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Flexible and Navigable Suction Ureteral Access Sheaths in Retrograde Intrarenal Surgery for Elderly Patients: A Retrospective Multicenter Study of Safety and Feasibility

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Abstract

Geriatric patients account for 9.6–16% of all individuals with urinary stones, and endoscopic management is challenging because of comorbidities and a higher risk of postoperative complications. Elevated intrarenal pressure (IRP) increases the risk of pain, fever and sepsis. Flexible and navigable suction ureteral access sheaths (FANS) have been introduced to mitigate these risks and improve stone-free rates (SFR).

This retrospective multicenter study evaluated intra- and post-operative outcomes of retrograde intrarenal surgery (RIRS) with FANS in patients aged ≥ 60 years (131 patients: 107 FANS, 24 traditional UAS), including a propensity-matched comparison (24 pairs), and compared SFR with the literature. To our knowledge, this is the first study of FANS in a geriatric cohort.

No Clavien-Dindo grade IV–V complications occurred in the FANS group. Operative time was shorter with FANS in the overall cohort (60 vs. 77.5 minutes, p = 0.001) but not significantly after matching (p = 0.059). Postoperative WBC, CRP, PCT and hemoglobin drop did not differ significantly between FANS and UAS, in either the overall or the matched cohort. SFR at first follow-up was 84.1% with FANS versus 75.0% with UAS, reaching 88.8% versus 83.3% at the last available follow-up (not significant).

FANS-assisted RIRS appears feasible and showed an acceptable safety profile in patients aged ≥ 60 years, with perioperative and stone-free outcomes that did not differ significantly from those of traditional UAS. Because of the small control group and the retrospective design, these findings are preliminary and larger prospective studies are needed to confirm them.

INTRODUCTION

The World Health Organization (WHO) generally classifies individuals aged 60 years and older as geriatric population, though many developed nations use 65 as a threshold.

The proportion of elderly individuals is growing rapidly, and is expected to exceed 20% of the total population in some countries by 2030 [1].

Prevalence of urolithiasis in elderly people is 14% (19.1% men vs 9.4% women) with geriatric population consisting of 9.6–16% of all patients affected by urinary stones [2, 3].

Endoscopic management of stones in the elderly represents a challenge for surgeons, due to high prevalence of comorbidities in this population (e.g. hypertension, diabetes, cardiac disease) leading to a higher rate of post-operative medical complications, reaching up to 42% according to some studies in this setting [2].

Current practice in endourology embodies, according to EAU guidelines, support of ureteral access sheath (UAS) in order to improve vision, decrease intrarenal pressure (IRP) and potentially reduce operating time [4, 5].

Specifically, high IRP is a risk factor for intra- and postoperative complications, such as pain, fever or sepsis [6, 7].

Reduction of IRP is one of the main goals of current research in endourology, with significant attention to suction ureteral access sheath (SUAS). Initial results on SUAS advantages on IRP were inconclusive [8]. Development of a new model of SUAS with omni directional-tip (flexible and navigable suction ureteral access sheath – FANS) has renewed interest toward this device due to low complications rate and high stone free rates (SFR) up to 97.2% at 30 days [9].

However, evidence on safety and efficacy of FANS-assisted fURS in the geriatric population, who carry higher comorbidity burden and complication risk, is currently lacking.

We conducted a retrospective multicentric study comparing outcomes of fURS performed with FANS versus traditional UAS in the geriatric population, between November 2023 and February 2026, and compared our results with literature.

MATERIALS AND METHODS

We conducted a retrospective, observational study in elderly patients with kidney stones who underwent flexible ureteroscopy (fURS) and lithotripsy using a flexible and navigable suction ureteral access sheath (FANS) at Urology Division of INRCA-IRCCS Hospital (Ancona, Marche Region, Italy) and “C. & G. Mazzoni” Hospital (Ascoli Piceno, Marche Region, Italy) from November 2023 to February 2026.

All patients provided institutional informed consent for data processing and scientific publication in accordance with local regulations. Approval was waived by the local Ethics Committee due to the retrospective, observational design.

Inclusion Criteria for fURS

Patients were eligible for inclusion if they met the following criteria:

- Indication for active treatment of kidney stones according to the European Association of Urology (EAU) guidelines.
- At least one of the following conditions:
    - Renal stones > 1 cm and < 2 cm.
    - Renal stones > 2 cm in patients unfit for or unwilling to undergo percutaneous surgery.
    - Renal stones < 1 cm in patients unfit for or unwilling to undergo extracorporeal shock wave lithotripsy (ESWL).

General exclusion Criteria for fURS

Patients were excluded if they had any of the following conditions:

- Ureteral stricture.
- Failure of ureteral access sheath (UAS) placement.
- Untreated positive urine culture.
- Urine culture not performed.
- Abdominal computed tomography (CT) scan performed more than three months before enrollment.

Specific exclusion Criteria for FANS

- ureteropelvic junction (UPJ) stricture

Treatment allocation

Patients meeting inclusion criteria and none of the general exclusion criteria underwent fURS with FANS. Patients with UPJ stricture (specific exclusion criterion for FANS) or those treated before FANS became available at the participating centers underwent fURS with traditional UAS instead.

Surgical Procedure

All procedures were performed by surgeons experienced in endourology.

Patients underwent fURS and stone fragmentation/retrieval under spinal or general anesthesia.

Patients meeting the inclusion criteria for FANS were treated with fURS using Holmium laser (RevoLix DUO, LISA Laser products, Katlenburg, Germany) or Thulium laser (RevoLix HTL, LISA Laser products, Katlenburg, Germany) combined with the Clear Petra® sheath (Well Lead Medical Co., Ltd., Panyu, Guangzhou, China) or Innovex Ureteral Access Sheath (Innovex Medical Co., Ltd., Shanghai China).

Patients in the control group were managed using the ReTrace® access sheath (Coloplast S.p.A., Bologna, Italy).

A post-operative JJ stent was placed in all patients.

Outcomes and Follow-Up

Intraoperative and post-operative complications were documented according to the Clavien-Dindo classification.

Post-operative blood tests (including complete blood count, renal function, procalcitonin and C-reactive protein) were performed the morning after surgery.

Post-operative follow-up was scheduled at one month; further follow-up was arranged only for patients with residual fragments.

Ultrasound (USS) was the chosen imaging modality at the one-month follow-up visit and was performed by expert radiologists. A CT scan was additionally scheduled only for patients with suspected residual stone fragments on ultrasound.

The stone-free rate (SFR) was defined as the complete absence of residual stone fragments on imaging (zero fragments).

Study Objectives

The primary objective was to evaluate intra and post-operative outcomes of kidney stone lithotripsy using FANS, compared with traditional UAS and with data from the literature.

Outcomes compared as primary endpoints between FANS and control groups were: intraoperative time, total stone clearance time, complications according to Clavien-Dindo, differences in WBC count, CRP and procalcitonin.

The secondary objective was to assess and compare the SFR between the FANS and control groups, as well as with published literature.

