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Patency and functional outcomes of endovascular treatment in juxta-anastomotic venous stenosis of native arteriovenous fistulas

Permeabilidad y resultados funcionales del tratamiento endovascular en la estenosis venosa yuxta-anastomótica de fístulas arteriovenosas nativas

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ABSTRACT

Introduction: Juxta-anastomotic venous stenosis is a frequent cause of dysfunction in native arteriovenous fistula (AVFs), compromising both maturation and long-term patency. Endovascular treatment has emerged as a minimally invasive alternative to surgical revision. We evaluated short-term patency and functionality outcomes and temporal patterns following endovascular treatment of juxta-anastomotic venous stenosis.
Materials and methods: We conducted a retrospective single-center observational study including adult patients with native AVFs who underwent endovascular treatment for juxta-anastomotic venous stenosis between January 2020, and June 2024. Analyses were performed at the patient level using the first (index) intervention. Assisted primary patency was assessed using Kaplan–Meier survival analysis. Exploratory associations with 6-month failure were evaluated using penalized logistic regression.
Results: Fifty patients were included. Median age was 72 years [IQR: 65–76], and 72% of patients were male, with a high burden of cardiovascular comorbidity. At intervention, 72% were on hemodialysis and 28% were followed in advanced chronic kidney disease (ACKD). Delayed AVF maturation accounted for 46% of cases. The median time from AVF creation to stenosis detection was 112.5 days (IQR 60.5–511), indicating heterogeneous temporal presentation. Stenosis was detected significantly earlier in AVFs treated for delayed maturation compared with established accesses (median 68.5 vs 388.5 days; $p = 0.001$). Conventional balloon angioplasty was performed in 98% of index procedures, with selective use of cutting balloons and drug-coated balloons. During 6-months of follow-up, 8 access failures occurred. Kaplan–Meier estimates of assisted primary patency were 90% at 90 days (95% CI 0.78–0.96) and 84% at 180 days (95% CI 0.71–0.92). Functional success at 6-months was 90% of patients.
Conclusions: In this single-center retrospective cohort, endovascular treatment was associated with high short-term assisted primary patency and functional success. These results represent real-world descriptive data and require confirmation in prospective studies with longer follow-up and comparative designs.

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Palabras clave:
Fístula arteriovenosa
Estenosis venosa yuxta-anastomótica
Tratamiento endovascular
Enfermedad renal crónica avanzada
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RESUMEN

Introducción: La estenosis venosa yuxta-anastomótica es una causa frecuente de disfunción en las fístulas arteriovenosas (FAV) nativas, comprometiendo tanto la maduración como la permeabilidad a largo plazo. El tratamiento endovascular ha surgido como una alternativa mínimamente invasiva frente a la revisión quirúrgica. Evaluamos los resultados de permeabilidad y funcionalidad a corto plazo, así como los patrones temporales, tras el tratamiento endovascular de la estenosis venosa yuxtaanastomótica.

Materiales y métodos: Realizamos un estudio observacional retrospectivo unicéntrico que incluyó pacientes adultos con FAV nativas sometidos a tratamiento endovascular por estenosis venosa yuxta-anastomótica entre enero de 2020 y junio de 2024. Los análisis se realizaron a nivel de paciente utilizando la primera (índice) intervención. La permeabilidad primaria asistida se evaluó mediante análisis de supervivencia de Kaplan-Meier. Las asociaciones exploratorias con el fracaso a 6 meses se evaluaron mediante regresión logística penalizada.

