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Retrospective analysis of stone basket combined with flexible ureteroscope holmium laser lithotripsy in the treatment of lower calyceal stones

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Abstract. – OBJECTIVE: The aim of the study was to investigate the efficacy of stone baskets combined with flexible ureteroscope holmium laser lithotripsy (FURL) in the treatment of lower calyceal stones (LCS).

PATIENTS AND METHODS: A total of 216 patients with LCS who underwent FURL in our hospital were analyzed retrospectively and divided into observation group (n=129, with stone basket) and control group (n=87, without the stone basket), according to whether the stone basket was used during FURL. The operation time, stone size, stone clearance rate, steinstrasse incidence rate and complication rate were collected and analyzed.

RESULTS: There were no significant differences between the two groups in preoperative gender, BMI, age, stone size and comorbid diseases ($p > 0.05$); no significant differences between the two groups in the change of procalcitonin, C-reactive protein, white blood cell count and hemoglobin after the operation ($p>0.05$); the operation time in the observation group was significantly higher than that in the control group (80.12±8.25 *vs.* 61.93±6.55, $p=0.019$); the short-term stone clearance rate (85.27% *vs.* 66.67%, p 0.001) and long-term stone clearance rate (95.35% *vs.* 85.06%, $p=0.021$) of the observation group were significantly higher than those of the control group; the incidence rate of steinstrasse (0% *vs.* 8.05%, $p<0.001$) and overall complications (7.75% *vs.* 16.09%, $p=0.009$) in the observation group were significantly lower than those in the control group.

CONCLUSIONS: Stone basket combined with FURL is safe and feasible for the treatment of LCS, which can improve the stone clearance rate and reduce the risk of steinstrasse formation after the operation.

Key Words:

Flexible ureteroscopic, Flexible ureteroscopic lithotripsy (FURL), Stone basket, Kidney stone, Holmium laser, Lower calyceal stones, Stone clearance rate, steinstrasse.

Introduction

Urinary calculi are the most common clinical urinary tract diseases, with an incidence of about 5-15%, of which kidney stones account for 40-50%[1-3]. Studies[1-3] have shown that 25-36% of kidney stones are lower calyceal stones (LCS), and about 40% of cases with LCS show clinical symptoms that require treatment. Due to the special anatomical structure of LCS, the stone-free rate (SFR) after surgery for LCS is lower than that of middle and upper calyx stones. Therefore, the choice of treatment strategy for LCS is particularly important[3-5].

Flexible ureteroscope holmium laser lithotripsy (FURL) is a safe and effective minimally invasive treatment for upper urinary tract stones[3-5]. Compared with percutaneous nephrolithotomy (PCNL), FURL has the advantages of less bleeding and lower incidence of postoperative complications[4,5]. It plays an important role in the treatment of LCS at present for its safety, efficacy, minimal invasiveness, and low incidence of postoperative complications[6,7]. However, there are some problems with FURL due to the special anatomical position of LCS, such as unsatisfactory lithotripsy effect, damage to the renal papilla and renal calyceal mucosa. etc.[8-11]; on the other hand, due to intraoperative stone movement and different stone sizes after lithotripsy, there is a risk of steinstrasse formation after postoperative stone clearance, which affects the efficacy of FURL on LCS[8-11]. Stone basket combined with FURL can solve the above problems effectively. Using a stone basket during surgery can pull stones and stone fragments at a larger angle to the renal pelvis or to a suitable angle for treatment, which improves the clearance rate of FURL and reduces the incidence of surgical complications to a large

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extent. Accordingly, this study will describe the efficacy of stone baskets combined with FURL in the treatment of LCS.

