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ORIGINAL ARTICLE

Outcome of flexible ureteroscopy for renal stone with overnight ureteral catheterization: a propensity score-matching analysis

Mitsuru Komeya[1,2] · Kimitsugu Usui[2] · Takuo Asai[2] · Takehiko Ogawa[1] · Masataka Taguri[3] · Koshi Kataoka[3] · Masahiro Yao[1] · Junichi Matsuzaki[2]

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Abstract

Purpose To evaluate the influence of overnight ureteral catheterization and determine if routine long-term post-stenting can be avoided in flexible ureterorenoscopy (fURS) procedure for kidney stone.

Methods Three hundred ninety-three patients who underwent single fURS for kidney stone between January 2013 and June 2016 at a single institute were retrospectively analyzed. The stone-free (SF) and perioperative complication rates in patients with routine long-term post-stenting after fURS (long-term stent group) were compared with those of patients with overnight ureteral catheterization (short-term stent group). Propensity score-matching analysis was used to adjust the difference in baseline preoperative parameters between the two groups. All preoperative parameters were chosen to develop the propensity score, and 74 patients in the short-term stent group were retrospectively matched with the patients in the long-term stent group at a 1:1 ratio.

Results Patient characteristics included age, sex, side of involvement, height, body weight, body mass index, number of stone(s), stone volume, Hounsfield units of stone, preoperative white blood cell count, preoperative C-reactive protein, preoperative creatinine, pretreatment, pre-stenting, stenosis of the ureter, and procedure duration. The SF rates were 91.9 and 93.2% in the short-term and long-term stent groups, respectively. Perioperative complications were 14.9 and 12.2%. No difference was noted between the two groups in terms of SF and perioperative complication rates.

Conclusions Short-term post-stenting using overnight ureteral catheterization in uncomplicated cases after fURS for kidney stone was as effective as conventional long-term post-stenting in reducing postoperative complications. These preliminary data suggest the possibility that routine long-term post-stenting was unnecessary.

Keywords Flexible ureterorenoscopy · Ureteroscopy · Kidney stone · Lithotripsy · Post-stenting

Introduction

When fURS was first introduced, the associated stone-free (SF) rate was far below and the rate of adverse effect was high. However, currently, the ureterorenoscopic procedure has become efficient and safe owing to technological advances such as endoscope miniaturization, improved deflection mechanism, higher image resolution, along with supportive tools such as the detractor system [1–6]. Therefore, fURS has become widely used for renal stone treatment [1, 2, 4, 7–10]. In addition, fURS does not need renal puncture and is theoretically free from severe renal bleeding. The minimally invasive nature of fURS is its strong benefit, which appeals to the current medical society and meets the demands of patients. Stenting after fURS is frequently performed to prevent acute ureteric obstruction, renal pain, and

✉ Mitsuru Komeya
urology_ycu@yahoo.co.jp

[1] Department of Urology, Yokohama City University Graduate School of Medicine, 3-9 Fukuura, Kanazawa-ku, Yokohama, Kanagawa 236-0004, Japan

[2] Department of Urology, Ohguchi East General Hospital, 2-19-1 Irie, Kanagawa-ku, Yokohama, Kanagawa 221-0014, Japan

[3] Department of Biostatistics, Yokohama City University Graduate School of Medicine, 3-9 Fukuura, Kanazawa-ku, Yokohama, Kanagawa 236-0004, Japan

delayed ureteric stricture. However, stenting is associated with higher postoperative morbidity; thus, routine stenting before and after fURS for renal urolithiasis is one of the burdens of patients. In the uncomplicated patients undergoing URS for ureteral stones without residual fragments, ureteral trauma, bleeding, perforation, or upper urinary tract infections, routine pre-stenting and post-stenting are thought to be unnecessary. Moreover, post-stenting might be associated with higher postoperative morbidity in uncomplicated cases [11, 12]. However, the effect of routine stenting before and after fURS for kidney stone is unclear. In this study, we first evaluated the influence of post-stenting by comparing short-term stenting, using overnight ureteral catheterization, with conventional long-term stenting.

