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Review Article

Single-Use Flexible Ureteroscopes: How Do They Compare with Reusable Ureteroscopes?

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Abstract

Flexible ureteroscopy has become an important tool in the urologist's armamentarium. Until recently, reusable ureteroscopes were the only tools available to perform ureteroscopy. However, in recent years, single-use flexible and semirigid ureteroscopes have been developed as an alternative to reusable ureteroscopes. These disposable ureteroscopes were designed to mitigate problems associated with the use of reusable ureteroscopes, including the high costs related to ureteroscope acquisition, maintenance, processing, sterilization, and repairs. In this review, we provide an overview of currently available single-use flexible ureteroscopes, which include LithoVue, Uscope, NeoFlex, and Shaogang, as well as the Neoscope semirigid ureteroscope. The functional capabilities (deflection, irrigation, and optical properties) of each ureteroscope are also discussed.

Keywords: digital ureteroscope, single use ureteroscopes, flexible ureteroscopy

Introduction

In the last century, the ureteroscope has become an indispensable tool in treatment of urolithiasis.[1] The first documented case of ureteroscopy (URS) was conducted in 1912 by Hugh Hampton Young and RW MacKay using a 9.5F pediatric cystoscope.[2] In 1964, with advancements in technology and development of fiber optics, creation and use of the first ureteroscope were achieved.[3] This early flexible endoscope was limited in its capabilities as it lacked both a working channel and the ability of active deflection. However, in iterations that followed, improvements were made so that ureteroscopes eventually gained the ability to allow irrigation and to actively deflect, transitioning from strictly diagnostic to therapeutic tools.[4]

Eventually, with the advent of digital image sensors, digital flexible ureteroscopy (fURS) was made possible in 2006 with the introduction of Invisio DUR-D from Olympus (Gyrus ACMI).[5,6] Since then, reusable, digital flexible ureteroscopes have been adopted by increasing numbers of urologists.[6,7]

However, the use of reusable flexible ureteroscopes is associated with a high financial burden. There is an initial purchasing cost of ~$25,000 USD plus costs for the video processor and viewing monitor.[5] The durability of reusable digital ureteroscopes, while superior to that of fiber-optic models, continues to be an issue of concern.[5,8,9] With each use, recurrent damage can occur, leading to problems such as deflection loss and, in turn, degradation of ureteroscope performance for subsequent patients.[10]

Following their purchase, reprocessing, maintenance, and repair costs can approach USD $90,000–$100,000 per year.[11,12] Despite the effectiveness of fURS, high continuing costs and the problem of durability of reusable ureteroscopes serve as the chief factors that hinder fURS from being embraced worldwide, particularly in developing countries.[7] Finally, an important concern for the use of reusable flexible ureteroscopes is sterility.[10,13] A study conducted by Ofstead and colleagues[13] showed that even when reusable ureteroscopes were cleaned manually and sterilized by hydrogen peroxide gas, contamination (by bacteria, adenosine triphosphate, hemoglobin, and/or protein) could still be found in the ureteroscopes tested. To circumvent these problems with existing reusable ureteroscopes, single-use flexible ureteroscopes have long been proposed and have recently come to fruition.

Continued innovation has resulted in the recent development of these disposable ureteroscopes by several companies. The first single-use ureteroscope was the PolyScope (Lumenis, Yokneam, Israel) in 2011, which utilized a reusable fiber-optic bundle that could be attached to disposable flexible catheters.[14] While some studies did show efficacy of this ureteroscope, the model was not widely adopted.[15] More recently, several ureteroscopes have been introduced in which the entire instrument is intended to be disposed of at the conclusion of the procedure. There are a large number of single-use ureteroscopes available and under development,

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most of which provide a digital image. Current commercially available devices at the time of writing are LithoVue™ (Boston Scientific, Natick, MA), Uscope (Zhuhai Pusen Medical Technology Co., Ltd., Zhuhai, China), NeoFlex (Neoscope, Inc., San Jose, CA), and Shaogang or YC-FR-A (YouCare Tech, Wuhan, China) to name a few.

The goal of this review is to provide an overview of these disposable flexible ureteroscopes and to examine and compare their functional capabilities.

