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Original Article

Surgical technique to achieve high durability of flexible ureteroscopes: A single hospital experience

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ARTICLE INFO

Article history:
Received 21 February 2018
Accepted 5 October 2018
Available online 11 January 2019

Keywords:
Flexible ureteroscopes
Renal stone
Retrograde intrarenal surgery

ABSTRACT

Background: To describe a novel operative technique resulting in extended durability and improved ease of use of current flexible ureteroscopes (FURS). A surgical method employing a modified technique of using an Olympus digital flexible URF-V ureteroscope was developed.

Methods: We retrospectively studied 546 patients who underwent retrograde intrarenal surgery (RIRS) using this modified approach performed by a single surgeon at our hospital, and investigated the outcome and durability of the ureteroscope.

Results: Through the study period, the URF-V ureteroscope required repair five times in total. During factory maintenance, distal working channel damage was noted twice, and outer bending rubber damage was noted once. The most recent two repairs were required due to laser penetration. Despite the damage and repairs, the deflection system was almost entirely intact after high-frequency use. The durability of FURS determines the efficacy of RIRS for renal stones.

Conclusion: In this report, we described our modified upside-down technique for manipulation of FURS under unequal dual deflection in order to preserve the deflection apparatus, which yielded a greatly prolonged durability. Additionally, the use of mimic drive turning decreased the time needed to train urologists.

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Peer review under responsibility of Chang Gung University.
https://doi.org/10.1016/j.bj.2018.10.002

At a glance of commentary

Scientific background on the subject

The fragility and high repair costs of fURS hinder the widespread use in the urological practice. To invent a modified manipulation in RIRS is mandatory for the development of this operation and make the fURS much durable simultaneously.

This study adds to the field

We share our upside down manipulation technique in the reverse type fURS with an unequal dual deflection to preserve the best durability. The associated mimic drive turning decreases the learning curve of young surgeons and makes the RIRS operation easier.

Retrograde intrarenal surgery (RIRS) is a remarkable innovation in the history of renal stone management. With the improvement of ureteroscope design and accessory instruments, the indications for this operation have increased, as has procedure safety [1]. However, the high purchase and repair costs of flexible ureteroscopes (FURS) have limited the use of RIRS in the clinical setting, suggesting that development of a modified technique or a redesign of the ureteroscope is required to extend the life of the scope. In terms of parts that are most vulnerable to incurring damage, these include tip deflection, and damage to the inner lining of the ureteroscope and the fiber-optic bundles [2]. Careless deflection of the distal tip of the ureteroscope or firing of a laser within the scope may easily damage the working channel, which is the part of the device most commonly damaged [3]. In order to improve the durability of the scope, this common type of damage can be eliminated by retaining the scope in a straight position when the laser fiber is passed through the channel, and ensuring that the laser is not fired inside the scope. Additionally, by using new ureteroscopic accessories in combination, such as a ureteral access sheath [UAS], 200-μm holmium laser fiber, and nitinol devices, damage to the delicate endoscopes can be reduced [4]. Damage may also occur during the handling and sterilization processes, which can be reduced by providing sufficient training to staff [5]. By implementing the aforementioned precautions regarding the working channel, the durability of FURS can be extended to 30 cases. Furthermore, to increase the durability of FURS to the maximum, deflection system maintenance is the most critical component. We devised a novel method of manipulating the ureteroscope during surgery, which achieved extended durability of the apparatus and shortened the learning curve for urologists.

Materials and methods

Subjects

We retrospectively collected data of 546 consecutive patients who underwent RIRS using FURS for renal stones at our institution between July 2014 and March 2017 from our institution's medical database. Each patient was informed about the benefits and risks of employing the ureteroscope, of possible alternative treatments, and of the potential need for a staged procedure to achieve satisfactory stone clearance. The patients were asked to sign an informed consent document prior to the surgery. The inclusion criteria for this study were: age 18–86 years; renal stones ≥0.5 cm in diameter. Pregnant patients were excluded.

Clinical features and outcome

We reviewed the demographic data, renal stone characteristics and procedure-related outcomes and complications. Routine preoperative and 1-month postoperative work-ups included recording medical history, physical examination, urinalysis, urine culture, and blood tests. An abdominal kidney ultrasound plus kidney, ureter and bladder radiography (KUB) were performed. Intravenous urogram pyelography and non-contrast computed tomography (NCCT) were selectively performed preoperatively. The operative duration was calculated from the time of first insertion of the endoscope (cystoscope or ureteroscope) to the completion of stent placement. Peri- and postoperative complications were reported according to the Clavien classification system [6]. The stone successful rate (SSR) was defined as residual fragments up to a maximum of 4 mm in diameter detected on ultrasonography or NCCT at the 1-month follow-up. The stone diameter was defined as the maximum diameter of the biggest stone plus one quarter of the diameter of the second largest stone; the others were neglected in cases of multiple renal stones.

