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# Comparison of suction-evacuation and conventional access sheaths in flexible ureteroscopy for upper tract stone management

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**Abstract**
Flexible ureteroscopy (f-URS) has become a widely accepted and effective minimally invasive approach to the management of upper urinary tract stones because of significant advancements in endourological techniques over the years.
Patients with a burden of less than 20 mm in kidney calculi can choose RIRS as their initial surgical treatment, as it has a favourable stone-free rate (SFR) and a lower incidence of intraoperative and postoperative complications, as per the guidelines of the American Urologic Association (AUA) and the European Association of Urology (EAU).
Laser lithotripsy, in conjunction with f-URS, has become the standard treatment for renal and upper ureteric stones, particularly in cases where extracorporeal shock wave lithotripsy (ESWL) is ineffective or contraindicated. Procedure allows direct visualization and precise fragmentation of stones; however, the efficiency of stone evacuation remains a major concern. The primary therapeutic methods for renal calculi, in addition to conservative treatment, are ESWL and minimally invasive endoscopic surgical methods, such as retrograde intrarenal surgery (RIRS) and percutaneous nephrolithotomy (PCNL).
The utilization of RIRS for urinary stones has expanded substantially because of advancements in minimally invasive technology and equipment, and the indications have been widely extended. RIRS can enhance surgical vision, reduce intrarenal pressure (IRP), and reduce postoperative infectious complications using a ureteral access sheath (UAS).
This review article aimed to compare the feasibility (success of access and easy drainage of fragments) of suction evacuation UAS versus standard UAS during f-URS in upper urinary tract stones lithotripsy.

**Keywords:** Suction-evacuation, conventional access sheaths, flexible ureteroscopy, upper tract stone management

## Introduction

Incidence rates of urinary calculi have been on the rise annually, and treatment approaches have become simpler. Percutaneous nephrolithotomy (PCNL) has evolved from conventional channels to miniaturized and ultra-miniaturized approaches, despite the fact that traditional open and laparoscopic surgeries have become relatively uncommon. Flexible ureteroscopy with laser lithotripsy (FURL) has become a more prevalent treatment option for upper urinary tract stones, particularly renal stones, because of the advancements in endoscopic technology and the development of laser lithotripsy systems [1]. FURL is now one of the most frequently employed treatments for upper urinary tract stones that are less than 2 cm in size, in accordance with the recommended protocols of the EAU and AUA. Currently, the conventional method of FURL involves ureteral access sheath (UAS) use in conjunction with a flexible ureteroscope. The conventional application of UASs enables the flexible ureteroscope to enter and exit urinary tract, thereby expanding the field of view through continuous discharge. Nevertheless, conventional unmanned aerial systems (UAS) have certain constraints, such as an intrarenal pressure (IRP) that is uncontrollable and a postoperative stone clearance rate that is suboptimal [1].
Upper urinary tract stones are a broadly and increasingly prevalent urological condition, driven by dietary patterns, lifestyle factors, and a higher prevalence of metabolic conditions. These stones may result in significant morbidity, presenting with renal colic, hematuria, or

urinary tract infection. If left untreated, they can cause ureteral or renal obstruction, potentially leading to progressive deterioration of renal function and hydronephrosis [2].

**Management of stones**
**Indication of intervention**
The following patients require active stone removal through either ureteroscopy (URS) or shock wave lithotripsy (SWL) [3]:

- Urolithiasis causing obstruction.
- Stones are not likely to go away spontaneously.
- Pain that persists despite adequate analgesia.
- Decreased kidney function either due to renal failure, solitary kidney, or bilateral obstruction.

**Extracorporeal shock wave lithotripsy (ESWL)**
ESWL has been implemented to dissolve stones in renal and upper urinary tract using shock waves. At the present time, the ESWL is employed to process small stones with a maximum diameter of 20 mm. ESWL has an overall SFR of 66% for stones 20 mm or smaller and 49% for stones greater than 20 mm, according to reports. ESWL is generally limited to stones with a diameter of 10 mm, and it is crucial to recognize that the clearance rate of lower calyceal stones is diminished following the procedure. Consequently, RIRS or PCNL are more effective treatments for decrease pole stones that exceed 1.5 cm in diameter [4].

**Percutaneous nephrolithotomy (PCNL)**
In reverse, complication rate for PCNL is high, rendering it preferred method for large or complex renal calculi (kidney stones larger than 2 cm). Intraoperative and postoperative complications are two different categories of complications [5].

**Retrograde intrarenal surgery (RIRS)**
A variety of upper urinary tract conditions are treated through RIRS, a minimally invasive endoscopic procedure. Other indications of RIRS included stones smaller than 1.5 cm, lower calyx stones, and failure of previous SWL. In recent years, the indications for RIRS have been broadened to include stones measuring less than two cm as a first-line treatment option in addition to SWL. Furthermore, it may function as an alternative to PCNL for stones that are larger than two cm and located in lower calyx. As a result of its relatively lower morbidity, RIRS has increasingly been implemented. Potential indications have been reported, despite the absence of absolute indications [6]:

- SWL-resistant stones.
- Medium-sized stones that is not suitable for SWL or PCNL.
- Non-opaque stones.
- Existence of anatomic abnormalities (acute IPA, narrow infundibulum, long lower pole calyx).
- Bleeding disorders.
- Co-existence of renal and ureteral stones.
- Combined or ancillary procedures following PCNL.
- Need to treat bilateral renal stones successfully in a single session.
- Patient habitus (obese, musculoskeletal deformities).

RIRS is a treatment option that is both dependable and effective for patients with musculoskeletal deformities, infundibular stenosis, hemorrhage disorders, and obesity when other treatment options are either insufficient or hazardous [6].

**Laparoscopic pyelolithotomy or ureterolithotomy**
Laparoscopic removal of ureteral or renal calculi is a technique that is implemented in exceptional circumstances where stone therapy employing shock wave lithotripsy or endoscopic techniques is inadequate. This method is used in situations such as the co-occurrence of nephrolithiasis and other kidney disorders that require laparoscopic treatment, such as laparoscopic pyeloplasty for ureteropelvic obstruction related to stones, and anatomical variations in kidney shape or location (e.g. horseshoe kidney, pelvic kidney) [7].

**Open surgery**
In the event of a complex stone burden failure, concurrent open surgery, patient preference, and the use of less invasive modalities, open surgery is required. Patients who may still benefit from treatment through an open surgical technique are given consideration to these factors. There are less invasive methods that can be used to treat the majority of cases with urinary tract calculi [8].

**Retrograde intrarenal surgery (RIRS)**
**Types of fURS**
**Digital flexible ureteroscopy**
The replacement of fiberoptics with digital imaging endoscopes achieves superior visualization with a high level of clarity that is equivalent to 10 times pixel resolution of traditional fiberoptic endoscopes. No separate light cord or camera head is required for these endoscopes, which feature a distal digital chip-based camera and an integrated light source. This is a matter of access, as the digital chip camera necessitates a larger outer endoscopy diameter. Due to the acoustic percussions produced by the digital processing of colored light, particularly red light, and issues with chip stability during laser lithotripsy, digital images are disrupted. Distal video chip sensor technology utilizes a charge-coupled device (CCD) image sensor or complementary metal oxide semiconductor (CMOS) to transform incoming light photons, including color accuracy, into an electrical charge and then, a digital form. This technology functions as a miniature camera. CCD and CMOS chips produce a very high-quality image with a resolution up to 40,000 pixels in its viewing area, while fiberoptic endoscopes come with 3,500 pixels [9].

**Disposable flexible ureteroscopy**
An initial disposable f-URS for the purpose of accessing the upper urinary system was established by Bagley in 1987 [10].
A variety of single-use flexible ureteroscopes (SU fURS) that are currently commercially available have recently underscored the novel technical advancement in the increasing endourology field.
A laboratory study was conducted to compare two single-use one reusable ureteroscope and ureteroscopes. Reusable ureteroscope demonstrated favorable optical and technical features, while both single use ureteroscopes demonstrated an important decrease in light emission. Interesting, IRP was maximum with the Pusen Uscope, which may have a

clinical impact on the patient's safety. The Pusen Uscope was previously utilized in a clinical setting for ten procedures. The results of the study indicated that the device's maneuverability, deflection, and image quality all decreased during the procedures. In a human cadaveric model, the LithoVue (Boston Scientific) was identified as equivalent to conventional scopes in terms of visibility and manipulation within the upper urinary system [11].