Overview of Single-Use Flexible Ureteroscopes

Uscope UE3011

The Uscope UE3011™ is touted by PUSEN Medical as one of the first commercially available, contemporary single-use ureteroscopes (Fig. 1). It is constructed somewhat differently from traditional ureteroscopes with the control handle designed to be held in a dorsal manner rather than the ventral. This handle consists of a scroller wheel to control bidirectional 270° deflection.[16] With respect to the technical parameters of the endoscope, Uscope UE3011 weighs a mere 91.0 g.[17] The working length of the endoscope is 630 mm. The outer and tip diameters are both 9.0F. For optics, the tip of the endoscope uses a complementary metal-oxide semiconductor (CMOS) imager system and provides the endoscope with a depth of view of 3–50 mm while illumination is provided by optical fibers. The working channel is 3.6F.[16–18]

LithoVue

One of the pioneers of single-use, digital flexible ureteroscope development is LithoVue (Boston Scientific). LithoVue was officially launched by Boston Scientific in January 2016.[19] It is created with an ergonomic design that allows it to be maneuvered in a similar manner to reusable flexible ureteroscopes.[10,19] In addition to its physical shape, this ureteroscope weighs only 277.5 g, making it lighter than many reusable flexible ureteroscopes and presumably resulting in reduced user fatigue. The length of the ureteroscope is 955 mm.[20] The outer diameter is 9.5F and tip diameter is 7.7F.[21] These diameters allow the ureteroscope to work with ureteral access sheaths currently on the market provided the inner lumen is large enough. The ureteroscope tip houses a CMOS imaging system, which maximizes the ureteroscope's vision by providing a depth of view of 2–50 mm.

With regard to deflection, it is capable of 270° in both directions (Table 1). The handle of the endoscope is equipped with a single light-emitting diode (LED) light source for illumination.[21] This confers an advantage over ureteroscopes using fiber-optic illumination as the use of LEDs eliminates the need for an external light source.[5] The working channel of the ureteroscope is 3.6F, making it compatible with various ancillary working instruments. The controller/processing box is housed within the monitor, which can sit on its own stand or be routed through to an existing video tower system.

Uscope UE3022

The Uscope UE3022™ (Zhuhai Pusen Medical Technology Co., Ltd.) is a single-use, flexible digital ureteroscope introduced subsequent to UE3011. With UE3022, Pusen provides the control handle in a classic configuration similar to many existing flexible ureteroscopes. Furthermore, the outer diameter and working length are slightly increased to 9.5F and 650 mm, respectively (Table 1). It is lightweight, weighing 147 g.[22] Uscope has an integrated camera and utilizes CMOS imaging; the camera can be connected to its dedicated monitor or to an operating room monitor using a digital visual interface (DVI) connection.[22] The processor/controller is housed within the dedicated monitor and can also act as a hard drive to record video or capture screenshots during the operation.

NeoFlex- Flexible Single Use Ureteroscope

The NeoFlex- Flexible, Single Use Ureteroscope™ is a digital flexible ureteroscope produced by Neoscope, Inc. This ureteroscope is 9.0F in diameter and possesses a 3.6F working channel. Similar to the other disposable flexible ureteroscopes, a CMOS imaging system is used for optics. Illumination is provided by LEDs. The ureteroscope is also capable of deflecting 280° in both up and down directions.[23] One unique feature of NeoFlex is an innovation that allows for an attached universal serial bus (USB) 2.0 cable to connect directly to any high definition (HD)-compatible video monitor.