Surgical technique

We used an Olympus digital flexible URF-V ureteroscope (Olympus America Inc., Tokyo). All surgeries were performed by a single surgeon (CC Lin). The modified operative method (namely, the upside-down maneuver) was designed according to the URF-V ureteroscope manual protocol, but applied conversely. The image of surgical technique was showed in Fig. 1.

Analysis

Patients were divided into four groups according to stone size (maximum diameter): ≤10 mm (group 1), >10 and ≤20 mm (group 2), >20 and ≤30 mm (group 3), and >30 mm (group 4). The primary end point was the evaluation of the effectiveness of using the ureteroscope for the treatment of renal stones, expressed as the SSR. The secondary end point was the assessment of the safety of the procedure, expressed as the complication rate.

Ethics compliance

The study protocol conformed to the ethical guidelines of the 1975 Declaration of Helsinki and was approved by the Ethics Committee of Chang Gung Memorial Hospital, Keelung Division.

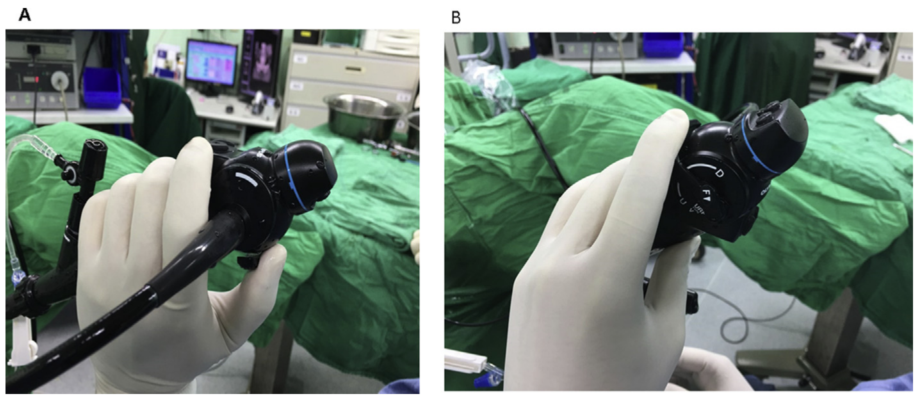

Fig. 1 Image of surgical technique. (A): Operating lever beneath the hand piece with thumb manipulate it; (B): Operating level above the hand piece and work by index and middle fingers.

Results

On retrospective analysis, we identified 546 patients: 281 males and 265 females, with a mean age of 47.6 ± 12.5 years [Table 1]. The mean overall stone size was 18.6 ± 9.5 mm. UAS placement was possible in all patients. Overall, post-procedure stent placement was 98.2%. The overall primary SSR was 76.9%. The mean operative duration was 57.2 ± 20.4 min [Table 2]. Patients who were not stone-free refused other procedures because they were already asymptomatic or were free of urinary tract infection and/or obstruction. Complications were reported for 98 patients (17.9%) overall, of Clavien grade 1 in 65 patients (11.9%), grade 2 in 25 patients (4.6%), grade 3 in 3 patients (0.6%), grade 4 in 4 patients (0.7%), and grade 5 in 1 patient (0.2%).

During our study period, the ureteroscope required repair on three separate occasions. The first occurred after 31 cases; the second after a further 84 cases; and the third after another 201 operations had been performed. Fourth and fifth repairs were required after another 126 and 28 cases, and we were able to use the scope for another 76 cases following the last repair [Table 3]. Total 5 repaired in 470 cases and In the first two repairs, the distal working channel required fixing. The third repair required fixing of the outer rubber. The fourth and fifth repairs were needed owing to vertebrae punctures due to laser fiber snapping. However, the deflection system remained almost intact (the maximum ventral and dorsal deflection has deteriorated at 180–160 and 275–250, respectively), even after high-frequency use.

Table 1 Demographic variables and stone characteristics by group.

Characteristic	Group 1	Group 2	Group 3	Group 4
Patients, *n* (%)	85 (15.6)	278 (50.9)	121 (22.2)	62 (11.4)
Sex, *n* (%)				
Male	48 (56.5)	145 (52.2)	57 (47.1)	31 (50)
Female	37 (43.5)	133 (47.8)	64 (52.9)	31 (50)
Age, *years*, mean (SD)	45.2 (11.3)	47.9 (11.9)	45.7 (11.5)	46.2 (15.6)

Stone size: group 1 ≤ 10 mm; group 2 > 10 and ≤20 mm; group 3 > 20 and ≤30 mm; and group 4 > 30 mm.