Single-use fURS provides a viable alternative that is effortless to maintain and is readily accessible, while maintaining comparable functionality. An additional benefit of su-fURS usage is absence of pre-use contamination. Although these advantages are evident, it is unclear whether a complete transition from reusable to single-use scope would be economically advantageous. A prospective multi-center RCT study was conducted to demonstrate the non-inferiority of single use ureteroscopes in terms of maneuverability, deflection, and limb fatigue. In contrast to reusable ureteroscopes, Lithovue single-use instruments were additionally discovered to decrease operative time. Su-fURS would be cost-effective in low-volume centers, as evidenced by the health economy evaluations that are currently available. Nevertheless, this cost benefit would be more advantageous for high-volume centers that exceed 99 fURS cases, which suggests that reused fURS would be less expensive [12].

A study has demonstrated that single-use digital flexible ureteroscopes are a preferable alternative to reusable flexible ureteroscopes in the presence of upper urinary calculi, as they exhibit increased surgical efficacy and safety. There are numerous brands and variants of su FURS that have been developed and implemented in medical practices. Recently introduced single-use ureteroscopes include the Innovex US31-B12, OTU-100RR, Redpine RP-U-C12, Sciavita SUV-2A-B, and Seplou URS3016E. The OTU and Seplou devices exhibited the maximum irrigation flow rates on empty channels, with each recording 110 mL/min. Disposable devices experienced irrigation flow losses that were comparable. The irrigation flow rates of device that can be utilized may be lower than those of the disposable device due to the working channel's impact on the device's surface after conducting numerous procedures. The OTU device exhibited the most favorable mechanical characteristics among the disposable ureteroscopes that were evaluated. This was confirmed by its small loop diameter, high deflection angles, and minimal irrigation flow loss. All five single-use models exhibited identical resolutions at 1 cm from the image in terms of their optical properties [13].

A variety of criteria are employed to determine the "stone-free rate" (SFR). This is why the current consensus and previous consensus regarding residual fragments following surgical treatment of lithiasis are examined. To measure residual stone fragments, various studies evaluating SFR employed a variety of techniques, including intravenous urography, abdominal radiography, and tomography. The techniques were either employed individually or in combination. Extracorporeal lithotripsy techniques were employed to characterize the initial concept of SFR. Residual fragments that were clinically insignificant were defined as noninfectious calculi that remained after the procedure and were less than 4mm large. Nevertheless, numerous publications have shown that up to 40% of patients with a systolic flow rate (SFR) of less than 4mm will require later interventions. The discussion concerning the precise measure that should be employed to define SFR after FURSL is substantiated by these findings. Several experts believe that the term "clinically insignificant residual fragments" is inappropriate due to its potential to act as a nidus for the formation of new stones, which could result in an increase in the number of symptomatic episodes and surgical re-interventions. Given the initial treatment of calculi, morphology, and size, it appears that the clinical significance of residual fragments is contingent [14].

It is advisable to standardize the diagnostic method for each group to determine stone-free rate. Most dependable method for evaluating residual stone fragments after intervention is uro-CT scan, as it enables the identification of radiolucent lithiasis and residual lithiasis less than 5mm, as well as the standardization of an evaluation methodology for future research. In a review of 154 studies that evaluated the treatment of urolithiasis, the appropriate interval for evaluating SFR is further discussed. Postoperative imaging was employed to evaluate residual calculi an average of 49 days after treatment, with a range of 1 to 365 days. The evaluation was conducted by our group at the end of one month after the procedure, utilizing the concept of "ureteral evacuation" with an average of 30 days for ureteral stones [15].

Following ureteroscopy or extracorporeal lithotripsy, alternative methodologies have been suggested for the determination of SFR. S.T.O.N.E. score is one of them, and It evaluates the density in Hounsfield units, the number of stones present, obstruction by hydronephrosis, the size of the calculus (ureter, upper or lower renal pole), and the location of the calculus. It was possible to identify statistically significant findings in terms of location, size, degree of hydronephrosis, and SFR, even though this score has not yet been validated. The investigation had an SFR of 82% [16].

**Factors affecting stone-free rate**

The daily implementation of technological advancements and revisions to this intervention, and modification of FURSL indications and limits, are several factors that influence SFR [17].

**Lithiasic size**

Treatment with FURSL has historically produced comparable outcomes in cases with stones that are less than 1.5 cm in size. However, FURSL has emerged as the treatment of choice in place of PCNL due to the increased potential for treating larger kidney stones or individual conditions of patients (anatomical alterations, infundibular narrowing, and blood dyscrasias), despite the size of the calculus. Consequently, the SFR has been altered in this patient group, which has an impact on the intervention's outcome. Numerous interventions are frequently necessary for stones larger than 1.5cm, and the initial approach should be regarded as a multi-stage procedure. This has been demonstrated. Following the initial procedure, the SFR was 56.8%, and it was 86.3% following second intervention. An SFR is defined as a thickness of less than 4mm. It is associated with stones larger than 1.5cm when SFR is not achieved during a single FURSL procedure. Lithium volume is the most significant preoperative predictive factor for surgical efficacy in terms of SFR [18].

**Location of calculi**

An essential factor that can influence evacuation of residual stone fragments during endourological procedures is the location of stones in the lower pole of the kidney, as it complicates the discharge of fragments. This factor is the second most significant factor influencing SFR, immediately following magnitude. The geometric and anatomical characteristics of the lower calyx have been suggested as an important factor in the determination of SFR. These characteristics consist of a volume of the collecting system, an infundibulum-pelvic angle greater than 90°, and an infundibular length or diameter less than 30mm or 5mm. However, the evidence supporting this assertion remains contentious to this day. There is insufficient evidence to ascertain whether the geometric features of the lower collecting system are advantageous in clinical practice for determining SFR, according to the EAU [19].

**Flexible ureteroscopy**

**Description of flexible ureteroscopes**

However, there are little differences between several endoscopes; all recent fURS are composed of 4 main components: illumination system, mechanical system, optical bundles, and working channel irrigation system. This endoscope may also be divided into 3 parts: the control body, insertion tube and actively deflecting tip (Figure 1) [20].

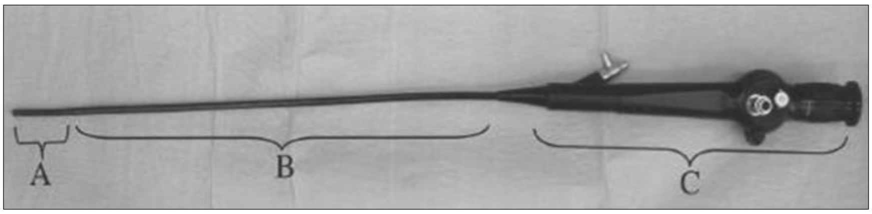


**Fig 1:** Three divisions of flexible endoscope. A, actively deflecting tip, B, insertion tube and C, control body [20]

The tube is made mainly by nitinol shaft with fibers passing inside the endoscope. They range from 54 to 70 cm in working length with a shaft diameter increasing proximally. The proximal shaft diameter ranges from 6.3 Fr to 11 Fr. It extends from the control body to the deflecting tip and contains the illumination system, optical bundle, working irrigation channel and deflecting mechanism. The diameter of the tip ranges from 4.9 Fr to 11 Fr. The tip of the modern ureteroscope houses the fragile lenses or the video camera sensor chip to record image, the opening of the working channel and the light bundle tip, which mostly is split at the sides of the tip (Figure 2). The field of view usually is 100° with depth of view 2-50 mm and direction of view is forward. The control body of the endoscope is the wide upper portion that houses the objective lens or video system, deflection lever, entry access for the working irrigation port and light cable in cases of fiber optics endoscope [21].