Patients and methods

Three hundred ninety-three patients who received fURS for renal stones between June 2013 and June 2016 at a single institute (Ohguchi East General Hospital) were retrospectively analyzed. After excluding patients who underwent multiple fURS for the same stone or with coexisting ureteral stones, 330 patients who underwent URS for renal stones for the first time remained. One hundred thirty-seven patients were further excluded from statistical analysis due to missing or insufficient medical records of preoperative parameters. The patients were divided into two groups: those who had conventional post-stenting after fURS (long-term stent group) and those who had overnight ureteral catheterization (short-term stent group) based on surgeon's preference. The patients with high risk of the perioperative complications, for instance, the stenosis of ureter, large stones, and prolonged procedure time, tended to be divided into the long-term stent group. In the long-term stent group, the ureteral stent (6 or 8 Fr) was usually removed 3–4 weeks after the surgery. In the short-term stent group, the ureteral catheter [5 Fr Tigertail ureteral catheter (Bard Medical Division, Covington, GA)] was removed the morning on postoperative day (POD) 1. In both groups, the urethral catheter was removed on POD-1. Propensity score-matched analysis was used to adjust the difference in baseline preoperative parameters between the two groups. All preoperative parameters were chosen to develop the propensity score. Seventy-four patients in the short-term stent group were retrospectively matched to the long-term stent group at a 1:1 ratio.

Our strategy in the treatment of renal stones was based on the guideline of the European Association of Urology, which recommended PCNL for renal stones >20 mm in diameter, and either shockwave lithotripsy or fURS for renal stones <20 mm in diameter. The final decision was made based on the preference of both the patient and the surgeon [8, 13]. This study was approved by the Institutional Ethics Committee of Ohguchi East General Hospital. We obtained written informed consent from all patients for the use of their data for research purposes.

Surgical techniques

Details of the surgical procedures were as previously described [8, 13]. Briefly, fURS was started with the observation of the upper urinary tract, using a 6/7.5-Fr semi-rigid ureteroscope (Wolf™; Richard Wolf GmBH, Knittlingen, Germany) to select the adequate diameter of ureteral access. After the placement of ureteral access sheaths [9.5 or 12/14 or 14/16 Fr (Cook Medical, Bloomington, IN, USA) or 11/13 or 13/15 Fr (Boston Scientific, Natick, MA, USA)], lithotripsy based on the fragmentation technique was performed using a 6-Fr flexible ureteroscope (Olympus P-5TM; Olympus, Tokyo, Japan) with 200-μm holmium:yttrium–aluminum–garnet laser. The renal pelvis was the target insertion of the access sheath, and the access sheath was inserted as close as possible to the renal pelvis when the surgeon felt resistance during insertion. Such a situation was defined as stenosis of the ureter. In all cases, 1.5- and/or 2.2-Fr tipless nitinol baskets were used for stone removal and clearance of residual fragments. After fURS, the injury in the upper urinary tract was evaluated by retrograde pyelography and observation of the lumen using endoscopy. Preventive infusion of antibiotics was performed at the beginning of the surgery.

Preoperative and postoperative evaluation

Preoperative parameters included age, sex, height, body weight, body mass index, side of involvement (right or left), number of stones, stone volume (mL), Hounsfield unit of the stone, pre-stenting, shockwave lithotripsy pretreatment, stenosis of the ureter, procedure duration, white blood cell count, C-reactive protein, and creatinine. The side of involvement and the number of stones were confirmed by preoperative non-contrast CT (NCCT). The volume and Hounsfield unit of the stones were measured using 5-mm axial and 3.5-mm reconstructed coronal NCCT images, as previously reported [14, 15]. Postoperative evaluation consisted of the SF rates and perioperative complications regarding the surgery. Stone status was evaluated using kidney–ureter–bladder X-ray imaging on POD-1 and using NCCT 3 months after the surgery. SF was defined as either complete absence or presence of stones <4 mm in diameter on NCCT imaging. The presence of hydronephrosis was also evaluated by the postoperative NCCT. To evaluate perioperative complications, the precise examinations like blood examination, urinalysis, ultrasound, kidney–ureter–bladder X-ray imaging, and NCCT images were performed when patients showed some symptoms or abnormal vital signs.

Postoperative pain was evaluated by checking for acetaminophen, nonsteroidal anti-inflammatory drugs (NSAIDs), and opioid use in the patient's records. The patients were guided to use pain killers on demand. When patients felt severe pain, the infusion of opioid was performed. Patients with mild or moderate pain used NASIDs. In case of contraindications to NSAIDs use like allergy and renal dysfunction, acetaminophen was used instead of NSAIDs. The Numeric Rating Scale (NRS) of pain during the hospitalization was also evaluated at the day of the discharge [16]. The patients were interviewed during their first follow-up visit on the incidence of colic pain and NSAID use.

