two groups (n, %)

	FURS group (n=159)	RURS group (n=148)	χ^2	P
Vomiting	0	0		
Pain	2 (1.26)	12 (8.11)		
Ureteral injury	3 (1.89)	6 (4.05)		
Ureteral perforation	1 (0.63)	1 (0.68)		
Bleeding	1 (0.63)	5 (3.38)		
Fever	2 (1.26)	7 (4.73)		
Incidence of complications	5.67	20.95	15.80	0.01

Note: FURS, flexible ureteroscope; RURS, rigid ureteroscope.

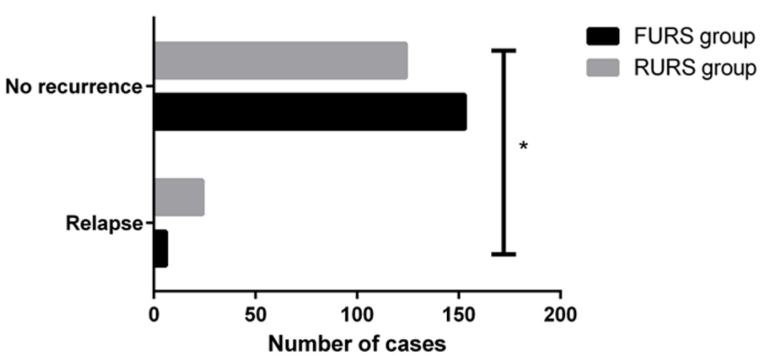

Figure 1. Recurrence of calculi in both groups. In the FURS group, there were 6 cases of stone recurrence, the recurrence rate was 3.77%; in the RURS group, there were 24 cases of stone recurrence, and the recurrence rate was 16.22%. Comparing the recurrence rate of the two groups of stones, χ^2=13.46, *P=0.02; the difference was statistically significant. FURS, flexible ureteroscope; RURS, rigid ureteroscope.

tripsy duration compared to the RURS group (P=0.01). The effective rate of treatment in the FURS group was 95.60%, which was significantly greater than that of 83.79% in the RURS group (P=0.01). In terms of postoperative complications, the incidence rate was 5.66% in the FURS group and 20.95% in the RURS group. The FURS group had significantly lower cases with postoperative complications than the RURS group (P=0.01). See **Tables 2-4**.

Prognosis comparison

A total of 307 patients were followed up and the overall success rate was 100.00%. In the FURS group, there were 6 cases with stone recurrences with a recurrence rate of 3.77%. In the RURS group, there were 24 cases of stone recurrences with a recurrence rate of 16.22%. Thus, the prognosis in the FURS group was significantly better than that in the RURS group (χ^2=13.46, P=0.02). See **Figure 1**.

Discussion

In the course of the ureteral calculi treatment, the traditional open surgery can also provide better therapeutic effects; however, the traditional open surgery involves a significantly large body surface area which can cause greater morbidity and injury to the patient's body and can delay the postoperative recovery time. So, it has been gradually replaced by the ureteroscopic lithotripsy [14, 15]. Ureteroscope can locate 80% of the ureteral calculi; combined with holmium laser lithotripsy, it generally results to better therapeutic effects [16]. However, there are a few differences between FURS and RURS in the study of ureteroscopes locally and globally. Thus, the application of the two specific types of ureteroscopes has been controversial. Therefore, we retrospectively analyzed the patients who have undergone ureter lithotripsy in this hospital to verify which type of ureteroscope has higher therapeutic application value.

The results of this study showed that the FURS did not only provide better curative effects, but could also shorten the postoperative recovery time with lower calculi recurrence rates compared to that by using RURS. This was also consistent with the results of the study by Tao et al. [17]. The key to the difference in the efficacy of the application of the two ureteroscopic lithotripsy techniques is presumed to be the flexibility of the ureteroscope. FURS is soft and slender which can be flexed and turned several times, making it easier upon insertion into the ureter [18]. In contrast, the RURS is inflexible and the mirror is smaller. For some stones in the ureter, the stones may not be explored [19].

In this study, the incidence of complications in the FURS group was lower than that in the RURS group. It may be due to the fact that FURS has a certain protective effect on the guide sheath, which can reduce the mucosal damage caused by ureteroscopes within the ureter. This can also greatly reduce the risks of infection in patients [20]. The soft body of the FURS is also more conducive to the backflow of irrigation fluid during surgery, which reduces the internal pressure of the renal pelvis. This effectively avoids renal dilatation and hemorrhage which may be caused by increased renal pelvis pressure [21]. Through many turns and bends, the residual stones in the ureter can be explored completely without causing substantial injuries of the urethral tube and pelvis mucosa in the course of the surgical operation, which is one of the reasons for the differences in prognosis between the two groups.

For stones drifting into the kidneys, it is speculated that FURS can crush stones in time, avoiding secondary injury. In addition, Kozminski et al. had achieved a 100% success rate in a research study of ureteral calculi being managed using FURS [22]. Kumar et al. also showed that FURS could effectively reduce postoperative complications and recurrence rates in patients with ureteral calculi [23]. Therefore, FURS is considered to be more valuable than RURS in the application of ureteral calculi management.

However, there are still certain limitations in this study which may include a small sample size and the focus on a single type of ureteral calculi. Follow-up of the subjects for a longer period of time must be implemented to assess the long-term results of the two specific types of ureteroscopes, which may be refined by future experiments.

In conclusion, FURS can effectively shorten the surgical operation time of ureteroscopic lithotripsy, significantly improve the curative outcomes, and reduce the postoperative complications and recurrence rate of the patients with ureteral calculi in comparison with RURS. Therefore, FURS is more highly recommended in ureteral lithotripsy as part of the management of ureteral calculi.

Disclosure of conflict of interest

None.

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