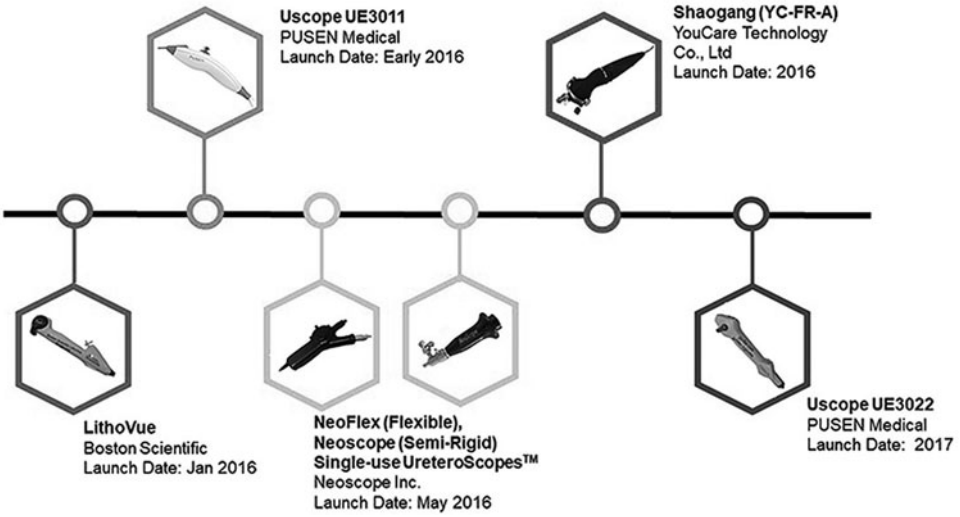

FIG. 1. Timeline of single-use ureteroscope availability. Contemporary single-use ureteroscope launch dates.

Table 1. Single-Use Ureteroscope Specifications

Flexible					*Semirigid*	
	LithoVue	*Uscope UE3022*	*NeoFlex*	*YC-FR-A*	*Uscope UE3011*	*Neoscope*
Tip (outer) diameter	9.5F	9.5F	9.0F	8F	9.0F	9.0F
Working channel (F)	3.6F	3.6F	3.6F	4.2F	3.6F	4.2F
Deflection up/down	270°/270°	270°/270°	280°/280°	270° unilateral	—	—
Imager technology	CMOS	CMOS	CMOS	CMOS	CMOS	CMOS
Illumination	LED	Optical fiber	LED	LED	Optical fiber	LED
Light source location	Handle	Handle	Handle	Handle	Handle	Handle

CMOS = complementary metal-oxide semiconductor; LED = light-emitting diode.

This connectivity feature enables NeoFlex to be completely portable compared with other reusable and single-use flexible ureteroscopes that require an endoscopic video tower to function (Fig. 2). The ureteroscope is completely powered by its USB connection and does not require a separate processor or light source. Its portability is a major advance as this ureteroscope can be used in diverse environments, including remote and developing areas of the world.[23]

YC-FR-A (Shaogang)

The YC-FR-A, also known as the Shaogang Scope, is a lightweight, single-use, fiber-optic flexible ureteroscope. It weighs 95.0 g and has a working length of 630 mm. The outer diameter is 8.0F, while its working channel is 4.2F.[24] In contrast to other disposable ureteroscopes currently available, deflection of the instrument is controlled by a U-shaped lever on the control handle. Another difference between this device and other competing ureteroscope models is that deflection is unilateral and reaches its maximum at 270°. Similar to NeoFlex, there are limited published reports and specifications regarding this ureteroscope.[24]

Single-Use Semirigid Ureteroscope

Neoscope

Neoscope™ (Neoscope, Inc.) is the sole commercially available, single-use, semirigid digital ureteroscope (Fig. 1).

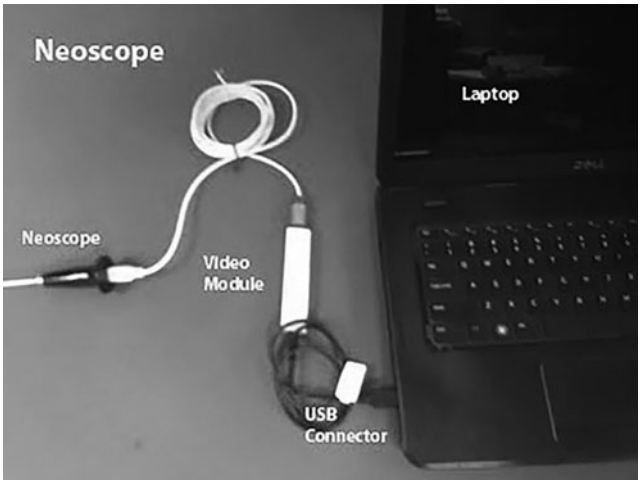

FIG. 2. Neoscope video module allowing portability. Picture courtesy A. Desai. USB = universal serial bus.

