

Unfavorable factors in accessing the pelvicalyceal system during retrograde flexible ureteroscopy (fURS)

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DOI

10.25122/jml-2023-0005

Dates

Received: 9 January 2023

Accepted: 28 February 2023

ABSTRACT

Flexible ureteroscopy (fURS) is a well-established procedure for treating multiple upper-urinary tract pathologies, particularly renoureteral lithiasis. Endoscopes have undergone significant advancements, including miniaturization, improved optics, and increased maneuverability. In addition, advancements in accessory instruments, such as the performance of laser fibers, guidewires, and extraction probes, have played a significant role in improving the overall performance of flexible ureteroscopy procedures. However, despite these advancements, unique circumstances can make achieving optimum results during flexible ureteroscopy challenging. These include congenital renal anomalies (horseshoe kidneys, ectopic kidneys, rotation anomalies), as well as the unique intrarenal anatomy (infundibulopelvic angle, infundibular length) or the specifications of the endoscope in terms of maneuverability (active and passive deflection). This review explored challenging scenarios during flexible ureteroscopy procedures in the pyelocalyceal system.

KEYWORDS: flexible ureteroscopy, renal malformations, horseshoe kidney, ectopic kidney, passive deflection.

INTRODUCTION

In the past three decades, flexible ureteroscopy (fURS) has undergone substantial technological and technical developments, leading to its widespread use for treating various upper urinary tract disorders, primarily urolithiasis. Since Marshall's initial description of fURS in 1964, flexible ureteroscopes have undergone major technological advances [1]. As a result, these devices now exhibit a high success rate in clinical settings, a low incidence of related morbidity, and are relatively easy to use. Marshall's original description of the ureteroscope only allowed passive deflection and lacked a working channel. Later, Takayasu introduced a ureteroscope that integrated active deflection. In 1987, Demetrius Bagley introduced the flexible ureteroscopy as we know it today [2-4].

The successful development of the flexible intracorporeal lithotripter Holmium: Yttrium Aluminium Garnet (Ho: YAG) laser with a good safety margin has raised interest in treating urolithiasis as a retrograde intrarenal surgery (RIRS) [5,6]. More recently, the introduction of the Thulium laser (TFL) marked a new milestone in the evolution of intracorporeal lithotripsy and ureteroscopy, adding value to the already established techniques in this surgical field. It permits the energy to travel more effectively than Ho: YAG in a more focused beam and at a wavelength with a higher water absorption coefficient [7,8]. Studies conduct-

ed in vitro and ex vivo with TFL have revealed that less time and energy are needed to remove kidney stones because of their technical characteristics [9,10]. In conjunction with the advancements in laser technology, the anatomy of modern ureteroscopes has also undergone significant changes. Other technological developments in recent years have improved active deflection and reduced scope caliber, resulting in better surgical outcomes and shorter operating times [11]. The transition from optical systems using optical fiber to digital ureteroscopes represented a new achievement in developing modern and durable devices with improved visualization and a longer lifespan [12,13]. The development of ideal smaller diameter endoscopes, enhanced image quality, and maneuverability along with long-lasting durability have been the goals of ongoing technological advancements [14]. The possible benefits of endoscope miniaturization include potential reductions in pre-stenting rates, better irrigation outflow, improved irrigation turnover, better manipulation, and perhaps reduced risk of ureteral injury [15]. The introduction of single-use flexible ureteroscopes has significantly increased their accessibility in the healthcare setting, leading to a rise in the number of minimally invasive procedures for kidney stone removal [16]. Boston Scientific unveiled the LithoVue™, the first digital single-use ureteroscope, in January 2016 [17]. With innovative single-use technologies, flexible ureteroscopy, and retrograde intrarenal surgery entered a new age (RIRS). The introduction of

Pusen's (Pusen™ - Zhuhai Pusen Medical Technology Co, Ltd., Zhuhai, China) new 7.5 Fr single-use flexible ureteroscope has revolutionized the flexible ureteroscope industry, introducing a powerful and practical instrument that has the advantage of increased maneuverability, excellent visualization, lightweight, and at the same time does not require resterilization, maintenance costs and does not predispose to cross infections. The thinnest single fURS has an outer shaft diameter of 7.5Fr and a working channel diameter of 3.6Fr. This approach can address accessibility issues without needing an access sheath or a smaller access sheath, thereby reducing procedure-related morbidity and allowing passage through a narrow ureter. This can also be particularly useful in solving more complex cases where access with a standard ureteroscope is challenging [18,19].

However, despite these technical advancements, there are still instances where procedures may not be straightforward. Factors such as anatomical anomalies of the reno-ureteral system, difficult positioning of the calculus at the lower calyx level, or suboptimal maneuverability of the ureteroscope when accessing a certain point in the pelvicalyceal system can make the technique challenging, leading to suboptimal outcomes. This review aimed to evaluate situations where access of the flexible ureteroscope is difficult due to patient-related factors or technical characteristics of the endoscope.

Renal malformations leading to access difficulties

Patients with renal anatomical anomalies represent a unique population that requires special consideration in managing upper urinary tract lithiasis [20]. Pelvic anatomic anomalies, such as aberrant vessels that obstruct the pelvic ureteric junction (PUJ), PUJ stenosis, and the presence of diverticula or other congenital renal malformations, pose challenges for the urologist when performing flexible ureteroscopy. Different defects in embryological development result in defective kidneys. These could be connected to irregular rotation, ascent, fusion, or a combination of these changes. Horseshoe kidneys (HSK) are the most common congenital renal malformations, with an incidence rate of 1 in 400, while ectopic kidneys (EK) are less commonly observed, with an incidence rate of 1 in 3000 [21]. These structural abnormalities enhance the incidence of urolithiasis and compromise renal drainage [22]. Endourological care is difficult because access to the upper urinary tract is challenging. Although shockwave lithotripsy (SWL) and percutaneous nephrolithotomy (PCNL) can be an option in these cases, the complication rates are higher, and the failure of definitive treatment of the stone is lower compared to anatomically normal kidneys [23-25].

Technological and procedural advancements have greatly expanded the indications for flexible ureteroscopy (fURS), making it a highly effective therapeutic option for complex intrarenal anatomy considering the advent of smaller caliber ureteroscopes enhanced with greater deflection capabilities and modern fiber lasers [26]. A study by Jie Ding [27] investigated the outcomes of fURS in patients with kidney stones and horseshoe kidneys. The study found that the average calculus size was 29±8 mm, with a total operative time of 92±16 minutes. Of the total number of patients, 62.5% achieved stone-free status after the first procedure, and for the remaining patients, the total stone-free rate reached 87.5% after the second procedure. The study reported no major complications associated with the procedure.

