

## Optimizing RIRS in Complex Renal Anatomy: A Comparative study of Tip-Flexible Suction versus Conventional Ureteral Access Sheath

Ovidiu-Cătălin Nechita<sup>1,2</sup>, Daniel Liviu Bădescu<sup>1,2\*</sup>, Cosmin-George Radu<sup>1,2</sup>, Cristian-Valentin Toma<sup>1,2</sup>,  
 Cristian-Sorin Sima<sup>1,2</sup>, Ionuț Dițescu<sup>1,2</sup>, George Sabin Popescu<sup>1,2</sup>, Justin Aurelian<sup>1,2</sup>, George Daniel Rădăvoi<sup>1,2</sup>,  
 Bogdan Geavlete<sup>1,3</sup>, Viorel Jinga<sup>1,2</sup>

<sup>1</sup>Department of Urology, Carol Davila University of Medicine and Pharmacy, Bucharest, Romania

<sup>2</sup>Department of Urology, Prof. Dr. Th. Burgele Clinical Hospital, Bucharest, Romania

<sup>3</sup>Department of Urology, Saint John Emergency Clinical Hospital, Bucharest, Romania

### \*Corresponding author:

Daniel Liviu Bădescu, MD  
 Department of Urology,  
 Carol Davila University of Medicine  
 and Pharmacy, Bucharest, Romania  
 E-mail: [badesudanieliviu@gmail.com](mailto:badesudanieliviu@gmail.com)

### Abbreviations:

ADPKD: Autosomal Dominant  
 Polycystic Kidney Disease;  
 CT: Computed Tomography;  
 CTU: Computed Tomography  
 Urography;  
 EAU: European Association of Urology;  
 ECG: Electrocardiogram;  
 HSK: Horseshoe Kidney;  
 IRP: Intrarenal Pressure;  
 IVU: Intravenous Urography;  
 KUB: Kidney-Ureter-Bladder (X-ray);  
 MDPI: Multidisciplinary Digital  
 Publishing Institute;  
 PCNL: Percutaneous Nephrolithotomy;  
 RIRS: Retrograde Intrarenal Surgery;  
 SFR: Stone-Free Rate;  
 TFS-UAS: Tip-Flexible Suction  
 Ureteral Access Sheath;  
 T-UAS: Traditional Ureteral Access  
 Sheath;  
 UAS: Ureteral Access Sheath;  
 UTI: Urinary Tract Infection.

Received: 28.07.2025

Accepted: 27.11.2025

### Rezumat

*Optimizarea chirurgiei intrarenale retrograde în contextul anatomiei renale complexe: studiu comparativ între teaca de acces ureteral cu aspirație și vârf flexibil și teaca de acces ureteral convențională*

**Obiective:** Gestionarea litiazei renale la pacienții cu anomalii congenitale, precum rinichiul în potcoavă sau rinichiul ectopic, prezintă provocări tehnice semnificative în cadrul chirurgiei urologice minim invazive. Anatomia alterată poate limita accesul ureteral convențional și impune un control riguros al presiunii intrarenale. În acest context, utilizarea unei teți ureterale cu vârf flexibil și sistem de aspirație activă (TFS-UAS) a fost propusă ca alternativă promițătoare. Scopul acestui studiu este de a evalua eficiența acestei tehnici în cadrul chirurgiei intrarenale retrograde (RIRS), comparativ cu teaca ureterală convențională (T-UAS), în populația cu anomalii renale congenitale. **Materiale și Metode:** A fost realizată o analiză retrospectivă pe un lot de 67 de pacienți diagnosticați cu anomalii renale congenitale și calculi renali cu dimensiuni cuprinse între 2 și 4 cm, la care s-a practicat RIRS în două centre universitare, în perioada octombrie 2022 – decembrie 2024. Lotul a fost împărțit în două grupuri în funcție de tipul de teacă utilizată: TFS-UAS (teacă cu vârf flexibil și aspirație activă) și T-UAS (teacă convențională). Parametrii analizați au inclus: rata de clearance complet al calculilor (stone-free rate – SFR) la 30 de zile, rata complicațiilor, durata intervenției și perioada de spitalizare postoperatorie. **Rezultate:** Grupul tratat cu TFS-UAS a prezentat o rată de SFR superioară (94,3%) comparativ cu grupul T-UAS (81,3%), fără atingerea pragului de semnificație statistică. Deși durata intervenției a fost semnificativ mai mare în grupul TFS-UAS ( $p < 0,001$ ), această diferență a fost contrabalansată de o reducere semnificativă a duratei spitalizării ( $p = 0,003$ ). Nu au fost evidențiate diferențe semnificative în ceea ce privește incidența complicațiilor postoperatorii între cele două grupuri.

