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Literature Review

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FANS – How it works, how best to use it and implications for stone treatment

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Abstract

Introduction: Conventional flexible ureteroscopy (fURS) techniques are limited by residual fragments, infectious complications and stone size. Flexible and Navigable Suction Ureteral Access Sheaths (FANS) have been developed to address these limitations through controlled suction and pressure modulation within the pelvico-calyceal system (PCS).
Methods: This narrative review summarises the design principles of FANS, outlines practical considerations for their use, and synthesises evidence on their use.
Results: FANS incorporate a flexible distal tip permitting advancement into the PCS. By bypassing the pelvico-ureteric-junction (PUJ), FANS establish a low-resistance outflow, lowering IRP and increasing effective irrigation flow. Higher flow rates and continuous evacuation of stone dust may improve endoscopic visibility and enhance heat dissipation. Clinical studies demonstrate higher stone-free rates and lower infectious complications compared with conventional fURS. Non-inferior stone-free rates have been reported compared with mini-percutaneous nephrolithotomy for high stone burdens, with lower major complications. Their optimal use requires understanding the interaction between sheath and scope size, irrigation and suction pressure to avoid PCS collapse or over-pressurisation.
Conclusions: FANS represent a potential paradigm shift in RIRS with improved SFRs and reduced infectious complications. Long-term data are required to quantify the risk of PUJ strictures and to quantify cost-effectiveness and clinical benefits, especially in larger stone burdens.

Level of evidence: 5

Keywords

flexible ureteroscope, FANS, ureteral access sheath, suction, intrarenal pressure, renal stone, RIRS

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Introduction

Since 2020, there has been a 257% increase in ureteroscopy, overtaking SWL to make it the most commonly performed procedure for renal stones.[1] Flexible ureteroscopy (fURS) has become central to contemporary stone management owing to its high efficacy, broad applicability, and relatively low complication profile. Advances in endoscopic optics, digital imaging, and laser technology have further expanded its role across a wide range of stone sizes and locations.

Despite these advances, fURS has historically been limited by several important challenges related to drainage

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of the pelvi-calyceal system (PCS). Traditional ureteroscopic techniques rely on passive drainage through the ureter or ureteric access sheath (UAS), which creates a relatively high outflow resistance system. This can limit irrigation flow, impair fragment clearance, and predispose to pressure-related complications.

Poor outflow can lead to incomplete stone clearance, impaired intra-operative visibility due to stone dust and debris, and the risk of infectious complications related to elevated intrarenal pressure (IRP) and pyelovenous backflow.[2] Residual fragments, even when small, are increasingly recognised as clinically relevant, with long-term risks of stone regrowth, recurrent symptoms, and re-intervention.[3]

Consequently, there has been growing interest in technologies designed to improve PCS outflow during fURS. The first reports of suction-assisted ureteroscopy emerged in 2016,[4] and subsequent technological refinement has led to wider adoption. By combining flexible navigation within the collecting system with controlled suction and pressure regulation, Flexible and Navigable Suction Ureteral Access Sheaths (FANS) aim to enhance fragment clearance, optimise vision, and maintain low intrarenal pressures during fURS.

This article reviews the principles underpinning FANS technology, describes its practical use during flexible ureteroscopy, and explores its implications for contemporary stone treatment.

How it works?

A FANS access sheath shares several structural similarities with traditional (rigid) UAS but incorporates key design modifications. First, the distal tip of the FANS is flexible (Figure 1), allowing it to be navigated beyond the pelviureteric junction (PUJ) and advanced within the PCS.[5,6] This enables targeted positioning close to the stone-bearing calyx. Second, the sheath incorporates an additional proximal port that permits the application of suction through the main working lumen (Figure 1). Finally, the suction port includes a pressure control vent that modulates the effective suction transmitted to the PCS.

With the pressure vent uncovered, which represents the default configuration for most systems, minimal, if any, negative pressure is transmitted distally.[7] This allows passive drainage while reducing the risk of excessive intrarenal pressure fluctuations. Suction can then be intermittently activated by temporarily occluding the vent, enabling the surgeon to regulate aspiration in real time according to procedural requirements.

