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Endovascular treatment of femoro-popliteal occlusions with retrograde tibial access after failure of the antegrade approach

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Abstract

Background: Despite the development in endovascular technologies and the introduction of new tools in clinical practice, the endovascular crossing of femoropopliteal occlusions is not always possible with the antegrade approach, with a failure rate that can be up to 20%. This study aims to assess the feasibility, safety, and efficacy in terms of acute outcome of the endovascular retrograde crossing of femoro-popliteal occlusions with tibial access.

Methods: This study is a single-centre, retrospective analysis of prospectively collected data of 152 consecutive patients, who had undergone, from September 2015 to September 2022, endovascular treatment of femoro-popliteal arterial occlusions with retrograde tibial access after the failure of the antegrade approach.

Results: The median lesion length was 25 cm and 66 patients (43.4%) had a calcium grading according to the peripheral arterial calcium scoring system of 4. Angiographically, 44.7% of the lesions were TASC II category D. In all cases, successful cannulation and sheath introduction were performed with an average cannulation time of 150.4 s. Femoropopliteal occlusions were successfully crossed with the retrograde route in 94.1% of cases; the intimal approach was performed in 114 patients (79.7%). The mean time from puncture to retrograde crossing was 20.5 min. Acute vascular access-site complications were noted in 7 (4.6%) patients. Thirty-day major adverse cardiovascular events rate and 30-day major adverse limb events rate of 3.3% and 2%, respectively, were observed.

Conclusions: The results of our study indicate that retrograde crossing of femoro-popliteal occlusions with tibial access is a feasible, effective, and safe approach in case of failed antegrade approach. The results presented represent one of the

Abbreviations: 6MWT, 6-min walk test; ABI, ankle-brachial index; ACT, activated clotting time; ADL, activities of daily living; CFA, common femoral artery; CI, confidence interval; CLI, critical limb ischemia; COAD, chronic obstructive arterial disease; CT, computed tomography; CTO, chronic total occlusion; DUS, doppler ultrasound; HR, hazard ratio; IQR, interquartile range; LER, lower-extremity revascularization; MACE, major adverse cardiovascular events; MALE, major adverse limb events; PAD, peripheral artery disease; SFA, superficial femoral artery; TASC II, Trans-Atlantic Inter-Society Consensus for the Management of Peripheral Arterial Disease II; TLR, target lesion revascularization; VASC, vascular access site complication.

largest investigations ever published on tibial retrograde access and contribute to the small body of literature present on this topic to date.

KEYWORDS
endovascular recanalization, femoropopliteal artery recanalization, femoropopliteal occlusion, retrograde crossing, retrograde tibial access

1 | INTRODUCTION

Endovascular recanalization is increasingly used as the initial revascularization strategy for the arterial occlusive disease of the femoro-popliteal district.[1–8] The standard route for the treatment of femoro-popliteal arterial disease is the anterograde approach via the common femoral artery, because of its large diameter and unique anatomical location. Despite the development in endovascular technologies and the introduction of new tools in clinical practice,[5] the endovascular crossing of femoro-popliteal occlusions is not always possible with the antegrade approach, especially in long chronic occlusions, heavily calcified lesions or when the femoral artery is inaccessible.[9,10] The failure rate can be up to 20%.[11] In cases of failure of the antegrade approach, crossing the lesion in a retrograde fashion represents a safe and effective alternative.[9,12–15] The distal end of a chronic total occlusion (CTO) is often tapered with a softer cap, resulting in easier penetration of the guidewire compared to the proximal cap.[16] If intimal plaque tracking fails, subintimal tracking with a variety of devices, re-entry or combined techniques, can be performed.[5,10] The main techniques described in the literature are the STAR and its variants, the SAFARI, the CART and the reverse CART, with a multitude of other techniques used less frequently.[10,17–21] To the best of our knowledge, very few papers have investigated retrograde crossing of femoro-popliteal occlusions and even less retrograde crossing with tibial access.[9,11–15] This study aims to assess the feasibility, safety and efficacy in terms of acute outcome of the endovascular retrograde crossing of femoro-popliteal occlusions with tibial access, after the failure of the antegrade approach.