Resultados: Se incluyeron 50 pacientes. La mediana de edad fue de 72 años [IQR: 65–76], y el 72% eran varones, con una elevada carga de comorbilidad cardiovascular. En el momento de la intervención, el 72% estaban en hemodiálisis y el 28% en seguimiento en consultas de enfermedad renal crónica avanzada (ERCA). El retraso en la maduración de la FAV representó el 46% de los casos. La mediana de tiempo desde la creación de la FAV hasta la detección de la estenosis fue de 112,5 días (IQR 60,5-511), lo que indica una presentación temporal heterogénea. La estenosis se detectó significativamente antes en las FAV tratadas por retraso de maduración en comparación con los accesos ya establecidos (mediana 68,5 vs 388,5 días; p = 0,001). La angioplastia con balón convencional se realizó en el 98% de los procedimientos índice, con uso selectivo de balones de corte y balones recubiertos de fármaco. Durante 6 meses de seguimiento, se produjeron 8 fracasos del acceso. Las estimaciones de Kaplan-Meier de la permeabilidad primaria asistida fueron del 90% a los 90 días (IC 95% 0,78-0,96) y del 84% a los 180 días (IC 95% 0,71-0,92). El éxito funcional a los 6 meses fue del 90% de los pacientes.

Conclusiones: En esta cohorte retrospectiva unicéntrica, el tratamiento endovascular se asoció con una elevada permeabilidad primaria asistida a corto plazo y con un alto éxito funcional. Estos resultados representan datos descriptivos de práctica real y requieren confirmación en estudios prospectivos con mayor seguimiento y diseños comparativos.

Introduction

Native arteriovenous fistulas (AVFs) are considered the vascular access of choice for hemodialysis patients for their superior durability and lower rate of infectious complications than central venous catheters and grafts.[1] However, AVF dysfunction remains a significant clinical challenge, with juxta-anastomotic venous stenosis emerging as one of the leading causes of this issue.[2]

Juxta-anastomotic venous stenosis is typically located within the first 5 cm of the arteriovenous anastomosis.[3] This lesion accounts for a considerable proportion of early AVF dysfunction,[4] affecting both maturation and long-term patency. The etiology of these stenoses is multifactorial, involving hemodynamic factors that induce vascular wall stress and promote intimal hyperplasia.[2,5,6] The presence of juxta-anastomotic venous stenosis can lead to reduced blood flow through the AVF, resulting in ineffective hemodialysis sessions and an increased risk of access thrombosis.[7] Additionally, these complications increase morbidity and healthcare costs related to repeated interventions and increase of hospitalizations.[8,9]

The management of juxta-anastomotic venous stenosis has been a subject of debate, with treatment options including surgical interventions and endovascular therapies. Traditionally, surgical correction by creating a new proximal anastomosis has been the preferred approach.[10–12] However, in recent decades, endovascular interventions, such as percutaneous transluminal angioplasty (PTA), have gained prominence for their minimally invasive nature and the ability to be repeated as needed.[13–15]

Despite the multiple therapeutic options available, the optimal treatment for juxta-anastomotic venous stenosis remains controversial. This study aimed to describe short-term assisted primary patency and functional outcomes at six months following endovascular treatment of juxta-anastomotic venous stenosis in a real-world clinical setting. Particular attention was given to the temporal presentation of stenosis and to outcomes in fistulas undergoing intervention for delayed maturation, as these scenarios are highly relevant in advanced chronic kidney disease (ACKD) programs aiming to avoid catheter-dependent dialysis initiation.

Material and methods

Study design and setting

This was a single-center, retrospective observational study conducted at a tertiary care center. We included adult patients who underwent endovascular treatment for juxta-anastomotic venous stenosis of AVFs between January 1, 2020, and June 30, 2024.

Participants

Eligible patients had AVFs, either in use or in the maturation process, with a diagnosis of juxta-anastomotic venous stenosis confirmed by Doppler ultrasound or angiography.

In our institution, systematic preoperative vascular ultrasound mapping is routinely performed prior to native AVF creation, in accordance with national and international vascular access guidelines. Preoperative assessment includes evaluation of arterial and venous diameter, vessel patency, and anatomical suitability.

Exclusion criteria were stenosis located outside the juxta-anastomotic segment, non-recanalizable complete thrombosis, or a prior endovascular intervention at the same anatomical site within the previous 3 months. All procedures were performed as part of routine clinical care, following standard interventional radiology protocols.

Variables and definitions

Juxta-anastomotic venous stenosis was defined as a stenosis located within the area extending from the anastomosis up to 5 cm post-anastomosis.