The tip of the FANS can be passively navigated with an indwelling flexible ureteroscope to be close to a renal stone. The ureteroscope, with indwelling laser fibre, is then used for renal stone laser fragmentation in traditional fashion. Having the FANS within the PCS, within close proximity of the renal stone allows good drainage of fluid and stone particles.[8] This configuration facilitates the continuous efflux of irrigation fluid and suspended particulate matter.

Figure 1. Demonstration of a FANS (ClearPetra®, Wellead Medical, Guangzhou, China). Left–suction port (with pressure control vent) on FANS. Right–flexible tip of FANS allowing passive navigation in pelvico-calyceal system.

Stone dust particles, typically defined as fragments smaller than 250 µm, remain suspended within irrigation fluid and are a major contributor to visual degradation during lithotripsy.[9] With FANS in situ, these particles may be continuously evacuated alongside the ureteroscope, even with minimal active suction.[10] This may limit the formation of dust clouds and improve endoscopic visibility throughout fragmentation.

Larger fragments are less likely to be passively transported by irrigation flow alone.[10] In these situations, the ureteroscope can be temporarily withdrawn, leaving the FANS lumen unobstructed. Commonly used sheaths (10/12Fr and 11/13Fr) provide internal diameters of approximately 3.3–3.7 mm, creating a large conduit for fragment evacuation.[10] Activation of suction generates a negative pressure gradient that actively draws fragments out of the PCS and into the sheath.[10]

Beyond fragment removal, FANS fundamentally alter intrarenal fluid dynamics. In conventional fURS, the PUJ and ureter form a high-resistance outflow pathway, resulting in elevated intrarenal pressures and reduced effective irrigation flow at any given inflow pressure.[11] By bypassing this high-resistance segment, FANS establishes a low-resistance drainage system . Even with minimal active suction, this configuration lowers IRP and increases irrigation flow rates.[8]

Reduced intrarenal pressure may mitigate the risk of pyelovenous and pyelolymphatic backflow, thereby lowering infectious risk.[12] Simultaneously, improved flow enhances visual clarity and facilitates convective heat dissipation during laser activation, potentially reducing thermal injury.[13,14]

How best to use it?

While there is an increasing body of evidence supporting the use of FANS in contemporary practice, as with most new technologies there are not yet clear guidelines for how to use FANS or indeed when, and in which patients. We do however have evidence from bench and clinical studies which can be used to form a foundation for a surgeon to introduce FANS into their clinical practice and through an iterative process develop their technique to give the best outcomes.

The use of UAS to improve flow out of the kidney during fURS is well established, and by the same mechanism, they reduce pressure within the kidney during fURS procedures. These effects are however mitigated by keeping the sheath below the PUJ and hence the effectiveness is subject to variations between patients caused by anatomical differences at the PUJ itself. As described above by keeping the tip of the FANS within the PCS these pressure variations are minimised which makes for more predictable procedures. In some patients, however, having the FANS within the PCS leads to collapsing of the system, loss of view, and sometimes bleeding which then compromise surgical success. It is imperative therefore to understand the relationship between pressure and flow, in particular noting the impact of different size scopes and FANS sheaths.

With potential for large volume egress of fluid, for example with a large difference between scope and sheath sizes, it may be required to increase flow into the scope to maintain PCS filling, vision and effective flow through the system. This may be achieved by increasing irrigation pressure or with a pump device to improve flow. While flow rates and irrigation pressures do have a positive correlation with intrarenal pressure, and concerns therefore relating to sepsis and other complications, this is not always linear and the surgeon needs to understand the relationship between pressure and flow for the equipment combinations they use regularly.[8] For example, when studying the most commonly used combination of scope and sheath (7.5Fr scope, 10/12Fr FANS sheath), it has been shown that to keep IRP less than 30 mmHg, a flow rate of approx. 30 ml/min or less and irrigation pressures of approx. 150 mmHg or less will keep the IRP < 30. With a 7.5Fr scope in a 11/13Fr sheath however, to maintain the same IRP < 30 mmHg, flow rates of just over 60 ml/min and irrigation pressures of approx. 300 mmHg are potentially achievable, but at the cost of larger and potentially more traumatic access sheath sizes. The surgeon therefore needs to continue to tailor the equipment in use to their patient.