Statistical analysis

The propensity score-matched analysis was used to adjust the difference in baseline preoperative parameters between the two groups. All preoperative parameters were chosen to develop the propensity score. Matching was performed using greedy matching based on the logit of the propensity score with a caliper of 1.0 standard deviation (SD). Continuous variables were analyzed using Student's *t* tests and expressed as mean (SD). Proportions of categorical variables were compared with Fisher's exact test. Statistical significance was set at $p < 0.05$, and all reported *p* values were two-sided. All statistical analyses were performed with EZR (Saitama Medical Center, Jichi Medical University, Saitama, Japan), which is a graphical user interface for R (The R Foundation for Statistical Computing, Vienna, Austria), and JMP Pro version 12.2.0 (SAS Institute Inc., Cary, NC, USA). More precisely, EZR is a modified version of the R commander designed to add statistical functions that are frequently used in biostatistics [17].

Results

Patient characteristics

The preoperative parameters of the two groups after propensity score-matching are shown in Table 1. All preoperative parameters were statistically similar between the groups. All procedures were performed under general anesthesia. A ureteral access sheath was used in all cases.

Surgical outcome

The surgical outcome, including the SF rates and perioperative complications, are summarized in Table 2. The SF and postoperative complication rates between the two groups were not significantly different. In the short-term stent group, seven febrile patients (Clavien–Dindo grade II) and

Table 1 Comparison of patient characteristics

Variable	Long-term stent group (*N* = 74)	Short-term stent group (*N* = 74)	*p* value
Age (years)	57.19 (13.92)	57.34 (16.57)	0.953
Sex			
Female	34 (45.9%)	31 (41.9%)	0.741
Male	40 (54.1%)	43 (58.1%)	
Side of involvement			
Right	34 (45.9%)	36 (48.6%)	0.869
Left	40 (54.1%)	38 (51.4%)	
Height (cm)	161.49 (10.00)	161.55 (9.77)	0.967
Body weight (kg)	63.45 (17.33)	60.86 (14.44)	0.325
Body mass index (kg/m^2)	24.18 (5.85)	23.14 (4.47)	0.223
Number of stone(s)			
Single	35 (47.3%)	34 (45.9%)	1
Multiple	39 (52.7%)	40 (54.1%)	
Stone volume (mL)	1.45 (1.52)	1.32 (1.02)	0.518
Hounsfield units	881.22 (302.14)	890.73 (363.87)	0.863
Preoperative white blood cell count (/μL)	6531.89 (1733.96)	6607.84 (2102.93)	0.811
Preoperative C-reactive protein (mg/dL)	0.44 (1.19)	0.50 (1.07)	0.776
Preoperative creatinine (mg/dL)	0.85 (0.32)	0.84 (0.30)	0.891
Pretreatment +/−	17/57	18/56	1
Preoperative stenting +/−	48/26	46/28	0.865
Stenosis of ureter +/−	12/62	13/61	1
Procedure duration (min)	84.54 (23.80)	77.26 (30.78)	0.11

Table 2 Surgical outcome: stone-free and perioperative complication rates

Variable	Long-term stent group ($N=74$)	Short-term stent group ($N=74$)	p value
Stone-free rate	69 (93.2%)	68 (91.9%)	1
Perioperative complication rate	9 (12.2%)	11 (14.9%)	0.811
Clavien–Dindo classification			0.387
I	0 (0.0%)	0 (0.0%)	
II	7 (77.8%)	7 (63.6%)	
III	0 (0.0%)	3 (27.3%)	
IV	2 (22.2%)	1 (9.1%)	
Period of hospitalization (days)	6.23 (3.20)	6.78 (3.80)	0.339

one septic patient (Clavien–Dindo grade IV) were treated conservatively. Ureteral re-stenting was performed due to the postoperative pyelonephritis on POD-3 and POD-7 in two patients and abdominal pain with grade-1 hydronephrosis on POD-1 in one patient. In the long-term stent group, seven febrile (Clavien–Dindo grade II) and two septic patients (Clavien–Dindo grade IV) were treated conservatively. All febrile patients were diagnosed with urinary tract infection by the precise examination described above. The injury of the upper urinary tract after fURS was not observed in both groups. Both groups had the same period of hospitalization. Patients with hydronephrosis were not observed by the postoperative NCCT.