Data Analysis

Normality in distribution for continuous variables was assessed via Shapiro-Wilk test. Mean and standard deviation or median and interquartile range were reported as as appropriate, while categorical variables were expressed as absolute and relative frequencies (percentages). Comparison between cases and controls were evaluated, for continuous variables, by means of unpaired t test or Mann-Whitney U test according to their distribution, while Chi-Square tests was applied to compare categorical variables. The propensity score matching (PSM) analysis was performed to reduce potential confounding due to differences in baseline characteristics between cases and controls. First, propensity scores were estimated using a multivariable logistic regression model, with treatment allocation (continuous suction) as the dependent variable and sex, age, age-adjusted Charlson Comorbidity Index, cumulative stone diameter, symptomatic infections within the previous three months, number of separate stones, and preoperative stenting as covariates; total intraoperative time, being an outcome measured after treatment, was not included in the model. The outcomes selected for PS matching were: at least one post-operative complication; White Blood Cells, C-Reactive Protein and Procalcitonin equal or greater their median. In order to obtain an accurate comparison between the two groups by making sure that their socio-demographic characteristics are as similar as possible, cases were matched 1:1 to controls using optimal matching on the logit of the propensity score without a caliper, since a caliper of 0.2 times its standard deviation allowed only 16 of the 24 controls to be matched with adequate balance; covariate balance was assessed with standardized mean differences. The initial analyses were

performed with Stata/MP 19.0 (StataCorp LP, CollegeStation, TX, USA); the propensity score matching and the revised analyses reported here were performed with Python 3 (pandas, SciPy). P values less than 0.05 (two-sided) were considered statistically significant. Fisher's exact test was used instead of the Chi-square test when expected cell counts were below 5. Post-operative white blood cell (WBC) counts, which were recorded in different units across centers (x10³/µL or absolute cells/µL), were harmonized to x10³/µL before analysis, and post-operative hemoglobin was analyzed as the drop from the pre-operative value (g/dL). Because a second follow-up was arranged only for patients with residual fragments at one month, stone-free status at the second follow-up was analyzed only among patients who underwent a second assessment, and the cumulative SFR was defined as stone-free status at the first or, when performed, at the second follow-up. Patients without any follow-up assessment (three patients in the FANS group) were counted as not stone-free in the main analysis, and results among patients with an available follow-up are reported as a sensitivity analysis. This study is reported in accordance with the STROBE guidelines. All consecutive patients who met the eligibility criteria during the study period were included, and no formal sample size calculation was performed. To limit confounding, propensity score matching was used; because controls were treated before FANS became available, residual confounding by period and center cannot be excluded. Variables with missing data were analyzed on available cases without imputation, and the number of missing values is reported in Supplementary Table S1. Effect estimates are reported as Hodges-Lehmann shifts with bootstrap 95% confidence intervals (CI) for continuous variables, and as risk differences (Newcombe 95% CI) and odds ratios (Woolf 95% CI) for binary variables (Supplementary Tables S2 and S3). The comparison between the overall and the matched cohorts served as a sensitivity analysis.

Results

Patient characteristics and perioperative and follow-up outcomes are summarized in Tables 1 and 2. A total of 131 patients underwent flexible ureteroscopy (fURS) during the observation period: 107 underwent fURS with a flexible access sheath (FANS group), whereas 24 underwent fURS using a traditional ureteral access sheath (UAS group). Patient flow is shown in Fig. 1.

Table 1
Patient characteristics and outcomes of the overall cohort

Gender, n(%)	**Total** **N = 131**	**Controls** **N = 24**	**Cases** **N = 107**	**p-value**
				0.261
Male	84(64.1%)	13(54.2%)	71(66.4%)	
Female	47(35.9%)	11(45.8%)	36(33.6%)	
Age (years), median[IQR]	71[66–74]	66[60–72]	72[67-75.8]	0.003
Age adjusted Charlson comorbidity Index, mean ± sd	3.0 ± 1.1	2.4 ± 1.1	3.1 ± 1.1	0.006
Cumulative size of residual stones 2 (mm) (patients with second follow-up only), mean ± sd	4.4 ± 3.6	3.5 ± 1.9	4.8 ± 4.2	0.490
Cumulative stone diameter (mm), median[IQR]	12[10-16.8]	14.5[11.5–21]	12[9–16]	0.009
Mean stone density (HU), median[IQR]	1000[925–1200]	1100[950–1200]	1000[875–1200]	0.255
Total Intra-operative time (mins) from cystscope to catheter insertion, median[IQR]	60[51.3–80]	77.5[70–90]	60[50-77.3]	0.001
Stone clearance time (mins): lithotripsy time, median[IQR]	45[30–50]	52.5[37.5–60]	40[25–50]	0.018
Post-operative length of stay (days), median[IQR]	2[1–2]	2[2–3]	2[1–2]	0.134
Post-operative WBC (x10^3/μL), median[IQR]	7.9[6.4–9.7]	7.7[6.2–9.5]	8[6.4–9.8]	0.677
Post-operative WBC ≥ 11.4, n(%)	16(12.2%)	4(16.7%)	12(11.2%)	0.493
Post-operative Hgb drop (g/dL), median[IQR]	0.5[0.3–0.9]	0.7[0.4-1]	0.5[0.3–0.9]	0.498
Post-operative CRP, median[IQR]	1.4[0.6–3.8]	1[0.5–2.2]	1.4[0.6–4.3]	0.265
Post-operative PCT, median[IQR]	0.1[0-0.2]	0[0-0.7]	0.1[0-0.2]	0.637
Cumulative size of residual stones (mm), median[IQR]	0[0–0]	0[0-1.5]	0[0–0]	0.332
Time of follow up 1 (mo), median[IQR]	1[1–2]	1[1–1]	1[1–2]	< 0.001
Time of follow up 2 (mo), median[IQR]	5[3–6]	3[3–3]	6[3.8–7.5]	0.086

Gender, n(%)	Total N = 131	Controls N = 24	Cases N = 107	p-value
				0.261
Number of separate stones, median[IQR]	1[1–2]	1[1–2]	1[1–2]	0.873
Number of cases performed by surgeon per year, median[IQR]	30[29–38]	30[30–30]	30[23–38]	0.941
Laterality, n(%)				0.084
Left	59(45.0%)	7(29.2%)	52(48.6%)	
Right	72(55.0%)	17(70.8%)	55(51.4%)	
Neurogenic Bladder, n(%)	2(1.5%)	1(4.2%)	1(0.9%)	0.334
Multiple sclerosis, n(%)	1(0.8%)	0(0.0%)	1(0.9%)	1.000
Ischemic heart disease, n(%)	17(13.0%)	2(8.3%)	15(14.0%)	0.737
Hypertension, n(%)	77(58.8%)	11(45.8%)	66(61.7%)	0.154
COPD, n(%)	3(2.3%)	0(0.0%)	3(2.8%)	1.000
Symptomatic Infections within 3 months prior to surgery, n(%)	19(14.5%)	3(12.5%)	16(15.0%)	1.000
Hydronephrosis, n(%)				< 0.001
None	64(48.9%)	22(91.7%)	42(39.3%)	
Mild	34(26.0%)	2(8.3%)	32(29.9%)	
Moderate	25(19.1%)	0(0.0%)	25(23.4%)	
Severe	8(6.1%)	0(0.0%)	8(7.5%)	
Pre-operatively stented, n(%)	58(44.3%)	12(50.0%)	46(43.0%)	0.532
Pre-operatively nephrostomized, n(%)	4(3.1%)	1(4.2%)	3(2.8%)	0.560
Duplex system, n(%)	3(2.3%)	1(4.2%)	2(1.9%)	0.458
Pielo-ureteric junction obstruction, n(%)	10(7.6%)	6(25.0%)	4(3.7%)	0.003
Ptosic\malrotated kidney, n(%)	4(3.1%)	2(8.3%)	2(1.9%)	0.153
Stone culture, n(%)				1.000
Not performed	130(99.2%)	24(100.0%)	106(99.1%)	
Negative	1(0.8%)	0(0.0%)	1(0.9%)	