Indication for intervention and reintervention

The indication for endovascular treatment was primarily based on clinical criteria of access dysfunction, including inadequate dialysis parameters (reduced blood flow or elevated venous pressures), cannulation difficulties, prolonged bleeding after needle withdrawal, or failure of AVF maturation. These findings were systematically confirmed by Doppler ultrasound demonstrating hemodynamically significant juxta-anastomotic stenosis, defined as a luminal reduction ≥50% associated with flow alterations or increased peak systolic velocities. When angiography was performed, a stenosis ≥50% was considered significant. Reintervention was indicated in the presence of recurrent clinical dysfunction confirmed by imaging using the same criteria.

Primary outcomes were:

- Assisted primary patency at 6 months, defined as the time from the index intervention to reintervention for access dysfunction.
- Functional success, defined as adequate use of the AVF for hemodialysis without the need for additional procedures at 6 months.
- Recurrence, defined as reappearance of stenosis at the same location requiring reintervention.

Definitions were aligned with commonly used vascular access reporting standards. In this study, assisted primary patency was operationalized as time from the index endovascular intervention to first reintervention for access dysfunction, allowing maintenance procedures while the access remained functional.

Additional variables included age, sex, body mass index, comorbidities (hypertension, diabetes, dyslipidaemia, ischemic heart disease, atrial fibrillation, cerebrovascular and peripheral artery disease), AVF characteristics (location, maturation status), pharmacological treatment (antiplatelets, anticoagulants), and type of angioplasty balloon used.

All procedures were performed by interventional radiologists under fluoroscopic guidance. Vascular access was obtained through ultrasound-guided retrograde puncture of the venous segment distal to the stenosis or, in selected cases, via retrograde arterial access. A diagnostic angiography was then performed with contrast injection to determine the location and severity of the stenosis. Angioplasty was conducted using conventional balloons, cutting balloons and drug-coated balloons (DCB) according to the operator's clinical judgment. The choice of balloon type was based on lesion characteristics and prior restenosis history. As a post-angioplasty control, a follow-up angiography was performed to verify stenosis resolution. Technical success was defined as a reduction of the stenotic lumen to less than 30% of the post-intervention vessel diameter.

Data sources and management

Clinical and procedural data were collected from the hospital's electronic medical record system, and the database of the interventional radiology and nephrology services. Data were anonymized and managed in accordance with institutional data protection policies.

Statistical analysis

Analyses were performed at the patient level using the first (index) endovascular procedure per patient in order to avoid within-patient correlation from repeated interventions. Assisted primary patency was defined as the time from the index intervention to the first reintervention for access dysfunction. Patients without reintervention were censored at 6 months or at last follow-up. Time-to-event analysis was conducted using Kaplan–Meier survival estimates, with patency reported at 90 and 180 days along with 95% confidence intervals (CI).

Given the anticipated low number of events, conventional Cox proportional hazards regression could be affected by small-sample bias or complete separation. Therefore, associations with 6-month failure were planned to be evaluated using penalized logistic regression (Firth method), which allows stable estimation in the presence of sparse data. These analyses were considered exploratory.

Categorical variables were compared using Fisher's exact test when appropriate due to small cell counts. A two-sided p-value < 0.05 was considered statistically significant. Analyses were performed using Stata 17 (Stata-Corp, College Station, TX, USA). No formal sample size calculation was performed, and the study was not powered to detect independent predictors of failure.

Ethical considerations

The study was approved by the Institutional Ethics Committee of Vall d'Hebron University Hospital, with a waiver of informed consent due to its retrospective nature. The study adhered to the principles of the Declaration of Helsinki and local data protection regulations.

Results

Baseline characteristics of the study population

Fifty patients were included in the analysis after restricting the cohort to the first (index) endovascular intervention per patient. Median age was 72 years [IQR 65–76], and 72% of patients were older than 65 years. Most patients were male (72%). Cardiovascular comorbidity was highly prevalent including hypertension (100%), diabetes mellitus (50%), dyslipidemia (62%), ischemic heart disease (38%), and atrial fibrillation (32%). Additionally, 24% had a history of cerebrovascular disease, and 20% had peripheral artery disease. The etiology of chronic kidney disease (CKD) was undetermined in 52%, diabetes in 16%, glomerulonephritis in 10%, vascular in 8%, vasculitis in 6%, and polycystic kidney disease in 4% and other causes in 4%. Antiplatelet therapy was prescribed in 54% of patients and oral anticoagulation in 30% (Table 1).