It has dual working channels of 3.6F and 2.3F. There are two available instrument lengths of 35 and 45 cm.[25] As with most contemporary ureteroscopes, there is a video processing module capable of recording still as well as live video, and similar to the flexible NeoFlex ureteroscope by the same company, Neoscope also has a USB interface for direct connection to any high-definition-compatible video monitors. The manufacturer claims a resolution of 400×400 pixels using the CMOS imaging sensor. Neoscope utilizes a micro-LED light source in the handle for illumination. To our knowledge, there have been no peer-reviewed publications comparing the use of this single-use semirigid ureteroscope with reusable ureteroscopes.

Functionality of Single-Use Flexible Ureteroscopes

Deflection

The ability of a flexible ureteroscope to deflect is critical for intrarenal procedures[21] as it is necessary for access and navigation of the renal pelvis, calices, and diverticula.[7,22] It is especially important when attempting treatment of lower pole calculi as the lower pole of the kidney has been noted to be more challenging to access.[21,22]

In one of the first studies investigating multiple single-use ureteroscopes, Tom and colleagues[26] evaluated the Shaogang, NeoFlex, and LithoVue single-use devices compared with the digital Flex-X^c (Karl Storz & Co. KG, Tuttlingen, Germany) and the fiber-optic Cobra (Richard Wolf, Knittlingen, Germany) in an *in vitro* setting. They found superior deflection ability in the unidirectional Shaogang ureteroscope.[26] A recent presentation by Dragos and colleagues[27] discussed their investigation of the deflection capability of four disposable flexible ureteroscopes (LithoVue, Uscope, NeoFlex, and Shaogang) compared with reusable flexible ureteroscopes in an *in vitro* study.

Deflection of the ureteroscopes was tested in 10 different conditions (empty working channel and occupied channel with various ancillary URS equipment: 200-μm, 273-μm, and 365-μm laser fibers; 1.5F, 1.9F, and 2.2F baskets; 0.038″ polytetrafluoroethylene (PTFE) and 0.035″ nitinol guidewires; and Piranha biopsy forceps). Most of the single-use flexible ureteroscopes demonstrated overall superiority in their deflection capabilities; it is only with the guidewires and 365-μm laser fibers where the reusable ureteroscopes had greater deflection capabilities than single-use ureteroscopes. When compared within the single-use flexible ureteroscope group, the cumulative degrees of deflection (sum of all deflection angles when working channel was occupied) were

greatest with NeoFlex (5043°), followed by LithoVue (4772°), then Uscope (4633°), and Shaogang (3912°).[27]

In fact, the Shaogang ureteroscope had the smallest cumulative deflection of all disposable and reusable ureteroscopes; however, this discordance with the article by Tom and colleagues [26] is due to the methodology of cumulative deflection and since the Shaogang ureteroscope only deflects in one direction, a low total value is expected. In a similar *in vitro* study using a K-box simulator, deflection capabilities of the same four reusable and disposable ureteroscopes were evaluated.[28] The ureteroscopes were tested under the same 10 conditions, but each condition had 2 subcategories: access to simple calix and access to difficult calix. LithoVue was reported to have the best deflection capabilities of both single-use and reusable ureteroscopes. It gained access in all conditions except while attempting to access a difficult calix with Piranha biopsy forceps in its working channel.

Both Uscope and NeoFlex fared equally well as they were able to access both simple and difficult calices in all conditions except when equipped with the Piranha biopsy forceps.[28]

An *ex vivo* study conducted by Hennessey and colleagues[29] that compared deflection capabilities of LithoVue against two reusable ureteroscopes, URF-V (Olympus, Tokyo, Japan) and Flex-X^c (Karl Storz & Co. KG), showed similar results. LithoVue demonstrated the greatest angles of deflection in a variety of scenarios (empty working channel, 200-μm laser fiber, and 1.9F stone basket), but had a lower deflection angle compared with reusable ureteroscopes when used with a 3F biopsy forceps. However, in contrast to the study by Dragos and colleagues,[28] LithoVue maintained the highest angle of deflection when hydrophilic and PTFE-Nitinol guidewires were inserted into its working channel.

The authors have performed an *in vitro* evaluation of LithoVue and Uscope compared with the Flex-X^c reusable ureteroscope (Fig. 3). In this study, LithoVue was also found to have superior deflection at all parameters tested (empty working channel, 200-μm laser fiber, and 2.4F stone basket).[30] A welcome feature of both Uscope and Shaogang is the self-locking technology that allows continuous maintenance of deflection, thus decreasing user strain and improving surgeon ergonomics.