Gender, n(%)	Total N = 131	Controls N = 24	Cases N = 107	p-value
				0.261
Positive	0(0.0%)	0(0.0%)	0(0.0%)	
Post-operative Alpha-blockers, n(%)	4(3.1%)	2(8.3%)	2(1.9%)	0.153
Post-operative stent-related symptoms, n(%)	9(6.9%)	3(12.5%)	6(5.6%)	0.365
ASA Score, n(%)				0.231
1	5(3.8%)	2(8.3%)	3(2.8%)	
2	84(64.1%)	17(70.8%)	67(62.6%)	
3	42(32.1%)	5(20.8%)	37(34.6%)	
Motility, n(%)				0.455
Normal	128(97.7%)	23(95.8%)	105(98.1%)	
Wheelchair bound	1(0.8%)	0(0.0%)	1(0.9%)	
Bedbound	2(1.5%)	1(4.2%)	1(0.9%)	
Diabetes, n(%)				0.589
No	104(79.4%)	18(75.0%)	86(80.4%)	
Type 1	2(1.5%)	0(0.0%)	2(1.9%)	
Type 2	25(19.1%)	6(25.0%)	19(17.8%)	
LUTS, n(%)				0.363
No	120(91.6%)	22(91.7%)	98(91.6%)	
Indwelling urethral catheter	5(3.8%)	0(0.0%)	5(4.7%)	
Suprapubic catheter	0(0.0%)	0(0.0%)	0(0.0%)	
IPSS > 7	6(4.6%)	2(8.3%)	4(3.7%)	
Pre-operative urine culture, n(%)				0.729
Negative	120(91.6%)	22(91.7%)	98(91.6%)	
Asymptomatic bacteriuria	8(6.1%)	1(4.2%)	7(6.5%)	
Symptomatic bacteriuria	3(2.3%)	1(4.2%)	2(1.9%)	
Stone location, n(%)				0.380

Gender, n(%)	Total N = 131	Controls N = 24	Cases N = 107	p-value
				0.261
Pelvis	56(42.7%)	11(45.8%)	45(42.1%)	
Lower pole	35(26.7%)	4(16.7%)	31(29.0%)	
Mid pole	8(6.1%)	3(12.5%)	5(4.7%)	
Upper pole	6(4.6%)	2(8.3%)	4(3.7%)	
Multiple sit	26(19.8%)	4(16.7%)	22(20.6%)	
Previous surgery on same kidney, n(%)				0.461
No	114(87.0%)	23(95.8%)	91(85.0%)	
ESWL	7(5.3%)	1(4.2%)	6(5.6%)	
RIRS	8(6.1%)	0(0.0%)	8(7.5%)	
PCN	2(1.5%)	0(0.0%)	2(1.9%)	
Open surgery	0(0.0%)	0(0.0%)	0(0.0%)	
Ureteral stenosis, n(%)	1(0.8%)	1(4.2%)	0(0.0%)	0.183
Pre-RIRS ureteroscopy, n(%)	60(45.8%)	17(70.8%)	43(40.2%)	0.006
Type of irrigation during surgery, n(%)				< 0.001
None	14(10.7%)	0(0.0%)	14(13.1%)	
Pump	2(1.5%)	0(0.0%)	2(1.9%)	
Intermittent syringe irrigation	44(33.6%)	24(100.0%)	20(18.7%)	
Traxer’s flow	71(54.2%)	0(0.0%)	71(66.4%)	
Stone biochemistry, n(%)				< 0.001
Not performed	82(62.6%)	1(4.2%)	81(75.7%)	
Dihidrate calcium oxalate	0(0.0%)	0(0.0%)	0(0.0%)	
Monohidrate calcium oxalate	1(0.8%)	0(0.0%)	1(0.9%)	
Uric acid	4(3.1%)	2(8.3%)	2(1.9%)	
Cistine	0(0.0%)	0(0.0%)	0(0.0%)	
Struvite	0(0.0%)	0(0.0%)	0(0.0%)	

Gender, n(%)	Total N = 131	Controls N = 24	Cases N = 107	p-value
				0.261
Calcium phosphate	0(0.0%)	0(0.0%)	0(0.0%)	
NA	44(33.6%)	21(87.5%)	23(21.5%)	
Post-operative early clinically relevant infections, n(%)	13(9.9%)	3(12.5%)	10(9.3%)	0.706
All complications according to Clavien-Dindo, n(%)				0.230
None	113(86.3%)	21(87.5%)	92(86.0%)	
1	4(3.1%)	0(0.0%)	4(3.7%)	
2	12(9.2%)	2(8.3%)	10(9.3%)	
3a	1(0.8%)	0(0.0%)	1(0.9%)	
3b	0(0.0%)	0(0.0%)	0(0.0%)	
4a	0(0.0%)	0(0.0%)	0(0.0%)	
4b	1(0.8%)	1(4.2%)	0(0.0%)	
5	0(0.0%)	0(0.0%)	0(0.0%)	
Type of infection, n(%)				0.271
None	117(89.3%)	21(87.5%)	96(89.7%)	
Fever	10(7.6%)	2(8.3%)	8(7.5%)	
Severe sepsis	2(1.5%)	0(0.0%)	2(1.9%)	
Septic shock	1(0.8%)	1(4.2%)	0(0.0%)	
ICU admission	0(0.0%)	0(0.0%)	0(0.0%)	
Death	0(0.0%)	0(0.0%)	0(0.0%)	
NA	1(0.8%)	0(0.0%)	1(0.9%)	
Q-sofa, n(%)				0.204
0	4(3.1%)	2(8.3%)	2(1.9%)	
1	2(1.5%)	0(0.0%)	2(1.9%)	
2	2(1.5%)	1(4.2%)	1(0.9%)	
NA	123(93.9%)	21(87.5%)	102(95.3%)	

Gender, n(%)	Total N = 131	Controls N = 24	Cases N = 107	p-value
				0.261
Stone related events within 3 months post-op, n(%)	4(3.1%)	0(0.0%)	4(3.7%)	1.000
Stone free, n(%)	108(82.4%)	18(75.0%)	90(84.1%)	0.371
Imaging used to assess stone free state, n(%)				0.372
Ultrasound	106(80.9%)	18(75.0%)	88(82.2%)	
CT	22(16.8%)	6(25.0%)	16(15.0%)	
X-ray KUB	0(0.0%)	0(0.0%)	0(0.0%)	
X-ray + ultrasound	0(0.0%)	0(0.0%)	0(0.0%)	
NA	3(2.3%)	0(0.0%)	3(2.8%)	
Stone free 2 (patients with second follow-up only), n/N(%)	7/19(36.8%)	2/6(33.3%)	5/13(38.5%)	1.000

Note. Overall cohort. Continuous variables: Mann-Whitney U test (median[IQR]) or t test (mean ± SD); categorical variables: Chi-square test, or Fisher exact test for 2x2 tables with expected counts < 5. Percentages are calculated on the number of patients in each group. WBC are expressed in x10^3/µL (values harmonized across centers); Hgb drop = pre-operative minus post-operative hemoglobin. Second follow-up was performed only in patients with residual fragments at one month.