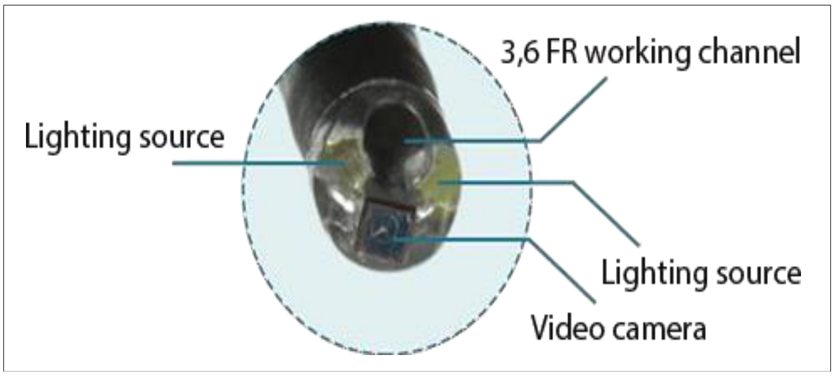


**Fig 2:** WiScope® Single-use digital flexible ureteroscope tip (21)

**The optical system**

The optical system is designed by fiberoptic light fibers, which are from molten glass that are covered with an additional layer of an altered refractive index glass to enhance light transmission and internal reflection. Distal light bundle splits to deliver a well light distribution with a more aligned working channel. Furthermore, small lenses are placed proximally and distally to afford extensive field of view and proper image intensification [22].

**Mechanical system**

The deflecting tip: usually the distal 3 cm of the insertion tube, allows for active curvature of the tip. Active movement of tip of the fURS is controlled via the deflecting mechanical mechanism that are activated by the flexion of the thumb, and a thumb-controlled lever in the control mechanism. During the manipulation of the lever, the distal tip will be deflected in a single plane by deflecting it through multiple wires that travel length of the endoscope and are related to lever. The tip of the endoscope is deflected downward because of thumb actuator shifting downward. The rationale for selecting this option was that most deflection attempts would involve lowering the tip into the mid to lower calyces of the kidney. It was considered logical deflection, Down is down. Storz, Wolf, and ACMI fURS have "intuitive" or "logic" active deflection. While the Olympus scope is "counterintuitive" or "unlogic" in which upward deflection of the lever brings tip in the downward direction (Figure 3). Ureteroscope distal tip articulates to 275 degrees in two directions (Figure 4) [23].

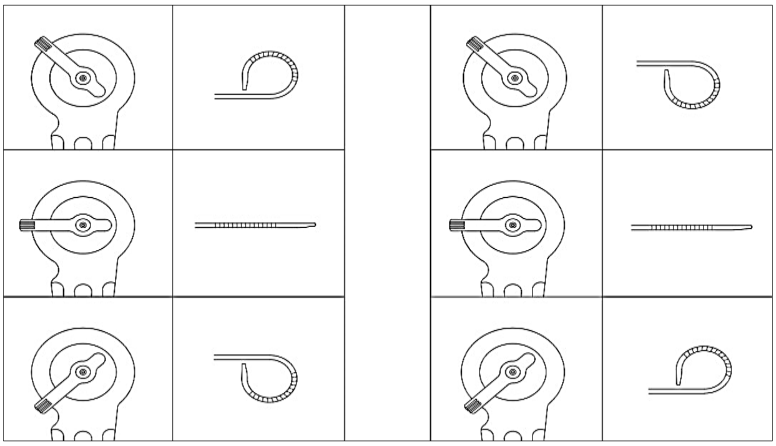

**Fig 3:** Standard deflection models and reverse deflection model [(21)]

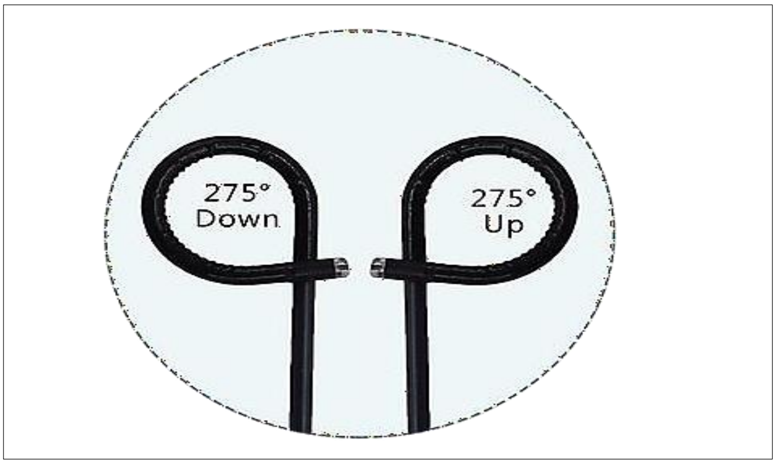


**Fig 4:** WiScope® single-use digital FURS OUT-100 deflecting tip [(21)]

Most modern flexible endoscopes have also a passive deflection area, located about 5 cm proximal to active deflection area. It is more flexible than the rest of ureteroscope. This allows deflection of the distal shaft of the URS of superior portion of renal pelvis that in turn allows the ureteroscope to acquire a complete circle, bringing tip of endoscope to look into a lower calyx (Figure 5) [21].

**Fig 5:** Area of secondary passive deflection [21]

Progress in endourological technology has enabled development of ureteroscopes with much reduced diameter, enhanced image quality, and increased durability. Many fURSs are available from a variety of companies and can now be utilized in clinical practice (Table 1) [24].

**Table 1:** The specification of current available fURSs [24]

| Company | fURS | Imaging system | Field of view (°) | Active deflection (up/down; °) | Length (mm) | Working channel (Fr) | Diamter (tip/shaft; Fr) |
|---|---|---|---|---|---|---|---|
| Lumenis | Polyscope | Optical | - | 180/0 | - | 3.6 | 8.0/8.0 |
| Olympus Gyrus ACMI | DUR-8 Elite | Optical | 80 | 270/270 | 640 | 3.6 | 8.7/9.4 |
| | DUR-8 Ultra | Optical | 80 | 270/270 | 650 | 3.6 | 8.6/9.36 |
| | DUR-D | Digital | 80 | 250/250 | 650 | 3.6 | 8.7/9.3 |
| Olympus | URF P5 | Optical | 90 | 275/180 | 670 | 3.6 | 5.3/8.4 |
| | URF P6 | Optical | 90 | 275/275 | 670 | 3.6 | 4.9/7.95 |
| | URF P7 | Optical | 90 | 275/275 | 670 | 3.6 | 4.9/7.95 |
| | URF V2 | Digital | 80 | 275/275 | 670 | 3.6 | 8.5/9.9 |
| Storz | FLEX-X2s | Optical | 110 | 270/270 | 675 | 3.6 | 7.5/8.4 |
| | FLEX-Xc | Digital | 90 | 270/270 | 700 | 3.6 | 8.5/8.5 |
| Wolf | Cobra-M | Optical | 85 | 270/270 | 680 | 3.3 (dual) | 6.0/9.9 |
| | Viper | Optical | 86 | 270/270 | 680 | 3.6 | 6.0/8.8 |
| | Boa-vision | Digital | - | 270/270 | - | 3.6 | 8.7/- |
| | Cobra-vision | Digital | - | 270/270 | - | 3.6/2.4 | 9.9/- |
| Stryker | Flex Vision U-500 | Optical | 90 | 275/275 | 640 | 3.6 | 6.9/7.1 |

fURS, flexible ureteroscope; -, no information.

In the training of novices, as well as in cases with large stones, complicated anterior lower pole stones, lower pole stones, and anomalous renal anatomy, a su fURS can be highly beneficial. However, it is important to note that fURS can be easily damaged during this process. Treatment of upper urinary tract diseases is now possible with availability of numerous single use fURSs. In contrast to reusable fURSs, these single use fURSs possess significantly thicker tips and shafts, despite their nearly identical specifications. As a result, it is frequently challenging to reach upper urinary tract in cases with a narrow ureter and when employing a UAS that is less than 10 to 12 Fr (Table 2) [25].