2 | METHODS

2.1 | Study design

This study is a single-centre, retrospective analysis of prospectively collected data of consecutive patients, who had undergone, from September 2015 to September 2022, endovascular treatment of femoro-popliteal arterial occlusions with retrograde tibial access after the failure of the antegrade approach. Inclusion criteria, met by all patients, are (I) occlusion of various lengths of the femoro-popliteal artery; (II) grade 3, 4, or 5 chronic obstructive arterial disease according to Rutherford classification; (III) evaluation by a multidisciplinary team of vascular surgeons, interventional radiologists, and anaesthetists; (IV) in case of CTO, refusal of surgical reconstruction by patients or being considered unfit for surgery: absence of an adequate great saphenous vein, poor distal bypass target vessels, severe comorbidities (acute coronary syndrome or stroke within the previous 6 weeks, severe chronic obstructive pulmonary disease); (V) failure of antegrade crossing and subsequent execution, in the same session, of retrograde tibial access as the first alternative strategy. Exclusion criteria are (I) glomerular filtration rate <30 mL/min in nondialyzing patients; (II) previous surgery or endovascular treatment involving the target lesion; (III) CTO of the popliteal artery and proximal trifurcation vessels or other causes of choosing retrograde access as the initial strategy; (IV) untreated ipsilateral iliac stenosis >70%; (V) contraindications to heparin or antiplatelet drugs. In all cases, a computed tomography (CT) angiography was performed to plan the recanalization procedure; the ankle-brachial index (ABI) and the symptomatic classification by Rutherford were recorded before and after endovascular treatment.

Ethics committee approval was not necessary due to the retrospective nature of the study. The study has been conducted in accordance with the Helsinki Declaration. All patients signed a written informed consent before receiving the endovascular treatment.

2.2 | Treatment and follow-up

The endovascular procedure was performed in dedicated angiographic suites by experienced interventionists (at least 10 years of experience). An ultrasound-guided trans-tibial vascular access was created to attempt the retrograde crossing of the femoro-popliteal occlusion, following the failure of the antegrade approach (Figure 1). A fluoroscopic approach with road mapping was used for deeper or heavily calcified vessels (Figure 2). The sheath-less approach has never been used. An antispasmodic cocktail including 200 µg of nitroglycerin and 2.5 mg of verapamil was given via intra-arterial sheath and intra-venous heparin (50–100 units/kg) was administered after sheath introduction. Activated clotting time was checked 20 min later with a goal of 250 s. PTA was performed with 180 s average inflation times. Stenting was performed only in the cases of PTA failure, defined by severe elastic recoil or flow-limiting dissection or residual stenosis >30%. Hemostasis of the vascular access site has been achieved by manual compression in the distal tract of the tibial arteries and by ultrasound-guided compression in the proximal tract of the anterior tibial artery. After the endovascular treatment,