In the overall cohort, patients in the FANS group were older than those in the UAS group (median age, 72 vs. 66 years; p = 0.003) and had a higher age-adjusted Charlson Comorbidity Index (3.1 ± 1.1 vs. 2.4 ± 1.1; p = 0.006). The FANS group also had a smaller median cumulative stone diameter (12 vs. 14.5 mm; p = 0.009). In the unadjusted comparison, total intraoperative time and stone clearance time were significantly shorter in the FANS group (60 vs. 77.5 minutes, p = 0.001, and 40 vs. 52.5 minutes, p = 0.018, respectively; Hodges-Lehmann shift − 15.0 minutes [95% CI − 25.0 to − 10.0] and − 10.0 minutes [95% CI − 15.0 to − 5.0]). Sex, stone density, number of stones, preoperative stenting and most comorbidities did not differ significantly between groups, whereas hydronephrosis (p < 0.001), ureteropelvic junction obstruction (25.0% in the UAS group vs. 3.7% in the FANS group, p = 0.003), ureteroscopy before RIRS (70.8% vs. 40.2%, p = 0.006) and time to the first follow-up (median 1 month [IQR 1–1] vs. 1 month [1–2], p < 0.001) did.

The type of irrigation used during surgery differed significantly between groups. All patients in the UAS group underwent intermittent syringe irrigation, whereas 13.1% of patients in the FANS group required no irrigation and 66.4% were managed using Traxer's flow (p < 0.001).

In the overall cohort, postoperative WBC did not differ significantly between the FANS and UAS groups (median 8.0 [IQR 6.4–9.8] vs. 7.7 [6.2–9.5] x10³/µL; p = 0.677), and the proportion of patients with WBC ≥ 11.4 x10³/µL was similar (11.2% vs. 16.7%; p = 0.493; risk difference − 5.5%, 95% CI − 25.2 to 7.0). Postoperative hemoglobin drop (median 0.5 vs. 0.7 g/dL in the FANS and UAS groups; p = 0.498), CRP and PCT did not differ significantly between groups. Postoperative length of stay was comparable, with a median of 2 days in both groups.

After propensity score matching, 48 patients were retained (Table 2), with 24 patients in each group. Matching substantially reduced baseline differences between the FANS and UAS groups (standardized mean difference for age from 0.72 to 0.24, for the age-adjusted Charlson Comorbidity Index from 0.65 to 0.08, and for cumulative stone diameter from − 0.49 to − 0.13), and age, Charlson index, cumulative stone diameter and stone density no longer differed significantly between groups. In the matched cohort, median total intraoperative time was 60 minutes in the FANS group and 77.5 minutes in the UAS group (p = 0.059; Hodges-Lehmann shift − 10.0 minutes, 95% CI − 20.0 to 0.0), while median stone clearance time was 47.5 and 52.5 minutes, respectively (p = 0.250). Some imbalances remained for variables not included in the model, such as laterality (p = 0.042), ureteropelvic junction obstruction (0% vs. 25.0%, p = 0.022), type of irrigation and stone biochemistry (both p < 0.001).

Table 2
Patient characteristics and outcomes of the propensity score-matched cohort

Gender, n(%)	**Total** **N = 48**	**Controls** **N = 24**	**Cases** **N = 24**	**p-value**
				0.771
Male	27(56.3%)	13(54.2%)	14(58.3%)	
Female	21(43.8%)	11(45.8%)	10(41.7%)	
Age (years), median[IQR]	67[64.5–72]	66[60–72]	67[65–73]	0.432
Age adjusted Charlson comorbidity Index, mean ± sd	2.4 ± 1.0	2.4 ± 1.1	2.5 ± 0.9	0.773
Cumulative size of residual stones 2 (mm) (patients with second follow-up only), mean ± sd	3.5 ± 1.9	3.5 ± 1.9	.	.
Cumulative stone diameter (mm), median[IQR]	15[11–20]	14.5[11.5–21]	15[10.5–19.5]	0.605
Mean stone density (HU), median[IQR]	1000[950–1200]	1100[950–1200]	950[700–1075]	0.098
Total Intra-operative time (mins) from cystscope to catheter insertion, median[IQR]	70[60–90]	77.5[70–90]	60[60–75]	0.059
Stone clearance time (mins): lithotripsy time, median[IQR]	50[35–60]	52.5[37.5–60]	47.5[32.5–50]	0.250
Post-operative length of stay (days), median[IQR]	2[2–3]	2[2–3]	2[1-2.5]	0.429
Post-operative WBC (x10^3/μL), median[IQR]	7.8[6-9.8]	7.7[6.2–9.5]	8[6-10.5]	0.788
Post-operative WBC ≥ 11.4, n(%)	9(18.8%)	4(16.7%)	5(20.8%)	1.000
Post-operative Hgb drop (g/dL), median[IQR]	0.5[0.3–0.9]	0.7[0.4-1]	0.5[0.3–0.9]	0.368
Post-operative CRP, median[IQR]	1[0.3–2.2]	1[0.5–2.2]	0.9[0.3-2]	0.529
Post-operative PCT, median[IQR]	0[0-0.3]	0[0-0.7]	0[0-0.1]	0.769
Cumulative size of residual stones (mm), median[IQR]	0[0–0]	0[0-1.5]	0[0–0]	0.162
Time of follow up 1 (mo), median[IQR]	1[1–1]	1[1–1]	1[1–2]	0.004
Time of follow up 2 (mo), median[IQR]	3[3–3]	3[3–3]	.	.
Number of separate stones, median[IQR]	1[1–2]	1[1–2]	1[1–2]	0.856

