

Effectiveness of the self-retrieval basketing technique for stone extraction during flexible ureteroscopy for urolithiasis

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Abstract

Background

To assess the safety and effectiveness of using the self-retrieval basketing technique by solo surgeon as a method for stone extraction during flexible ureteroscopy (f-URS) for urolithiasis.

Methods

This retrospective study enrolled patients with urinary calculus who underwent f-URS at two institutions in Japan between September 2014 and November 2019. A total of 100 cases were performed by one experienced surgeon using the self-retrieval basketing technique. With this approach, the f-URS apparatus was manipulated with the nondominant hand and the basket catheter was manipulated with the dominant hand. The self-retrieval basketing technique employed two parts—specifically, a “front catch” and “side catch” to gather fragmented stones visible in the front and side of the ureteroscopic view, respectively. We retrospectively examined perioperative results, complications, and the stone free rate (with “stone-free” defined as ≤ 2 mm with kidney ureter bladder (KUB) 1 month after f-URS) to estimate the safety and effectiveness for comparison with results of the conventional retrieval basketing technique.

Results

Among our study population, the median stone size was 14 mm and the median operative time was 80 minutes. A stone free status was achieved in 87 patients (87%). The median stone fragmentation time was 16 minutes and the stone retrieval time was 32 minutes. All included cases were completed with the self-retrieval basketing technique. Complications related to stone retrieval were identified in two cases (2%); the degree of ureter injury being Clavien grade IIIa. There were no intraoperative complications such as heavy hematuria not to detect ureteral mucosa.

Conclusions

The self-retrieval basketing technique is safe and effective for the extraction of stone fragments during f-URS for urolithiasis. The self-retrieval basketing technique does not require assistance for basketing; therefore, f-URS with active retrieval basketing could be completed by solo surgeon.

Background

The treatment of urolithiasis has evolved over the years from open lithotomy to minimally invasive endoscopic lithotripsy [1]. In particular, the number of flexible ureteroscopy (f-URS) procedures has increased dramatically alongside ongoing improvements in laser and surgical instruments [2, 3]. Two

basic options exist for treating stones under ureteroscopy. The basketing retrieval technique is used when the stones have fragmented into pieces typically 2 to 4 mm in size, whereas the stone dusting technique is more appropriate when the stones have fragmented to submillimeter pieces (mostly ≤ 2 mm). The latter technique is used to promote the spontaneous passage of stones through the ureter [3, 4]. At most institutions, the technique (basketing or dusting) used is determined according to factors such as surgeon preference, stone size, stone position, stone composition, and renal and ureteral anatomy [3]. There are some reports that have compared stone fragmentation and dusting with f-URS [5–8]. The potential advantages of the dusting technique over the basketing retrieval approach include a shorter operative time, reduced cost due to a decreased use of a ureteral access sheath (UAS) and a basketing device, and decreased potential trauma associated with repeated basketing and the use of a UAS [6–8]. Further, with the basketing retrieval technique, there is a need for an assistant to operate the basket device. Conversely, potential advantages of the basketing retrieval technique are a higher stone free rate and a decrease in postoperative stone related pain and emergency visits after surgery [6–8]. Furthermore, total laser energy has been typically low with basketing retrieval than with dusting. The dusting technique involves thermal warming in the urinary tract due to laser energy application [9, 10]; these thermal effects might result in several injuries in the urinary tract tissues. On the other hand, given that UAS is essential in the basketing retrieval approach, it might result in ureter injury in some cases [11].