Another recent study compared retrograde endoscopic treatment (fURS-RIRS) and percutaneous nephrolithotomy (PCNL) in treating renal lithiasis associated with horseshoe kidneys. The

study followed 49 patients who received both treatments, with 21 undergoing PCNL and 28 RIRS [28]. Although the stone-free rates were comparable for both methods, the postoperative complications and perioperative morbidity associated with PCNL were much lower compared to fURS, considering it a viable option for these patients. A recent paper published in late 2021 [29] compared retrograde stone treatment with single-use flexible ureteroscopes (su-fURS) (14 patients) and reusable flexible ureteroscopes (re-fURS) (15 patients) following 29 patients with horseshoe kidneys over 5 years. The study found that both methods resulted in similar outcomes in terms of complications, operation time, mean stone burden, and stone-free rates, concluding that fURS is a safe alternative for treatment in these problematic cases. The study used the PU3022 ureteroscope from Zhuhai Pusen Medical Technology, which demonstrated exceptional accessibility, maneuverability, and operating time, reaffirming the safety and reliability of modern single-use instruments that are economically efficient and do not require maintenance costs. These instruments offer the added advantage of surgeon safety, enabling them to solve particularly difficult cases without fear of damaging expensive, reusable instruments. The authors highlighted the clear advantage of these new instruments, especially in cases where intrarenal access is difficult.

Ectopic kidneys result from impaired embryological development, and patients with this condition are more likely to experience various disorders, including hydronephrosis and nephrolithiasis, due to the abnormal position, orientation, and form of the pelvic kidney. The anatomical and architectural abnormalities associated with ectopic kidneys make it difficult for urologists to treat pelvic kidney stones [30,31]. Many studies have followed the incidence of renal lithiasis in this type of malformation and optimal methods of minimally invasive treatment.

Although ureteroscopy may be difficult in these particular patients, a systematic review conducted in 2020 by Lisa Lavan *et al.* [32] examined 117 cases of ectopic kidney along with other kidney anomalies and demonstrated that endourological technique advancements had made ureteroscopy an effective and safe procedure, combined with minimal rates of complications and promising postoperative stone-free status. A study conducted by Omer Faruk Bozkurt *et al.* [33] investigated retrograde fURS management in 26 patients with renal lithiasis associated with ectopic kidneys [33]. The study reported a stone-free rate of 84.6% (22 patients), while 4 patients (15.4%) failed retrograde treatment due to fragment obstruction or the difficult position of the stone in the lower calyx, despite the best possible ureteroscope deflection. Another article published in mid-summer 2021 [34] compared the effectiveness of fURS in managing ectopic pelvic kidneys in 11 patients over 3 years, analyzing mean operative time, hospital stay, stone-free rate, and complications. The stone-free status (fragments <3 mm) after one session was 60.1%, followed by 84.1% after the second session and 94.4% after the third intervention, respectively. The average stone burden was 30 ± 9 mm (17 to 49 mm). In terms of complications, the overall rate was 19.7%, according to the Clavien-Dindo system. The authors concluded that fURS was an efficient treatment strategy with a high stone-free rate and low complication profile in ectopic kidney calculi.

In a comprehensive review published in 2017 in the World Journal of Urology [35], Mahesh Desai compared the current standard treatment options for renal stones, including SWL, fURS, and PCNL, citing guidelines from the American Urology Association and European Association of Urology [35]. It highlighted the important role of each specified procedure in

a different situation and concluded that none of the aforementioned techniques is optimal for all situations. Each procedure has advantages and disadvantages, and various cases should be considered individually to achieve the best results. It highlights the importance of fURS in abnormal kidneys when the stone is located in the lower pole measuring 1.5-2cm (considering the unfavorable factors for SWL) or stones located in a diverticulum or a diverticular neck.

The 2022 guidelines of the European Association of Urology on Urolithiasis [36] underline the importance of considering special problems in stone removal, such as calyceal diverticulum stones, horseshoe kidneys, or stones in the pelvic kidney, where a retrograde approach is a feasible option with minimal complications and substantially stone-free rates. A special category of abnormalities is represented by patients with obstruction of the UPJ, where PCNL should be considered the first option in stone removal. However, even in these cases, the retrograde approach can achieve good results if associated with Ho: YAG laser endopyelotomy. When none of the aforementioned procedures succeeds, open surgery to correct the UPJ obstruction (pyeloplasty) and remove stones is the ultimate option. In fact, UPJ obstruction represents perhaps the most important anatomical modification of the kidney that makes it difficult for the ureteroscope to access the pyelocaliceal system. Multiple studies [37-39] suggest the particular complexity of these cases associated with renal lithiasis, which determines other procedures as primary options in treating these patients. A comprehensive review published by Andreas Skolarikos in Urolithiasis [40] aimed to determine the optimal approach of renal stones associated with UPJ obstruction. The review concluded that in these particular cases, the best approach would be laparoscopic or robotic pyeloplasty associated with stone removal in the same operative setting. It is safe to conduct and has a high success rate for maintaining UPJ patency and stone-free status. When treating concurrent renal stones and ureteropelvic junction stenosis, minimally invasive pyeloplasty should be the first option considering that endopyelotomy has poorer long-term obstruction-free rates.

Difficulties in intrarenal handling of the ureteroscope

With improvements in optical systems, digital video capability, laser lithotripsy, smaller ureteral stone baskets, and dual working channels that enable continuous pressurized irrigation for improved visualization, ureteroscopy has attained the imaging capability, precision, versatility, safety, and reliability needed to become a standard tool in the armamentarium of every urologist. However, with all these improvements, the literature still highlights multiple situations that make it difficult for the ureteroscope to access all the intrarenal areas. One of the most serious situations that complicate ureteroscopy in the retrograde treatment of renal lithiasis is the lower pole stone. Multiple systematic publications have tried to determine objectively the factors that make it difficult to access the lower renal pole [41,42]. Traditionally, it is considered that an infundibulopelvic angle (IPA) $<30^\circ$ and a long infundibular length (IL) (>3 cm) are determining factors [43]. A recent large-scale study published in the International Journal of Urology in October 2022 aimed to determine the specific parameters of the "inaccessible" anatomy of the lower pole in 854 patients with kidney or ureteral stones [44]. The mean values determined were IPA = 54.6° , infundibular width (IW) = 9.4 mm, and calyceal pelvic height (CPH) = 30.9 mm. IPA 45.8° and IW 7.8 mm were unfavorable predictors for accessing the kidney lower pole in fURS.

Stone replacement is one of the most common techniques several authors have described in managing lower renal pole stones. The success rate of fURS in treating lower pole stones has increased thanks to a procedure that involves moving the stone to a more accessible calyx using tipless Nitinol baskets before laser lithotripsy (Figure 1 A-D).

Compared to the thinnest laser fiber, baskets result in a little loss of irrigation flow and endoscope active deflection, enabling effective access to the lower pole with improved visibility [45-48]. Gokce *et al.* [49] compared SWL with fURS in 67 patients, emphasizing the advantage of calculus repositioning from the lower calyx level to increase the success of the intervention, resulting in a stone-free rate of 73.9% in fURS.

Flexible ureteroscopes typically consist of a working channel, a deflection mechanism, and an optical system that utilizes fiber-optic images and light bundles. The most important feature of current ureteroscopes is the deflection mechanism, which theoretically allows the visualization of the entire pyelocaliceal system. Over time, the deflection systems of ureteroscopes have undergone significant advancements. Recently, deflection angles were increased to 275 degrees, allowing ureteroscopic tips to access even the farthest point of lower minor calyces. Table 1 provides a comparison of the commonly used ureteroscopes [50,51].