Patients and Methods

Case Collection

A retrospective analysis was performed on 216 patients with LCS who underwent FURL in our hospital between March 2016 and October 2021. The observation group was treated with stone basket combined with FURL (n=129), while the control group with FURL only (n=87). Inclusion criteria: patients aged more than 20; LCS diameter of 1.0-2.0 cm confirmed by abdominal CT scan or intravenous pyelography (IVP); patients received FURL for the first time; patients and family members agreed and signed the operation informed consent. Exclusion criteria: patients with contraindications for FURL; with severe cardiopulmonary functions who cannot tolerate surgery; with immune system diseases; with hematological diseases; with severe liver and kidney insufficiency; accompanied by an infection of other organs or febrile diseases. In addition, all patients included in this study signed informed consent. This study was approved by the Ethics Committee of Yuechi People's Hospital, in accordance with Animal Welfare Guidelines and the Declaration of Helsinki.

Surgical Methods and Instruments

The FURL operation steps are the same as those reported in previous studies[12-14], all of which are performed by the same senior physician. American Lumenis medical laser machine and supporting optical fiber are applied for the holmium laser. German Olympus electronic ureteroscope is used for the flexible ureteroscope, whose sheath is made by COOK Company in the United States. The set of stone baskets is COOK's NGE-017115 type 1.7F. FURS laser pulse energy is set as 1.0-1.2 J; the frequency as 20-25 Hz. A 200 μm laser fiber is used. The same size of optical fiber and the same energy of holmium laser are used in the observation group to crush and try to completely pulverize the stones; there is no need for the control group to pulverize the stones, just crush them to an appropriate size (3-4 mm in diameter); for LCS with small angles and stones with narrow calyx necks, we first move them to the middle and upper calyx using the stone basket, and then crush them. Most of the stone fragments are taken out with the stone basket under direct vision.

Collection of Observation Indicators

We collected and analyzed general clinical data, operation time, hospital stay, short-term stone clearance rate, long-term stone clearance rate (30 days after the operation) and surgical complications. Among them, the operation time was calculated from the beginning of holmium laser lithotripsy to the end of the ureteral stent placement. Changes of patients' body temperature before and after surgery were monitored and recorded, and postoperative body temperature >38°C was considered as fever. Indicators such as hemoglobin, procalcitonin, C-reactive protein, and white blood cell count were collected within 2 hours after operation for analysis. Short-term stone clearance rate refers to the percentage of patients with no obvious residual stones or residual stones <3 mm in diameter among all patients who re-examined the kidney ureter bladder (KUB) on the second day after surgery[15]; long-term stone clearance rate refers to the percentage of patients with no obvious residual stones or residual stones <3 mm in diameter in the KUB re-examination 1 month after surgery among all cases[15]. The incidence of steinstrasse refers to the percentage of patients who develop steinstrasse within 1 month after surgery in the KUB review among all cases; the incidences of surgical complications, including sepsis, ureteral avulsion, gross hematuria, ureteral injury, and renal colic, were collected and analyzed.

Statistical Analysis

The data were processed with SPSS 20.0 software (IBM Corp., Armonk, NY, USA). One-sample K-S test was used for the normal distribution test, and the measurement data were expressed as mean±standard deviation (x±s); a *t*-test was used for comparison between groups; the count data were analyzed by χ^2 test or Fisher's exact test and expressed as frequency or rate (%); non-normal data were represented by the median, and non-normal distribution data were analyzed by Mann-Whitney U test; statistical significance was considered when $p<0.05$.

Results

Comparison of Clinical Characteristics Between the Two Groups

As shown in Table I, there were no significant differences between the two groups ($p>0.05$)

Table I. Comparison of basic data between the two groups.