Gender, n(%)	Total N = 48	Controls N = 24	Cases N = 24	p-value
				0.771
Number of cases performed by surgeon per year, median[IQR]	30[30–30]	30[30–30]	30[29–38]	1.000
Laterality, n(%)				0.042
Left	21(43.8%)	7(29.2%)	14(58.3%)	
Right	27(56.3%)	17(70.8%)	10(41.7%)	
Neurogenic Bladder, n(%)	1(2.1%)	1(4.2%)	0(0.0%)	1.000
Multiple sclerosis, n(%)	0(0.0%)	0(0.0%)	0(0.0%)	.
Ischemic heart disease, n(%)	5(10.4%)	2(8.3%)	3(12.5%)	1.000
Hypertension, n(%)	27(56.3%)	11(45.8%)	16(66.7%)	0.146
COPD, n(%)	0(0.0%)	0(0.0%)	0(0.0%)	.
Symptomatic Infections within 3 months prior to surgery, n(%)	6(12.5%)	3(12.5%)	3(12.5%)	1.000
Hydronephrosis, n(%)				0.057
None	37(77.1%)	22(91.7%)	15(62.5%)	
Mild	5(10.4%)	2(8.3%)	3(12.5%)	
Moderate	5(10.4%)	0(0.0%)	5(20.8%)	
Severe	1(2.1%)	0(0.0%)	1(4.2%)	
Pre-operatively stented, n(%)	21(43.8%)	12(50.0%)	9(37.5%)	0.383
Pre-operatively nephrostomized, n(%)	1(2.1%)	1(4.2%)	0(0.0%)	1.000
Duplex system, n(%)	1(2.1%)	1(4.2%)	0(0.0%)	1.000
Pielo-ureteric junction obstruction, n(%)	6(12.5%)	6(25.0%)	0(0.0%)	0.022
Ptosic\malrotated kidney, n(%)	3(6.3%)	2(8.3%)	1(4.2%)	1.000
Stone culture, n(%)				.
Not performed	48(100.0%)	24(100.0%)	24(100.0%)	
Negative	0(0.0%)	0(0.0%)	0(0.0%)	
Positive	0(0.0%)	0(0.0%)	0(0.0%)	
Post-operative Alpha-blockers, n(%)	3(6.3%)	2(8.3%)	1(4.2%)	1.000

Gender, n(%)	Total N = 48	Controls N = 24	Cases N = 24	p-value
				0.771
Post-operative stent-related symptoms, n(%)	5(10.4%)	3(12.5%)	2(8.3%)	1.000
ASA Score, n(%)				0.706
1	3(6.3%)	2(8.3%)	1(4.2%)	
2	33(68.8%)	17(70.8%)	16(66.7%)	
3	12(25.0%)	5(20.8%)	7(29.2%)	
Motility, n(%)				1.000
Normal	47(97.9%)	23(95.8%)	24(100.0%)	
Wheelchair bound	0(0.0%)	0(0.0%)	0(0.0%)	
Bedbound	1(2.1%)	1(4.2%)	0(0.0%)	
Diabetes, n(%)				0.477
No	38(79.2%)	18(75.0%)	20(83.3%)	
Type 1	0(0.0%)	0(0.0%)	0(0.0%)	
Type 2	10(20.8%)	6(25.0%)	4(16.7%)	
LUTS, n(%)				0.513
No	44(91.7%)	22(91.7%)	22(91.7%)	
Indwelling urethral catheter	1(2.1%)	0(0.0%)	1(4.2%)	
Suprapubic catheter	0(0.0%)	0(0.0%)	0(0.0%)	
IPSS > 7	3(6.3%)	2(8.3%)	1(4.2%)	
Pre-operative urine culture, n(%)				0.364
Negative	43(89.6%)	22(91.7%)	21(87.5%)	
Asymptomatic bacteriuria	4(8.3%)	1(4.2%)	3(12.5%)	
Symptomatic bacteriuria	1(2.1%)	1(4.2%)	0(0.0%)	
Stone location, n(%)				0.215
Pelvis	19(39.6%)	11(45.8%)	8(33.3%)	
Lower pole	13(27.1%)	4(16.7%)	9(37.5%)	

Gender, n(%)	Total N = 48	Controls N = 24	Cases N = 24	p-value
				0.771
Mid pole	4(8.3%)	3(12.5%)	1(4.2%)	
Upper pole	2(4.2%)	2(8.3%)	0(0.0%)	
Multiple sit	10(20.8%)	4(16.7%)	6(25.0%)	
Previous surgery on same kidney, n(%)				0.491
No	44(91.7%)	23(95.8%)	21(87.5%)	
ESWL	3(6.3%)	1(4.2%)	2(8.3%)	
RIRS	0(0.0%)	0(0.0%)	0(0.0%)	
PCN	1(2.1%)	0(0.0%)	1(4.2%)	
Open surgery	0(0.0%)	0(0.0%)	0(0.0%)	
Ureteral stenosis, n(%)	1(2.1%)	1(4.2%)	0(0.0%)	1.000
Pre-RIRS ureteroscopy, n(%)	28(58.3%)	17(70.8%)	11(45.8%)	0.079
Type of irrigation during surgery, n(%)				< 0.001
None	4(8.3%)	0(0.0%)	4(16.7%)	
Pump	0(0.0%)	0(0.0%)	0(0.0%)	
Intermittent syringe irrigation	32(66.7%)	24(100.0%)	8(33.3%)	
Traxer’s flow	12(25.0%)	0(0.0%)	12(50.0%)	
Stone biochemistry, n(%)				< 0.001
Not performed	18(37.5%)	1(4.2%)	17(70.8%)	
Dihidrate calcium oxalate	0(0.0%)	0(0.0%)	0(0.0%)	
Monohidrate calcium oxalate	0(0.0%)	0(0.0%)	0(0.0%)	
Uric acid	2(4.2%)	2(8.3%)	0(0.0%)	
Cistine	0(0.0%)	0(0.0%)	0(0.0%)	
Struvite	0(0.0%)	0(0.0%)	0(0.0%)	
Calcium phosphate	0(0.0%)	0(0.0%)	0(0.0%)	
NA	28(58.3%)	21(87.5%)	7(29.2%)	

Gender, n(%)	Total N = 48	Controls N = 24	Cases N = 24	p-value
				0.771
Post-operative early clinically relevant infections, n(%)	6(12.5%)	3(12.5%)	3(12.5%)	1.000
All complications according to Clavien-Dindo, n(%)				0.219
None	39(81.3%)	21(87.5%)	18(75.0%)	
1	3(6.3%)	0(0.0%)	3(12.5%)	
2	5(10.4%)	2(8.3%)	3(12.5%)	
3a	0(0.0%)	0(0.0%)	0(0.0%)	
3b	0(0.0%)	0(0.0%)	0(0.0%)	
4a	0(0.0%)	0(0.0%)	0(0.0%)	
4b	1(2.1%)	1(4.2%)	0(0.0%)	
5	0(0.0%)	0(0.0%)	0(0.0%)	
Type of infection, n(%)				0.549
None	42(87.5%)	21(87.5%)	21(87.5%)	
Fever	5(10.4%)	2(8.3%)	3(12.5%)	
Severe sepsis	0(0.0%)	0(0.0%)	0(0.0%)	
Septic shock	1(2.1%)	1(4.2%)	0(0.0%)	
ICU admission	0(0.0%)	0(0.0%)	0(0.0%)	
Death	0(0.0%)	0(0.0%)	0(0.0%)	
NA	0(0.0%)	0(0.0%)	0(0.0%)	
Q-sofa, n(%)				0.491
0	3(6.3%)	2(8.3%)	1(4.2%)	
1	0(0.0%)	0(0.0%)	0(0.0%)	
2	1(2.1%)	1(4.2%)	0(0.0%)	
NA	44(91.7%)	21(87.5%)	23(95.8%)	
Stone related events within 3 months post-op, n(%)	0(0.0%)	0(0.0%)	0(0.0%)	.