However, some authors suggest that even with this wide deflection, in many cases, it is difficult to access the lower renal pole or kidneys with anatomical anomalies, so other "tips and tricks" methods must be used to advance anywhere in the pyelocaliceal system. In some situations, active deflection is not enough, and passive deflection is defined as bending the tip of the ureteroscope by supporting it against the calyx (most frequently) or another intrarenal structure to "passively" orient the ureteroscope optics in the opposite direction [52]. Although the concept of using a ureteroscope with two deflections, one active and one passive, was described in 1992 [53] and was very popular at the time, the advancement of technology, the digitalization of ureteroscopes, and their decreasing size led to a relative decrease in the popularity of this approach [54]. However, despite these technological advances, there are still situations in which certain areas of interest cannot be accessed during renoureteroscopies, and therefore, these "tips and tricks" remain valuable tools in the hands of expert urologists (Figures 2 A-C and 3 A-D).

Passive deflection allows for the extension of the deflected section, providing complete inspection and treatment of the intrarenal collecting system. The more flexible section of the ureteroscope, placed just proximal to the site of active deflection, enables secondary passive deflection, facilitating the bending of the angled tip of the ureteroscope off the superior border of the renal pelvis or the neck of a middle-pole calyx when there is a baggy extrarenal pelvis. This effectively extends the ureteroscope's tip, enabling better visualization of the lower pole calyces. The use of passive deflection in combination with active deflection enables a larger proportion of the renal cavities to be visualized with relative ease [55,56]. New-generation ureteroscopes with small calibers, such as Pusen 3022A or 3033A, have emerged as a potential solution to the challenge of accessing difficult-to-reach areas of the pyelocaliceal system. These ureteroscopes offer improved maneuverability, deflection, and limb fatigue performance and are at least competitive with regular f-URS in these aspects. The intrarenal visualization provided by these small-caliber ureteroscopes is comparable to that of the ureteroscopes commonly used in clinical practice. The significant advantage of these devices is their disposability, as they can be easily replaced at any time with minimal costs, making them a cost-effective option for tackling

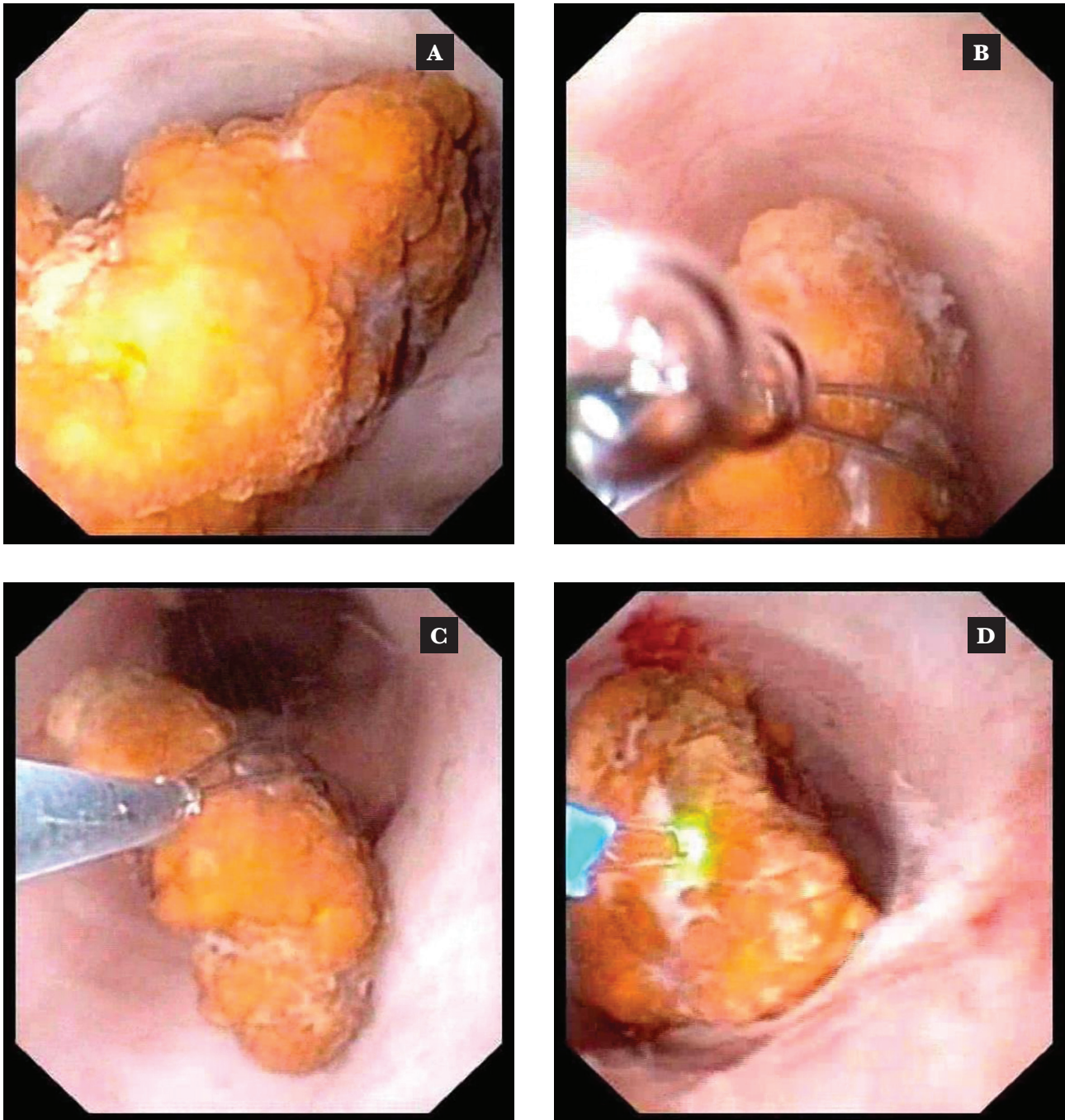


Figure 1. Intraoperative images of stone relocation. A – stone located in the inferior calyx; B, C – relocating the stone to the upper calyx; D – laser lithotripsy of the upper calyx.

Table 1. The main characteristics of various flexible ureteroscopes in current use [50,51].

Characteristics	Pusen	Boston Scientific	Olympus		Karl Storz	Richard Wolf
	PU3033A	LithoVue	URF-P5,6	URF-V2	Flex-X2	Viper
Use	Single-use	Single-use	Reusable	Reusable	Reusable	Reusable
Tip diameter (Fr)	7.5	7.7	4.9	8.4	7.5	6
Shaft diameter (Fr)	7.5	9.5	7.95	8.5	7.5	8.8
Working length (mm)	650	680	670	670	670	680
Channel size (Fr)	3.6	3.6	3.6	3.6	3.6	3.6
Deflection angle	2700/2700	2700/2700	1800/2750	2750	2700	2700

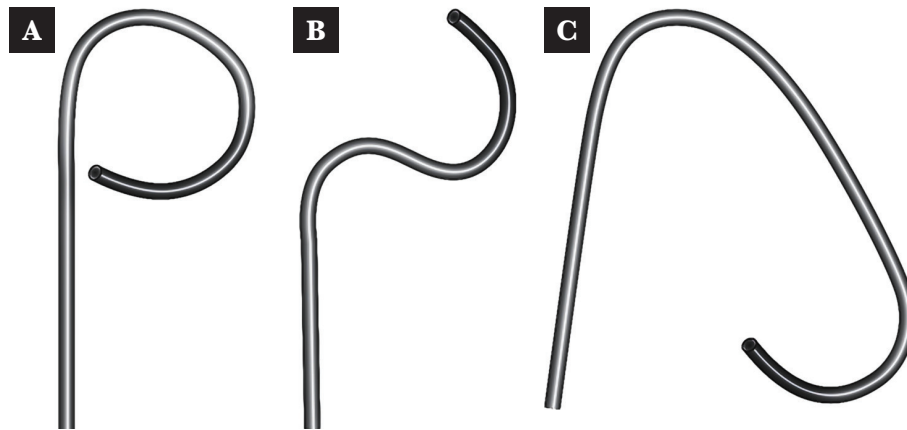


Figure 2. Graphic representation of active and passive deflection in different situations.