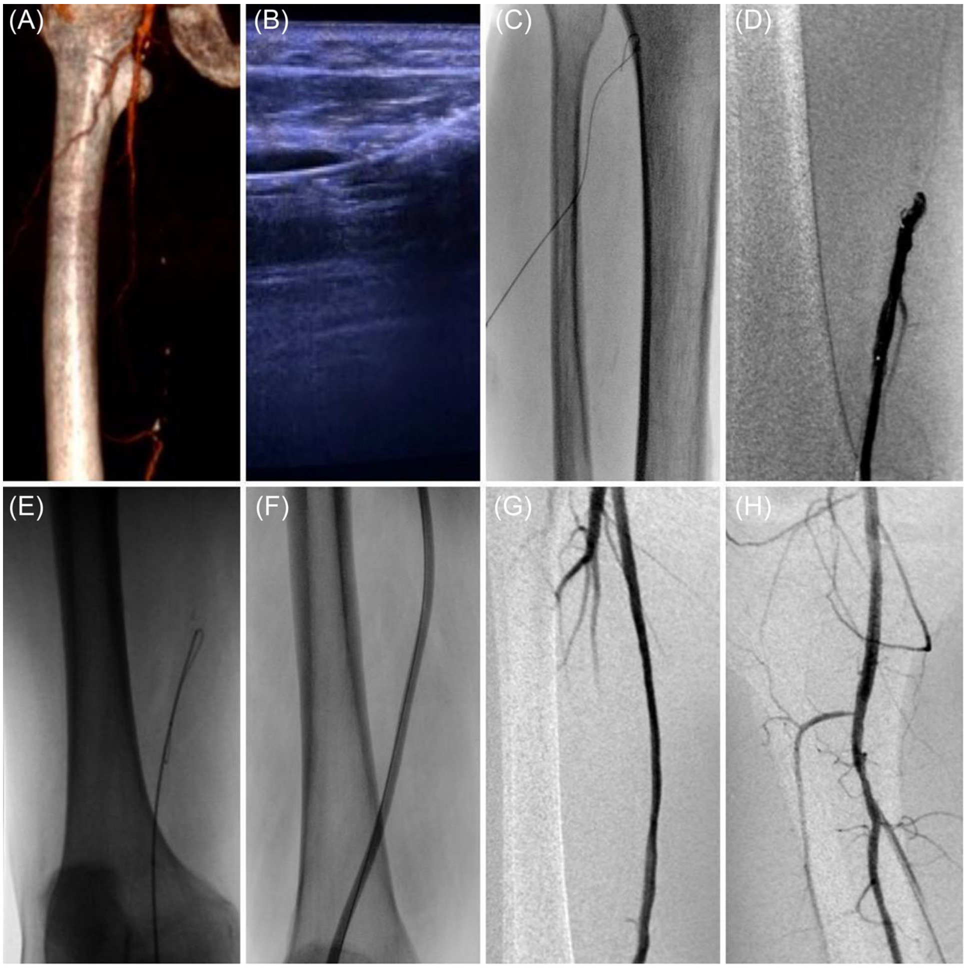

FIGURE 1 3D reconstruction of a computed tomography angiography showing occlusion of the right superficial femoral artery (A). Us-guided access to the proximal tract of the anterior tibial artery (B), with guidewire advancement under fluoroscopic guidance (C). The subsequent angiography shows the distal end of the occlusion (D). Successful retrograde crossing with percutaneous transluminal angioplasty (E, F). Digital subtraction angiography demonstrates successful recanalization of the right superficial femoral artery and good BTK runoff (G, H). BTK, below-the-knee. [Color figure can be viewed at wileyonlinelibrary.com]

whenever possible, a Rivaroxaban (2.5 mg twice daily) and Aspirin (100 mg once daily) therapy was started,[22] or the best medical treatment recognized at the time of the procedure for patients undergoing lower-extremity revascularization due to symptomatic peripheral artery disease (PAD).

Patients underwent routine follow-ups with clinical examination, ABI evaluation and duplex ultrasound imaging, scheduled at 1 week, 1, 3, and 6 months after the procedure and every 6 months thereafter. CT-angiography was performed only in case of recurrent symptoms, if there is no flow through the lesion on doppler ultrasound or in case of PSV >300 cm/s or PSV ratio >2.5 across the lesion,[23,24] or if the condition of sustained hemodynamic success is lost (ABI index is not increased by at least 0.10 and the PVR amplitude by at least 50%, compared with preprocedural values).[25] In patients with critical limb ischemia (CLI), a quality-of-life questionnaire (VascuQol) was administered before the endovascular treatment, 30 days and 12 months after.[25,26] In patients with claudication, the walking ability was evaluated with the 6-min walk test (6MWT) before the endovascular treatment, 30 days and 12 months after.[25,27] In our retrospective analysis, only data collected up to 1 month after treatment were evaluated.

2.3 | Outcomes and definitions

The primary efficacy endpoint was the rate of successful retrograde crossing, to examine the efficacy of the retrograde tibial access in crossing femoro-popliteal occlusions. The technical success rate was selected as a secondary endpoint. The choice of the efficacy endpoints is determined by the fact that the study aims to assess the acute effects of the transtibial retrograde access in terms of target lesion crossing and not the treatment of the target lesion in itself.

The primary safety endpoint was the rate of acute (≤30 days) access site-specific complications. The secondary safety endpoints included the rate of major adverse cardiovascular events (MACE) at

FIGURE 2 Guidewire advancement under fluoroscopic guidance (A), after Us-guided access to the proximal tract of the anterior tibial artery. Digital subtraction angiography highlights the distal end of the SFA's occlusion with prominent collateral vessels (B). Retrograde crossing through the distal cap of the occlusion (C) and subsequent PTA of the SFA (D, E). Digital subtraction angiography demonstrates a dissection flap in the distal tract of SFA (F). After unsuccessful prolonged low-pressure balloon inflation, dissection was treated by placement of a balloon-expandable stent (G). Final angiography shows complete recanalization of the femoropopliteal tract (H).