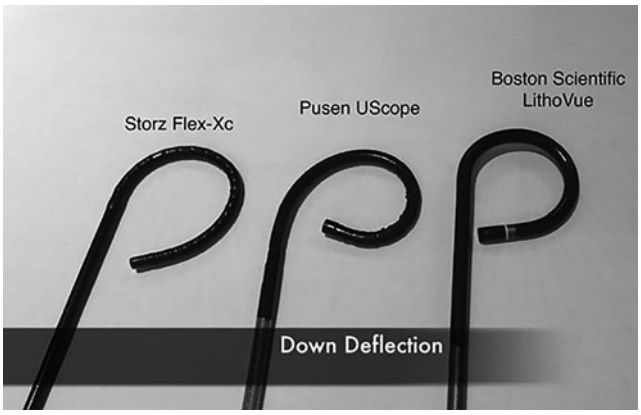

FIG. 3. *In vitro* comparison of deflection of flexible ureteroscopes. Benchtop comparison of downward deflection of reusable Flex-X^c and single-use Uscope and LithoVue ureteroscopes.

Aside from *in vitro* studies, LithoVue has also been tested in *in vivo* and clinical settings. In the *in vivo* study, Wiseman and colleagues[31] used a porcine model to evaluate the deflective capabilities of LithoVue. This study showed that LithoVue was capable of accessing all calices within the kidney.[31] The clinical study involved 40 patient cases and was conducted across multiple sites in Europe. Although this study did not directly measure the ability of the ureteroscope to access calices, there was a pre- and postoperative deflection assessment of the ureteroscope. In 39 of the cases, the ureteroscope maintained 270° deflection in both up and down directions.[31] The authors performed a small, pilot clinical study comparing the performance of LithoVue with Uscope in three patients.[30] Despite finding superior deflection of LithoVue in *in vitro* studies, deflection of both single-use devices and Flex-X^c was similar, even in the lower pole (Fig. 4).

Overall, deflection ability of the single-use flexible ureteroscopes tested appears to be comparable or superior to that of current reusable ureteroscopes. This was noted under various circumstances, including an empty working channel (Table 2), and with the use of ancillary equipment, including guidewires, laser fibers, and baskets.

Irrigation

Adequate irrigation is essential for URS. It allows for improved visualization of the urinary tract as irrigation serves as a means to clear away blood, urine, and debris from the ureteroscope's field of view.[32] Retrograde irrigation allows for distention of the urinary tract leading to enhanced examination of the urinary system, especially the upper urinary structures.[33] Inadequate irrigation can result from insertion of tools and laser fibers through the working channel with a reduction of as much as 95% in the irrigation flow rate.[34]

In a study conducted by Marchini and colleagues[17] to evaluate the irrigation flow rate of LithoVue, Uscope, and a reusable, fiber-optic flexible ureteroscope, Flex-X^2 (Karl Storz & Co. KG), the Uscope had the highest flow rate with an empty working channel compared with that of LithoVue and Flex-X^2 (Table 3). When instruments, including a 200-μm laser fiber, 365-μm laser fiber, and 1.3F basket, were inserted into the working channel, flow rates of both disposable ureteroscopes decreased, but were superior to that of Flex-X^2 in all of these conditions. When a 1.9F basket was introduced into the ureteroscopes, LithoVue demonstrated superior irrigation compared with that of both Uscope and Flex-X^2.[17] The findings from this study regarding LithoVue are similar to those resulting from *in vitro* testing conducted by Dale and colleagues[35] where flow rates for an empty working channel, 200-μm laser fiber, and 1.9F basket were measured.