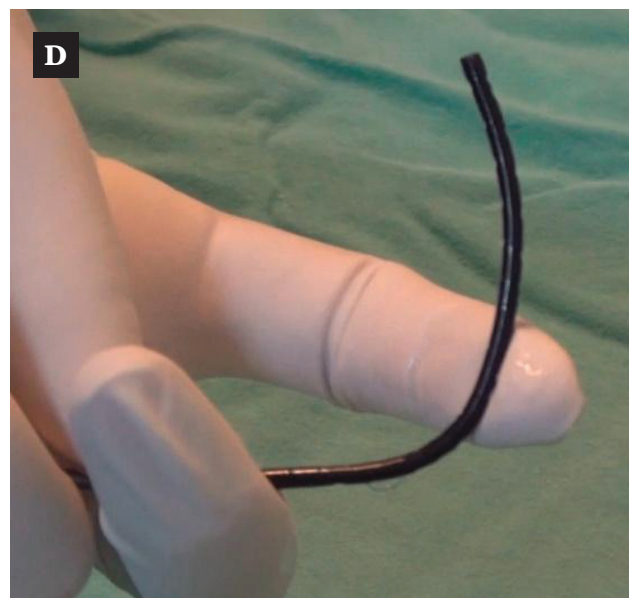
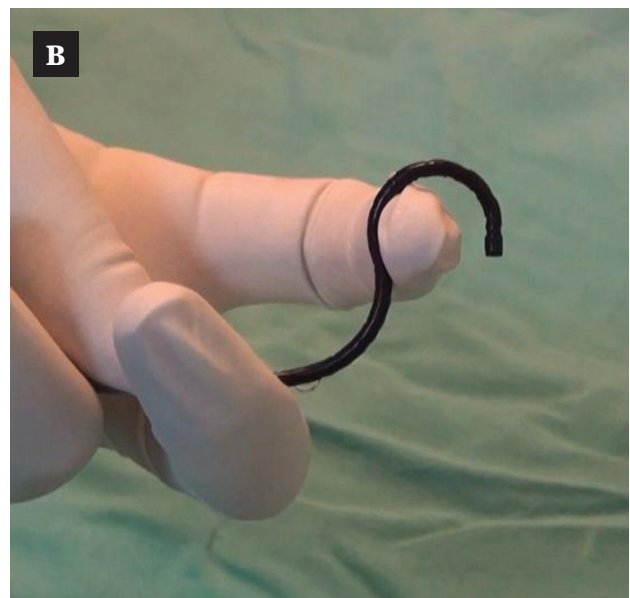
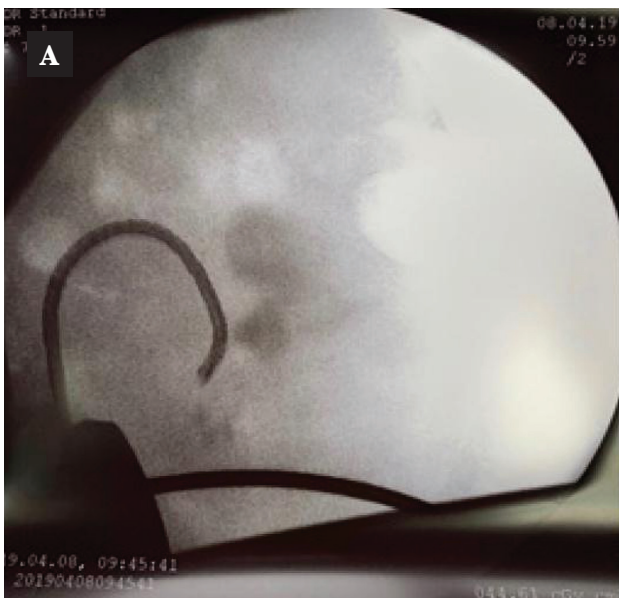


Figure 3. Intraoperative images of active and passive deflection during fURS. A – intraoperative fluoroscopic image; B, C, D – ex vivo representation of passive deflection).