Postoperative pain

The evaluation of postoperative pain is summarized in Table 3. During hospitalization, the average opioid usage count was similar in the two groups, whereas acetaminophen and NSAID usage count in the short-term stent group was greater than that in the long-term stent group. The average NRS was same in both groups (short-term stent group, 2.09; long-term stent group, 2.20; $p=0.548$). After discharge, there are no significant differences regarding the incidence of colic pain and NSAID usage count. The time course of opioid and NSAID/acetaminophen use is shown in Fig. 1. No difference was noted between the two groups in terms of the diurnal usage of pain killers. Approximately 95% of opioid was infused within POD-1. Ninety percent of NSAIDs and acetaminophen were used within POD-2 and 95% were used within POD-3. In uncomplicated cases receiving fURS for kidney stones, there was no difference regarding the surgical outcome, perioperative complication, and postoperative pain in both groups. These preliminary data suggested that routine long-term post-stenting was unnecessary in uncomplicated cases after fURS for kidney stone.

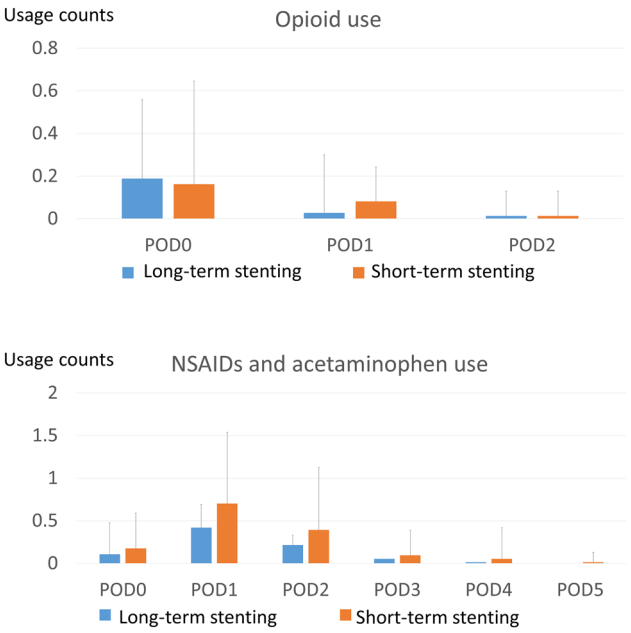

Fig. 1 Time course of opioid and NSAID/acetaminophen use

Table 3 Postoperative pain

Variable	Long-term stent group ($N=74$)	Short-term stent group ($N=74$)	p value
During hospitalization			
Acetaminophen and NSAID use (times)	0.78 (1.54)	1.43 (1.63)	0.014
Opioid use (times)	0.22 (0.63)	0.24 (0.57)	0.784
Numerical rating scale	2.09 (2.39)	2.20 (2.23)	0.548
After the discharge			
Incidence of colic pain (times)	0.49 (1.27)	0.47 (1.04)	0.908
NSAID use (times)	0.49 (1.64)	0.39 (1.25)	0.696

Discussion

Stenting before and after URS of urolithiasis was one of the burdens of patients because it is occasionally a nuisance and sometimes patients develop intolerance to the stent, but with advancements in scientific technology, ureterorenoscopy has become less-invasive and the problems associated with routine stenting were promptly solved. Many researchers reported the effect of routine stenting in patients receiving URS for ureter stones. Although pre-stenting improved the SF rate and declined the risk of perioperative complications, routine pre-stenting was thought to be unnecessary [14]. Randomized trials have shown that routine post-stenting was unnecessary after URS in uncomplicated cases [11, 12]. Regarding fURS for renal stones, the effect of pre-stenting was reported in many studies [14, 15, 18–21]. Lumma et al. [18] showed that pre-stenting improved the SF rate and reduced perioperative complications. Kawahara et al. [20] demonstrated that the improvement in the SF rate was obvious in a large stone with a diameter > 15 mm. However, the effect of post-stenting after fURS for renal stones was not well-evaluated. In our previous study, post-stenting was not performed in 18.8% of the patients receiving fURS for renal stones and the rate of perioperative complications did not increase [10]. This fact encouraged us to investigate the necessity of conventional long-term post-stenting after fURS for renal stones.