30 days (30-day MACE) and the rate of acute (≤30 days) intervention-specific complications.

The primary feasibility endpoint was the rate of successful cannulation and sheath introduction. The secondary feasibility endpoints included the cannulation time and the time for hemostasis.

Unless otherwise specified, reporting standards of the Society for Vascular Surgery for endovascular treatment of chronic lower extremity PAD have been used.[25] Functional status depends on the ability to perform all activities of daily living without assistance. Cannulation time is defined as the time between the end of local anaesthesia administration and the flushing of the vascular sheath immediately after its positioning. Failure of retrograde crossing is defined by the impossibility of crossing the target lesion with only the tibial retrograde approach, including those cases in which a combined antegrade and retrograde approach was required such as the CART technique. If a combined antegrade and retrograde approach was required, technical failure associated with the retrograde approach is determined even in the case of effective treatment of the target lesion with a combined approach. The severity of PAD, taking into account the variability in the runoff, has been gauged by using the modified SVS runoff score. The modified SVS runoff score has been calculated from angiographic images.[28,29] Complications were classified according to SVS reporting standards and to the CIRSE classification system.[25,30]

2.4 | Statistical analysis

Data were maintained in an Excel spreadsheet (Microsoft Inc.) and the statistical analyses were performed on an intention-to-treat basis, using SPSS software (SPSS, version 22 for Windows; SPSS Inc.) and R/R Studio software. Kolmogorov–Smirnov and Shapiro–Wilk tests were used to verify the normality assumption of data. Categorical data are presented as frequency (percentage value). Continuous normally distributed data are presented as mean ± standard deviation. Continuous not normally distributed data are presented as median (interquartile range: 25th and 75th percentiles). The unpaired Student *t*-test was used to assess statistical differences for continuous normally distributed data, while categorical and continuous not normally distributed data were assessed using the Chi-squared test and the Mann-Whitney test, respectively. Simple and multiple logistic regression analyzes were performed to assess for possible factors that would predict the successful retrograde canalization (80% of the dataset was used as a training set and the remaining 20% as a testing set). A simple logistic regression was conducted to predict the probability of class membership based on a single predictor variable. Subsequently, a multiple logistic regression was conducted to predict the probability of class membership based on multiple predictor variables. Last, the worst predictors were dropped from the model to avoid overfitting. Since they were low in number, they were manually selected and then a multiple logistic regression was performed again with the remaining predictors. A p value of <0.05 was considered statistically significant for the aforementioned tests.

3 | RESULTS

During the study interval (September 2015 to September 2022), a total of 152 patients (50.7% male; average age 74.6 years) underwent endovascular treatment of femoro-popliteal arterial occlusions with retrograde tibial access after the failure of the antegrade approach. Diabetes mellitus, hypertension, dyslipidemia and smoking history were present in approximately 55.9%, 90.1%, 71.7%, and 58.6% of the population, respectively. The most common clinical presentation was rest pain (category IV according to the Rutherford classification for CLI), observed in 67.8% of the patients. 82.2% of patients were on antiplatelet therapy. In patients with claudication, the average distance walked in the 6MWT was 360.7 (±116.2) meters. In patients with CLI, the mean VascuQOL Test result was 9.5 (±1.9) points. Demographics and comorbidities for the study population are reported in Table 1.

The median lesion length was 25 cm and 66 patients (43.4%) had a calcium grading according to the peripheral arterial calcium scoring system (PACSS) of 4. Angiographically, 44.7% of the lesions were TASC II category D, while 39.5% were TASC II category C. The below-the-knee (BTK) runoff, described as the number of patent vessels among anterior tibial, posterior tibial and peroneal arteries, was 2 vessels in 120 patients (78.9%) with a mean Modified SVS Runoff score of 9.2 (±3.8) points. Lesion data are detailed in Table 2.