Table 2 Intraoperative and postoperative outcomes by group.

	Group 1 (*n* = 85)	Group 2 (*n* = 278)	Group 3 (*n* = 121)	Group 4 (*n* = 62)
Overall OR duration, *min*, mean (SD)	36.3 (10.2)	49.5 (19.8)	71.4 (22.3)	92.6 (23.4)
Hospital stay, *days*, mean (SD)	2.1 (1.1)	2.3 (1.2)	2.6 (1.4)	2.5 (1.3)
Primary SSR, *n* (%)	78 (91.8)	233 (83.8)	90 (74.4)	19 (30.6)

Abbreviations: OR : operating room; SD : standard deviation; SSR : successful stone rate.
Stone size: group 1 ≤ 10 mm; group 2 > 10 and ≤20 mm; group 3 > 20 and ≤30 mm; and group 4 > 30 mm.

Table 3 Flexible ureteroscope damage reports and individual scope longevity.

Time sequence	Primary defect location	Defect type	No. of cases before failure
1	Distal working channel	Distal leak	31
2	Distal working channel	Distal leak	84
3	Angle cover	Outer rubber band damage	201
4	Distal vertebrae	Laser fiber snap puncture	126
5	Distal vertebrae	Laser fiber snap puncture	28

Discussion

The fragility and cost of FURS prevents widespread use in urologic practice [7]. Afane et al. [8] reported that FURS made by four manufacturers required main repairs after only 15 procedures or 13 h of usage. Shah et al. [9] reported that the average durability of the Olympus URF-V was 14 operations. When handled by expert practitioners, the life of a ureteroscope may be extended to 12.5 operations before requiring repair [10]. The three most commonly reported kinds of damage include loss of active tip deflection secondary to extreme ureteroscope deflection with or without an instrument [11,12], inadvertent firing of the laser in the working channel, and working channel damage resulting from instrument passage [13].

By taking the aforementioned precautions regarding the working channel, the durability of FURS can be easily extended to 30 cases. Furthermore, to increase the life of FURS to more than 100 operations, deflection system maintenance is the most critical component. It is well-known that the most fragile part of the device is the deflection unit [8]. The deflection mechanism of FURS permits free movement within the renal collecting duct system. This deflection is usually constructed by several wires running down the endoscope from end to end, connected to a manually-operated lever mechanism [Fig. 2]. The current instrument design trend is to have continuous controlled dual deflection with increased downward and upward deflection up to 275°, referred to as "exaggerated deflection", in both directions [12]. The purpose of this stressed design is to obtain lower pole access, where the urologist maximally deflects and advances the tip of the endoscope [12,13]. Traxer et al. [14] performed 50 operations using a new-generation flexible ureteroscope, and found that the need for repair occurred

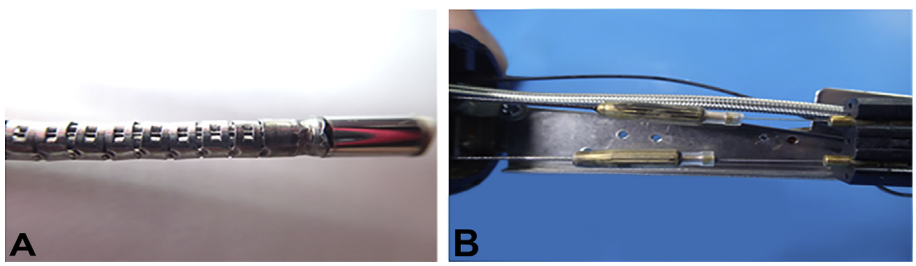

Fig. 2 The deflection apparatus has two wires on parallel sides, oppositely operated, running down the length of the endoscope, and attached to a lever that is manually operated. (A) Features of the deflection apparatus, the red circle indicating the stretched wires; (B) the location of the wires (the cover of the ureteroscope was removed).

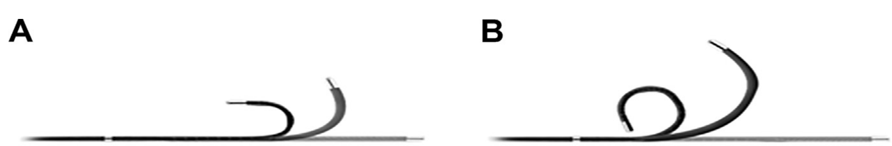

Fig. 3 The deflected radius of the 180-degree upward arm is shorter than that of the downward 275-degree arm, and acted with more agility. (A) 180-degree deflection; (B) 275-degree deflection.