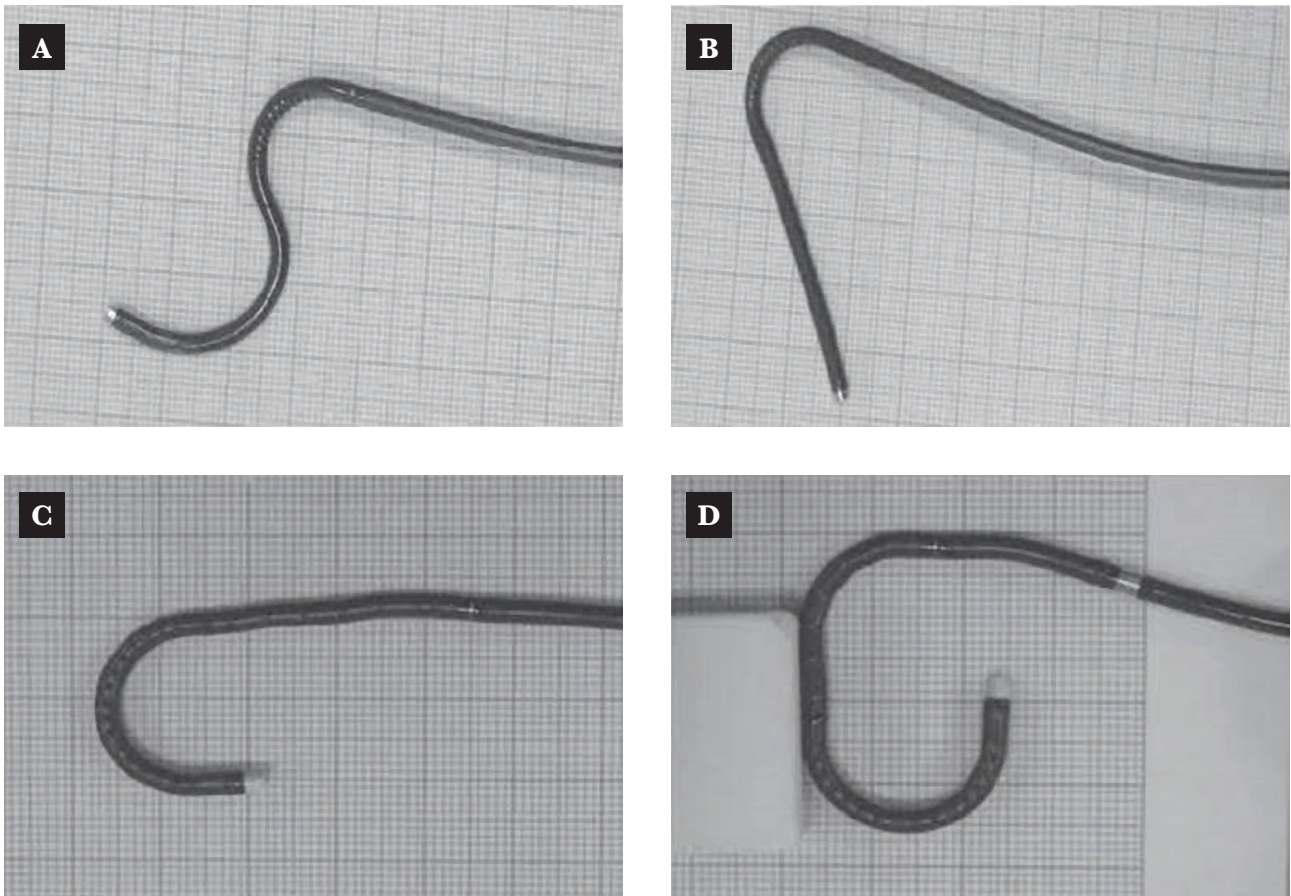


Figure 4. Examples of in-vitro passive deflection of flexible ureteroscope.

complex cases that would otherwise require the use of expensive, reusable tools [57,58].

Different single-use fURS from the authors' collection are represented in Figure 4 A-D and Figure 5.

DISCUSSION

The introduction of flexible ureteroscopy was one of the technological advancements that improved the surgical treatment

of renal stones throughout the last three decades (fURS). This tool has undergone numerous improvements, such as auxiliary equipment like graspers and baskets, the lithotripsy technique with Holmium: YAG laser, or newer technology such as Thulium laser, which have led to the expansion of its indications, to include the diagnostic and therapeutic management of upper urinary tract pathologies like urolithiasis and urothelial tumors [59-64].

Despite the new technological advances, the literature still describes multiple situations where accessing the pelvicalyceal system with the ureteroscope can be challenging. These difficulties

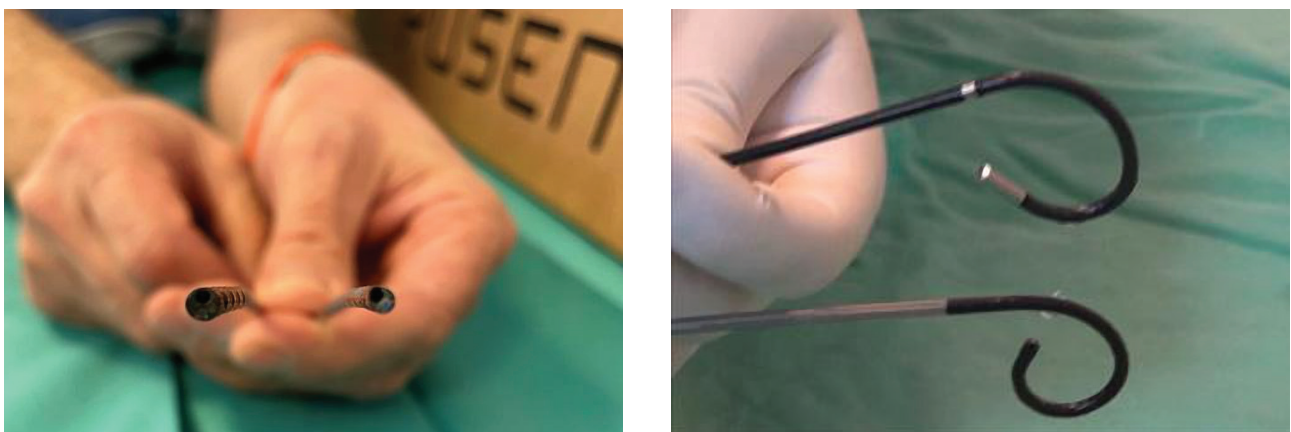


Figure 5. Differences between the 9.5 Fr Pusen (Zhuhai Pusen Medical Technology™) flexible ureteroscope and the new 7.5 Fr ultra-thin flexible ureteroscope.

may stem from a range of factors, including renal malformations, unique local anatomy, or the technical characteristics of the endoscope. Multiple studies have evaluated the safety profile and success rates of the procedure in abnormal kidneys, and the findings consistently demonstrate low complication rates. However, the stone-free rate did not exceed 90% in nearly all cases [32,65-67]. A 2017 study by Ergin *et al.* [68] assessed success rates (stone-free) in 101 patients with renal lithiasis and associated renal anatomical anomalies. The study found that patients with horseshoe kidneys had success rates of 72.2% for fURS and 90% for PCNL, while those with ectopic kidneys had success rates of 83.6% for fURS and 100% for laparoscopic pyelolithotomy. Additionally, patients with renal rotation abnormalities had stone-free rates of 75% for horseshoe kidneys and 83.3% for PCNL. These results suggest that although flexible ureteroscopy has lower complication rates than other kidney stone treatment methods, its success may be limited in special cases due to technical difficulty. Even in normal, conforming kidneys, there are certain situations where access of the ureteroscope is made difficult by the unfavorable local anatomy. The literature describes the most frequent situation when the calculus is associated with the lower calyx. According to a 2017 study [69], digital fURSs had limited end-tip deflection compared to fiberoptic fURSs and were less successful at reaching the inferior calyx's acute angle. As a result, it may be preferable to utilize a fiberoptic fURS while attempting to approach a challenging inferior calyx. Renoscopy for lower calyx calculus may involve relocating the calculus to another calyx using a nitinol basket [70] so that the angulation of the ureteroscope during lithotripsy is not very steep. This approach can improve the visualization of the calculus and protect the endoscope from unintended damage.

Another predictive factor for the success of ureteroscopy is the local intrarenal anatomy. Multiple studies have evaluated IPA, IL, and CPH [71,72]. A study by Tomasz Ozimek *et al.* (2018) [73] evaluated 381 fURS in terms of IPA, ureteroscope damage, and complication rates. It concluded that a steep IPA (<60°) is associated with higher rates of complications and an increased possibility of endoscope malfunctions. However, the latest study on this topic suggests that an IPA of <45.8° is a poor indicator for reaching the lower pole of the kidney during fURS.

When the area of interest cannot be properly visualized, another described technique is “passive deflection”. Only the distal tip of the ureteroscope experiences active deflection, and the deflected segment might not be long enough to reach the lower pole calyx. Due to a weakness in the durometer of the sheath, which is situated close to the point of active deflection, the majority of flexible ureteroscopes feature a more flexible segment of the ureteroscope [74]. This additional passive deflection mechanism is responsible for an additional deflection when the active one is not enough. The point of deflection on the ureteroscope is effectively pushed more proximally, expanding the tip of the ureteroscope by passively bending the tip off the superior border of the renal pelvis. In most patients, the lower pole calyx may be reached with passive deflection. However, there are also particular situations, such as patients with a high degree of hydronephrosis, which can make it difficult to use passive secondary deflection.