Gender, n(%)	Total N = 48	Controls N = 24	Cases N = 24	p-value
				0.771
Stone free, n(%)	39(81.3%)	18(75.0%)	21(87.5%)	0.461
Imaging used to assess stone free state, n(%)				0.199
Ultrasound	39(81.3%)	18(75.0%)	21(87.5%)	
CT	8(16.7%)	6(25.0%)	2(8.3%)	
X-ray KUB	0(0.0%)	0(0.0%)	0(0.0%)	
X-ray + ultrasound	0(0.0%)	0(0.0%)	0(0.0%)	
NA	1(2.1%)	0(0.0%)	1(4.2%)	
Stone free 2 (patients with second follow-up only), n/N(%)	2/6(33.3%)	2/6(33.3%)	–	–

Note. Propensity score matching 1:1 (optimal matching, no caliper) on sex, age, age-adjusted Charlson index, cumulative stone diameter, symptomatic infections within 3 months, number of separate stones and pre-operative stenting; operative time was not included in the model. Continuous variables: Mann-Whitney U test (median[IQR]) or t test (mean ± SD); categorical variables: Chi-square test, or Fisher exact test for 2x2 tables with expected counts < 5. Percentages are calculated on the number of patients in each group. WBC are expressed in x10^3/µL (values harmonized across centers); Hgb drop = pre-operative minus post-operative hemoglobin. Second follow-up was performed only in patients with residual fragments at one month.

In the matched cohort, postoperative WBC did not differ significantly between groups (median 8.0 [IQR 6.0–10.5] vs. 7.7 [6.2–9.5] x10³/µL; p = 0.788), and WBC ≥ 11.4 x10³/µL occurred in 20.8% of FANS patients compared with 16.7% of UAS patients (p = 1.000). Postoperative hemoglobin drop (median 0.5 vs. 0.7 g/dL; p = 0.368), CRP, and PCT also did not differ significantly between groups.

Postoperative complications and clinically relevant infections were comparable between groups in both the overall and matched cohorts. In the matched cohort, early clinically relevant infections occurred in 12.5% of patients in each group (p = 1.000), while the distribution of complications according to the Clavien-Dindo classification did not differ significantly (p = 0.219); any complication occurred in 25.0% of FANS patients and 12.5% of UAS patients (p = 0.461). One episode of septic shock occurred in the UAS group and none in the FANS group in the matched cohort. In the overall cohort, severe sepsis occurred in two FANS patients (1.9%), whereas septic shock occurred in one UAS patient (4.2%), and one FANS patient (0.9%) had a Clavien-Dindo grade IIIa complication (hydronephrosis requiring nephrostomy).

Regarding stone-free status, no significant difference was observed at the first follow-up. In the overall cohort, 84.1% (90/107) of patients in the FANS group and 75.0% (18/24) in the UAS group were stone-free (p = 0.371), and in the matched cohort 87.5% (21/24) versus 75.0% (18/24) (p = 0.461). Three FANS patients (one in the matched cohort) had no follow-up assessment and were counted as not stone-free; among patients with an available follow-up, the stone-free rate in the FANS group was 86.5% (90/104) in the overall cohort (p = 0.209) and 91.3% (21/23) in the matched cohort (p = 0.245). A second follow-up was performed only in patients with residual fragments at one month: it was available for 19 patients in the overall cohort (13 FANS, 6 UAS), of whom 38.5% of FANS and 33.3% of UAS patients were stone-free (p = 1.000). In the matched cohort, the second follow-up was available only for six UAS patients and for no FANS patient, precluding any comparison. Considering stone-free status at the last available follow-up, the cumulative SFR was 88.8% (95/107) in the FANS group and 83.3% (20/24) in the UAS group in the overall cohort (p = 0.493; risk difference 5.5%, 95% CI − 7.0 to 25.2), and 87.5% (21/24) versus 83.3% (20/24) in the matched cohort (p = 1.000; risk difference 4.2%, 95% CI − 16.9 to 25.0). Among patients with an available follow-up, the cumulative SFR in the FANS group was 91.3% in both the overall (95/104; p = 0.264) and the matched cohort (21/23; p = 0.666).

DISCUSSION

Urolithiasis in the elderly is common and increasing in prevalence, with predisposing factors including reduced mobility, inadequate fluid intake, and dietary habits [10, 11]

Complication rates after intrarenal surgery also increase with age, reaching 42.1% in patients ≥ 75 years versus 17.8% in those aged 60–74 [2].

To minimize complications and enhance stone-free rates (SFR), EAU guidelines support conventional UAS [5], while evidence specifically regarding suction-enabled devices remains limited.

Early non-flexible suction (SUAS) models showed disappointing results due to inadequate fragment aspiration, related to the distance between sheath and stone and difficulty reaching the pyeloureteral junction [7]. FANS addressed these limitations through an omnidirectional flexible tip, enabling calyceal exploration and real-time fragment suction, with a reported learning curve of only two cases [8]. By maintaining low IRP, FANS may reduce pyelovenous, pyelolymphatic, and pyelotubular reflux [6], and initial series have reported lower fever rates, reduced procalcitonin, and single-session SFR up to 94% [7, 12].

In this retrospective study, we assessed the safety and efficacy of FANS-assisted RIRS in patients aged ≥ 60 years.

Regarding safety, no complications were observed during FANS placement. Preoperative semirigid ureteroscopy was performed in 40.6% of FANS patients (43/106 with available data), which may further reduce the risk of access-related complications [13].

Median operative time (OT) in the FANS group was 60 minutes (IQR 50–77.3), consistent with values reported in the literature [14]. In the unadjusted comparison, OT and stone clearance time were significantly shorter with FANS than with traditional UAS (median OT 60 vs. 77.5 minutes, p = 0.001; Hodges-Lehmann shift − 15.0 minutes, 95% CI − 25.0 to − 10.0). The difference was in the same direction after propensity score matching (60 vs. 77.5 minutes; shift − 10.0 minutes, 95% CI − 20.0 to 0.0) but did not reach statistical significance (p = 0.059), possibly because of the smaller sample. A shorter OT may be explained by the better visibility due to reduced “snowball effect” of stone dust and fragments that continuous suction allows and less need for basket retrieval of fragments; however, we did not measure these variables, and the difference may also reflect differences between the groups in period, center, stone size and irrigation. Reducing OT is relevant, since prolonged surgical duration is positively correlated with an increased risk of severe adverse events [15].

The overall complication rate in the FANS group (14.0%, 15/107) was similar to the 11.5% reported by Zhu et al. [17]. Compared with Deng et al. [16], Clavien I complications were less frequent in our series (3.7% vs. 14%), whereas Clavien II complications were more frequent (9.3% vs. 2%); one Clavien IIIa event (0.9%) occurred in the FANS group, and there were no Clavien IV–V events. As for infectious complications, two FANS patients (1.9%) developed severe sepsis, compared with urosepsis in 1.8% of the patients of Zhu et al. [17]; in the UAS group, one patient (4.2%) developed septic shock.