The proximal tract of the anterior tibial artery was the vascular access site in 60.5% of patients. Ultrasound has been the preferred imaging guide for gaining vascular access. A mean of 1.3 (±0.5) punctures of the vascular access site was observed, with an average cannulation time of 150.4 s. In all cases, successful cannulation and sheath introduction were performed. Among sheath diameters, the 4F was the preferred choice (50.7%). Femoropopliteal occlusions were successfully crossed with the retrograde route in 94.1% of cases; the intimal approach was performed in 114 patients (79.7%).

TABLE 1 Population data.

Variables	All patients (n = 152)
Age (years)	74.6 (±7.7)
Male	77 (50.7%)
BMI	28 (24.75–31)
Risk factors	
Diabetes mellitus	85 (55.9%)
Coronary artery disease	47 (30.9%)
Congestive heart failure	33 (21.7%)
Cerebrovascular disease	8 (5.3%)
Smoking history	89 (58.6%)
Current smoker	53 (34.9%)
Dyspnea	38 (25%)
Hypertension	137 (90.1%)
Hyperlipidaemia	109 (71.7%)
Hypercoagulable state	15 (9.9%)
Chronic renal insufficiency (eGFR < 60 mL/min)	24 (15.8%)
Impaired functional status	99 (65.1%)
Rutherford categories at presentation	
3—severe claudication	34 (22.4%)
4—rest pain	103 (67.8%)
5—minor tissue loss	15 (9.9%)
Drug therapy	
Lipid-lowering	45 (29.6%)
Antiplatelet	125 (82.2%)
Anticoagulant	15 (9.9%)
6-Min Walk test—baseline	360.7 (±116.2)
VascuQOL test—baseline	9.5 (±1.9)

Abbreviation: BMI, body mass index.

The mean time from puncture to the retrograde crossing was 20.5 min, with a technical success rate of 92.1%. An average time to hemostasis of 14.2 min was recorded. Details about procedure data are given in Table 3.

Acute (≤30 days) vascular access-site complications (VASCs) were noted in 7 (4.6%) patients, with 2 pseudoaneurysms requiring prolonged ultrasound-guided compression. No VASCs prolonged the hospital stay. 19 (12.5%) acute (≤30 days) intervention-specific complications were observed. A total of 16 (10.5%) dissections were found after endovascular treatment, 6 of which required additional endovascular treatment performed during the same procedure. Acute (≤30 days) procedure-related systemic complications were recorded in 16 (10.5%) cases. Procedural success was achieved in 130 (85.5%) cases. A 30-day MACE rate and 30-day MALE (major adverse limb events)

TABLE 2 Lesion data.

Variables	All patients (*n* = 152)
Lesion length (cm)	25 (±8)
Lesion length grading	
≤6 cm/6–10 cm/≥10 cm	3 (2%)/2 (1.3%)/147 (96.7%)
Bollinger score	
13/15	29 (19.1%)/123 (80.9%)
TASC II category	
TASC A	3 (2%)
TASC B	21 (13.8%)
TASC C	60 (39.5%)
TASC D	68 (44.7%)
PACSS grading	
1	4 (2.6%)
2	13 (8.6%)
3	69 (45.4%)
4	66 (43.4%)
PACSS groups	
1–3	86 (56.6%)
4	66 (43.4%)
Calcium score	
1—<25% circumference	5 (3.3%)
2—25%–50% circumference	17 (11.2%)
3—>50% circumference	130 (85.5%)
BTK Runoff	
3 vessels	8 (5.3%)
2 vessels	120 (78.9%)
1 vessel	24 (15.8%)
Modified SVS Runoff Score	9.2 (±3.8)

Abbreviations: BTK, below-the-knee; PACSS, peripheral arterial calcium scoring system.

rate of 3.3% and 2%, respectively, were observed. Three cases requiring primary (≤30 days) conversion to open surgery occurred. Outcomes are detailed in Table 4.

Simple logistic regression analyzes showed that the lesion length ($p = 0.003$), the Modified SVS Runoff score ($p = 0.005$), and the Rutherford category ($p = <0.001$) were significant single predictors of unsuccessful retrograde crossing. Multiple logistic regression models failed to find significantly reliable predictors if multiple predictor variables are considered. Despite the absence of statistical significance, it is noted that the group with a PACSS score of 4 is associated with an average decrease of 5.49 in the log-odds of successful retrograde crossing. Details are given in Table 5.