In a similar study, Tom and colleagues[26] assessed irrigation abilities of the NeoFlex and Shaogang ureteroscopes using the same conditions applied by Dale and colleagues[35] to evaluate LithoVue. In all three experimental scenarios (empty working channel, 200-μm laser fiber, and 1.9F basket), Shaogang had the highest irrigation flow rates compared with NeoFlex.[26] Tom and colleagues[26] further compared the Shaogang and NeoFlex single-use devices with the Flex-X^c digital and Cobra fiber-optic flexible ureteroscopes and found a superior flow rate with the Shaogang ureteroscope. The

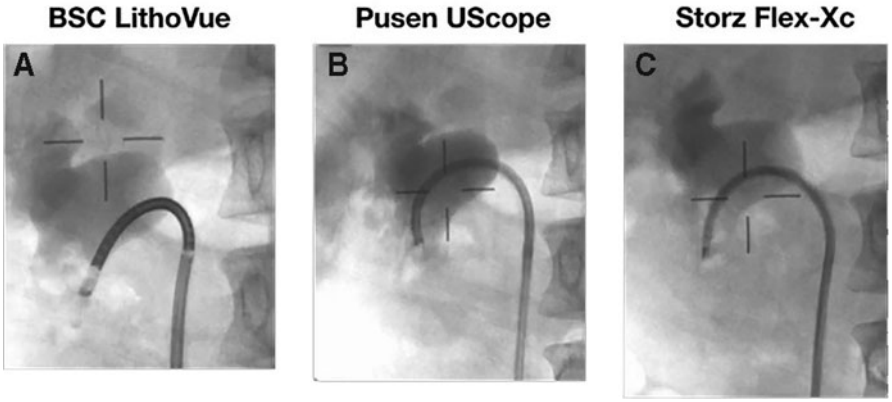

FIG. 4. Clinical evaluation of flexible ureteroscope deflection. Comparison of the deflection capability of **(A)** LithoVue, **(B)** Uscope, and **(C)** Flex-X^c into the lower pole of a single patient. BSC = Boston Scientific.

authors performed bench testing of irrigation flow rates of LithoVue and Uscope compared with the Flex-X^c reusable digital ureteroscope and found superior flow rates for LithoVue both with an empty working channel and with a 273-μm laser fiber.

Taking these studies into consideration, it would appear that single-use ureteroscopes are comparable or superior to reusable models evaluated with respect to irrigation flow rates.

Optical properties

Clear visibility is one of the most important factors in fURS and visibility is largely dependent on optical properties of ureteroscopes. Inadequate visualization during fURS compromises a urologist's ability to diagnose and surgically treat kidney stones. With improved optical properties, urologists are able to better visualize the urinary system, leading to improved surgical performance.[33] Optical properties that are important for flexible ureteroscopes include image resolution, distortion, color representation, and field and depth of view.

To evaluate the optical properties of LithoVue, Dale and colleagues[35] conducted an *in vitro* study that compared LithoVue with two reusable flexible ureteroscopes: the Flex-X^c digital ureteroscope (Karl Storz & Co. KG) and Cobra fiber-optic ureteroscope (Richard Wolf). Using a 1951 U.S. Air Force (USAF) Test Pattern Card, the study determined that at a distance of 10 mm, the image resolution for LithoVue (7.13 line/mm) was comparable with that of the Flex-X^c digital ureteroscope (8.00 line/mm) and 40% better than the Cobra fiber-optic ureteroscope.

When image distortion was evaluated with a multifrequency grid distortion target, LithoVue demonstrated superior imaging as its distortion was measured to be only 3.6%, while Flex-X^c and Cobra produced images with 22.6% and 16.7% distortion, respectively. LithoVue was also found to have a greater field of view (15.75 mm) than Flex-X^c (10.5 mm) and Cobra (14.25 mm) when the field of view was measured with a multifrequency grid target. However, Flex-X^c possessed the greatest depth of view (6.0 mm), followed by LithoVue (4.5 mm), then Cobra (4.0 mm). No significant difference was noted in color representation across the three ureteroscopes.[35] In contrast, the authors conducted *in vitro* and clinical evaluations of LithoVue and Uscope compared with the reusable Flex-X^c and found that Flex-X^c had the best image resolution, while Uscope had the superior field of view.[30]

This study also yielded different results regarding image distortion and color representation; image distortion was found to be comparable between all three ureteroscopes, while color representation was superior in Uscope and Flex-X^c. Although benchtop testing of the ureteroscopes revealed differences in optical performance, clinical evaluation of the ureteroscopes demonstrated similar visualization quality during passage through ureters and in laser lithotripsy.[30]