Aforementioned studies on RIRS have focused on the general population, with limited research comparing outcomes between younger and older patients. Among the few available studies, Gockcen et al. [12] reported higher complication rates (11.6%) and an increased need for additional interventions (18.6%) in older patients. In contrast, Berardinelli et al. [18] found no significant differences in perioperative outcomes—such as stone-free rate, operative time, and re-intervention rate—between patients younger and older than 65 years. Furthermore, both surgical and medical complication rates were comparable between age groups. Their findings suggest that age alone should not be considered an independent risk factor for complications in patients undergoing RIRS for renal stones.

An additional advantage of the FANS is excellent visualization reported by surgeons, along with the reduction of the “snowball effect” due to continuous suction, minimizing the need for manual irrigation, which was avoided in 13.1% of FANS surgeries. Manual irrigation, particularly when performed by inexperienced assistants, can lead to elevated intrarenal pressure (IRP), increasing the risk of sepsis and other severe complications [19].

SFR outcomes vary in the literature due to differing definitions and follow-up protocols: Deng et al. [16] reported 90.0–95.6% (with 4% requiring further intervention for fragments >4mm), Huang et al. [20] reported 87.5% immediate and 97.4% one-month SFR, and Gao et al. [21] found SFR > 87% for Guy Stone Score I versus < 80% for GSS ≥ II. Our findings are broadly consistent with these findings, with a one-month SFR of 84.1% in the FANS group (86.5% among patients with an available follow-up), reaching 88.8% (91.3%, respectively) at the last available follow-up.

Notably, 29% of stones in the FANS group were located in the lower pole, compared to 16.7% in the control group (not statistically significant). Together with the observed stone-free rate, this is compatible with good navigability of FANS in the lower pole, a site where clearance of dust and stone fragments is often poor; however, we did not analyze stone-free rates by stone location, and the study was not designed to test this.

STRENGTHS AND LIMITATIONS

First of all, ours is one of the few studies specifically evaluating results and complications of RIRS in the elderly. In addition, to our knowledge, this is the only study to assess safety and efficacy of FANS in this specific subset of patients.

First and main limitation of our study is the small number of patients, particularly in the control group (n = 24), which limits statistical power and results in wide confidence intervals. Non-significant differences, such as those in stone-free rates, should therefore not be interpreted as evidence of equivalence between the two devices. Second limitation, shared with most of the literature on urinary stones, is lack of a universally accepted definition of “stone free” and protocols for urinary stones follow-up.

Third, intrarenal pressure (IRP) was not directly measured in this study; therefore, the clinical outcomes reported here should be interpreted as indirect evidence of IRP-related benefits rather than direct confirmation. Fourth, controls were patients treated before FANS became available, so group allocation is partly confounded by period and center (for example, all UAS patients were irrigated with intermittent syringe irrigation), which propensity score matching could not fully address. Fifth, a second follow-up was available only for patients with residual fragments (19 patients overall), so stone-free status after the first follow-up could not be meaningfully compared between groups. Sixth, despite matching, some imbalances persisted for variables not included in the propensity model, such as laterality, ureteropelvic junction obstruction and type of irrigation. Stone density (HU) was available for only 36 of the 107 FANS patients (66% missing), so it could not be used in the propensity model and its comparison should be interpreted with caution. Seventh, three patients in the FANS group (2.8%) had no follow-up assessment and were counted as not stone-free in the main analysis, which may underestimate the stone-free rate. Eighth, failure of access sheath placement was an exclusion criterion, and patients excluded by the eligibility criteria before enrolment were not recorded; the results therefore refer only to patients in whom the access sheath could be positioned, and selection bias cannot be excluded. Finally, the results derive from two centers of the same region and from patients aged ≥ 60 years, and may not be generalizable to other settings or to younger patients.

CONCLUSIONS

To our knowledge, this is the first study to evaluate FANS in elderly patients. In this retrospective two-center series, no Clavien-Dindo grade IV–V complications were observed in patients managed with FANS, and the cumulative stone-free rate (SFR) was 88.8% at the last available follow-up, without

significant differences compared with traditional UAS, including in the propensity-matched cohort. The shorter operative time observed with FANS in the overall cohort was not confirmed after matching (p = 0.059).

In conclusion, FANS appears to be a feasible option with an acceptable safety profile in patients aged ≥ 60 years. Given the small control group, the retrospective design and the confounding by period and center, these findings are preliminary and need confirmation in larger prospective comparative studies.

Declarations

Author Contribution

Conceptualization: Agostini E., Dellabella M.; Methodology: Di Rosa M.; Formal analysis and investigation: Di Rosa M., Agostini E., Piergallini N., Milanese G.; Writing - original draft preparation: Agostini E., Milanese G.; Writing - review and editing: Agostini E., Di Rosa M., Milanese G., Dellabella M.; Funding acquisition: not applicable; Resources: Piergallini N.; Supervision: Agostini E., Dellabella M., Di Rosa M.

References

1. Hamidi M, Joseph B (2019) Changing epidemiology of the American population. Clin Geriatr Med 35:1–12. https://doi.org/10.1016/j.cger.2018.08.001
2. Koras O, Bozkurt IH, Karakoyunlu AN, Polat S, Yarimoglu S, Degirmenci T (2021) Safety and efficacy of flexible ureterorenoscopy surgery in different age groups. J Coll Physicians Surg Pak 31:679–685. https://doi.org/10.29271/jcpsp.2021.06.679
3. Prattley S, Voss J, Cheung S, Geraghty R, Jones P, Somani BK (2018) Ureteroscopy and stone treatment in the elderly (≥ 70 years): prospective outcomes over 5 years with a review of literature. Int Braz J Urol 44:750–757. https://doi.org/10.1590/s1677-5538.ibju.2017.0516
4. Stern JM, Yiee J, Park S (2007) Safety and efficacy of ureteral access sheaths. J Endourol 21:119–123. https://doi.org/10.1089/end.2007.9997
5. Geraghty RM, Davis NF, Tzelves L et al (2023) Best practice in interventional management of urolithiasis: an update from the European Association of Urology Guidelines Panel for Urolithiasis 2022. Eur Urol Focus 9:199–208. https://doi.org/10.1016/j.euf.2022.06.014
6. Croghan SM, Skolarikos A, Jack GS et al (2023) Upper urinary tract pressures in endourology: a systematic review of range, variables and implications. BJU Int 131:267–279. https://doi.org/10.1111/bju.15764
7. Ding J, Su T, Zhang X et al (2023) Omnidirectional (flexible) ureteral access sheath: safety, efficacy, and initial experience report. J Endourol 37:1184–1190. https://doi.org/10.1089/end.2023.0358
8. Gauhar V, Traxer O, Castellani D et al (2023) A feasibility study on clinical utility, efficacy and limitations of 2 types of flexible and navigable suction ureteral access sheaths in retrograde

intrarenal surgery for renal stones. Urology 178:173–179. https://doi.org/10.1016/j.urology.2023.05.032