Other important scope and sheath-related considerations include the ability of different scopes to deflect the sheath adequately to allow full inspection of the PCS and therefore complete stone clearance. In much the same way that instruments in the working channel of the ureteroscope impact deflection, the scope deflection is significantly compromised by an external sheath. While most contemporary ureteroscopes boast bi-directional deflection of at least 270°, trying to deflect a FANS sheath will reduce this to 111°-212°.[15] Different scopes have different deflection strengths, or bending forces, and it is important to understand the impact of the scope in use on its manoeuvrability. FANS sheaths however will advance around an already-deflected scope very well, without loss of deflection. It is therefore advised that stones are identified with the FANS held just inside the PUJ, and the sheath subsequently advanced over the deflected scope to reach the target calyx or stone to achieve the best results. While the scope can be manipulated while within the distal tip of the FANS sheath, this is a common cause of failure to reach the lower pole in particular. There is also a greater risk of scope failure with loss of deflection if persistent efforts are made to deflect the sheath with the scope at its tip.

As mentioned above, with the suction vent open in some FANS designs, there is minimal negative pressure at the tip of the sheath. If the FANS has a slider mechanism, this needs to be fully closed to be effective. Equally those sheaths with a pressure vent needing manual/fingertip cover may also need to be completely occluded for active suction to occur.[7] With the vent closed, having suction pressure that is too extreme will rapidly cause collapse of the PCS which is undesirable. While there are no clearly defined guidelines for what suction pressure to apply, it is best to start with low pressures (30-50 mmHg) and build up to what is effective. Newer fluid management systems will be more accurate and controlled in terms of suction pressure, whereas conventional wall suction via a carousel is probably inaccurate. It may be that larger calibre FANS sheaths require a slightly greater negative pressure to achieve evacuation of larger fragments, and similar to comments about flow and IRP, the setup used by each individual surgeon will need to adapt to what is needed. Some patients' PCS seem more prone to collapse than others, and this means even with an established setup that suction and other factors may need to be altered according to the patient in front of you.

Implications for stone treatment?

During laser lithotripsy, renal calculi are fragmented into thousands of particles ranging from sub-63 µm dust to fragments measuring several millimetres.[16] Traditionally, larger fragments are retrieved individually using baskets, while smaller fragments are left in situ with the expectation of spontaneous passage.[17] This approach is inherently inefficient and associated with high rates of residual stone burden.[18]

Real-world data from conventional fURS series report complete stone-free rates of approximately 50–60%.[18–20] Long-term follow-up studies demonstrate that nearly half of residual fragments smaller than 4 mm increase in size over time, with over one-fifth ultimately requiring re-intervention.[3] These findings underscore the clinical importance of maximising fragment clearance at the index procedure.

Multiple clinical studies have demonstrated improved stone-free rates with the use of FANS.[21–29] Reported series consistently show superior early and medium-term clearance compared with traditional techniques. Notably, a randomised controlled trial of 330 patients comparing conventional fURS with suction-assisted fURS demonstrated a 30-day CT-confirmed stone-free rate of 87.5% in the FANS group versus 70% in the control group.[23]

Infectious complications remain a significant concern in ureteroscopy. Reported rates of febrile urinary tract infection range from 0.2% to 18%, with urosepsis occurring in up to 5% of cases.[2,30–33] Accumulating evidence implicates elevated intrarenal pressures as a key risk factor through pyelovenous backflow and bacterial translocation.[12,34–37] By improving drainage and maintaining low IRP, FANS may offer a physiological mechanism for reducing infectious risk.

Two randomised trials have demonstrated reduced infectious morbidity with suction-assisted techniques. Zhu et al.[38] reported a reduction in sepsis rates from 6.7% to 1.8% by using FANS, while Zhang et al.[39] observed significantly fewer overall infectious complications compared with conventional access sheaths. These findings support the role of pressure modulation as a clinically meaningful benefit of FANS.

fURS operative duration is commonly limited to 60–90 minutes due to concerns regarding infection and thermal injury.[40] Improved pressure control may permit longer safe operative times, facilitating more complete treatment of larger stone burdens, but there is not yet adequate data to show that this is safe in routine practice.