**Table 2:** The specification of single-use fURSs [24]

| Company | Single-use Furs | Imaging system | Active deflection (up/down; °) | Working channel (Fr) | Length (mm) | Diamter (tip/shaft; Fr) |
|---|---|---|---|---|---|---|
| Boston Scientific | LithoVue | CMOS | 270/270 | 3.6 | 680 | 7.7/9.5 |
| PUSEN | Uscope UE3022 | CMOS | 270/270 | 3.6 | 630 | 9.5/9.5 |
| Neoscope Inc | Neo Flex | CMOS | 280/280 | 3.6 | - | -/9.0 |
| YouCare Tech | YC-FR-A | CMOS | 270/unilateral | 4.2 | - | -/8.0 |
| OTU medical | Wiscope | - | 275/275 | 3.6 | 905 | 7.4/8.6 |
| Karl-Storz | Video uretero-renoscopes | CMOS | 270/270 | 3.6 | 700 | -/8.5 |

fURS, flexible ureteroscope; -, no information.

**Irrigation and working channel**

Adequate irrigation is essential for good visibility. Saline is the standard irrigation in ureteroscopic procedures. Once laser fibers or other instruments have been placed, it may compromise irrigation flow. There are mainly three types of irrigation system: Continuous irrigation with a 3 L bag elevated at 60 cm $H_2O$ most of the time, Continuous and constant basal irrigation rate with manual hand pump to increase temporarily pressure when needed (Figure 6) and continuous irrigation with automatically programmed irrigation rate reported that continues the same irrigation flow over time for most of the procedure [26].

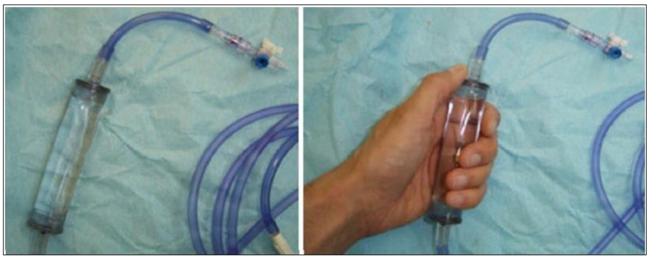

**Fig 6:** Hand-assisted irrigation device [24]

Ideally, the intra-renal pressure must be less than 30 mmHg. Over distention of collecting system may cause post-operative sepsis and significant postoperative pain experienced by some patients. The working channel is at least 3.6 Fr, to allow passage of various accessories, such as baskets, graspers, laser fibers and wires, within endoscope. Such instruments are composed of polymer material to tolerate high grade deflection and manipulation. Improper use of instruments, especially holmium laser, might cause damage to the working channel, that occurs when fiber firing end is positioned too near to scope tip. The working channel is protected from thermal injury by the addition of ceramic rings at 1.5 cm tip [27].

**Equipment and instrumentation**

Most fURS instruments are covered with polymer sheath. Over time, these sheath diameters have become small enough to allow passage within the typical 3.6 Fr working channels [28].

**Guidewires**

Mostly guidewires are approximately 150 cm in length; shorter wires are not optional because of the longer length of fURS: Standard 0.035 and/or 0.038-inch polytetrafluoroethylene (PTFE) wires which have floppy tips "double-floppy", terumo glide wires which are merely hydrophilic with curved or straight tips and are particularly beneficial in situations where ureteral access is difficult. Sensor "Hybrid" guidewires are used as access guidewires, not as working guidewires. They feature a soft hydrophilic nitinol-based distal tip that may be curved or straight, a stiffer non-hydrophilic bend-resistant shaft made from a nitinol alloy core (which is easier to handle), and a PTFE-coated stainless-steel coat that enhances stiffness and prevents scope buckling during scope introduction into the ureter. In typical situations, the Zebra wire (PTFE coated with a nitinol core), PTFE guide wire, and super-stiff "Extra-stiff" PTFE wires are advantageous for enabling the scope tip to access the ureter [28].

**Ureteral stents**

Ureteral stents are commonly used, they are used to promote healing post-operative, to passively dilate the ureter preoperatively and in case of trauma or iatrogenic injury. They are either an internal stent like Double J or an external ureteric catheter. Stents are mainly made from polyurethane or silicon [29].

**Use of ureteral access sheaths**

Since beginning of this surgical technique, UAS have been broadly employed during FURSL. Takayasu *et al.* [30] Initially, the utilization of Teflon conduit was documented in 1974. The utilization of ureteral access sheaths was, however, initiated by Newman 2 decades ago. However, it was only a few years ago that the significance of these access sheaths was brought to light because of the introduction of new materials in their production. These materials have allowed for improved performance with reduced ureteral injury. The necessity of their routine use is a subject of considerable debate on a global scale. UAS are primarily justified by their capacity to atraumatically dilate ureter and facilitate the repeated insertion and withdrawal of apparatus as necessary. However, ureteroscope's passage is now reduced to a single insertion, and residual stone fragments are millimetric with the introduction of laser lithotripsy. This explains why the routine use of ureteral access sheaths may appear redundant, unnecessary, and possibly risky.

The primary factor in management of lithiasic pathology of the upper urinary tract is the extent of calculus. The worldwide tendency to treat stones larger than 2cm through percutaneous access poses minor risks and implications in terms of ureteral injury and surgical time. Consequently, "insertion and withdrawal" of equipment is restricted in the case of smaller stones, resulting in a considerably greater SFR when the "dusting or pulverization" technique is adopted.

An additional factor that encourages routine use of ureteral access sheaths is enhancement of irrigation fluid discharge through sheath and around ureteroscope. However, this aspect is not substantiated by empirical evidence, as the membrane is typically located at a significant distance from the lithiasic bulk that is to be treated. Even though the sheath does not encase the proximal urethral mucosa, it will eventually accumulate around the sheath's lumen, thereby obstructing optimal drainage. Additionally, the mucosa may demonstrate a certain edema and inflammation degree, which may result in perforation and eventual stricture of this urethral segment as a result of the repeated passage of the equipment [3].

However, the positioning of the access sheath necessitates the use of a guidewire, which is typically a hydrophilic guidewire with a rigid end. During the positioning of sheath, this guidewire generates a force that can cause damage to the urethral mucosa, thereby increasing the risk of ureteral injury. A deformation of the apparatus may obstruct its passage through the ureter. As an approach to averting deformation and simplifying insertion of apparatus, UAS have been suggested. It is, however, suggested that ureters that exhibit edema or inflammation may lack the flexibility necessary to accommodate a sheath and rectify potential buckling, which could result in ureter damage during the introduction of the sheath [31].

There are surgeons who have proposed that UAS aid in the regulation of the ureteroscope's performance. Nevertheless, this has not been verified, as equipment's longevity can also be influenced by operator, their experience, support staff, and the sterilization techniques being used. In contrast, some contend that utilization of ureteral access sheaths may result in increased ureteral injury, which could potentially lead to lumen stricture in the long term. There have been no prospective studies that have effectively documented rate of stricture formation after positioning UAS. Delvecchio *et al.* [32] reported a stricture rate of 1.7% in a retrospective report of 62 cases. The use of a UAS may alter the perfusion of urethral mucosa by compression. While removing the access sheath, the process of mucosal reperfusion may cause the exposure of tissue to free radicals, leading to subsequent damage, especially in long procedures.

UAS utilization has yet to be determined for an appropriate duration. Consequently, the duration of the surgical procedure is directly correlated with the size of the stone to be treated, the characteristics of the patient's ureter, and the experienced of the surgeon. A 2013 study evaluated the safety of UAS in FURSL, a subject that had previously caused considerable controversy. After the procedure was completed, the authors conducted a retrospective review of the data collected from the ureteroscopy. In conjunction with the UAS's transit, they devised a classification scale for iatrogenic ureteral trauma. The endoscopic classification of the five degrees of injury (0-4) is divided into two categories: high-grade (2, 3, and 4) and low-grade (grade 0 and 1) lesions respectively. The spectrum of classification encompasses the absence of injury (grade 0) to total ureteral avulsion (grade 4) [33].