Parameter	Observation group (n = 129)	Control group (n = 87)	*p*-value
Gender (%)			0.438
Male	73 (56.58%)	51 (58.62%)	
Female	56 (43.42%)	36 (41.38%)	
Age (years)	40.60 ± 7.60	41.40 ± 5.35	0.171
BMI (kg/m^2)	27.22 ± 3.02	27.91 ± 2.32	0.532
Stone size	1.83 ± 0.31	1.77 ± 0.37	0.392
Diabetes	9 (6.98%)	7 (8.05%)	0.237
Hypertension	15 (11.63%)	9 (10.34%)	0.753
Coronary heart disease	4 (3.11%)	3 (3.5%)	0.631
Affected kidney site			0.375
Left	60 (46.51%)	42 (48.28%)	
Right	69 (53.48%)	47 (54.02%)	

in gender, age, BMI, stone size, affected kidney site, or comorbid diseases, indicating the clinical baseline data of the two groups were comparable.

Comparison of Blood Indexes and Stone Clearance Rate Between the Two Groups

As shown in Table II, there were no significant differences between the two groups in procalcitonin, C-reactive protein, white blood cell count or hemoglobin changes after surgery (p>0.05). The operation time of the observation group was significantly longer than that of the control group (80.12±8.25 *vs.* 61.93±6.55, p=0.019); the short-term stone clearance rate (85.27% *vs.* 66.67%, p<0.001) and long-term stone clearance rate (95.35% *vs.* 85.06%, p=0.021) in the observation group were significantly higher than those in the control group. As shown in Table II and Figure 1, the incidence of steinstrasse (0% *vs.* 8.05%, p<0.001) in the observation group was significantly lower than that in the control group.

Comparison of Surgical Complications Between the Two Groups

As shown in Table III, no urosepsis, ureteral injury or ureteral avulsion occurred in both groups; no significant difference in postoperative fever between the two groups; the incidences of renal colic (2.16% *vs.* 8.05%, p=0.014), perinephric hematoma (0% *vs.* 2.29%, p=0.029) and overall morbidity (7.75% *vs.* 16.09%, p=0.009) in the control group were significantly higher than those in the observation group.

Discussion

At present, the effective minimally invasive treatments for LCS mainly include extracorporeal shock-wave lithotripsy (ESWL), percutaneous nephrolithotomy (PCNL) and FURL[3,16-18]. Among them, ESWL treatment is simple and convenient but with low efficacy of stone clearance, and repeated ESWL will damage the renal tissue[16-18]; PCNL is one of the effective methods for LCS, while there is still a high risk of postoperative bleeding although its stone clearance

Table II. Comparison of blood indexes and stone clearance rate between the two groups.

Parameter	Observation group (n = 129)	Control group (n = 87)	*p*-value
Operation time (min)	80.12 ± 8.25	61.93 ± 6.55	0.019
Hemoglobin protein changes (g/L)	5.51 ± 1.63	6.14 ± 1.34	0.624
Procalcitonin (ng/ml)	0.31 ± 0.21	0.28 ± 0.48	0.586
C-reactive protein (mg/ml)	21.23 ± 8.61	20.05 ± 11.21	0.124
White blood cell count (10^9/L)	9.05 ± 4.43	8.57 ± 6.94	0.102
Short-term stone clearance rate (%)	110/129 (85.27%)	58/87 (66.67%)	< 0.001
Long-term stone clearance rate (%)	123/129 (95.35%)	74/87 (85.06%)	0.021
Stone street incidence (%)	0%	7/87 (8.05%)	< 0.001