Enhanced irrigation flow rates achievable with FANS also have important thermal implications. Laboratory studies have demonstrated very high flow rates at low IRPs.[8] High flow rates are known to attenuate laser-induced temperature rises, potentially allowing the safe use of higher laser power settings.[13,14] This may accelerate stone ablation and further improve procedural efficiency potentially allowing larger stones to be treated with fURS. Several studies have reported reduced operative times associated with FANS use. Zhu et al.,[38] in a matched cohort study, demonstrated a significant reduction in mean operative duration compared with conventional sheaths. Improved visibility, faster fragmentation, and active fragment evacuation likely contribute to these gains. These benefits may be enhanced with integration of FANS with fluid management systems, as seems to be the next iteration of this technology.[41]

Finally, emerging evidence suggests a potential role for FANS in managing larger renal stones traditionally treated with percutaneous nephrolithotomy (PCNL). A recent multicentre randomised trial involving 720 patients with 2–3 cm stones demonstrated non-inferior stone-free rates for FANS-assisted fURS compared with mini-PCNL and reduced major complications and blood transfusions.[42] Although operative time was longer in the FANS group, complication rates were lower, highlighting a potential role for suction-assisted ureteroscopy as a less invasive alternative in selected patients. It should be noted, however, that post-operative QoL and pain may be marginally worse in patients undergoing fURS versus PCNL (in pre-FANS data).[43]

Given the novelty of FANS, we are lacking long-term data on their use. It should be noted that there remain some concerns about the risk of PUJ strictures with prolonged passage of larger calibre tools (such as FANS) through the PUJ, but we await long-term data. At 3 months, PUJ stricture rate has been reported at 0.3%.[44] In addition their successful use is dependent on small-calibre high-quality endoscopes. These are invariably single-use with cost and environmental considerations. This may prevent adoption in low- to middle-income countries.

Conclusion

FANS offers clear benefits in terms of surgical success and stone-free rates (Table 1). There is increasing evidence of safety benefits, specifically infection-related concerns, although these data are more limited. While there is some data suggesting increasing operating time, and therefore treating larger stone burdens may be safe, this is to date from small series conducted by experts and may not translate to wider practice. As experience and data matures, however, this may present opportunities for further significant changes in practice.

With a good understanding of the relationship between equipment, pressure, flow and suction, surgeons now have tools in their armamentarium to deliver better outcomes and potentially reduce complications and future stone-related events for patients. While we wait for long-term outcome data, assessments of the applicability of bench science, and experience from more extensive real-world practice, the evolution of FANS has shown itself to be a potential game-changer in Endourology. The explosion in small-calibre high quality endoscopes has no doubt contributed to the success of FANS and its speed of uptake around the world, but cost and environmental concerns are

Table 1. A summary of the key clinical outcomes when using a FANS during RIRS.

High SFRs	Higher SFRs achieved with RIRS with FANS vs. sheathless fURS or conventional UAS[21–25,27–29]
Reduced infectious complications	Lower infectious complications with RIRS with FANS vs. sheathless fURS or conventional UAS[28,38,39]
Utility in large stone burden	High SFRs and equivalent complications in heavy stone burden: >2-cm renal stones; multiple stones in several calyces[27,28,42,45]
High stone-free rate in lower pole stones	High SFRs in lower pole stones–equivalent to non-lower pole stones-with RIRS with FANS[46]
FANS vs. mPCNL	Non-inferior SFR vs. mPCNL for renal stones 2–3 cm with reduced complications [42],[47]
Need for pre-stenting	Pre-stenting does not seem obligatory prior to the use of FANS[48]
Deflection of FANS	Deflection of the fURS is limited by the FANS but can be improved by progressing the FANS over the already-deflected ureteroscopy[15]
Post FANS PUJ strictures	Lacking long-term data. 3-month data suggests stricture rate of 0.3%[44]

worth bearing in mind, and may prevent adoption in low- to middle-income countries in particular, limiting the global expansion of this technology.

When FANS is combined with the increasing experience in measuring and controlling intrarenal pressure and temperature, it presents an opportunity for paradigm shifts in practice which will hopefully lead to better outcomes and safer surgery for our patients.

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