**Concluzii:** În contextul anomaliilor congenitale renale, utilizarea unei teți ureterale cu aspirație activă și vârf flexibil în timpul RIRS poate oferi beneficii clinice relevante, contribuind la o rată mai mare de clearance al calculilor și la o recuperare postoperatorie rapidă. Deși timpul operator este mai mare, balanța beneficiilor clinice sugerează un profil favorabil al acestei tehnici, în special în cazurile cu anatomie renală complexă.

**Cuvinte cheie:** chirurgie intrarenală retrogradă, teacă de acces ureteral cu aspirație, anomalii renale congenitale, litiază renală, ureteroscopie flexibilă, presiune intrarenală, rinichi în potcoavă, rinichi ectopic, boală polichistică renală autozomal dominantă

## Abstract

**Background/Objectives:** Managing kidney stones in patients with congenital renal anomalies - such as horseshoe kidney or ectopic kidney - presents unique challenges for endourologists. In these anatomically complex cases, standard ureteral access can be difficult, and pressure management becomes critical. Suction-assisted ureteral access sheaths have emerged as a promising solution, but clinical data in this population remain limited. This study evaluates whether using a tip-flexible suction UAS improves outcomes in retrograde intrarenal surgery compared to conventional access.

**Methods:** We retrospectively reviewed 67 patients with confirmed renal anomalies and stones sized 2-4 cm who underwent RIRS at two academic centers between October 2022 and December 2024. Patients were grouped based on the type of UAS used: suction-assisted (TFS-UAS) or conventional (T-UAS). Surgical and postoperative outcomes, including stone-free rate (SFR), complication profile, operative time, and hospital stay, were compared.

**Results:** The TFS-UAS group showed a higher 30-day SFR (94.3%) compared to the conventional group (81.3%), although the difference was not statistically significant. Operative time was longer with TFS-UAS ( $p < 0.001$ ), but this was offset by a shorter hospital stay ( $p = 0.003$ ). No major differences were seen in complication rates.

**Conclusions:** Using a suction-assisted UAS during RIRS in patients with congenital renal anomalies offers notable clinical benefits. Primarily, it increases the chance of removing all stone fragments and often results in a shorter, easier recovery. While this technique may increase procedural time, the overall advantages, such as improved success rates and easier recovery, typically justify the additional time.

**Keywords:** RIRS, suction-assisted UAS, congenital renal anomalies, kidney stones, flexible ureteroscopy, intrarenal pressure, horseshoe kidney, ectopic kidney, ADPKD

## Introduction

Nephrolithiasis continues to be one of the most frequently encountered urological disorders worldwide (1), with its incidence steadily climbing due to changing lifestyle and dietary habits (2). Recent decades show a shift from traditional open surgeries to less invasive methods, with retrograde intrarenal surgery (RIRS) emerging as a leading option. The European Association of Urology (EAU) now considers RIRS the preferred method for stones under 2 cm (3). However, for larger calculi exceeding this threshold, there is no clear clinical consensus, as both RIRS and percutaneous nephrolithotomy (PCNL) are used variably across institutions (4).

Despite the proven efficacy of PCNL in achieving high stone-free rates (5), it carries a notable risk of morbidity. Complications may

include febrile episodes (fever  $\geq 38$  °C), major bleeding requiring transfusion, thoracic injuries, and, more rarely, visceral trauma (6). The introduction of mini-PCNL has reduced some of these concerns; however, transfusion requirements remain relevant, particularly in patients with atypical renal anatomy or challenging clinical profiles (7).

Cases involving congenital abnormalities - such as ectopic or horseshoe kidneys, and autosomal dominant polycystic kidney disease (ADPKD) present additional technical challenges (8). These anatomical variants frequently complicate percutaneous access due to aberrant vascular anatomy, restricted working space, and increased procedural complexity in establishing a safe tract (9).

Advancements in flexible ureteroscopy, particularly in imaging resolution and accessory instrumentation, have significantly expanded the therapeutic scope of RIRS (10). These innovations

effectively manage larger renal stones, especially with new access systems. Notably, the tip-flexible, suction-enabled ureteral access sheath (TFS-UAS) is a significant advance (11). Its design enhances calyceal navigation and active suction, thereby improving stone clearance, lowering intrarenal pressure (IRP), and reducing the risk of stone migration, which is essential for patients with complex renal anatomy to prevent complications such as forniceal rupture or sepsis (12,13).