YC-FR-A (Shaogang) and NeoFlex have also undergone *in vitro* evaluation of their optical properties. The study by Tom and colleagues[26] used the 1951 USAF Test Pattern to test the image resolution of both ureteroscopes at 10 mm. In this study, Shaogang displayed a resolution of 5.04 lines/mm, while NeoFlex exhibited a sharper resolution of 10.1 lines/mm. In addition, testing of image distortion with a multifrequency grid distortion target revealed that Shaogang had an image distortion of 4.3% and NeoFlex had an image distortion of 14.0%. Color representation, field, and depth of view were found to be similar between both ureteroscopes.[26]

Despite discrepancies of the various studies investigating optical parameters of different single-use ureteroscopes (Table 4), some conclusions can be made. The LithoVue, Shaogang, Uscope, and NeoFlex ureteroscopes demonstrate image resolution that is at least comparable with contemporary reusable ureteroscopes. Image distortion and color representation were generally similar as well.

Clinical performance

There have been several studies comparing the clinical outcomes of procedures using LithoVue with a reusable

Table 2. Ureteroscope Deflection with an Empty Working Channel

Author	*LithoVue*	*Uscope UE3022*	*NeoFlex*	*YC-FR-A*	*Flex-X^c*
Dale et al.[35]	276°	X	X	X	263°
Tom et al.[26]	276°	X	226°	339°	263°
Hennessey et al.[29]	286°	X	X	X	219°
Scotland et al.[30]	295°	290°	X	X	285°

Table 3. Irrigation Flow Rates of Single-Use Ureteroscopes

	Marchini et al.[17]		*Dale et al.*[35]	*Tom et al.*[26]	
	LithoVue	*Uscope UE3011*	*LithoVue*	*NeoFlex*	*YC-FR-A*
Empty channel	42 mL/min	52 mL/min	40 mL/min	40 mL/min	59 mL/min
200-μm Laser fiber	21 mL/min	21 mL/min	22 mL/min	16 mL/min	28.7 mL/min
365-μm Laser fiber	7 mL/min	7 mL/min	X	X	X
1.3F Basket	18 mL/min	18 mL/min	X	X	X
1.9F Basket	7 mL/min	3.5 mL/min	8 mL/min	8 mL/min	16.7 mL/min

ureteroscope.[36–38] These have generally found comparable clinical performance and surgical outcomes when compared with reusable ureteroscopes. A recent study evaluated Uscope in treatment of nephrolithiasis in 71 procedures.[22] They reported a stone-free rate of 95.2% with mean stone size of 1.14 cm and 28.2% of stones located in the lower pole of the kidney, mirroring results that have traditionally been reported utilizing reusable ureteroscopes. The authors have performed a small clinical evaluation of LithoVue and Uscope and found comparable performance in the areas of visualization and maneuverability (Fig. 4).[30] Further studies must be done investigating surgeon ergonomics as well as other patient outcomes, including stone-free rates.

Cost

Treatment of urolithiasis is a significant financial burden on the health care economy with projections of approximately US $3 billion by 2030.[39] It has been proposed that conducting fURS with single-use flexible ureteroscopes in lieu of reusable flexible ureteroscopes may serve as a means of alleviating high costs of treating renal stones. Currently, the only disposable flexible ureteroscope that has undergone thorough economic analysis is LithoVue.

One study conducted an analysis of fURS using LithoVue and the reusable URF-V over a 30-month period.[40] In this study, they found that cumulative costs (purchase cost, maintenance, and repair) of 28 procedures for the reusable ureteroscope, UFR-V, were ~$50,000, which averages to $1,786 per case. These costs could be lowered if a single LithoVue ureteroscope costs only $1,200 as 28 fURS procedures would only amount to ~$35,000. Conversely, if LithoVue was priced at $2,500, then 28 fURS procedures would cost ~$70,000, thus favoring the use of URF-V from a financial standpoint. In addition to cost analysis, this study identified staghorn stones and stones located in the lower pole to be significant risk factors for ureteroscope damage and thereby increasing the average cost of reusable ureteroscope fURS.