The process of stone retrieval using a basket device is a stressful task. It requires handling of a flexible ureteroscope while simultaneously manipulating the basket device. Thus, about two-thirds of urologists use dusting technique that does not require need a basket device during f-URS [3]. However, it has been reported that about 20% of patients who develop stone dust or small fragments of size less than 4 mm experience emergency visits within five years after f-URS [12, 13]. Basketing retrieval of stone fragments might help alleviate to alleviate such postoperative problems. Further, depending on the case, basketing retrieval is actually considered to be a necessary approach. However, there are a few reports available regarding use of the self-retrieval basketing technique [14, 15]. In most cases, the two-persons conventional extraction method have been used at the time of extraction of f-URS; therefore, the presence of a surgeon and an assistant is necessary during the surgery. In this study, we estimated the effectiveness and safety of the self-retrieval basketing technique, enabling the surgery to be performed by solo surgeon. It has been suggested that the results of the self-retrieval extraction method may not be inferior to those of the two-persons conventional extraction method. However, there is no report on a specific method for involving a basket in the self-retrieval basketing technique. In fact, the self-retrieval basketing technique is not particularly widespread or common. If the self-retrieval basketing technique becomes common, there will be a possibility of choosing a retrieval method for f-URS. This technique requires the need to be little familiar on the use of the basket and flexible ureteroscope, and learning this technique might not be difficult. We consider this technique as one of the effective surgical methods for f-URS. The purpose of this study was thus to evaluate the safety and efficacy of the self-retrieval basketing technique and discuss our experience with this technique.

Methods

Study design

This retrospective study considered patients with urinary calculus who underwent f-URS from September 2014 to November 2019 at St. Luke's International Hospital and Tohoku Medical and Pharmaceutical University Hospital, Japan. A self-retrieval basketing method during f-URS was performed to extract stones. While more than 200 consecutive patients underwent f-URS during the above period, we included 100 patients treated with a single surgeon (G.A) who had the experience of performing over 100 cases of f-URS. The inclusion criteria included patients between 20 and 90 years of age. We excluded patients who were initially scheduled for two-stage surgery because the stone size was too large as well as those with malformations in the urinary tract, such as cases after urinary diversion. The ethical committee of Tohoku Medical and Pharmaceutical University Hospital School of Medicine, Sendai, Japan approved the study protocol based on the guidelines of the Declaration of Helsinki (no. 2019-2-056).

Equipment

The following equipment was used a 100-W holmium:yttrium aluminum garnet (YAG) laser (VersaPulse PowerSuite; Lumenis, Yokneam, Israel) with a 200 or 365 μm laser fiber (SlimLine 200 or 365 μm ; Lumenis, Yokneam, Israel), a flexible ureteroscope (7.5-French (Fr) FlexX2; Karl Storz, Tuttlingen, Germany or 7.95-Fr URF-P6; Olympus, Tokyo, Japan), a semirigid ureteroscope [6.0/7.5 or 8.0/9.8 Fr; Wolf, Knittlingen, Germany], an irrigation system (single action pumping system; Boston Scientific, Natick, MA, USA), a ureteral access sheaths (Flexor12/14 Fr; Cook Medical, Bloomington, IN, USA), a single-use basket holder (M-arm; MC Medical, Tokyo, Japan), and a basket catheter (N-gage, 1.7 Fr, Cook Medical, Bloomington, IN, USA).

Surgical technique

All patients underwent a standard surgical procedure. In brief, a semirigid ureteroscope (6.0/7.5 or 8.0/9.8 Fr rigid ureteroscope) was inserted into the urethra, and the bladder was examined under general anesthesia. A straight guidewire was inserted into the ureteral orifice on the diseased side, and the semirigid ureteroscope was passed over the guidewire through the ureteral orifice, as far as was safely achievable up to the renal pelvis region or to the ureteric stone. The presence or absence of ureteral stenosis or ureteral stones was confirmed using a rigid ureteroscope before a UAS insertion in all cases. When there was ureteral stenosis, ureteral dilation was performed or a ureter stent was placed, and two-stage f-URS procedure was scheduled.