Although initial results with the TFS-UAS and digital flexible ureteroscopes in the treatment of renal calculi <2 cm have been promising (14), evidence regarding their application in cases involving complex renal anatomies and larger stones remains limited. The anatomical complexity of congenital renal abnormalities underscores the need for a more thorough assessment of the safety and effectiveness of these emerging technologies. This study aims to address this gap by comparing the clinical performance of conventional versus suction-assisted ureteral access sheaths in RIRS procedures for patients with structurally atypical kidneys.

## Materials and Methods

This retrospective comparative study was carried out at two academic urology centers in Eastern Europe, both recognized for their expertise in renal stone management. Ethical clearance was obtained from the review board of each institution, and all participants provided written informed consent prior to enrollment.

Between October 2022 and December 2024, data were collected from patients diagnosed with renal calculi and associated with anatomical anomalies, including horseshoe kidney (HSK), ectopic kidney, or autosomal dominant polycystic kidney disease (ADPKD). Anomalies were defined based on imaging and intraoperative findings that significantly altered renal anatomy or impacted surgical access. HSK cases included variable fusion patterns and isthmus composition (fibrous or parenchymal). Ectopic kidneys were classified according to location (pelvic, iliac, or abdominal) and the presence of rotation anomalies. ADPKD cases were included when the cystic burden resulted in calyceal distortion or made endoscopic procedures more technically demanding.

### Inclusion and Exclusion Criteria

Inclusion criteria required both radiological confir-

mation of 2-4 cm renal stones and the presence of one of these anatomical anomalies in patients considered suitable for endoscopic treatment under general anesthesia. This range of stone dimensions was chosen because stones larger than 2 cm fall into the category for which current EAU and AUA guidelines recommend PCNL as first-line treatment, whereas flexible ureteroscopy may be considered in select cases when PCNL is not feasible or not preferred. We set the upper limit at 4 cm to focus on stone burdens that remain a realistic option for endoscopic management and to align with the 20–40 mm range commonly used in mini-PCNL studies.

Exclusion criteria were: uncontrolled urinary tract infection, sepsis, uncorrected coagulopathy or the need for uninterrupted anticoagulation, history or suspected ureteral strictures on the affected side, pregnancy, and severe cardiopulmonary disease that contraindicated general anesthesia. Patients who met any of these conditions were excluded because they were not deemed suitable for endoscopic treatment. All patients underwent preoperative non-contrast computed tomography (CT) for stone and anatomical assessment, supplemented by intravenous urography (IVU) or computed tomography urography (CTU) when additional detail on the collecting system or infundibulopelvic angle was needed. The standard preoperative work-up included laboratory tests, urinalysis, urine culture, and electrocardiogram (ECG).

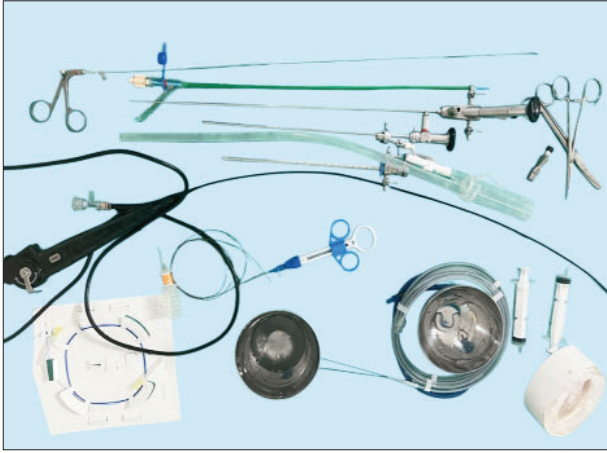
Patients were divided into two groups based on the type of ureteral access sheath used during RIRS:

- TFS-UAS Group (Observation): flexible ureteroscopy with a tip-flexible suction UAS.
- T-UAS Group (Control): flexible ureteroscopy using a conventional UAS (ureteral access sheath) without suction.

All procedures were conducted under general anesthesia with orotracheal intubation, with patients placed in lithotomy position. A semirigid 7.5F ureteroscope was initially used to assess the ureter, followed by insertion of a hydrophilic guidewire under direct vision. *Fig. 1* illustrates the surgical setup, including the digital flexible ureteroscope (7.5F) and the suction equipment.

### TFS-UAS Group – Surgical Approach

An 11–13F TFS-UAS (length: 45 cm for males, 38 cm for females) was advanced over the guidewire. The suction port of the sheath was connected to



**Figure 1.** Operative setup for suction-assisted flexible ureteroscopy

a vacuum bottle and a central suction system, delivering continuous negative pressure of 150-200 mmHg. A 7.5F reusable digital flexible ureteroscope was introduced, and a systematic evaluation of the collecting system was conducted. Holmium laser lithotripsy (200  $\mu$ m fiber, 1.0 J  $\times$  30 Hz) was used to fragment the stones. Smaller fragments were aspirated through the gap of the sheath; larger ones were removed via scope withdrawal. On completion, mucosal integrity was inspected. A double-J stent (6–7 CH) was placed under fluoroscopy, and retrieved fragments were sent for infrared spectroscopy.