Clinical status and vascular access characteristics

At the time of intervention, 36 patients (72%) were receiving hemodialysis and 14 (28%) were followed in ACKD clinics. Delayed AVF maturation was observed in 46% of cases and required endovascular intervention to restore function. In all cases with delayed maturation the procedure enabled subsequent functional use of the AVFs for hemodialysis. Additionally, 8% of patients had a history of kidney transplantation.

AVF types included 46% radio-cephalic, 10% brachial-cephalic, 42% brachio-basilic, and 2% humeral-axillary. The median time from AVF creation to stenosis detection was 112.5 days (IQR 60.5–511). In patients undergoing intervention for delayed AVF maturation, stenosis was detected significantly earlier compared with those with established access (median 68.5 [IQR 56–113] vs 388.5 [105–877] days; Wilcoxon $p = 0.001$).

Endovascular treatment and assisted primary patency

The most frequently used revascularization strategy was conventional balloon angioplasty, performed in 98% of cases. Cutting balloons were used in 18% of patients, and DCB in 4%. No stents were used. During the 6-month follow-up, 8 access failures occurred. Kaplan–Meier estimates of assisted primary patency were 90% at 90 days (95% CI 0.78–0.96) and 84% at 180 days (95% CI 0.71–0.92) (Fig. 1). At 6 months, 42 of 50 patients maintained assisted primary patency. Functional success at 6 months was achieved in 45 patients (90%). Stenosis recurrence was observed in 4 patients (8%). The need for more than one endovascular intervention was documented in

Table 1
Baseline characteristics of patients with juxta-anastomotic venous stenosis.

Variables	$n = 50$
Age, years (median [IQR])	72 (65–76)
Age >65 years, *n* (%)	36 (72)
Sex male, *n* (%)	36 (72)
BMI, kg/m^2 (median [IQR])	26.0 (23.7–29.6)
Hypertension, *n* (%)	50 (100)
DM, *n* (%)	25 (50)
Dyslipidemia	31 (62)
Ischemic heart disease, %	19 (38)
Atrial fibrillation, %	16 (32)
Etiology of CKD (unknown/DM/GN/vascular/vasculitis/ADPKD/other), *n* (%)	26(52)/8(16)/5(10)/4(8)/3(6)/2(4)/2(4)
Stroke, %	12 (24)
Peripheral arteriopathy, *n* (%)	10 (20)
Patient status (ACKD/HD), *n* (%)	14(28)/36(72)
Previous kidney transplant, *n* (%)	4 (8)
Antiplatelet use, %	27 (54)
Anticoagulants use, %	15 (30)
Type of AVFs (RC/BC/BB/AH), *n* (%)	23 (46)/5(10)/21(42)/1(2)
Maturation delay *n* (%)	23 (46)
Angioplasty conventional, *n* (%)	49 (98)
Cutting balloons, *n* (%)	9 (18)
Drug-coated balloons, *n* (%)	2 (4)
Assisted primary at 6 months, *n* (%)	42 (84)
Functional success at 6 months, *n* (%)	45 (90)
Recurrence, *n* (%)	4 (8)
Time to recurrence, days	157 (95–180)

Values are expressed as median (IQR) or *n* (%). BMI: body mass index; CKD: chronic kidney disease; DM: diabetes mellitus; GN: glomerulopathy; ADPKD: polycystic kidney disease; ACKD: advanced chronic kidney disease; HD: hemodialysis; KT: kidney transplant; RC: radio-cephalic; BC: brachial-cephalic; BB: brachio-basilic; AH: humeral axillary.