4 | DISCUSSION

Endovascular recanalization is increasingly used as the initial revascularization strategy for the arterial occlusive disease of the femoro-popliteal district.[1–8] Antegrade crossing of femoro-popliteal occlusions may fail in about 20%–25% of cases, even in high volume centres with experienced operators and despite the development in endovascular technologies and the introduction of new tools in clinical practice such as re-entry devices.[5,9–11,31,32] In cases of failure of the antegrade approach, crossing the lesion in a retrograde fashion represents a safe and effective alternative.[9,12–15] Retrograde crossing of occlusive femoro-popliteal lesions is associated with a high (>90%) technical success rate and a low rate of procedural complications.[33,34]

Several advantages have been described with the use of retrograde access. The distal end of the occlusion is often softer than the proximal cap due to the presence of less calcific tissue, resulting in easier penetration of the guidewire.[16] The proximity of the vascular access site to the occluded segment provides more pushability and torquability of the guidewire through the occlusion.[13,33,35,36] The small calibre of the tibial vessels further facilitates the pushability of the catheter.[35] Besides, collateral vessels directly arising from the proximal cap of the occlusion make difficult its wiring in an antegrade manner.[34] Last, the retrograde approach requires the use of basic tools readily available in every angiography suite and at a low cost.[35] Possibly, a complex interventional procedure such as CART and SAFARI can be performed in those cases where the simple retrograde approach is not sufficient to treat the target lesion.[13,37]

Despite these advantages and the growing evidence and indications in support of endovascular treatment also for complex femoro-popliteal TASC C or D lesions,[6,7,38,39] limited data are currently available to evaluate the retrograde crossing of femoro-popliteal occlusions with tibial access. Other options as retrograde vascular access sites include the distal SFA, popliteal and pedal artery. Distal SFA is usable only when the femoral-popliteal tract is not part of the target lesion. The popliteal approach necessitates repositioning in a prone position, with an increased risk of sheath dislodgement, hematoma, and neurologic access site complications.[40–42] The pedal artery requires the use of low-profile devices.[43] Giusca et al.[14] evaluated the impact of retrograde access in 25 patients with long chronic de novo femoro-popliteal occlusions after failed antegrade approach: only in 2 cases crossing of the lesion was not feasible from either retrograde or antegrade route (lesion crossing rate of 92%). A total of 44% of the distal access was gained in the distal SFA and another 44% was gained in the anterior or posterior tibial artery, with a technical success rate of 92%.[14] More recently, Leon et al.[12] found a lesion crossing rate and a technical success rate of 92.9% in 14 patients undergoing retrograde distal access for infrainguinal CTO and unsuccessful antegrade crossing. In eight patients (57.1%), a tibial artery was used as a vascular access site. In a recent investigation on the primary retrograde tibio-pedal approach in the treatment of femoro-popliteal CTO, 44 (36%) lesions required additional vascular access to successfully treat 122 (99%) lesions.[13] Our study highlights that the lesion crossing rate of femoro-popliteal occlusions with tibial

TABLE 3 Procedure data.

Variables	All patients ($n = 152$)
Number of punctures of vascular access-site	1.3 (±0.5)
Cannulation time (seconds)	150.4 (±25.6)
Vascular access-site	
Anterior tibial art.—proximal	92 (60.5%)
Anterior tibial art.—distal	39 (25.7%)
Posterior tibial art.—distal	21 (13.8%)
Image guide for vascular access	
Us/fluoroscopy/combined	135 (88.8%)/7 (4.6%)/10 (6.6%)
Successful cannulation and sheath introduction, no/yes	0 (0%)/152 (100%)
Sheath diameter, 4 F/5 F/6 F/7 F	77 (50.7%)/57 (37.5%)/18 (11.8%)/0 (0%)
Successful retrograde crossing, no/yes	9 (5.9%)/143 (94.1%)
Intimal	114 (79.7%)
Subintimal	29 (20.3%)
Time from puncture to retrograde crossing (min)	20.5 (±4.1)
Technical success rate	140 (92.1%)
Time for hemostasis (min)	14.2 (±2.9)
Heparin (IU)	3240.1 (±611.6)
Contrast volume (mL)	128.5 (±23.3)
Procedure duration (min)	106.9 (±16.5)
Fluoroscopy time (min)	49 (±11.6)
Cumulative air kerma (mGy)	473.4 (±77.6)
Dose-area product (DAP) (Gy/cm^2)	46.1 (±6.5)

retrograde access after the failure of the antegrade approach is higher than that of the primary antegrade approach[11,31] and is comparable to other retrograde access sites such as distal SFA, popliteal and pedal artery. The lesion crossing rate slightly higher than that of previous studies is probably due to the presence in our study of some shorter femoral-popliteal occlusions compared to the CTOs treated in the aforementioned studies. From the logistic regression results, it can be noticed that the lesion length and the Modified SVS Runoff score were significant predictors of unsuccessful retrograde crossing.