Next, a UAS (12/14Fr Cook Flexor sheath) was introduced over the guidewire and positioned under the ureteral stone or in the renal pelvis to reduce intrarenal pressure and to facilitate the extraction of large or multiple renal stones. A holmium laser was used to crush the stones to sizes of 2–4 mm by f-URS (Storz FlexX2 or Olympus P6). All stones were managed by laser fragmentation (0.5–1.0 J \times 5–10 Hz). In the case of upper ureter stones or pelvic stones, mostly 365 μm laser fibers were used because this size of fibers, due to a larger surface area offers a higher degree of lithotripsy efficiency. In the above cases, the patient position was changed to head-down to prevent the stone fragments from moving to the lower

pole because the difficulty of retrieving the fragments can be increased in such a scenario. In kidney pole stone cases, mostly 200 μm laser fibers were used because the flexibility of f-URS could be deployed maximally. After crushing the observed stones into fragments that could easily be extracted (≤ 4 mm), a basket catheter (N-gage, 1.7-Fr; Cook Medical, Bloomington, IN, USA) (Figure 1) with an M-arm (MC Medical, Tokyo, Japan) attached to a flexible ureteroscope was inserted.

This basket catheter typically took up about one-quarter of the screen view in front or to the side of the target stone (Figure 2a). The flexible ureteroscope was manipulated with the nondominant hand, and the basket catheter was manipulated with the dominant hand. The basket was half-opened, and the flexible ureteroscope moved from the near side to the calculus position (Figure 2b). The self-retrieval basketing technique was executed in one of two ways: the front catch (Figures 3a–3d) or the side catch (Figures 3e–3h) method. In large spaces, such as the renal pelvis, the basket catheter was moved straight ahead to capture stones using the front catch technique, whereas, in narrow spaces such as a renal pole, the basket catheter was moved laterally, and stones were captured using the side catch technique. The calculus was confirmed to have entered the basket catheter, and the basket catheter was closed slowly with the dominant hand (Figure 2c). The basket catheter holding the calculus was moved a little closer to the flexible ureteroscope, and an endoscope monitor was used to confirm that the calculus had entered the tip of the access sheath. The fragments were removed from the body via the access sheath. This procedure was repeated by solo surgeons until all fragments that could be enclosed by the basket catheter had been retrieved. In all cases, a 5-Fr ureteral stent was placed just after f-URS and later removed via flexible cystoscopy with local anesthesia at two weeks after f-URS.

During f-URS, we used the single action pumping system to provide a high irrigation flow to ensure a clear view was present to help avoid ureter injury when the flexible ureteroscope was inserted from the access sheath into the ureter and renal pelvis. Essentially, the single action pumping system was not used except for in cases of poor visual access when the stones were being crushed and retrieved in the renal pelvis and kidney pole. This procedure prevented overpressure within the renal pelvis. In most cases, a 5-Fr double-J stent was placed just after f-URS and later removed via flexible cystoscopy with local anesthesia at two weeks after f-URS.

Parameters

The total operating time, stone fragmentation time, and stone retrieval time were evaluated. All patients were assessed two weeks postoperatively for ureteral stent removal and postoperative stone status. The definition of being stone-free was ≤ 2 mm with KUB 1 month after f-URS. We also reviewed intraoperative complications, such as heavy hematuria and ureteral injury, and postoperative complications such as postoperative fever and postoperative ureteral stenosis. Postoperative fever was defined as a significant fever over 38.0°C . Complications were evaluated according to the modified Clavien grading system [16].

Results

A total of 100 cases were included in this analysis. Patient background details are presented in Table 1. The median patient age was 63 (31–87) years and there were 58 males and 42 females. Among the total study population, 56 patients had kidney stones and 44 had upper ureteral stones, with 43 patients affected on the right side, 56 patients affected on the left side, and one patient affected on both sides. Initial symptoms included 20 cases of pyelonephritis, 33 cases of pain, 35 cases of abnormal health checkup findings, 8 cases of hematuria, and 3 cases of acute renal failure. Forty-three patients had been implanted with a double-J stent before f-URS, while 34 patients presented with impacted stones (i.e., no change in stone position for at least three months).