CONCLUSION

Flexible ureteroscopy has become an essential tool in the arsenal of modern urologists for the treatment of renal lithiasis. Technological advances have made this procedure safe, and efficient, and provided excellent results in the benefit-safety ratio.

However, achieving maximal success rates in terms of stone-free status can be challenging, and multiple parameters such as anatomical anomalies or special characteristics of the intrarenal anatomy must be considered before any procedure. Nevertheless, experienced surgeons can increase the success rate using various “tips and tricks” maneuvers tailored to individual cases.

ACKNOWLEDGMENTS

Conflict of interest

The authors declare no conflict of interest.

Authorship

PG and CM contributed to conceptualization. BG and CM contributed to the methodology. RM, R-IP, and CE contributed to validation. CM, PG, CE, and RM contributed to the investigation. CM and RM contributed to resources. CM and PG contributed to the writing and original draft preparation. BG, CM, and PG contributed to writing, reviewing, and editing. BG, RM, R-IP, and CE contributed to the visualization. BG and PG contributed to supervision. All authors read and agreed to the published version of the manuscript.

REFERENCES

1. Marshall VF. Fiber Optics in Urology. *J Urol.* 1964 Jan;91:110-4. doi: 10.1016/s0022-5347(17)64066-7.
2. Takayasu H, Aso Y. Recent development for pyeloureteroscopy: guide tube method for its introduction into the ureter. *J Urol.* 1974 Aug;112(2):176-8. doi: 10.1016/s0022-5347(17)59675-5.
3. Johnston WK 3rd, Low RK, Das S. The evolution and progress of ureteroscopy. *Urol Clin North Am.* 2004 Feb;31(1):5-13. doi: 10.1016/S0094-0143(03)00100-9.
4. Doizi S, Traxer O. Flexible ureteroscopy: technique, tips and tricks. *Urolithiasis.* 2018 Feb;46(1):47-58. doi: 10.1007/s00240-017-1030-x.
5. Denstedt JD, Razvi HA, Sales JL, Eberwein PM. Preliminary experience with holmium: YAG laser lithotripsy. *J Endourol.* 1995 Jun;9(3):255-8. doi: 10.1089/end.1995.9.255.
6. Aldoukhi AH, Roberts WW, Hall TL, Ghani KR. Holmium Laser Lithotripsy in the New Stone Age: Dust or Bust? *Front Surg.* 2017 Sep 29;4:57. doi: 10.3389/fsurg.2017.00057.
7. Traxer O, Keller EX. Thulium fiber laser : the new player for kidney stone treatment ? A comparison with Holmium : YAG laser. *World J Urol.* 2020;38(8):1883-1894. doi: 10.1007/s00345-019-02654-5.
8. Kronenberg P, Traxer O. The laser of the future: reality and expectations about the new thulium fiber laser-a systematic review. *Transl Androl Urol.* 2019;8(4):S398-S417. doi: 10.21037/tau.2019.08.01.
9. Traxer O, Corrales M. Managing Urolithiasis with Thulium Fiber Laser: Updated Real-Life Results-A Systematic Review. *J Clin Med.* 2021 Jul 30;10(15):3390. doi: 10.3390/jcm10153390.
10. Ulvik Ø, Æsøy MS, Juliebo-Jones P, Gjengsto P, Beisland C. Thulium Fibre Laser versus Holmium:YAG for Ureteroscopic Lithotripsy: Outcomes from a Prospective Randomised Clinical Trial. *Eur Urol.* 2022 Jul;82(1):73-79. doi: 10.1016/j.eururo.2022.02.027.
11. Scotland KB, Chan JYH, Chew BH. Single-Use Flexible Ureteroscopes: How Do They Compare with Reusable Ureteroscopes? *J Endourol.* 2019 Feb;33(2):71-78. doi: 10.1089/end.2018.0785.
12. Keller EX, De Coninck V, Traxer O. Next-Generation Fiberoptic and Digital Ureteroscopes. *Urol Clin North Am.* 2019 May;46(2):147-163. doi: 10.1016/j.ucl.2018.12.001.
13. Gridley CM, Knudsen BE. Digital ureteroscopes: technology update. *Res Rep Urol.* 2017 Jan 27;9:19-25. doi: 10.2147/RRU.S104229.
14. Alnezi H, Denstedt JD. Flexible ureteroscopy: Technological advancements, current indications and outcomes in the treatment of urolithiasis. *Asian J Urol.* 2015 Jul;2(3):133-141. doi: 10.1016/j.ajur.2015.06.002.
15. Juliebo-Jones P, Keller EX, Haugland JN, Aesoy Sorstrand M, *et al.* Advances in Ureteroscopy: New technologies and current innovations in the era of Tailored Endourological Stone Treatment (TEST). *Journal of Clinical Urology.* 2022;0(0). doi:10.1177/20514158221115986
16. Mazzucchi E, Marchini GS, Berto FCG, Denstedt J, *et al.* Single-use flexible ureteroscopes: update and perspective in developing countries. A narrative