Based on this finding, in institutions where LithoVue is not the economical choice, the study suggests using LithoVue only in complex cases, such as those with difficult to reach lower pole and staghorn stones, to lower costs associated with fURS.[40] This recommendation is further supported by Molina and colleagues[41] who investigated the financial impact associated with the use of LithoVue compared with URF-V and URF-V2 reusable ureteroscopes (Olympus) in high-risk breakage cases (HRBC). Their cost analysis revealed that implementing disposable ureteroscopes for HRBC can result in savings of $229 per case. They further stipulate that the magnitude of savings associated with disposable flexible ureteroscopes could be even higher as their analysis excluded costs of cleaning, sterilization, and storage of reusable ureteroscopes.[41]

Hennessey and colleagues[29] also performed a cost analysis and found cost savings of $15 000 Australian dollars over 28 cases compared with the use of the reusable URF-V ureteroscope (Olympus). However, this only held true provided that LithoVue is sold at $1200 per device.[29] Although these studies provide evidence that the use of disposable ureteroscopes can serve as a way to lower fURS costs in cases where damage to reusable devices is likely, using disposable ureteroscopes in all cases of fURS may not currently yield significant economic benefits in high-volume centers.

Microcosting is a method of analysis that enables precise economic assessment of resources used for a given process. A recent analysis comparing the costs associated with LithoVue and the reusable flexible ureteroscope, URF-P6 (Olympus), was performed by Taguchi and colleagues.[8] Data were collected from 2 weeks of fURS performed with LithoVue or URF-P6. The factors that were considered in the microcosting evaluation included operating room cost, labor costs related to reprocessing, consumable costs for reprocessing, ureteroscope repair costs, and ureteroscope acquisition costs. The study's analysis determined that the total cost per case using LithoVue was $2852.29, whereas the total cost per case using URF-P6 was $2799.72. Although the total cost per case with LithoVue was greater, the difference was found to be insignificant. While this study indicated that the costs per case associated with reusable and disposable ureteroscopes are comparable, these results could vary from institution to institution as certain costs such as repair and reprocessing costs are often institution specific.[37]

One important factor that can influence economic implications of fURS at individual institutions is the volume of

Table 4. Field of View Comparisons of Flexible Ureteroscopes

Author	*LithoVue*	*Uscope UE3022*	*NeoFlex*	*YC-FR-A*	*Flex-X*[c]
Dale et al.[35]	15.75 mm	X	X	X	10.50 mm
Tom et al.[26]	15.75 mm	X	13.80 mm	14.00 mm	10.50 mm
Dragos et al.[27]	15.50 mm	9.50 mm	11.00 mm	9.5 mm	10.50 mm
Scotland et al.[30]	11.00 mm	X	16.00 mm	X	15.00 mm

fURS cases. A cost–benefit analysis that compared the costs of performing fURS with the reusable Flex-X^c ureteroscope and the potential costs of LithoVue was performed at the Mayo Clinic.[9] This study determined that after 99 fURS cases, the cost–benefit analysis favored the use of reusable ureteroscopes rather than disposable ureteroscopes. This finding suggests that health care institutions with a high volume of fURS cases would save on cost by using reusable ureteroscopes, while institutions with a low volume of fURS cases may financially benefit from the use of disposable ureteroscopes.[9]

To date, no extensive cost comparisons have been performed using the other single-use ureteroscopes. Furthermore, total costs may vary by institution, making any such analysis difficult to generalize. Nonetheless, the use of these devices in cases that the surgeon anticipates will be challenging to gain access may prove to be cost-efficient by sparing reusable ureteroscopes that would be at a high risk of damage in such cases.

Conclusions

The development of single-use flexible ureteroscopes is a major technological advancement in the field of endourology. Initial studies indicate that these ureteroscopes may be viable and cost-effective alternatives to reusable flexible ureteroscopes. Inconsistencies in results of studies to date, particularly with respect to benchtop testing of parameters, may be due to inconsistencies in the quality of these first-generation ureteroscopes or differences in testing circumstances. Concerns for the effect of ureteroscope variability and fidelity of ureteroscope performance persist. However, this is an active field and there are several devices currently under development.

Moreover, currently available models continue to undergo rapid innovation with new iterations of several models promised. Continued innovation and healthy competition in this field will lead to improved devices that are more cost-effective. In this rapidly changing field, more research is needed to validate the clinical performance and efficacy of these single-use flexible ureteroscopes.

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Author Disclosure Statement

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Abbreviations Used

CMOS = complementary metal-oxide semiconductor
fURS = flexible ureteroscopy
HRBC = high-risk breakage cases
LED = light-emitting diode
URS = ureteroscopy
USAF = U.S. Air Force
USB = universal serial bus