The median stone size among our cohort was 14 (5–36) mm and the median operative time was 80 (25–209) minutes. The stone free rate was 87% (87 of 100 patients) at 1 month postoperatively. The median stone fragmentation time was 16 (1–87) minutes and the median stone retrieval time was 32 (2–94) minutes. Complications related to stone retrieval were identified in two cases (2%); two patients experienced Clavien grade IIIa ureter injury caused by the basket device. No cases of poor visibility due to hematuria during the self-retrieval basketing were observed. There was also no case wherein an assistant was required during the process of stone retrieval. Considering total intraoperative complications, ureteral injury happened in five cases (5%), with the degree of injury ranging between Clavien grade II and IIIa. Postoperative fever was reported in three cases (3%). Two patients required ureteral dilatation because of postoperative ureteral stenosis. The average length of postoperative stay was 2 days.

Discussion

Generally, use of the basketing retrieval technique necessitates an assistant to operate the basket device. However, the self-retrieval basketing technique in this study could be performed by just one person; thus, one of the advantages of the self-retrieval basketing technique is the possibility for solo surgeon to perform f-URS with active retrieval basketing. It has been reported that the single-surgeon basketing technique is comparable to the two-persons basketing technique [14]. All cases of f-URS were performed safely in this study and the applied self-retrieval basketing technique was considered an effective method of stone fragment removal.

Comparing the results reported in relation to the dusting technique and conventional basketing retrieval technique [5, 14, 15, 17], our operation time was a little longer than those from other reports; however, there was no difference in stone free rate (Table 2). Our self-retrieval basketing technique tends to be difficult to perform but, with the right instruction, can be conducted adequately by a new operator within the span of just a few cases. In fact, although excluded from the scope of our study during the same time period, another 100 f-URS procedures were performed by eight inexperienced surgeons. These cases were completely performed independently by these operators after assisting a mentor with three to five introductory cases. Therefore, the self-retrieval basketing technique is not extremely difficult to learn.

The advantages of performing basketing retrieval as compared with dusting encompass several points. One of the advantages is the ability to extract the complete stone in uncomplicated cases, and calculus

analysis is possible from stone fragmentation. Second, the total laser energy was typically low with basketing retrieval than with the dusting technique [9, 10]. Low laser energy may result in lowering the urinary tract temperature, resulting in less urinary heat damage [9, 10]. However, given the use of UAS is essential in the basketing retrieval approach, such might injure the ureter in some cases [11]. Overall, one cannot clearly state that either the basketing retrieval technique or dusting technique is better; instead, each technique has its unique advantages and disadvantages, and surgeons should be familiar with both techniques and choose between them on a case-by-case basis [18]. It has been reported that about two-thirds of urologists use the dusting technique during f-URS [3]. However, it is necessary to decide which method is appropriate with consideration of the patient background, stone size, and stone position. In patients with infected stones, poor Performance Status, or with single kidneys, complete removal of stones might be considered as particularly useful for preventing postoperative complications. If the self-retrieval basketing technique is acquired, basketing retrieval could be possible in various cases, such as in those mentioned above.

In the self-retrieval basketing technique, there are two catch methods—that is, front catch and side catch. In a large space, opening the basket well in front of the stone and advancing the endoscope to capture the stone into the open basket from the front is feasible. Conversely, in a smaller space, opening the basket well in side of the stone and shaking the endoscope to capture the stone from the side into the open basket is likely preferable. Both approaches are effective in the self-retrieval basketing technique. During this study period, 8 surgeons who were inexperienced in performing the self-retrieval basketing technique performed 100 f-URS under the instructions of an experienced instructor. After performing f-URS in some cases (range 3–5 cases), they could perform f-URS with the self-retrieval basketing technique as solo surgeon. Review of the operation videos revealed that the instructor tended to select more side catch than front catch, whereas the inexperienced surgeons tended to select more front catch than side catch (date not shown). This is because inexperienced surgeons found it visually easy to first understand the front catch.

There are several limitations to this study. First, this was a retrospective study and could not compare our self-retrieval basketing technique with the conventional two-persons basketing technique. Therefore, a future prospective study conducted under strict conditions is needed to prove the utility of the self-retrieval basketing technique. Second, since we only included cases from one experienced surgeon in this investigation, verification of the technique by multiple surgeons is required. However, we believe that the self-retrieval basketing technique might be one of the effective surgical methods for f-URS because there was no significant difference in either intraoperative or postoperative complications as compared with in other reports.