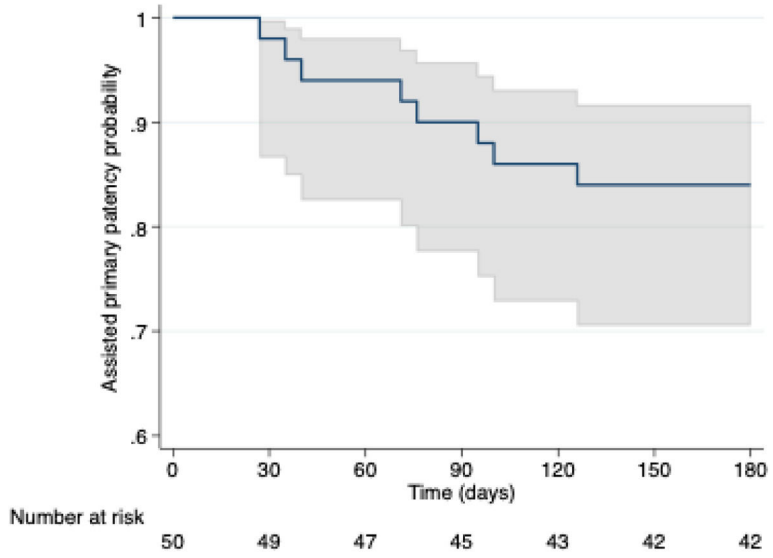

Fig. 1. Kaplan–Meier curve showing assisted primary patency after endovascular treatment of juxta-anastomotic venous stenosis ($n = 50$). Shaded areas represent 95% confidence intervals.

6 AVFs (12%), with a median time to second recurrence of 157 days (IQR 95–180). All observed failures occurred in patients older than 65 years and among those receiving antiplatelet therapy. Given the small number of events, this distribution likely reflects sparse-data strata and should be interpreted descriptively.

Exploratory analysis of 6-month failure

Penalized logistic regression (Firth method) was performed as an exploratory analysis. In the multivariable model, antiplatelet therapy was associated with higher odds of 6-month failure (OR 18.1; 95% CI 0.97–337.32; $p = 0.052$). Age >65 years showed a non-significant association with failure (OR 7.9; 95% CI 0.37–166.26; $p = 0.185$), and AVF type was not associated with outcome (OR 1.00; 95% CI 0.65–1.53; $p = 0.990$).

Subgroup analysis according to maturation status

A subgroup analysis was performed comparing patients undergoing intervention for delayed AVF maturation ($n = 23$) versus those with established hemodialysis access ($n = 27$). Baseline characteristics were largely comparable between groups, although differences were observed in patient status (HD vs. ACKD) and time from AVF creation to stenosis detection (Table 2). At 6 months, assisted primary patency did not significantly differ between groups (log-rank $p = 0.27$) (Fig. 2). Recurrence occurred in 4.3% of patients in the delayed maturation group compared with 11.1% in those with established access. Functional success was achieved in 20 out of 23 patients (87%) undergoing intervention for delayed maturation. These findings should be interpreted in light of the limited sample size and short follow-up.

Table 2
Comparison between fistulas treated for delayed maturation and established accesses.

Variable	Established access (n = 27)	Delayed maturation (n = 23)	p value
Age, years (median [IQR])	69.4 (58.3–76.3)	72.0 (67.0–77.4)	0.31
Male sex, n (%)	20 (74%)	16 (70%)	0.86
Diabetes mellitus, n (%)	10 (37%)	15 (65%)	0.088
Antiplatelet therapy, n (%)	14 (52%)	13 (57%)	0.78
Patient status (HD), n (%)	22 (81%)	14 (61%)	0.042
Time creation stenosis, days (median [IQR])	388.5 (105–877)	68.5 (56–113)	0.001
Assisted primary patency at 6 months, n (%)	24 (89%)	18 (78%)	0.44
Functional success at 6 months, n (%)	25 (93%)	20 (87%)	0.65
Recurrence, n (%)	3 (11%)	1 (4%)	0.61

Values are expressed as median (interquartile range) or n (%). Continuous variables were compared using the Mann–Whitney U test and categorical variables using Fisher's exact test. IQR: interquartile range; HD: hemodialysis.