- review. *Int Braz J Urol.* 2022 May-Jun;48(3):456-467. doi: 10.1590/S1677-5538.IBJU.2021.0475.
17. Butticiè S, Sener TE, Netsch C, Emiliani E, *et al.* LithoVue™: A new single-use digital flexible ureteroscope. *Cent European J Urol.* 2016; 69:302-5.
 18. Geavlete B, Ene C, Iordache V, Geavlete P. Initial Experience with the New Super Thin Single-use Pusen Flexible Ureteroscope 7.5 Fr in Renal Stones Endoscopic Treatment. *Chirurgia (Bucur).* 2021 May-Jun;116(3):354-360. doi: 10.21614/chirurgia.116.3.354.
 19. Agrawal S, Patil A, Sabnis RB, Singh AG, *et al.* Initial experience with slimmest single-use flexible ureteroscope Uscope PU3033A (PUSEN™) in retrograde intrarenal surgery and its comparison with Uscope PU3022a: a single-center prospective study. *World J Urol.* 2021 Oct;39(10):3957-3962. doi: 10.1007/s00345-021-03707-4.
 20. Ganpule AP, Desai MR. Urolithiasis in kidneys with abnormal lie, rotation or form. *Curr Opin Urol.* 2011;21:145-153
 21. Alan JW, Louis RK, Alan W, Partin, Craig A, Peters, Campbell-Walsh Urology, Eleventh edition, International edition, Elsevier, Philadelphia, PA 19103-2899, ISBN 978-0-323-34148-6, Principles of Urological Endoscopy, p1244-1245.
 22. Symons SJ, Ramachandran A, Kurien A, Baiysha R, Desai MR. Urolithiasis in the horseshoe kidney: a single-centre experience. *BJU Int.* 2008 Dec;102(11):1676-80. doi: 10.1111/j.1464-410X.2008.07987.x.
 23. Viola D, Anagnostou T, Thompson TJ, Smith G, *et al.* Sixteen years of experience with stone management in horseshoe kidneys. *Urol Int.* 2007;78(3):214-8. doi: 10.1159/000099340
 24. Ray AA, Ghiculete D, D'A Honey RJ, Pace KT. Shockwave lithotripsy in patients with horseshoe kidney: determinants of success. *J Endourol.* 2011 Mar;25(3):487-93. doi: 10.1089/end.2010.0213.
 25. Raj GV, Auge BK, Assimos D, Preminger GM. Metabolic abnormalities associated with renal calculi in patients with horseshoe kidneys. *J Endourol.* 2004 Mar;18(2):157-61. doi: 10.1089/089277904322959798.
 26. Giusti G, Proietti S, Pescechiera R, Taverna G, *et al.* Sky is no limit for ureteroscopy: extending the indications and special circumstances. *World J Urol.* 2015 Feb;33(2):257-73. doi: 10.1007/s00345-014-1345-y.
 27. Ding J, Huang Y, Gu S, Chen Y, *et al.* Flexible Ureteroscopic Management of Horseshoe Kidney Renal Calculi. *Int Braz J Urol.* 2015 Jul-Aug;41(4):683-9. doi: 10.1590/S1677-5538.IBJU.2014.0086.
 28. Kartal I, Çakıcı MÇ, Selmi V, Sari S, *et al.* Retrograde intrarenal surgery and percutaneous nephrolithotomy for the treatment of stones in horseshoe kidney; what are the advantages and disadvantages compared to each other? *Cent European J Urol.* 2019;72(2):156-162. doi: 10.5173/ceju.2019.1906.
 29. Geavlete B, Popescu R, Iordache V, Geavlete P. Single-Use vs Reusable Ureterscopes in Horseshoe Kidney Stones. *Maedica (Bucur).* 2021 Dec;16(4):568-573. doi: 10.26574/maedica.2021.16.4.568.
 30. Zafar FS, Lingeman JE. Value of laparoscopy in the management of calculi complicating renal malformations. *J Endourol.* 1996 Aug;10(4):379-83. doi: 10.1089/end.1996.10.379.
 31. Wang C, Jin L, Zhao X, Li G, Xue B. Minimally invasive treatment of an ectopic kidney stone: a case report and literature review. *J Int Med Res.* 2019 Sep;47(9):4544-4550. doi: 10.1177/0300060519865845.
 32. Lavan L, Herrmann T, Netsch C, Becker B, Somani KB. Outcomes of ureteroscopy for stone disease in anomalous kidneys: a systematic review. *World J Urol.* 2020 May;38(5):1135-1146. doi: 10.1007/s00345-019-02810-x.
 33. Bozkurt OF, Tepeler A, Sninsky B, Ozyuvallı E, *et al.* Flexible ureterorenoscopy for the treatment of kidney stone within pelvic ectopic kidney. *Urology.* 2014 Dec;84(6):1285-9. doi: 10.1016/j.urol.2014.07.041.
 34. Geavlete B, Popescu R, Georgescu D, Geavlete P. Single-use ureterscopes in ectopic pelvic kidney stones. *J Med Life.* 2021 Jul-Aug;14(4):557-564. doi: 10.25122/jml-2021-0251.
 35. Desai M, Sun Y, Buchholz N, Fuller A, *et al.* Treatment selection for urolithiasis: percutaneous nephrolithotomy, ureteroscopy, shock wave lithotripsy, and active monitoring. *World J Urol.* 2017 Sep;35(9):1395-1399. doi: 10.1007/s00345-017-2030-8.
 36. Skolarikos A, Neisius A, Petrick A, Somani B, *et al.* EAU Guidelines on Urolithiasis. European Association of Urology: Arnhem, The Netherlands. 2022
 37. Rivas JG, Alonso Y, Gregorio S, Sánchez LC, *et al.* Approach to kidney stones associated with ureteropelvic junction obstruction during laparoscopic pyeloplasty. *Cent European J Urol.* 2014;66(4):440-4. doi: 10.5173/ceju.2013.04.art13.
 38. Wei C, Wang T, Chen S, Ren X, Chen X. Concomitant management of renal calculi and recurrent ureteropelvic junction obstruction with percutaneous nephrolithotomy and antegrade balloon dilation. *J Int Med Res.* 2020 May;48(5):300060520911252. doi: 10.1177/0300060520911252.
 39. Saussine C, Lechevallier E, Traxer O. Calculs et syndrome de la jonction pyélo-urétérale [Urolithiasis and ureteropelvic junction obstruction]. *Prog Urol.* 2008 Dec;18(12):986-8. French. doi: 10.1016/j.purol.2008.09.002.
 40. Skolarikos A, Dellis A, Knoll T. Ureteropelvic obstruction and renal stones: etiology and treatment. *Urolithiasis.* 2015 Feb;43(1):5-12. doi: 10.1007/s00240-014-0736-2.
 41. Resorlu B, Oguz U, Resorlu EB, Oztuna D, Unsal A. The impact of pelvicalyceal anatomy on the success of retrograde intrarenal surgery in patients with lower pole renal stones. *Urology.* 2012 Jan;79(1):61-6. doi: 10.1016/j.urol.2011.06.031.
 42. Geavlete P, Multescu R, Geavlete B. Influence of pyelocalyceal anatomy on the success of flexible ureteroscopy approach. *J Endourol.* 2008;22:2235-2239.
 43. Jessen JP, Honeck P, Knoll T, Wendt-Nordahl G. Flexible ureterorenoscopy for lower pole stones: influence of the collecting system's anatomy. *J Endourol.* 2014;28:146-151.
 44. Inoue T, Hamamoto S, Okada S, Imai S, *et al.* Pelvicalyceal anatomy on the accessibility of reusable flexible ureteroscopy to lower pole calyx during retrograde intrarenal surgery. *Int. J. Urol.* 2022. <https://doi.org/10.1111/iju.15091>
 45. Kourambas J, Delvecchio FC, Munver R, Preminger GM. Nitinol stone retrieval-assisted ureteroscopic management of lower pole renal calculi. *Urology.* 2000 Dec 20;56(6):935-9. doi: 10.1016/s0090-4295(00)00821-9.
 46. Schuster TG, Hollenbeck BK, Faerber GJ, Wolf JS Jr. Ureteroscopic treatment of lower pole calculi: comparison of lithotripsy in situ and after displacement. *J Urol.* 2002 Jul;168(1):43-5.
 47. Portis AJ, Rygwall R, Holtz C, Pshon N, Laliberte M. Ureteroscopic laser lithotripsy for upper urinary tract calculi with active fragment extraction and computerized tomography followup. *J Urol.* 2006 Jun;175(6):2129-33; discussion 2133-4. doi: 10.1016/S0022-5347(06)00311-9.
 48. Turna B, Stein RJ, Smaldone MC, Santos BR, *et al.* Safety and efficacy of flexible ureterorenoscopy and holmium:YAG lithotripsy for intrarenal stones in anticoagulated cases. *J Urol.* 2008 Apr;179(4):1415-9. doi: 10.1016/j.juro.2007.11.076.
 49. Gokce MI, Tokatli Z, Suer E, Hajiyev P, *et al.* Comparison of shock wave lithotripsy (SWL) and retrograde intrarenal surgery (RIRS) for treatment of stone disease in horseshoe kidney patients. *Int Braz J Urol.* 2016 Jan-Feb;42(1):96-100. doi: 10.1590/S1677-5538.IBJU.2015.0023.
 50. Cho SY. Current status of flexible ureteroscopy in urology. *Korean J Urol.* 2015 Oct;56(10):680-8. doi: 10.4111/kju.2015.56.10.680.
 51. Proietti S, Dragos L, Molina W, Doizi S, *et al.* Comparison of New Single-Use Digital Flexible Ureteroscope Versus Nondisposable Fiber Optic and Digital Ureteroscope in a Cadaveric Model. *J Endourol.* 2016 Jun;30(6):655-9. doi: 10.1089/end.2016.0051.
 52. Rukin NJ, Somani BK, Patterson J, Grey BR, *et al.* Tips and tricks of ureteroscopy: consensus statement. Part II. Advanced ureteroscopy. *Cent European J Urol.* 2016;69(1):98-104. doi: 10.5173/ceju.2016.605b.
 53. Ankem MK, Lowry PS, Slovick RW, Munoz del Rio A, Nakada SY. Clinical utility of dual active deflection flexible ureteroscopy during upper tract ureteropyeloscopy. *Urology.* 2004 Sep;64(3):430-4. doi: 10.1016/j.urol.2004.04.011.
 54. Rajamahantya S, Grasso M. Flexible ureteroscopy update: indications, instrumentation and technical advances. *Indian J Urol.* 2008 Oct;24(4):532-7. doi: 10.4103/0970-1591.44263.
 55. Bagley DH. Intrarenal access with the flexible ureteropyeloscope: effects of active and passive tip deflection. *J Endourol.* 1993 Jun;7(3):221-4. doi: 10.1089/end.1993.7.221.
 56. Kavoussi L, Clayman RV, Basler J. Flexible, actively deflectable fiberoptic ureteronephroscopy. *J Urol.* 1989 Oct;142(4):949-54. doi: 10.1016/s0022-5347(17)38950-4.
 57. Schlager D, Obaid MA, Hein S, Wilhelm K, *et al.* Current Disposable Ureterscopes: Performance and Limitations in a Standardized Kidney Model. *J Endourol.* 2020 Oct;34(10):1015-1020. doi: 10.1089/end.2020.0185.
 58. Johnston TJ, Baard J, de la Rosette J, Doizi S, *et al.* A clinical evaluation of the new digital single-use flexible ureteroscope (UscopePU3022): an international prospective multicentered study. *Cent European J Urol.* 2018;71(4):453-461. doi: 10.5173/ceju.2018.1787.
 59. Sierra A, Corrales M, Traxer O. Ureteroscopic laser treatment of upper tract transitional cell carcinoma. *Urology Video Journal.* 2022;15. 100170, ISSN 2590-0897. <https://doi.org/10.1016/j.urolvj.2022.100170>.
 60. Wen J, Ji ZG, Li HZ. Treatment of upper tract urothelial carcinoma with ureteroscopy and thulium laser: a retrospective single center study. *BMC Cancer.* 2018 Feb 17;18(1):196. doi: 10.1186/s12885-018-4118-y.
 61. Territo A, Gallioli A, Meneghetti I, Fontana M, *et al.* Diagnostic ureteroscopy for upper tract urothelial carcinoma: friend or foe? *Arab J Urol.* 2021 Feb 16;19(1):46-58. doi: 10.1080/2090598X.2021.1883810
 62. Ryan JR, Nguyen MH, Linscott JA, Nowicki SW, *et al.* Ureteroscopy with thulium fiber laser lithotripsy results in shorter operating times and large cost savings. *World J Urol.* 2022 Aug;40(8):2077-2082. doi: 10.1007/s00345-022-04037-9.
 63. Geavlete B, Multescu R, Iordache V, Geavlete P. Romanian National premiere with the new Thulium SuperPulsed Laser in the endourological treatment of urolithiasis. *J Med Life.* 2021 May-Jun;14(3):316-322. doi: 10.25122/jml-2021-0103.
 64. Klimov RE, Lekarev VY, Tsarichenko DG, Dymov AM, *et al.* [Retrograde intrarenal surgery using a 1.94 m superpulsed thulium fiber laser]. *Urologiia.* 2021 Mar;(1):28-32. Russian.
 65. Singh AG, Chhabra JS, Sabnis R, Ganpule A, *et al.* Role of flexible ureterorenoscopy in management of renal calculi in anomalous kidneys: single-center experience. *World J Urol.* 2017 Feb;35(2):319-324. doi: 10.1007/s00345-016-1881-8.
 66. Geavlete B, Mares C, Multescu R, Georgescu D, Geavlete P. Hybrid flexible ureteroscopy strategy in the management of renal stones - a narrative review. *J Med Life.* 2022 Aug;15(8):919-926. doi: 10.25122/jml-2022-0110.