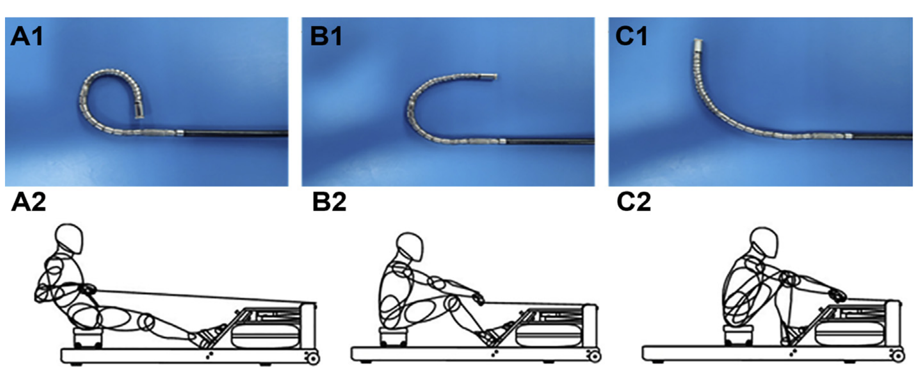

Fig. 4 The 275-degree arm wire is more prone to damage due to overstretching, especially when used to approach lower calyx stones. (A1, A2): 275-degree deflection and schematic image of A1; (B1, B2) 180-degree deflection and schematic image of B1; (C1, C2) 90-degree deflection and schematic image of C1. The wire utilized in the scope has greater durability when used with 180° deflection as opposed to 270° deflection due to the decreased tension placed on the wire. This is similar in respect to rowing sports where lesser deflection has decreased tension as show in A2, B2, C2.

less often; after 76 h of use, the maximal ventral and dorsal deflections had deteriorated at 270–208° and 270–133°, respectively. Another study found that the frequency of repair increased with decreasing device diameter and rising ureteroscope length, and major types of damage, such as working channel deterioration from laser burn or tool passage, are avoidable if physicians take adequate measures to protect their equipment [13].

The Olympus URF-V, which we employed, has an upward deflection angle of 180° and a downward deflection of 275°. The deflected radius of the 180-degree upward arm is shorter than that of the downward 275-degree arm, and acted with more agility [Fig. 3]. The 275-degree arm wire is more prone to damage due to overstretching, especially when used to approach lower calyx stones, as reported by Traxer et al. [14] [Fig. 4]. However, in our experience, lower calyx stones account for about 75% of kidney stones and can be easily managed by 180-degree deflection.

After examining these mechanisms, we operated the ureteroscope in different ways. We used the agile 180-degree upward deflection for each calyx approach and the fragile 275-degree downward deflection only for difficult stones in limited cases. This technique flips the surgical image upside down, but this can be easily overcome. Furthermore, the ureteroscope makes a right-tip rotation with a clockwise turn and a left-tip rotation with a counterclockwise turn. This motion is reminiscent of a steering wheel in vehicles, making it easier for inexperienced surgeons to use [Fig. 5]. We also used Storz, ACMI, Pantax, and other ureteroscopes in limited cases, and had similar experiences. We believe that this technical modification in the operating procedure keeps the deflection apparatus from being damaged and increases the