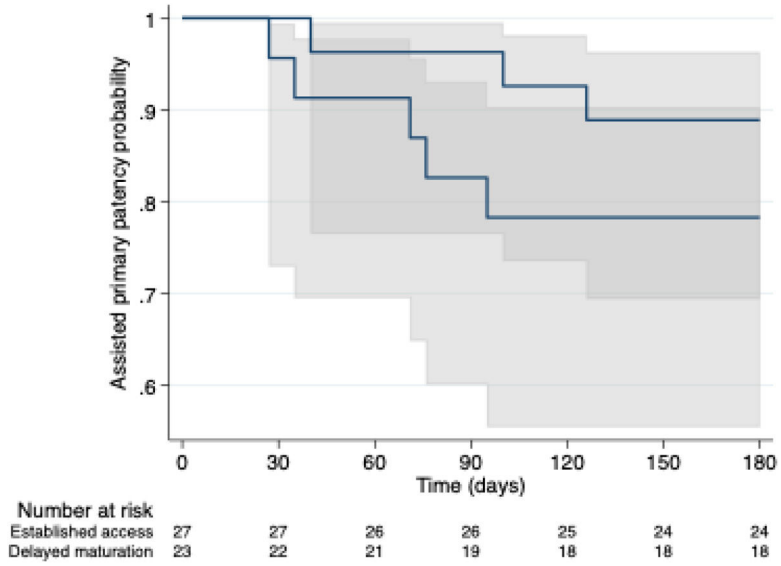

Fig. 2. Kaplan–Meier curves showing assisted primary patency following the index endovascular intervention, stratified by fistula maturation status (delayed maturation vs established access). Shaded areas indicate 95% confidence intervals. Comparison between groups was performed using the log-rank test (p = 0.27).

Discussion

Juxta-anastomotic venous stenosis in AVFs is a common cause of vascular access dysfunction in hemodialysis patients.[2,16] In this retrospective single-center cohort, endovascular treatment achieved favorable short-term outcomes, with assisted primary patency rate of 90% at 90 days and 84% at 6-months, together with a functional success rate of 90%. These findings are consistent with previous studies supporting PTA as an effective intervention to preserve AVF functionality and maintain access patency.[15,17]

The median time from AVF creation to stenosis detection was 112.5 days (IQR 60.5–511), underscoring the marked temporal heterogeneity of juxta-anastomotic lesions. As expected, stenosis was identified significantly earlier in AVFs undergoing intervention for delayed maturation compared with established accesses. As shown in Table 2, apart from this marked temporal difference, baseline characteristics and short-term outcomes were largely comparable between groups, although differences were observed in patient status (HD vs. ACKD) and time from AVF creation to stenosis detection. These findings suggest that early flow-limiting lesions during the maturation phase may reflect a different temporal presentation pattern, while short-term patency and functional success after intervention remain similar across maturation status.

The observed 6-month recurrence rate of 8% suggests that endovascular management of juxta-anastomotic lesions provides reasonable durability in this anatomical segment. Although most procedures in our cohort were performed using conventional balloons, adjunctive use of cutting balloons and DCB was reserved for selected cases based on lesion characteristics. Recent meta-analysis has suggested that DCB angioplasty may improve patency compared with conventional balloons in AVF stenosis.[18,19] However, their use in our cohort was limited, preventing a direct comparison within our study context.

All observed failures occurred in patients older than 65 years and among those receiving antiplatelet therapy. However, due to the limited number of events (n = 8) and the presence of complete separation, conventional Cox proportional hazards models yielded non-estimable hazard ratios. To address this limitation, we performed penalized logistic regression (Firth method) as an exploratory analysis. Although antiplatelet therapy showed a possible association with 6-month failure (OR 18.1; 95% CI 0.97–337.32), the wide confidence intervals indicate substantial statistical uncertainty. Age $>$65 years was not independently associated with failure in penalized models. Therefore, these findings should be interpreted cautiously and regarded as exploratory.