### *T-UAS Group – Surgical Approach*

The technique mirrored that of the TFS-UAS group, except that a conventional 11-13F T-UAS was used. A 7.5F flexible ureteroscope was introduced, and the same laser parameters applied. Fragments were removed using irrigation, scope withdrawal, or retrieval tools.

A final inspection was performed to assess for residual stones and mucosal damage. Double-J stents and urinary catheters were placed as in the TFS-UAS group, and fragments were analyzed via spectroscopy.

### *Preoperative and Postoperative Management*

Patients with negative urine culture received a preoperative dose of third-generation cephalosporin. Those with sterile pyuria began empirical IV antibiotics 48 hours before surgery. Positive cultures were treated with targeted antibiotics for 7 days, followed by a repeat culture. Post-surgery, standard care included IV fluids, analgesics, and

antibiotics. Daily blood tests, including CRP and renal function panels, were obtained. The urinary catheter was removed on the first postoperative day unless contraindicated by persistent fever or hematuria. A KUB X-ray was performed to confirm stent position and assess stone clearance. A 30-day CT scan evaluated final stone-free status. Stone-free status was defined as the absence of residual fragments  $\geq$ 4 mm on low-dose non-contrast CT performed at 30 days, as per EAU recommendations. (4) If residual fragments were present, patients were scheduled for secondary intervention. Double-J stents were removed in patients with confirmed stone-free status.

### *Statistical Analysis*

Statistical analysis was conducted using IBM SPSS Statistics v26.0 (IBM Corp., Armonk, NY, USA). Continuous data were compared with independent-samples *t*-tests and reported as mean  $\pm$  SD. Categorical data were analyzed with Chi-square or Fisher's Exact tests. A *p*-value  $<$  0.05 was considered statistically significant. Multivariate logistic regression identified predictors of stone-free status at 30 days, evaluating age, BMI, stone size, urine culture, surgical duration, and UAS type. Model fit was assessed using Omnibus Tests, Cox & Snell  $R^2$ , and Nagelkerke  $R^2$ .

## **Results**

### *Study Population*

Out of the 75 patients initially evaluated, 67 were included in the final analysis after excluding those with incomplete data. The group assignments were nearly equal: 32 patients underwent RIRS with a T-UAS and 35 were treated with a TFS-UAS. Among congenital anomalies, horseshoe kidney was the most prevalent ( $n = 37$ ), followed by ectopic kidney ( $n = 23$ ), and polycystic kidney disease ( $n = 7$ ).

### *Baseline and Clinical Characteristics*

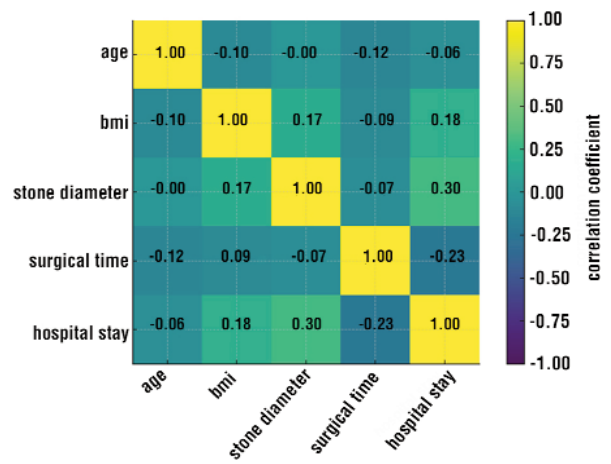
No significant differences were found between groups regarding age, BMI, gender distribution, urine culture or stone laterality (*Table 1*). Preoperative urinary findings were similar across groups. Positive urine cultures were found in 8 patients in the T-UAS group and 10 patients in the TFS-UAS group ( $p = 0.769$ ). Sterile pyuria was observed in seven patients, including two in the

**Table 1.** Baseline demographic and clinical characteristics of the study groups

Characteristics	T-UAS (n = 32)	TFS-UAS (n = 35)	t / $\chi^2$	P value
Gender			2.246	0.872
Male	18	19		
Female	14	16		
Age (years)	49.69 ± 15.00	47.94 ± 12.35	0.521	0.604
Kidney stone diameter (mm)	27.16 ± 3.15	24.31 ± 3.08	3.727	0.000
BMI (kg/m <sup>2</sup> )	26.47 ± 2.50	25.53 ± 2.72	1.467	0.147
Kidney stone location			0.109	0.741
Left	17	20		
Right	15	15		
Urine culture			0.086	0.769
Negative	24	25		
Positive	8	10		
Sterile pyuria	2	5		

T-UAS group and five in the TFS-UAS group, all of whom received empirical antibiotic therapy prior to surgery. A correlation matrix was generated to explore relationships among continuous variables like age, BMI, stone diameter, surgical duration, and hospital stay. The heatmap is illustrated in *Fig. 2*.