UAS was initially introduced by Takayasu and Aso [34] in year 1974. Teflon® "guide tube" (Du Pont, DE, USA) was a critical component of ureteroscopy at time. The ureteral orifice was crossed by this initial sheath to enable the passage of a 100% passive, flexible ureteroscope that was incapable of regulating deflection. There are numerous design improvements that the UAS underwent, as is now recognized. Among the enhancements are a hydrophilic coating that enables the sheath to pass, a hub-locking mechanism that enables the sheath and dilator to pass as a unified unit, a kink-resistant design, the capacity to perform a retrograde pyelogram through the dilator, and a range of lengths and diameters to accommodate the size of the patient and ureteroscope, as well as the nature of the pathology (Figure 7).

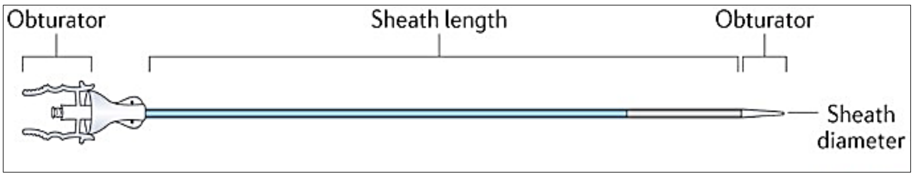


**Fig 7:** The ureteral access sheath. Such sheaths are available in a variety of lengths (from 13-55 cm) and diameters (inner, 9.5-14 French and outer, 11.5-18 French). An obturator passes through the sheath to enable safe passage of the ureteral access sheath (34)

The development of a UAS has been initiated in a manner similar to that of a percutaneous Amplatz sheath. It is employed to alleviate IRP during endourological procedures of the upper urinary tract and to facilitate fURS. It has the capacity to reduce IRP by discharging irrigation fluid around the scope and enabling multiple or recurrent access to the kidney, among other benefits. Consequently, fURS also facilitate diminutive stone fragments removal in this manner. The Ureteroscopy Working Group of Clinical Research Office of the Endourological Society (CROES) has published evidence that the use of UAS did not lead to any differences in SFR between the groups, nor did it increase the risk of ureteral injury or hemorrhage. Additionally, postoperative complications with infection were reported to have decreased. The potential consequences of the positioning of a UAS during the procedure include a decrease in ureteral blood flow, which may result in ureteral ischemia or a direct ureteral injury [35]. UASs should be positioned with caution, considering potential for overdistention and false passage. Always perform the placement over a guidewire while under fluoroscopic control. Guidewires are generally recommended for the purpose of stabilizing the ureter during the advancement of the UAS and facilitating the implantation of a DJ stent following the procedure. In accordance with the flexible ureteroscope employed, an appropriate UAS should be selected. Consideration should be given to the absence or minimalization of friction during the procedure. Outer diameter of the available UASs can range from 11.5 Fr to 16 Fr, while the inner diameters vary from 9.5 Fr to 14 Fr. The characteristics of unmanned aerial systems (UAS) are shown in Table 3 [6].

**Table 3:** Available UAS [6]

| Company | UAS | Length (cm) | Diameter (inner/outer; Fr) | Lumen |
|---|---|---|---|---|
| COOK Medical | Flexor | 20, 28, 35, 45, 55 | 9.5/11.5, 10.7/12.7, 12/14, 14/16 | 1 |
| COOK Medical | Flexor parallel | 20, 28, 35, 45, 55 | 9.5/11.5, 10.7/12.7, 12/14, 14/16 | 1 |
| Coloplast | Retrace | 35, 45 | 10/12, 12/14 | 1 |
| Boston Scientific | Navigator HD | 28, 36, 46 | 11/13, 12/14, 13/15 | 1 |
| Boston Scientific | Navigator NEO | 28, 36, 46 | 11/13, 12/14, 13/15 | 1 |
| Olympus | UroPass | 24, 38, 54 | 10/12, 12/14 | 1 |
| BARD | Proxis | 25, 35, 45 | 10/12, 12/14 | 1 |
| BARD | AQUAGUIDE | 35, 45 | 10 (12)/14, 11 (13)/15 | 2 |
| Rocamed | Bi-Flex | 35, 45 | 10/12, 12/14 | 1 |
| Takai | J Flexisheath | 28, 35, 45, 55 | 11/13, 12/14 | 1 |
| welllead | Clear Petra | 35,46 | 11/13 | 1 |

UAS, ureteral access sheath.

A partial or complete transection may result from the application of disproportionate force. The utilization of a 12/14-F UAS may result in a ureteral injury rate of up to 46.5%. This risk of mucosal ureteral injury is significantly increased by larger diameter UASs, and it may not inherently diminish with a smaller diameter sheath. Although the rate of generating deeper mucosal and smooth muscle lesions appears to be lower with a smaller diameter. UAS placement can result in ureteral injury; however, there is no recommendation to discontinue their use, as they provide evident advantages during RIRS. The Flexor Parallel Rapid Release UAS (Cook, Blooming, and USA) also includes a single wire that can serve as either a safety guidewire or a functional guidewire. There was only one independent risk factor identified: Stenting preoperatively [36].

**Types of ureteral access sheath**

UAS are medical devices used during ureteroscopy procedures to provide a stable and continuous access to renal and ureter pelvis. Ureteral access sheaths come in different types, sizes, and materials, each with their own advantages and limitations. Here are the most common types of UAS [37].

**Single-use ureteral access sheaths**

These are disposable sheaths that are designed for one-time use and then discarded. They are available in different sizes and lengths and are made of materials such as polyurethane, nylon, or Teflon. Single-use sheaths are convenient and eliminate the risk of cross-contamination, but they can be more expensive than reusable sheaths [38].

**Reusable ureteral access sheaths**

These are sheaths that can be used multiple times after sterilization. They are usually made of silicone or polyvinyl chloride (PVC) and are available in different sizes and lengths. Reusable sheaths are more cost-effective than single-use sheaths, but they require additional time and resources for sterilization [39].

**Multi-lumen ureteral access sheaths**

These sheaths have multiple channels or lumens that allow for the simultaneous insertion of multiple instruments, such as an ureteroscope and grasping forceps. Multi-lumen sheaths are available in both single-use and reusable varieties and can be useful in complex ureteroscopy procedures [40].

**Hydrophilic ureteral access sheaths**

The hydrophilic coating of these sheaths reduces friction and facilitates insertion of the sheath over a guidewire and into the ureter. Hydrophilic sheaths are available in both single-use and reusable varieties and can be useful in cases where the ureter is narrow or tortuous [41].

**A Suction evacuation ureteral access sheath**

A suction-evacuation ureteral access sheath (S-UAS) is a modified UAS with an integrated aspiration channel or side port that actively evacuates irrigation fluid, stone dust and small fragments during flexible ureteroscopy. The technique addresses two limitations of conventional UAS: incomplete evacuation of fine debris produced by lithotripsy and IRP elevations during high-flow irrigation. Therefore, the objective of active aspiration is to enhance visualization, increase immediate SFR, abbreviate the operative time, and decrease the risk of pyelovenous backflow and infectious complications [42].