9. Gauhar V, Traxer O, Castellani D et al (2024) 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. https://doi.org/10.1016/j.euf.2024.05.010. Eur Urol Focus
10. Trinchieri A (2008) Epidemiology of urolithiasis: an update. Clin Cases Min Bone Metab 5:101–106
11. Moudi E, Hosseini SR, Bijani A (2017) Nephrolithiasis in elderly population; effect of demographic characteristics. J Nephropathol 6:63–68. https://doi.org/10.15171/jnp.2017.11
12. Gokcen K, Dundar G, Bagcioglu M, Karagoz MA, Gokce G, Sarica K (2019) Safety and efficacy of RIRS in geriatric patients: a comparative evaluation on an age based manner. Urol J. https://doi.org/10.22037/uj.v0i0.4921
13. Boulalas I, De Dominicis M, Defidio L (2018) Semirigid ureteroscopy prior retrograde intrarenal surgery (RIRS) helps to select the right ureteral access sheath. Arch Ital Urol Androl 90:20. https://doi.org/10.4081/aiua.2018.1.20
14. Solano C, Chicaud M, Kutchukian S et al (2023) Optimizing outcomes in flexible ureteroscopy: a narrative review of suction techniques. J Clin Med 12:2815. https://doi.org/10.3390/jcm12082815
15. Sugihara T, Yasunaga H, Horiguchi H et al (2013) A nomogram predicting severe adverse events after ureteroscopic lithotripsy: 12 372 patients in a Japanese national series. BJU Int 111:459–466. https://doi.org/10.1111/j.1464-410X.2012.11594.x
16. Deng X, Song L, Xie D et al (2016) A novel flexible ureteroscopy with intelligent control of renal pelvic pressure: an initial experience of 93 cases. J Endourol 30:1067–1072. https://doi.org/10.1089/end.2015.0770
17. Zhu Z, Cui Y, Zeng F, Li Y, Chen Z, Hequn C (2019) Comparison of suctioning and traditional ureteral access sheath during flexible ureteroscopy in the treatment of renal stones. World J Urol 37:921–929. https://doi.org/10.1007/s00345-018-2455-8
18. Berardinelli F, De Francesco P, Marchioni M et al (2017) RIRS in the elderly: is it feasible and safe? Int J Surg 42:147–151. https://doi.org/10.1016/j.ijsu.2017.04.062
19. Corrales M, Sierra A, Doizi S, Traxer O (2022) Risk of sepsis in retrograde intrarenal surgery: a systematic review of the literature. Eur Urol Open Sci 44:84–91. https://doi.org/10.1016/j.euros.2022.08.008
20. Huang J, Xie D, Xiong R et al (2018) The application of suctioning flexible ureteroscopy with intelligent pressure control in treating upper urinary tract calculi on patients with a solitary kidney. Urology 111:44–47. https://doi.org/10.1016/j.urology.2017.07.042
21. Gao X, Zhang Z, Li X et al (2022) High stone-free rate immediately after suctioning flexible ureteroscopy with intelligent pressure-control in treating upper urinary tract calculi. BMC Urol 22:180. https://doi.org/10.1186/s12894-022-01126-0

Figures

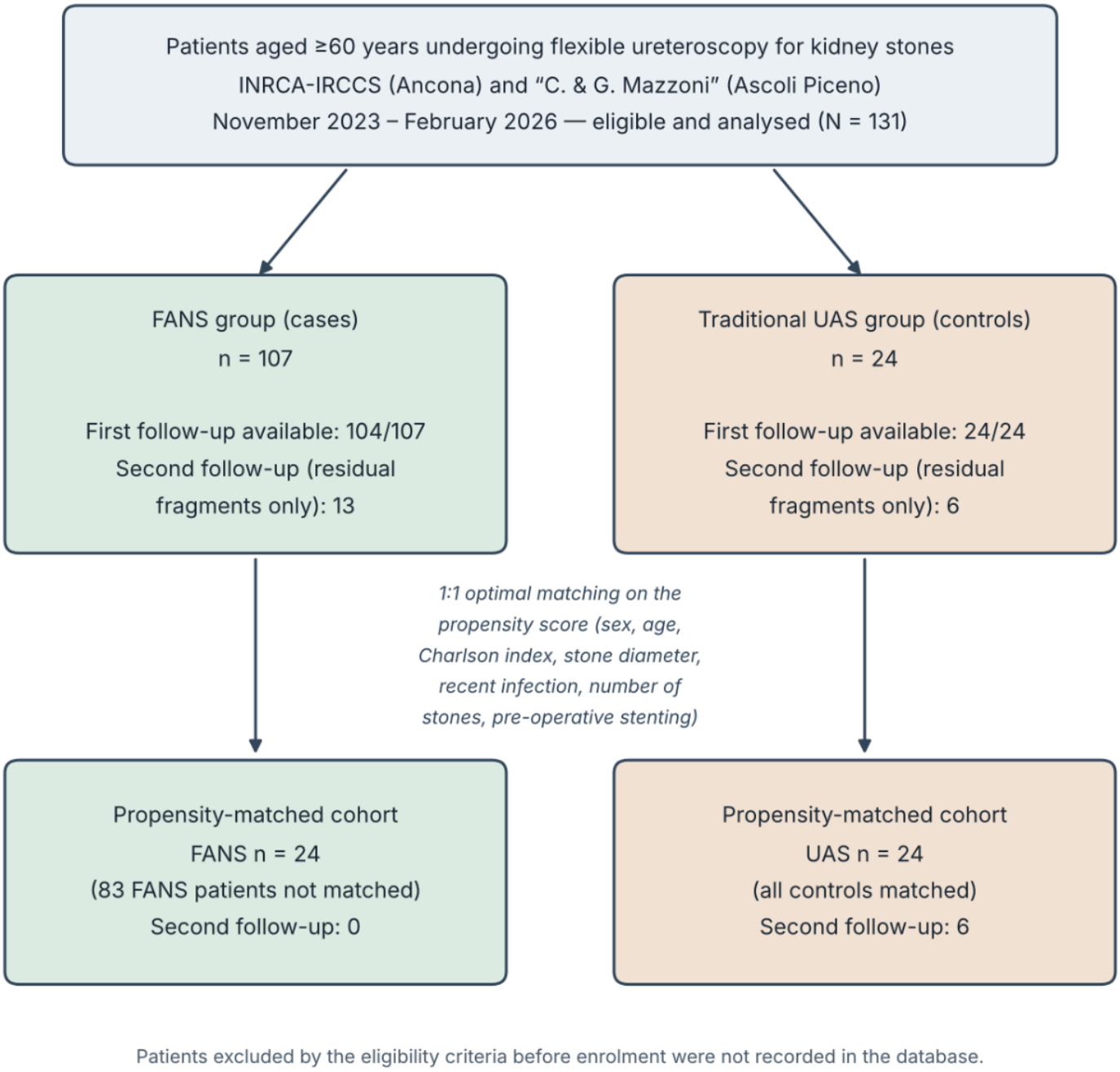

Figure 1

Flow diagram of the patients included in the study. FANS, flexible and navigable suction ureteral access sheath; UAS, traditional ureteral access sheath. Patients excluded by the eligibility criteria before enrolment were not recorded in the database.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- SupplementaryTables.docx