The distribution of renal stones varied among the cohort, with mixed calyceal involvement being most frequent at 44.8%, followed by stones in the renal pelvis at 28.4%. Isolated stones in the lower, upper, and middle calyces were found in 9.0%, 10.4%, and 7.5% of patients, respectively. Regarding stone burden, 46.3% of patients had a single stone, while 53.7% had multiple stones. The TFS-UAS group had a higher incidence of multiple stones (68.6%) than the T-UAS group (37.5%), a statistically significant difference [ $\chi^2(1) = 6.492, p = 0.011$ ].



**Figure 2.** Correlation matrix of continuous variables

**Operative Parameters**

Mean operative time was significantly longer in the TFS-UAS group compared to the T-UAS group ( $p < 0.001$ ). However, postoperative hospitalization was considerably shorter in the TFS-UAS group ( $p = 0.003$ ), with a mean reduction of 1.01 days (*Table 2*).

**Stone-Free Rate**

At the 30-day follow-up, the stone-free rate (SFR)

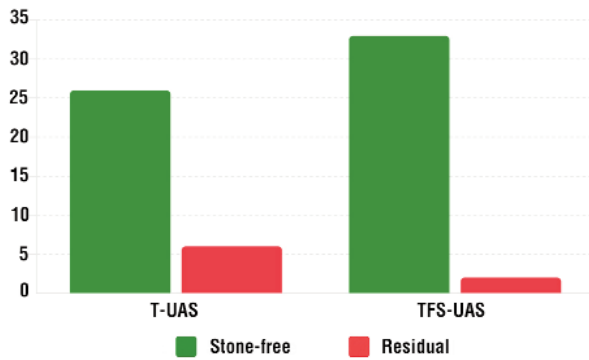
was 94.3% for the TFS-UAS group compared to 81.3% for the T-UAS group. Although the suction-assisted group had a higher rate numerically, this difference was not statistically significant ( $\chi^2(1) = 2.702, p = 0.100$ ; Fisher’s Exact  $p = 0.139$ ). *Fig. 3* shows the distribution of stone-free and residual cases in both groups.

**Postoperative Complications**

There were no statistically significant differences

**Table 2.** Operative and postoperative results

Characteristics	T-UAS	TFS-UAS	t/ $\chi^2$	P value
Surgical time (min)	67.16 ± 3.15	76.74 ± 3.33	-12.075	<0.001
Postoperative hospital stay (days)	2.47 ± 1.57	1.46 ± 1.07	3.114	0.003
SFR at postoperative day 30	26	33	2.702	0.100
Fever	3	1	1.265	0.261
Intraoperative bleeding	2	1	0.450	0.502
Mucosal injury	2	1	0.450	0.502



**Figure 3.** Stone-free versus residual cases in T-UAS and TFS-UAS groups.

between the groups regarding postoperative complications. Fever was infrequent and distributed evenly across groups ( $p = 0.261$ ; Fisher's Exact  $p=0.342$ ). Both intraoperative bleeding and mucosal injury were uncommon, with no significant differences observed between groups ( $p = 0.502$  for each).

### Predictors of Stone-Free Status

Multivariate logistic regression was conducted to evaluate factors associated with achieving stone-free status at 30 days. Covariates included age, BMI, maximum stone diameter, urine culture results, surgical time, and UAS type. Because these variables represent the main clinical factors known to influence perioperative outcomes, all covariates were entered simultaneously into the multivariable model. In the adjusted analysis, none of the examined covariates reached statistical significance as independent predictors of stone-free status on postoperative day 30. Larger stone diameter showed a positive but non-significant association (OR 3.80;  $p=0.166$ ), and the type of ureteral access sheath did not demonstrate an independent effect ( $p=0.463$ ). Age, BMI, preoperative urine culture, and surgical time also did not contribute meaningfully to the model. The overall performance of the model was acceptable for the sample, with a Nagelkerke  $R^2$  of 0.62 and an overall correct classification rate of 89.6% (Table 3).