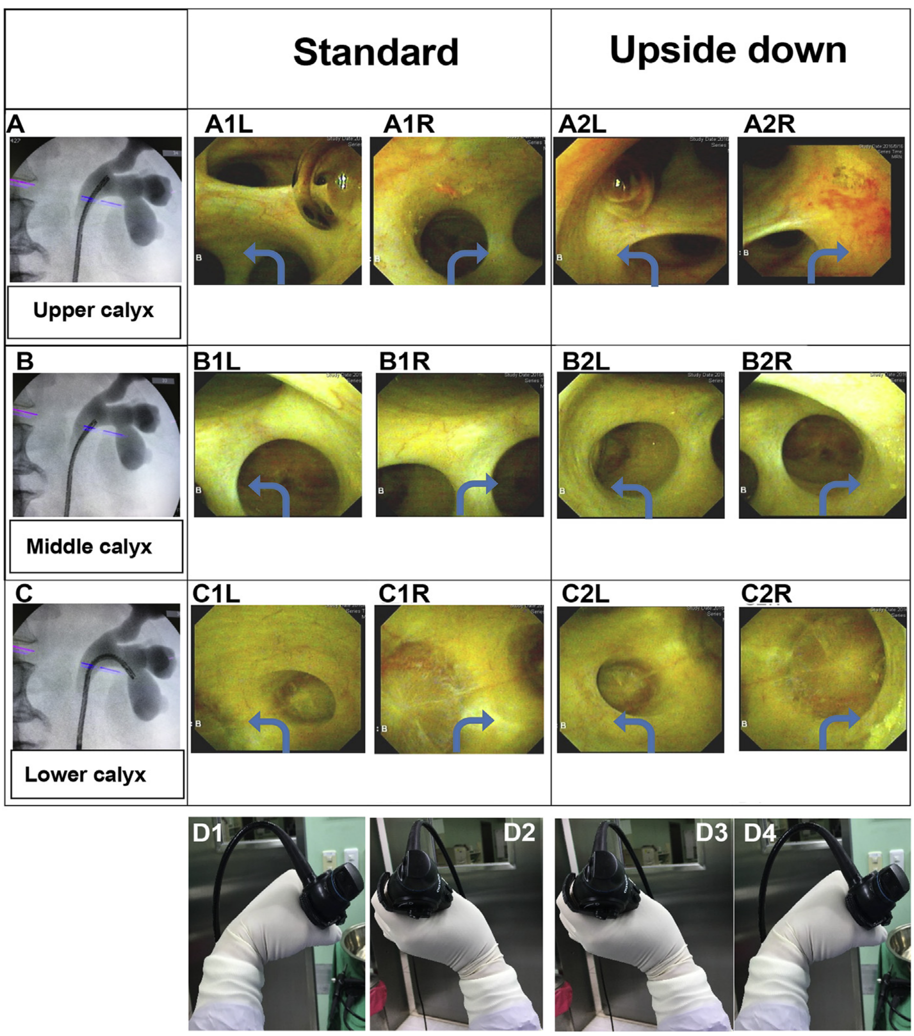

Fig. 5 The upside-down maneuver involved ureteroscope right-tip rotation with a clockwise turn and left-tip rotation with a counterclockwise turn. Standard: operation according to the manual procedure; Upside-down: operation using our modified procedure. (A) Fluoroscopic image of the upper calyx; A1L: left deviation, standard; A1R: right deviation, standard; A2L: left deviation, upside-down; A1R: right deviation, upside-down. (B) Fluoroscopic image of the middle calyx; B1L: left deviation, standard; B1R: right deviation, standard; B2L: left deviation, upside-down; B1R: right deviation, upside-down. (C) Fluoroscopic image of the lower calyx; C1L: left deviation, standard; C1R: right deviation, standard; C2L: left deviation, upside-down; C1R: right deviation, upside-down. (D) Various rotation techniques; D1: clockwise rotation; D2: counterclockwise rotation; D3: counterclockwise rotation; D4: clockwise rotation.

durability of the ureteroscope to more than 200 operations. This technique has been approved by the maintenance department at Olympus.

The stone free rate used FURS reported in previous studies. Lee et al. reported 97% stone free rate in cases of single stone and stone diameter >1 cm [15]. Kumar et al. showed 85.4% stone free rate in cases of single stone and stone diameter 1–2 cm [16]. Using our modified procedure, we observed stone free rate 76.9 in cases of multiple and bilateral stones and stone diameter 0.5–4.6 cm. Though our stone cases are more complicate, our modified procedure showed a good stone free rate.

Furthermore, the upside-down approach incorporates the deflection system concept, making it more ergonomic. Therefore, operators/surgeons can perform this operation while sitting in a relaxed position. As a result, the quality of the surgery increases, with higher SFRs and lower operation durations. Due to these findings, we believe that a manufacturer could design a ureteroscope with the above-described deflection and ergonomics. We also believe that a thinner, more flexible model could be developed. If these modifications were introduced, the ureteroscope life and the efficacy of operations in which it is used would increase dramatically.

Conclusion

The durability of FURS determines the efficacy of RIRS as a renal stone operative technique. Most pertinent studies have suggested ways in which to keep the working channel safe. In this report, we share our modified upside-down manipulation technique of the ureteroscope in unequal dual deflection to preserve the deflection apparatus, leading to a greatly-prolonged durability. Additionally, the use of mimic drive turning decreased the time needed to train urologists. With implementation of and additional practice in the described procedure, this modified technique will increase the ease of use of ureteroscopes in the future.

Conflicts of interest

None declared.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.bj.2018.10.002.

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