Many predictive parameters of SF after fURS, including stone volume, number of stone(s), pre-stenting, and the presence of lower pole calculi, were presented [8, 13, 22–26]. The sum of stone volumes was adapted to evaluate the influence of stone volume precisely instead of the stone diameter, stone burden, and gross stone area. The presence of lower pole calculi was not included due to the high proportion of missing medical records. A matched pair analysis using the propensity score compensated for the influence of all 16 preoperative characteristics (Table 1) on SF. Our data demonstrated that routine long-term post-stenting was unnecessary in improving the SF rate of uncomplicated patients receiving fURS. A recently published large-scale study included 1622 patients with renal stones who were treated with fURS, and the study concluded that preoperative stent increased the SF rates (79.6% with stent vs. 72.9% without stent) and decreased intraoperative complications (10.6% with stent vs. 13.2% without stent) [26]. The perioperative complication rate in our study was as same as that in the literature. Our data also showed that long-term post-stenting did not contribute to the reduction of perioperative early complications after fURS for renal stones (short-term stent group, 14.9%; long-term stent group, 12.2%; $p = 0.811$). This study evaluated postoperative pain precisely because it was one of the major concerns of patients. Long-term post-stenting decreased the average NSAIDs and acetaminophen use during hospitalization. However, the benefit of reduced NSAID and acetaminophen use was thought to be very low. This suggestion was supported by the same NRS score in both groups. The time course regarding analgesic use showed that 95% of opioid infusion was done within POD-1 and in all cases within POD-2. Regarding postoperative pain, hospitalization for 2 days after fURS seemed to be sufficient.

This study has some limitations. This retrospective study enrolled relatively few patients. Although this matched pair analysis included as many as 16 parameters, all parameters reported to influence surgical outcome and perioperative complications were not included, for example, presence of lower pole calculi, hydronephrosis, operator fURS experience, and injury to the upper urinary tract [10]. Injury to the upper urinary tract did not occur in the matched pair groups. The sum of stone volumes on NCCT imaging was adapted to measure the precise stone. However, the stone volumes on NCCT imaging were not popular due to the expensiveness. The size of the stone measured by diameter, burden, or gross area using kidney–ureter–bladder X-ray imaging should be applied for the universal use. The periods of admission were longer than those reported in other studies because the patients were hospitalized 1–2 days before surgery for preoperative preparation. Moreover, the decrease in the patients' quality of life due to discomfort and intolerance to stenting was not evaluated due to the lack of data. Late complications such as ureteric stricture were also not evaluated due to the loss of the long-term follow-up. To reduce the risk of ureteric stricture, the selection of the ureteral access sheath is thought to be important. Although the large access sheaths like 13/15 and 14/16 Fr were inserted in a few cases, the majority of patient received fURS with 9.5 or 11/13 Fr sheaths to avoid ureteral injury. Regarding early complications, three patients in the short-term stent group underwent ureteral re-stenting after fURS. The postoperative insertion of the stent should not be overlooked when applying this result for wider prevalence. Further examination should be done to reveal the risk factors of postoperative stent insertion and to set objective criteria for the use and non-use of conventional long-term post-stenting. In addition, more reliable studies such as matched pair analysis using the propensity score to adjust all conceivable preoperative parameters or randomized prospective analysis should be organized to reconfirm our results and to achieve a less-invasive surgical procedure for fURS of renal stone.

In conclusion, short-term post-stenting using overnight ureteral catheterization in uncomplicated cases after fURS for kidney stone was as effective as conventional long-term post-stenting in achieving SF condition and reducing

postoperative early complications. The investigation of late complications and ureteral stent symptoms in both groups is an issue in the future. These preliminary data suggested that routine long-term post-stenting was unnecessary and opens the way to challenge the induction of complete stent-less after fURS for kidney stone.

Author contribution MK: Project development, data collection, manuscript writing. KU: Data collection. TA: Data collection. TO: Project development, manuscript editing. MT: Data analysis. KK: Data analysis. MY: Project development. JM: Project development.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval For this type of study formal consent is not required.

Informed consent Informed consent was obtained from all individual participants included in the study.

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