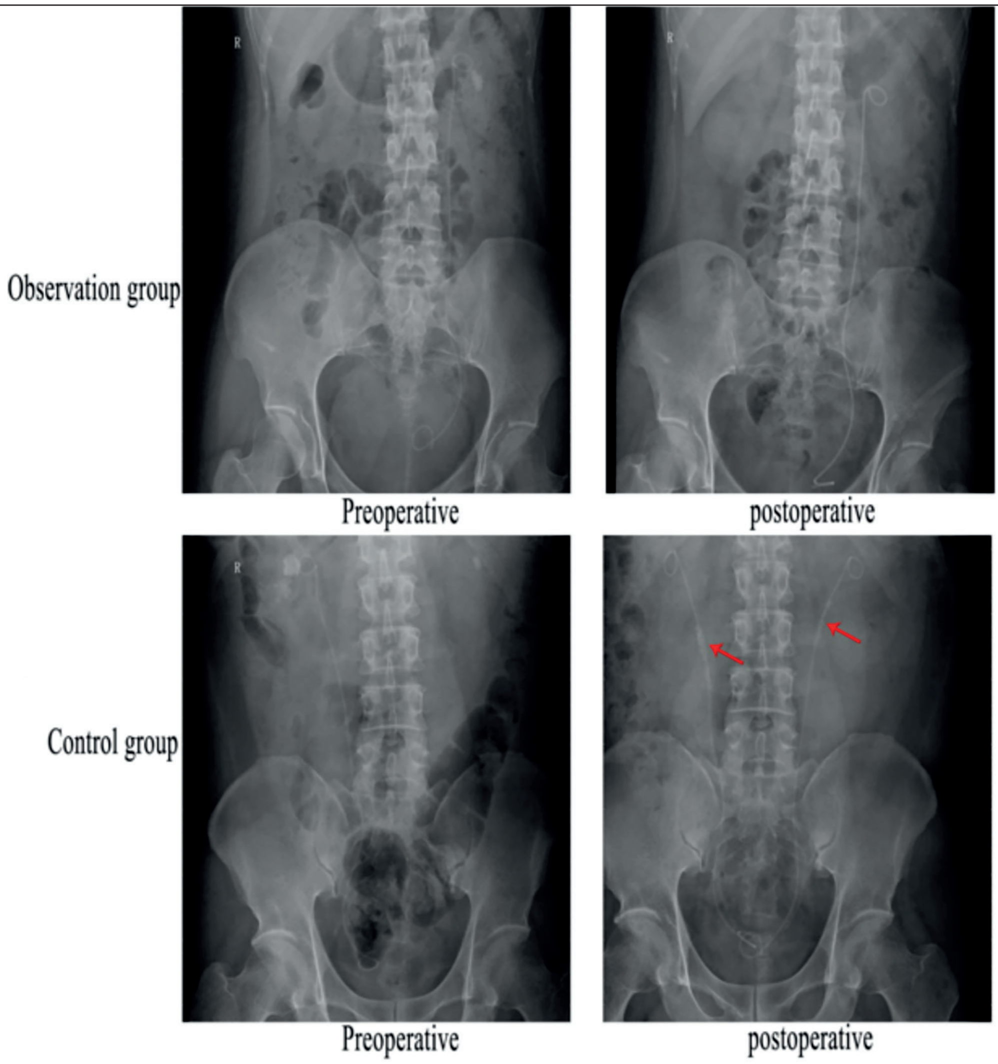

Figure 1. Example images of preoperative and postoperative X-rays in the observation group and in the control group. Arrows point to the steinstrasse.

rate is high[16-18]; FURL is flexible to enter each renal calyx to treat stones and has gradually become an effective way for LCS[16-18], but it is greatly affected by infundibulopelvic angle (IPA) in the treatment of LCS, although most of the renal pelvis and calyces can be seen by flexible ureteroscopy. If the IPA is too small, the bending angle of the flexible lens end of the ureter will be affected. Especially after the holmium laser fiber is inserted into its working channel, the bending

Table III. Comparison of surgical complications between the two groups.

Parameter	Observation group (n = 129)	Control group (n = 87)	*p*-value
Urosepsis	0 (0)	0 (0)	-
Fever	7/129 (5.04%)	5/87 (5.75%)	0.439
Renal colic	3/129 (2.16%)	7 (8.05%)	0.014
Perinephric hematoma	0 (0)	2 (2.29%)	0.029
Ureteral injury	0 (0)	0 (0)	-
Ureteral avulsion	0 (0)	0 (0)	-
Overall morbidity	10 (7.75%)	14 (16.09%)	0.009