The clustering of events among patients receiving antiplatelet therapy may reflect confounding by indication. Individuals prescribed antiplatelet agents generally have a higher burden of cardiovascular comorbidity, which itself may predispose to vascular access dysfunction. The literature regarding the role of antiplatelet therapy in AVF patency remains inconclusive.[20,21] While some studies suggest a potential benefit in reducing thrombosis, others report no significant

improvement in long-term patency and raise concerns regarding bleeding risk. Our study was not designed nor powered to clarify this relationship, and no causal inference can be established. Similarly, although advanced age has been described as a potential risk factor for vascular access dysfunction,[17] the limited number of events in our cohort precludes definitive conclusions.

From a clinical perspective, our finding supports endovascular therapy as a widely used first-line approach in current clinical practice. In a population characterized by advanced age and substantial cardiovascular comorbidity, percutaneous transluminal angioplasty provided high short-term patency while preserving native vascular capital and facilitating assisted maturation when required. These results are particularly relevant in advanced CKD programs, where timely access optimization may prevent unplanned dialysis initiation with central venous catheters. The minimally invasive and repeatable nature of endovascular intervention makes it especially suitable in nephrology practice, where the balance between durability, safety, and preservation of future access options is critical.

Several limitations must be acknowledged. First, the retrospective and single-center design limits external validity and may introduce selection bias. Moreover, the absence of a comparator group – either surgical or between different endovascular strategies – precludes any inference regarding comparative effectiveness. Therefore, our findings should be interpreted as descriptive of real-world outcomes rather than as evidence of superiority of endovascular treatment over alternative approaches. Second, the modest sample size and low number of events ($n = 8$) restrict the robustness of multivariable analyses and increase statistical imprecision. Although penalized logistic regression was used to mitigate small-sample bias and separation, the resulting confidence intervals were wide, and any observed associations should be considered exploratory and hypothesis-generating. Third, potential confounding by indication cannot be excluded, particularly in relation to antiplatelet therapy. Patients receiving antiplatelet agents had a higher burden of cardiovascular comorbidity, which may itself influence access outcomes. Finally, follow-up was limited to six months. While short-term patency is clinically relevant – especially in elderly patients with high comorbidity burden – longer-term durability (≥12 months) would be necessary to fully assess sustained access performance and allow comparison with series reporting medium- and long-term outcomes. In the absence of a direct surgical comparator, no conclusions can be drawn regarding the relative effectiveness of endovascular versus surgical revision.[18]

Despite these limitations, this study provides real-world data in an elderly and highly comorbid population and highlights distinct temporal patterns between maturation-related and established-access stenoses, with high short-term functional salvage in the delayed maturation setting. These aspects may be particularly relevant for advanced CKD programs seeking to reduce catheter dependence.

In conclusion, endovascular treatment of juxta-anastomotic venous stenosis in native AVFs, demonstrated high short-term patency and functional success rates in this cohort. Although exploratory analyses suggested possible association between patient characteristics and failure, these findings require confirmation in larger prospective studies. Within the context of current evidence and routine nephrology practice, PTA remains a valuable and pragmatic therapeutic approach in the management of AVF dysfunction.

Authors‘contributions

I.Z. collected and organized the clinical data. M.P.L., X.F., T.A., N. R.T., C.G.J., J.L.R., and M.G.R., critically reviewed the manuscript and contributed to its refinement. M.A.A., M.J.S., and N.T. conceived the study, supervised the project, and wrote the manuscript. All authors read and approved the final version of the manuscript.

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Conflict of interest

M.J.S. reports personal fees from Novo Nordisk, Jansen, Mundipharma, AstraZeneca, Esteve, Fresenius, Ingelheim Lilly, Vifor, ICU, Pfizer, Bayer, Travere Therapeutics, GE Healthcare, MEDICINE and grants and personal fees from Boehringer Ingelheim, outside the current study. I.Z., M.A.A., M.P.L., X.F., N.R.T., C.G.J., J.L.R., M.G.R., N.T., declare no conflicts of interest.

Data availability

The datasets generated and analyzed during the current study are not publicly available due to institutional privacy policies but are available from the corresponding author upon reasonable request.

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