In PCNL, suction sheaths have already been implemented. To facilitate simultaneous elimination of stone fragments and irrigation, these sheaths are equipped with built-in suction capabilities. New developments in the SUAS have resulted in flexible tips that can be advanced beyond the ureteropelvic junction and into the pelvicalyceal system. This allows the surgeon to remove dust and detritus, as well as stone fragments, and to reduce IRP and temperature [3]. Different from the previous incarnation of SUAS, the FANS sheath is also distinctive in several respects. Contrary to older sheaths, its primary advantage is flexibility of the proximal 10 cm of the tip, which can be guided into the desired calyx through passive and active deflection, particularly in presence of a dilated system. This was impossible with any other previously identified unmanned aerial systems (UAS) that were either equipped with or lacked vacuum. Yet, the second distinctive characteristic of FANS is that suction functions in the UAS even when the tip is bent in all calyces, including the lower pole. Additionally, FANS had an advantage over other conventional SUAS in that it could simultaneously aspirate dust particles and conduct in situ laser lithotripsy (i.e., within the sheath). This was facilitated by the UAS's capacity to contain the stone, which thereby prevents retropulsion of stone fragments. This eliminates need for a basket deployment for the purpose of fragment extraction or stone repositioning from the lower pole [42].

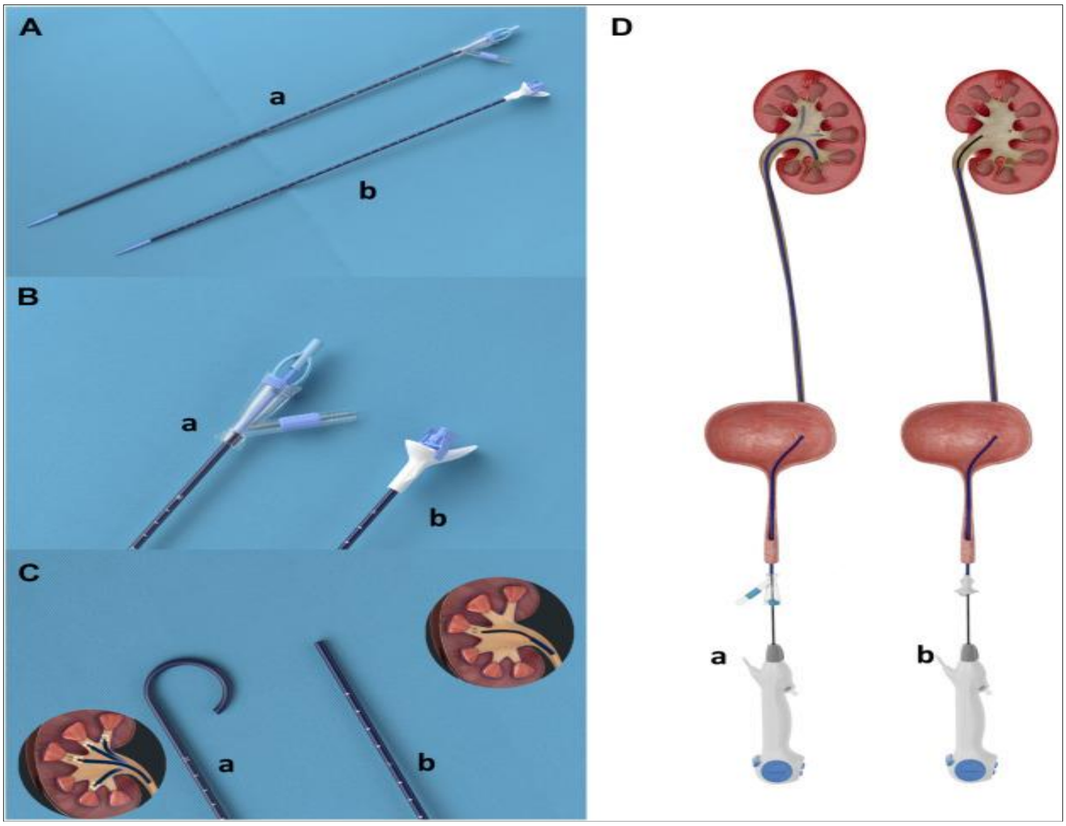


**Fig 8:** Demonstrated structural diagrams of tip bendable S-UAS and traditional UAS (43).

Figure 8: Structural diagrams of the tip bendable suction ureteral access sheath (S-UAS) and traditional ureteral access sheath (UAS). (A) Whole view of the S-UAS (a) and traditional UAS (b); (B) Diagram of the distal end of the S-UAS (a) and traditional UAS (b); (C) Diagram of the proximal end of the S-UAS (a) and traditional UAS (b); (D) Illustration highlighting the differences in RIRS procedures between S-UAS (a) and traditional UAS (b) [43].

**Complications of ureteral access sheath**

**Pain:** Several recent studies have assessed potential complications of postoperative pain related to use of a UAS (44).

**Infections:** Several recent studies have assessed postoperative infections risk associated with the use of unmanned aerial systems (UAS). The influence of UAS utilization on postoperative infectious complications following RIRS was previously demonstrated in a study. UAS utilization was related to a lower incidence of postoperative infections (16.3% vs. 37.1%) [45].

**Lesions**

Bozzini *et al.* [45] conducted a prospective study to investigate impact of a 10/12 Fr UAS on intraoperative ureteral injuries during RIRS without pre-stenting. Even though they categorized data based on the post-ureteroscopic lesion scale (PULS) grades, they did not observe any distinction in ureteral injuries between the use of a UAS and that of a non-UAS user.

**Strictures**

Long-term follow-up results were published in 2019 regarding the risk of strictures (ongoing hydronephrosis without an obstructing stone on follow-up imaging) in the context of prospectively endoscopically identified high-grade ureteral injuries induced by a 12/14 Fr UAS [44].

**Stone extraction devices**

Dormia baskets have 3, 4 or 5 wires and they are tipless, mostly 120 cm in length and made from nitinol. They come with 1.9, 2.5 and 3 Fr to adapt in the 3.6 Fr working channel. Baskets vary in their shape either parachutes, helical or double-helical. Graspers: two and three-pronged forceps mostly 3 Fr are better for impacted stones [28].

**Lithotripsy devices**

**Laser lithotripsy**

**Pneumatic lithotripsy (PL)**

Flexible pneumatic lithotripsy is available in 0.5- and 0.6-mm flexible probe. The probe tip strikes the stone with high energy in straight position. At 48-degree deflection, 30% fragmentation efficiency was achieved. So, PL devices are not the best choice for lithotripsy in flexible endoscopes [46].

**Ultrasonic lithotripsy (UL)**

The probes of ultrasonic lithotripsy devices are not suitable for flexible ureteroscopes as they are not flexible [47].

**Laser fragmentation**

Over fifty years ago, initial intracorporeal lithotripsy procedure to employ laser technology (light amplification by stimulated emission of radiation) was performed. A population of electrons that persist in an excited state is generated when an atom is stimulated by an external energy source, resulting in the production of laser energy. When their energy levels decrease, they release energy in the form of photons. Holmium: YAG lasers are extensively used and recognized as the gold standard for fURS. They emit energy pulses with a duration of 250-350µs and have a wavelength of 2140nm. The laser pulses are fired to initiate its action mechanism. The calculus's surface is heated by each pulse, which results in the vaporization of water both within and on the surface. This results in the tensorial forces within calculus being weakened. When these forces are confronted with feeble shock waves generated by a cavitation bubble generated by the laser pulse, the stone fragments [48].

**The holmium:** YAG laser is an optimal choice for management of urolithiasis due to its minimal tissue penetration and high water absorption from a distance of up to 3mm. This is a highly favorable characteristic. It has been established that the ureter's urothelium must be situated at 1mm to be injured. Laser fibers are available in a wide range of diameters, from 200µm to 1000µm. The optimal choice for fURS is 200- and 365-µm fibers, as they do not limit the equipment's deflection degree. Stone fragmentation is not significantly enhanced by larger fibers in a configuration of constant energy ≤1J, in contrast to smaller fibers. The following implications are caused by this: Energy density plays a more significant role in the fragmentation of stones than fiber diameter. Therefore, it is recommended that the fiber diameter be determined by the required deflection degree for fURS, rather than stone's size [49].