of the flexible lens end will be more limited due to the toughness of the fiber itself. Thus, some LCS cannot be touched[18,19], even if LCS can be observed, mucosal damage and lithotripsy failure will occur due to the bending angle limitation[18,19]. Currently, the limitations of FURL lie in the relatively low stone clearance rate and in the formation of postoperative steinstrasse[16-19]. Made of Nickel-titanium shape memory alloys, a material with good flexibility, the stone basket is used in minimally invasive surgery to capture, move and remove urinary calculus[20-22]. In addition, the unique headless design allows the stone basket to better surround the stones, which contributes to stone extraction and minimizes mucosal and renal papilla injury[20-22]. In previous studies of ureteral and renal stones, researchers found that stone baskets can significantly improve the stone clearance rate[23,24]. In this study, we found that the short-term stone clearance rate (85.27% *vs.* 66.67%, $p<0.001$) and long-term stone clearance rate (95.35% *vs.* 85.06%) of the observation group were significantly higher than those of the control group. In addition, the incidence of steinstrasse in the observation group (0% *vs.* 8.05%) was significantly lower than that in the control group. The above results suggest that the stone basket plays an important role in stone clearance in the treatment of LCS. The high stone removal efficiency of the stone basket combined with FURL on LCS is mainly related to the characteristics of the basket, which is a metal mesh structure. During the operation, some LCS can be moved to the middle and upper calyx before being crushed; it can also fix the stones, reduce their movement and then crush them[20-22]; in addition, it can cover stones with a diameter of 3-4 mm and then take them out of the body with ureteroscope, which can prevent the stones from moving upward to the greatest extent during the operation, so as to improve the success rate of lithotripsy and the rate of stone clearance[20-22]; moreover, the stone basket can remove stones with a diameter of 3-4 mm, improving the success rate of lithotripsy and reducing the incidence of postoperative steinstrasse[20-22].

It's controversial whether the stones should be removed during FURL. Because when using stone basket to remove stones, the ureteroscope will enter and exit repeatedly, resulting in prolonged operation time and surgical risks[21,25,26]. In this study, we found that the operation time in the observation group was significantly longer than that in the control group (80.12±8.25 *vs.* 61.93±6.55, $p=0.019$). However, there were no differences in the change of procalcitonin, C-reactive protein, white blood cell count, fever rate and hemoglobin after the operation. In terms of the incidence of complications, we found the incidences of renal colic (8.05% *vs.* 2.16%), perirenal hematoma (0% *vs.* 2.29%) and overall complications (16.09% *vs.* 7.75%) in the control group were significantly higher than those in the observation group. The above results suggested that using stone baskets during FURL for stone removal prolonged the operation time, but did not increase the incidence of complications, conversely, it reduced the incidence of postoperative renal colic and perirenal hematoma in patients. The possible reason is that the flexible ureteroscope was withdrawn from the renal pelvis during the removal of the stone basket, which reduced the high pressure in the renal pelvis; on the other hand, the stone basket can reduce the load of small kidney stones after stone extraction, thus reducing the possibility of small stones blocking the ureteral passage.

Inevitably this study will be flawed, and the main limitations are as follows: first, as a retrospective study, the study design itself is biased; second, the sample size of this study is small, and further research with larger samples is needed; third, this is a single-center study with the problem of research bias; and fourth, there are biases in the study due to differences in operators' experience, surgical equipment, and cultural difference.

Conclusions

The stone basket combined with FURL is safe and feasible in the treatment of LCS, which can not only improve the stone clearance rate, but also reduce the incidence of postoperative steinstrasse.

Conflict of Interest

The Authors declare that they have no conflict of interests.

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Authors' Contribution

Study conception and design: Du Jinhua, Du Wanlin. Acquisition of data: Analysis and interpretation of data: Du Jinhua, Du Wanlin. Drafting of manuscript: Du Jinhua, Du Wanlin. Critical revision: Du Jinhua, Du Wanlin.

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