## Discussion

The evolution of retrograde intrarenal surgery reflects a broader trend in endourology, toward more precise, efficient, and minimally invasive interventions for nephrolithiasis (15). Central to

this evolution is the refinement of UAS, particularly those incorporating active suction and pressure control. These advanced devices have shifted the UAS from a simple access tool to a dynamic operative component that improves irrigation, visibility, and fragment clearance, especially in anatomically challenging cases (16).

However, early designs offered no means of controlling IRP, a key factor in postoperative infection risk due to pyelovenous backflow, bacteremia, and sepsis. Elevated IRP also compromises visibility, increases operative time, and raises the risk of renal injury - especially in patients with abnormal anatomy (17).

To address these shortcomings, newer suction-enabled UAS models - such as the TFS-UAS and flexible, articulating versions like the FANS-UAS - have emerged. These devices generate negative pressure within the collecting system, promoting efficient stone fragment evacuation and maintaining IRP within safe physiological ranges. Prospective data suggest that these technologies improve stone-free rates, reduce febrile complications, and accelerate recovery (18).

The ability to modulate IRP in real time has become a critical advantage in RIRS. Recent pilot studies employing continuous IRP monitoring have shown that suction-assisted UAS maintains effective pressure control and surgical safety while improving visibility and precision, thereby supporting the integration of real-time feedback into tailored RIRS protocols (19).

Suction-enabled UAS are particularly beneficial in complex anatomical situations where distorted calyceal structures and limited working space increase procedural difficulty. In anatomically complex kidneys, the flexibility and active suction of advanced ureteral access sheaths improve irrigation efficiency and limit stone migration, challenges that remain insufficiently addressed in current randomized controlled trials.

Another important synergy exists between suction UAS and modern high-power laser

**Table 3.** Multivariate logistic regression analysis

Variable	Adjusted OR (95% CI)	P-value
BMI	0.982 (0.583 – 1.653)	0.946
Age	1.039 (0.968 – 1.115)	0.301
Stone diameter	3.799 (0.539 – 26.768)	0.166
Urine culture	0.905 (0.071 – 11.527)	0.936
UAS type	250.173 (0.001 – 104,927.80)	0.463
Surgical time	0.531 (0.088 – 3.210)	0.489

systems, including thulium fiber and holmium: YAG. While these lasers improve stone fragmentation efficiency, they also produce fine particulate debris (“stone dust”) that can affect vision and complicate fragment clearance. Suction improves visibility and helps minimize residual fragments, leading to more complete stone removal (20).

From an operational perspective, suction-enabled UAS diminish dependence on auxiliary equipment, for example stone baskets, which are related to increased procedural costs, extended surgery time, and a risk of ureteral trauma. In a comparative study, Yue Yu et al. reported a 70% decrease in basket use with suction UAS, aligning with efforts toward cost-effective, value-based care (21).

The clinical integration of suction UAS continues to evolve, and as our data indicate, surgical efficiency may be dependent not only on device features but also on intraoperative techniques that, while time-consuming, lead to improved fragment clearance and higher stone-free rates.

Unlike several prior reports in the literature, including the study by Zhang et al. (22), which observed shorter operative times when using TFS-UAS, the current analysis revealed a longer mean operative time in the intervention group compared to control. This difference may be explained by specific intraoperative strategies adopted in our cohort, specifically the frequent need to withdraw the ureteroscope to allow the evacuation of accumulated stone fragments within the sheath lumen. Although this strategy increased the length of the procedure, it also improved fragment clearance and contributed to a much better stone-free rate of the intervention group.

Furthermore, the ability of the flexible sheath to navigate and maintain access to secondary and peripheral calyces seemed essential in ensuring continuous fragment drainage during lithotripsy (23). This improved anatomical reach and fluid dynamics may have played a direct role in optimizing stone clearance outcomes, even at the expense of additional operative time. This advantage can be particularly important in anatomically modified kidneys, where improving access to isolated calyces significantly improves fragment retrieval and contributes to increased stone-free rates.

The intraoperative lithotripsy strategy also affected procedural duration. To reduce the risk of sheath obstruction or mechanical damage from the migration of larger fragments, dusting was

preferred to fragmentation. While dusting often produces smaller particles that may be cleared using suction, it is more time-consuming than fragmenting and extracting individual stone fragments. This strategic trade-off prioritized sheath integrity and endoscopic safety while preserving procedure effectiveness.

In line with the recommendations of Traxer et al. (24), the maintenance of low intrarenal pressure in the cohort managed with flexible suction sheaths was associated with a lower incidence of postoperative sepsis. This clinical benefit was further reflected in more favorable postoperative laboratory parameters, which contributed to an earlier discharge in the majority of patients.