For fragmentation initiation with 200- and 365-µm fibers, the optimal energy and frequency parameters are 0.6J and 6Hz. The laser should be configured with the lowest possible settings for practical purposes, and the parameters should be progressively increased. In addition, it is advised to initially increase energy and subsequently modify the frequency, as it has been discovered that high frequencies may impact visibility. The efficacy of fragmentation is diminished, and the fiber is more susceptible to damage from higher energy densities, so it is recommended to use an energy setting of less than 1.0J for 200-µm fibers. In lithiasic pathology, there are two primary types of laser fragmentation techniques: pulverization, which is intended to enable the spontaneous drainage of residual fragments and prevent the passage of instruments used for fragment removal by micro-pulverizing calculi using high frequency and low energy in the laser generator; and partial fragmentation, which is intended to fragment calculi into smaller fragments that can be recovered with baskets. High energy and low frequency are implemented in this method [50].

Fragmenting, dancing, refining, and popcorn techniques are the four distinct techniques that can be further organized from these two. Soft calculi are fragmented using the dancing technique. As the laser fiber's point is swept across the surface, the stone is fragmented layer by layer. An energy of 0.8-1.0J and a frequency of 08-10Hz are the recommended parameters. Hard calculi are generated through the cracking method. At an eccentric point, the energy is concentrated, causing the stone to rotate, and exposing a new surface for subsequent fracturing. Laser fibers are directed toward calculus's periphery and maintained at a fixed position. Parameters that are recommended are analogous to those of a dancing technique. For calculi that are exceedingly challenging, the fragmenting technique is implemented. The laser fiber is continuously discharged at the stone's center at this location, causing the calculus to diminish along its natural cleavage planes until it divides into segments that can pass spontaneously, if 1mm in length. 1.5-2.0J of energy and a frequency of 05-08Hz are the parameters that are recommended for this technique. The popcorn technique is implemented to induce stone accumulation in a renal calyx. To generate a "whirlpool-like phenomenon," the fiber must be situated near the stone and discharged at a high frequency on a continuous basis. In addition to laser energy, this leads to collisions between stone fragments, which expedite their rapid fragmentation. For this technique, optimal parameters are a frequency of 16-20Hz and an energy of 0.5-0.8J (Figure 9) [51].

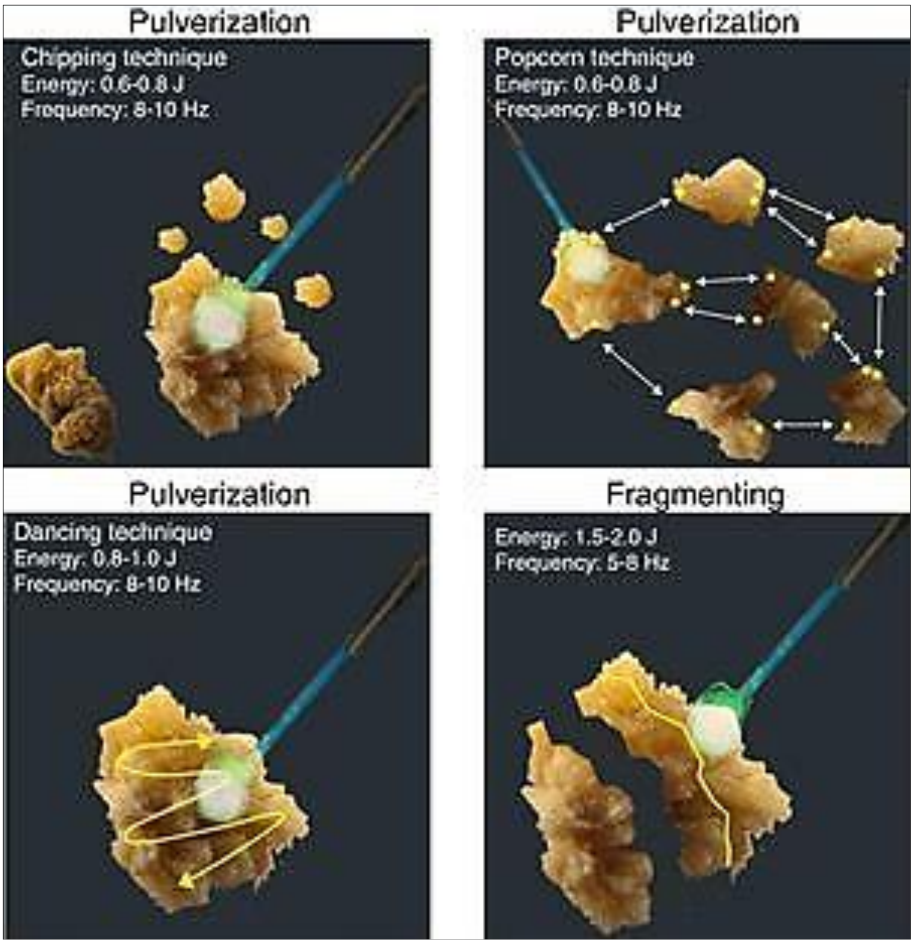


**Fig 9:** Laser fragmentation techniques (52)

Fragmentation and extraction with a basket have been the subject of discussion due to elevated risk of ureteral injury. On the other hand, it also elevates the rate of stone-free time. Understanding these principles for stone fragmentation is crucial for achieving superior surgical outcomes. The process of approaching the stone at acute angles is complicated by the reduction in the average deflection of the equipment's tip from 10° to 15° as the laser fiber travels through the working channel. For this reason, stones in difficult locations must be repositioned to allow for simple access, either by utilizing a container or hydro-washing (Figure 10) [53].

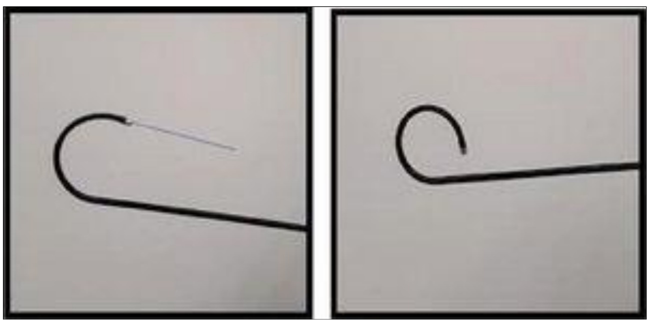

**Fig 10:** Loss of deflection of the flexible ureteroscope with laser fiber in its channel close to 40° (52)

### LASER lithotripsy

The absorptive active media and the light source generator used in the construction of lasers for stone disintegration are the primary factors that differentiate them. Understanding the fact that the wavelength of the laser and heat produced by different light generator sources and active media are of utmost importance. Former necessitates cooling and determines the laser's wall plug efficiency, which is percentage of primary power supply that is converted to laser power. Various tissue properties, as well as the material used to construct the active medium and the doping that covers it, are the primary determinants of the latter. It determines the profundity of tissue penetration of the beam. The extinction length, which is the depth at which 90% of the incident laser energy is absorbed and converted to heat, is employed to quantify laser penetration. To ensure adjacent tissues safety and disintegration of urinary calculi, the laser wavelength must be at or near the absorption peak of water (1940 nm), considering the water component and surrounding environment [54].

A pulsed laser excitation is also required for stone disintegration. When the excitation is conducted in a single pulse or in on-line pulses (free-running mode), a maximal power density of 105 W/cm2 can be attained for a duration of 10 ms to 100 µsec. The excitation energy is stored and released abruptly (q-switch mode or mode-locking), resulting in a maximal power density increase of up to 1010-1012 W/cm2 and a pulse duration of 100 nsec to 10 psec. The brief activity time and high effective power density of the laser beam are essential for the destruction of urinary calculi in various laser types. The photomechanical (10 psec-100 nsec; 108-1012 W/cm2) and photothermal (1 msec-100 sec; 1-106 W/cm2) effects are essential. Due to plasma expansion at the time of laser irradiation, the long-pulse Holmium: YAG (Ho: YAG) laser is not known to generate shock waves. Consequently, it is improbable that a photomechanical mechanism will be the primary mechanism of stone disintegration. The primary lithotripsy mechanism is intricate photothermal effect, which is primarily mediated by laser wavelength, most critical optical parameter. The chemical digestion of the calculi is initiated by the pressure build up that results from absorption of the heat of the laser radiation by the stone surface of the calculus [55].