Conclusions

This examination of 100 cases suggests our self-retrieval basketing method is a safe and effective means for stone fragment extraction. We discuss here the specific usage of the basket device and flexible

ureteroscope in f-URS but further investigations are required to better confirm the technique's safety and validity in larger groups and when performed by multiple surgeons.

Abbreviations

f-URS
flexible ureteroscopy
UAS
ureteral access sheath
YAG
yttrium aluminum garnet

Declarations

The paper adhered to the STROBE guidelines.

Ethics approval and consent to participate

This study was approved by the Ethics Committee of Tohoku Medical and Pharmaceutical University Hospital School of Medicine, Japan (Protocol 2019-2-056). Written informed consent for the current study was received from all patients

Consent for publication

Written informed consent was obtained from every patient for publication of this research report.

Availability of data and materials

All the data supporting our findings is contained within the manuscript, any missing details will be shared upon request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

GA, KK and SH made study conception and design. GA, KK, HI, YK1, JM, JI, YK2, MS, FE, and KH participated in the patient's medical treatment. GA, KK, HI, YK1, JM, and JI collected data and GA

performed statistical analysis. GA drafted the first version of the manuscript and SH, TY, YH, CO, KH and MS helped to draft the revised manuscript. All authors have read and approved of this submission.

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Tables

Table 1. Patients' backgrounds and results (median, range)

Age	63 (31–87)
Gender (male, %)	58 (58%)
Stone size (mm)	14 (5–36)
Stone location	
Upper ureter	44 (44%)
Kidney	56 (56%)
Operation time (min)	80 (25–209)
Fragmentation time (min)	16 (1–87)
Retrieval time (min)	32 (2–94)
Stone free rate (%)	87 (87%)
Laser energy (kJ)	2.4 (0.2–26.7)
Postoperative fever (%)	3 (3%)

Table 2. Comparison with our result and other reports

	Our study	Humphreys et al. ⁵⁾		Lee et al. ¹⁶⁾		Tabei et al. ¹⁵⁾		Okada et al. ¹⁴⁾
N	100	82	68	172	76	109	87	478
Age (years)	63	54	55	56	59	64	65	
Stone diameter (mm)	14	9	11	11	11	10	13	11
Operation time (min)	80	67	36	83	82	85	80	65
Basketing or dusting	Basketing	Basketing	Dusting	Basketing	Dusting	Basketing	Basketing	Basketing
Retrieval method (One-person/two-persons)	One-person	Two-persons	None	Two-persons	None	Two-persons	One-person	One-person
Stone free rate (%)	87	74.3	58.2	89	86.8	61.5	90.8	96
Stone-free definition	≤2 mm	No residual stone		≤3 mm	No residual stone		≤2 mm	
Laser energy (KJ)	2.4	20.2	49.5					

Figures



Figure 1

Basket device (N-gage) used during the self-retrieval basketing technique



Figure 2

The self-retrieval basketing technique performed during f-URS by solo surgeon. (a) The basket catheter was inserted after reaching the desired pelvic and renal cup area. (b) The endoscope was inserted so that the basket catheter can reach the target stone. (c) The basket catheter was closed to obtain the target stone.



Figure 3

The front catch and the side catch methods of the self-retrieval basketing technique. (a–d) Front catch method (a) A basket catheter was inserted to take up about one-quarter of the screen. (b) The basket catheter was opened to the size of the stone indicated for extraction. (c) The endoscope was advanced straight so that the open basket catheter grasped the stone. (d) The basket catheter was closed to capture the stone. (e–h) Side catch method (e) A basket catheter was inserted to take up about one-quarter of the screen. (f) The basket catheter was opened to the size of the stone indicated for extraction. (g) The endoscope was moved left, right, up, and down to get the stone into the open basket. (h) The basket catheter was closed to capture the stone.