Taken together, these results highlight the importance of balancing surgical efficiency with patient outcomes, particularly in the management of anatomically abnormal kidneys with suction-assisted RIRS. While specific intraoperative steps, such as the additional time for fragments removal or careful handling of the sheath, may slightly prolong the procedure (25), these changes are justified by the improved stone clearance, lower rate of infection-related complications, as well as quicker recovery noticed in this cohort.

Despite these promising clinical benefits, progress in optimizing suction-assisted RIRS is constrained by a significant lack of procedural uniformity among institutions (26). Variations in sheath diameter, tip flexibility, suction strength, and compatibility with different scopes may influence surgical outcomes (27), making direct comparisons across studies difficult.

In this context, the current analysis also has several limitations. Its retrospective design inherently carries a risk of selection bias, and, although the cohort was sufficient for comparative evaluation, the sample size restricts more detailed subgroup analysis. The anatomical variability within each malformation category may have affected the difficulty of procedures to different extents. Furthermore, intrarenal pressure was not monitored continuously, which prevented a direct assessment of how pressure dynamics contributed to postoperative outcomes. Future prospective multicenter studies with standardized protocols would help validate these findings and clarify their applicability in broader clinical settings practice.

## Conclusions

Patients with congenital renal anomalies and stones measuring 2–4 cm can benefit from suction-

assisted ureteral access sheaths, which improve the 30-day stone-free rate and reduce hospital stays. Although these sheaths lead to longer operative times due to systematic fragment removal, safety outcomes remain comparable to those of traditional sheaths, with no increase in infection or bleeding. Although no individual factor predicts success, suction-assisted RIRS shows promise for challenging calyceal access in altered kidneys. Further research is necessary to confirm these advantages across different malformation types and larger patient populations.

### Conflicts of Interest

The authors declare no conflicts of interest.

### Funding

This research received no external funding.

### Institutional Review Board Statement

The study was conducted according to the guidelines of the Declaration of Helsinki and approved by the Institutional Review Board of both participating academic centers.

### Informed Consent Statement

Informed consent was obtained from all subjects involved in the study.

### Data Availability Statement

Due to the nature of this study and the inclusion of patient data, the datasets are not publicly available. All clinical data are protected under institutional policy and European GDPR regulations. For reasons of confidentiality and ethical compliance, data access cannot be granted without formal approval.