### Modern types of laser lithotripters

### Holmium: YAG laser

The YAG laser is generated by a flash lamp and emitted onto a Yttrium-Aluminium-Garnet crystal that has been doped with chromium, thulium, and holmium ions ("Ho"). The final energy level that reaches the holmium ions is increased because thulium ions share low energy levels among themselves, while chromium absorbs white light and then transfers energy to them. The crystalline laser rod can be more effectively controlled in terms of temperature by interacting with thulium ions, and the Holmium laser can continue to operate in a repetition mode at ambient temperature. Ho: A YAG laser has a wavelength of 2120 nm, is highly absorbed by water, and disintegrates calculi through a photothermal effect. Ho-YAG lasers can fragment all stone compositions and densities due to their physical attributes. In addition, the pulsed phase of laser excitation operates at such a rapid pace that thermal conductivity and, as a result, thermal effects on the urinary tract wall are negligible. Additionally, laser fiber tip's tissue penetration depth is 0.4 mm, indicating that urothelium is not significantly damaged when it accidentally and sporadically brushes against it. The Ho's exceptional safety profile is underscored by the final two attributes: Intracorporeal lithotripsy of stones using the YAG laser [21].

The power output of Ho-YAG laser devices was initially marketed at 15-20 W. There has been a recent emergence of lithotripsy devices that have 120 W outputs and multiple laser cavities, which will reduce the procedural time. Nevertheless, the Ho: YAG machines' low wall-plug efficiency of 1%-2% is equivalent to the 98%-99% squandered energy that is converted to heat within the device, requiring the implementation of extensive water-cooling systems. This results in a substantial increase in the device's size, weight, and cost, which has a detrimental effect on the ergonomics of the operating room [56].

### Thulium: YAG and thulium fiber laser

The Yttrium-Aluminium-Garnet crystal is doped with high-power, thulium metals, and diode-laser-generated light is emitted onto it to produce the thulium: YAG laser [5] Thulium: YAG lasers are not suitable for stone treatment due to their solid-state design, which operates in a continuous mode at 2010 nm. The term "fiber laser" is used because the energy generated by a diode laser has been entirely generated in a chemically Thulium-ion doped compact laser fiber in recent years. Energy is subsequently communicated to the stone via an additional thin silica fiber. Over the past two decades, a modulated 100 W continuous wave TFL has been employed to conduct investigations on thulium lithotripsy. The new fiber laser boasts a maximal power that is five times greater than that of the previous model (500 W), which is why it is referred to as a "super pulse." [57].

The absorbed peak in water of TFL is four to five times greater than that of Ho: YAG lasers, as it operates at wavelengths of either 1908 or 1940 nm. TFL is appropriate for lithotripsy due to the current capability of pulsed laser emission in thulium technology. The TFL ablation threshold is reduced due to the increased water absorption, which results in stone fragmentation being superior to Ho: YAG lasers. The photothermal effect is the primary mechanism by which calculi are disintegrated, while the photomechanical effect is responsible for less fragmentation. The physical properties of thulium laser radiation provide the ability to fragment all stone compositions and densities, like holmium lasers. In addition, the safety profile of TFL may be more favorable than that of Ho: YAG lasers, as the vaporization of water by thulium lasers leads to the formation of smaller bubbles with lower collapse pressures [58].

Preclinical studies demonstrate some prospective advantages over holmium lithotripters, which constitute most of the evidence regarding TFL. In contrast to the non-uniform, multimodal beam of Ho: YAG, TFL exhibits a symmetrical, focused, and nearly single mode beam. This is anticipated to demonstrate substantial clinical advantages, as fibers with a diameter of 50/100/150 μm are subjected to TFL testing and are incompatible with the Ho:YAG laser. f-URS may be better facilitated by smaller fibers, which may facilitate irrigation and scope maneuverability. In addition, the TFL emanates pulse energies as low as 25 mJ (compared to 200 mJ) and frequencies as high as 2000 Hz (recently, 2400 Hz) (compared to 80 Hz), with a pulse width that is both longer and more uniform. The peak power of 500 W could be attained with TFL, as the pulse energy (PE) has the potential to reach 6 J. The absence of very low pulse energies, extended pulse durations, and increase frequencies is a characteristic of Ho: YAG lasers. These characteristics may be advantageous for the effective polishing of urinary calculi with TFL [59].

In comparison to Ho: YAG lasers, TFL device generates less heat and achieves a higher wall-plug efficiency (12% vs 1%-2%) by employing diode lasers to emanate light instead of flash lamps. Due to this, it appears that fan ventilation is sufficient for TFL, even when it is operated at high frequencies. Moreover, the TFL system is less susceptible to vibrations due to the absence of mirrors within the beam-producing cavity. These advantages are integrated into compact, tabletop devices that generate 50 W of power, in contrast to tabletop variants of Ho: YAG, which can generate up to 20 W [60].

### Laser parameters, new modes, settings, and techniques of lithotripsy

**Laser parameters:** Various parameters can be adjusted intraoperatively by modern laser devices in accordance with the clinical requirements. Each laser pulse energy, or PE, is widely regarded as most critical parameter in the process of disintegrating stone. Ho: YAG lasers permit PE settings ranging from 0.2 to 6.0 J and TFL settings ranging from 0.025 to 6.0 J. With an increase in PE, fragmentation also increases; however, this is counterbalanced by an increase in stone retropulsion and fiber-tip degradation. While fragmentation is less affected by the frequency of pulses, which is the number of pulses generated per second, it is a significant factor in stone polishing. Newer Ho: YAG lithotripters can operate at a maximum frequency of 80 Hz, while TFL devices can operate at a maximum frequency of 2400 Hz. However, experimental lithotripsy has been reported to operate at frequencies as high as 500 Hz [61].

Frequency and energy are multiplied to determine laser power, which is energy delivered per unit of time. ho: YAG laser units are available in two power levels: low (20-30 W) and high (80-120 W). The current operating power of TFL devices is 50 watts. It appears that power is not the most critical parameter in determining the effectiveness of the lithotripsy procedure on the stone. The cause of stone fragmentation or sprinkling is the alteration of the equation parameters, energy, and frequency. At the outset, the laser parameters that were historically preferred were 0.6-0.8 J and 6-8 Hz. The pulse mode, which is determined by pulse length, pulse width [PW], and pulse duration, establishes the duration of time during which the same amount of energy is transmitted. While the pulse width (PW) of the YAG laser ranges from 150 to 1300 µS, the TFL ranges from 200 to 12000 µS. The activating discharge tube was the primary factor in determining the pulse duration of the majority of the initial Ho: YAG laser devices, and the operator was unable to modify it. As a result, most of the devices were set up to operate in a fixed short pulse (SP) mode, with a typical duration of 150 to 350 µS. In the context of lithotripsy, contemporary laser devices facilitate the extension of the pulse width (PW) and encourage a more "dusting" approach. As it is up to 60% more ablative, it seems that the long pulse (LP) mode is more effective on finer stones. It has been reported that retropulsion decreases by 30% to 50% when LP mode is employed. The threshold for stone retropulsion is up to four times greater with TFL when the pulse energies are equivalent. Additionally, LP mitigates laser fiber tip degradation [62].

Although evidence suggests that SP lithotripsy causes more stone ablation, there is still significant debate regarding the matter. Some studies have demonstrated that both LP and SP modalities are equally effective, and the SP mode experiences less retropulsion than high-power LP mode. Wang *et al.* 2024 [63] indicated that suctioning UAS group had a marginally greater overall SFR (92.96%) than traditional UAS group (85.14%). Despite fact that traditional UAS group (35.14%) had a substantially increase incidence of overall complications than suctioning UAS group (16.90%), this study diverges from current study in terms of complications. This discrepancy may be attributed to divergent irrigation techniques and surgical procedures.

## Conclusion

The use of UAS with facilities of suction and bendable distal part is valuable and effective alternative to the standard UAS during RIRS.

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