67. Bansal P, Bansal N, Sehgal A, Singla S. Flexible ureteroscopy for lower calyceal stones in a horseshoe kidney—is it the new treatment of choice? *Afr J Urol.* 2016;22:199–201.
68. Ergin G, Kirac M, Unsal A, Kopru B, *et al.* Surgical management of urinary stones with abnormal kidney anatomy. *Kaohsiung J Med Sci.* 2017 Apr;33(4):207-211. doi: 10.1016/j.kjms.2017.01.003.
69. Dragos LB, Somani BK, Sener ET, Buttice S, *et al.* Which Flexible Ureterscopes (Digital vs. Fiber-Optic) Can Easily Reach the Difficult Lower Pole Calices and Have Better End-Tip Deflection: In Vitro Study on K-Box. A PETRA Evaluation. *J Endourol.* 2017 Jul;31(7):630-637. doi: 10.1089/end.2017.0109.
70. Auge BK, Dahm P, Wu NZ, Preminger GM. Ureterscopic management of lower-pole renal calculi: technique of calculus displacement. *J Endourol.* 2001 Oct;15(8):835-8. doi: 10.1089/089277901753205852.
71. Dresner SL, Iremashvili V, Best SL, Hedican SP, Nakada SY. Influence of Lower Pole Infundibulopelvic Angle on Success of Retrograde Flexible Ureterscopy and Laser Lithotripsy for the Treatment of Renal Stones. *J Endourol.* 2020 Jun;34(6):655-660. doi: 10.1089/end.2019.0720.
72. Karim SS, Hanna L, Geraghty R, Somani BK. Role of pelvicalyceal anatomy in the outcomes of retrograde intrarenal surgery (RIRS) for lower pole stones: outcomes with a systematic review of literature. *Urolithiasis.* 2020 Jun;48(3):263-270. doi: 10.1007/s00240-019-01150-0.
73. Ozimek T, Cordes J, Wiessmeyer JR, Schneider MH, *et al.* Steep Infundibulopelvic Angle as a New Risk Factor for Flexible Ureterscope Damage and Complicated Postoperative Course. *J Endourol.* 2018 Jul;32(7):597-602. doi: 10.1089/end.2018.0147.
74. Alan JW, Louis RK, Alan WP, Craig AP. *Campbell-Walsh Urology, Eleventh edition.* International edition, Elsevier, Philadelphia, PA 19103-2899, ISBN 978-0-323-34148-6. Principles of Urological Endoscopy; p136-152