### References

- Turney BW, Reynard JM, Noble JG, Keoghane SR, Appleby PM. Kidney stone epidemiology in England and Wales: admission rates. *BJU Int.* 2012;109(6):765-73.
- Ferraro PM, Taylor EN, Gambaro G, Curhan GC. Dietary and lifestyle factors associated with incident kidney stone formation: a systematic review and meta-analysis. *Eur J Epidemiol.* 2017;32(4):343-58.
- Aboumarzouk OM, Monga M, Kata SG, Somani BK. Retrograde intrarenal surgery for renal stones >2 cm: a systematic review and meta-analysis. *J Endourol.* 2017;31(1):38-49.
- Türk C, Petrik A, Sarica K, Seitz C, Skolarikos A, Straub M, et al. EAU guidelines on interventional treatment for urolithiasis. *Eur Urol.* 2016;69(3):475-82.
- Sun Y, Gao B, Tan X, Zhao Z. PCNL versus RIRS for large renal stones: a meta-analysis. *Medicine (Baltimore).* 2017;96(50):e9238.
- Miller NL, Matlaga BR, Handa SE, Munch LC, Lingeman JE. The presence of horseshoe kidney does not affect the outcome of percutaneous nephrolithotomy. *J Endourol.* 2008;22(6):1219-25.
- Khargi R, Bamberger JN, Ricapito A, Gupta K, Yaghoobian AJ, Khusid JA, et al. Comprehensive analysis of factors associated with significant blood loss during percutaneous nephrolithotomy. *Am J Clin Exp Urol.* 2023;11(5):420-428. eCollection 2023.
- Zhu W, Huang Z, Zeng G. Miniaturization in percutaneous nephrolithotomy: what is new? *Asian J Urol.* 2023;10(3):275-80.
- Ergin G, Kirac M, Unsal A, Kopru B, Yordam M, Biri H. Surgical management of urinary stones with abnormal kidney anatomy. *Kaohsiung J Med Sci.* 2017;33(4):207-211.
- El Ghoneimy MN, Kodera AS, Emran AM, Orban TZ, Shaban AM, El Gammal MM. Percutaneous nephrolithotomy in horseshoe kidneys: is rigid nephroscopy sufficient tool for complete clearance? A case series study. *BMC Urol.* 2009;9:17.
- Stonebrook E, Hoff M, Spencer JD. Congenital anomalies of the kidney and urinary tract: a clinical review. *Curr Treat Options Pediatr.* 2019;5(3):223-35.
- Talyshinskii A, Tzelvel L, Ventimiglia E, Yuen SKK, Gauhar V, Traxer O, Somani B. Technological innovation and revolution with single-use digital flexible ureteroscopes: a review from section of EAU Endourology. *Curr Opin Urol.* 2025;35(4):360-367.
- Bai J, Shangquan T, Zou G, Liu L, Xue X, Lin J, et al. Efficacy and intrarenal pressure analysis of flexible and navigable suction ureteral access sheaths with flexible ureteroscopy in modified surgical positions for 2-6 cm upper urinary tract stones: a multicenter retrospective study. *Front Med (Lausanne).* 2024;11:1501464.
- Tokas T, Herrmann TRW, Skolarikos A, Nagele U; Training and Research in Urological Surgery and Technology (T.R.U.S.T.)-Group. Pressure matters: intrarenal pressures during normal and pathological conditions, and impact of increased values to renal physiology. *World J Urol.* 2019;37(1):125-131.
- Xu X, Xu F, Mao K, Zhong W, Zhang M, Huang W, et al. First clinical application of the novel 6.3 Fr disposable digital flexible ureteroscope for treatment of lower calyx renal stones in anticoagulated patient. *Urol Case Rep.* 2025;60:103015.
- Inoue T, Okada S, Hamamoto S, Fujisawa M. Retrograde intrarenal surgery: past, present, and future. *Investig Clin Urol.* 2021;62(2):121-35.
- Ding T, Xu Z, Huang Z, Hu W, Xiao B, Li J, et al. Optimizing aspiration efficiency in RIRS: the impact of ratio of endoscope-sheath diameter, irrigation flow, and negative pressure in an in vitro study. *Urolithiasis.* 2025;53(1):102.
- Yuen SKK, Zhong W, Chan YS, Castellani D, Bhojani N, Agarwal MS, et al. Current utility, instruments, and future directions for intra-renal pressure management during ureteroscopy: scoping review by global research in intrarenal pressure collaborative group initiative. *Ther Adv Urol.* 2025;17:17562872251314809.
- Geavlete B, Mulescu R, Vranceanu D. Challenges in endoureteral treatment of stones in horseshoe kidneys. *Urol J.* 2022;19(1):45-52.
- Gauhar V, Traxer O, Castellani D, Sietz C, Chew BH, Fong KY, et al. Could use of a flexible and navigable suction ureteral access sheath be a potential game-changer in retrograde intrarenal surgery? Outcomes at 30 days from a large, prospective, multicenter, real-world study by the European Association of Urology Urolithiasis Section. *Eur Urol Focus.* 2024;10(6):975-982.
- Zhu W, Yuen SKK, Cao J, Chai CA, Liu S, Du J et al. Intrarenal pressure monitoring via flexible and navigable suction ureteral access sheath in retrograde intrarenal surgery: a preclinical animal study and a pilot clinical study. *Clin Transl Disc.* 2025;5(1):e70031.
- Gauhar V, Traxer O, Fong KY, Sietz C, Chew BH, Hamri SB, et al. Comparing Thulium Fiber Versus High-Power Holmium Laser Lithotripsy Combined with the Flexible and Navigable Suction Access Sheath in Flexible Ureteroscopy for Kidney Stone Disease: A Propensity Score Matched Analysis by the Global FANS Collaborative Group. *J Endourol.* 2025;39(1):42-49.
- Yu Y, Chen Y, Zhou X, Li X, Liu W, Cheng X, et al. Comparison of novel flexible and traditional ureteral access sheath in retrograde intrarenal surgery. *World J Urol.* 2024;42(1):7.
- Zhang Z, Xie T, Li F, Wang X, Liu F, Jiang B, et al. Comparison of traditional and novel tip-flexible suctioning ureteral access sheath combined with flexible ureteroscopy to treat unilateral renal calculi. *World J Urol.* 2023;41(12):3619-3627.
- Liang H, Liang L, Lin Y, Yu Y, Xu X, Liang Z, et al. Application of tip-bendable ureteral access sheath in flexible ureteroscopic lithotripsy: an initial experience of 224 cases. *BMC Urol.* 2023;23(1):175.
- Pauchard F, Ventimiglia E, Corrales M, Traxer O. A practical guide for intra-renal temperature and pressure management during RIRS: what is the evidence telling us? *J Clin Med.* 2022;11(12):3429.
- Lin CB, Chuang SH, Shih HJ, Pan Y. Utilization of ureteral access sheath in retrograde intrarenal surgery: a systematic review and meta-analysis. *Medicina (Kaunas).* 2024;60(7):1084.