A successful cannulation and sheath introduction was achieved in all cases of tibial artery puncture. These results are in keeping with those observed by previous investigations in this field.[12,13] The mean cannulation time was short and did not significantly affect the total procedure time. Hemostasis of the proximal tract of the anterior tibial artery has been achieved by ultrasound-guided compression due to its depth, while manual compression has been used for the distal tract of tibial arteries which are more superficial. These strategies generally ensured that hemostasis was achieved within a time window of between 10 and 20 min. Hence, retrograde tibial access is a feasible approach in the endovascular treatment of femoro-popliteal occlusions after failed antegrade crossing.

Despite the low complication rate documented in prior investigations,[12–15] the debate is still open on the use of retrograde access as a primary approach or only as a bail-out strategy after the failure of the antegrade route. Thrombotic occlusion, dissection and pseudoaneurysm are much-feared complications for several speculations. The vascular access site can become unsuitable for a possible bypass in the future. In claudication patients with limited run-off, progression to critical limb ischemia may occur. It has been speculated that retrograde access of proximal arteries would minimize the chances of vessel occlusion given their larger lumen; furthermore, minimizing the number of punctures of the vascular access site and achieving patent hemostasis could reduce the risk of VASCs.[12,15,44]

In our study, a low rate of VASCs has been observed. According to both the SVS and the CIRSE classification systems, no patient experienced complications requiring surgical treatment or significant prolongation of hospital stay. Previous investigations have observed a similar low complication rate associated with distal vascular access sites.[11–14,33,34,36,45] The rate of VASCs was also comparable to other

TABLE 4 Outcomes.

Variables	All patients (*n* = 152)
Acute (≤30 days) vascular access-site complications, no/yes	145 (95.4%)/7 (4.6%)
Hematoma	5 (3.3%)
Pseudoaneurysm	2 (1.3%)
Arteriovenous fistula	0 (0%)
Thrombosis	0 (0%)
Dissection	0 (0%)
Neuropathy	0 (0%)
Infection	0 (0%)
Others	0 (0%)
Grading, according to SVS reporting standards	
Mild/moderate/severe	7 (4.6%)/0 (0%)/0 (0%)
Grading, according to CIRSE classification system	
1/2/3/4/5/6	5 (3.3%)/2 (1.3%)/0 (0%)/0 (0%)/0 (0%)/0 (0%)
Required treatment, no/yes	150 (98.7%)/2 (1.3%)
Medical/interventional/surgery	2 (1.3%)/0 (0%)/0 (0%)
Acute (≤30 days) intervention specific complications, no/yes	133 (87.5%)/19 (12.5%)
Microembolization	2 (1.3%)
Pseudoaneurysm	0 (0%)
Arteriovenous fistula	1 (0.7%)
Thrombosis	0 (0%)
Dissection	16 (10.5%)
Vessel rupture	0 (0%)
Central neurologic complication (embolic)	0 (0%)
Others	0 (0%)
Grading, according to SVS reporting standards	
Mild/moderate/severe	19 (12.5%)/0 (0%)/0 (0%)
Grading, according to CIRSE classification system	
1/2/3/4/5/6	17 (11.2%)/0 (0%)/2 (1.3%)/0 (0%)/0 (0%)/0 (0%)
Required treatment, no/yes	133 (87.5%)/19 (12.5%)
Medical/interventional/surgery	13 (8.6%)/6 (3.9%)/0 (0%)
Acute (≤30 days) procedure-related systemic complications, no/yes	136 (89.5%)/16 (10.5%)
Cardiac	8 (5.3%)
Respiratory	4 (2.6%)
Renal	3 (2%)
Neurologic	1 (0.7%)

(Continues)

TABLE 4 (Continued)

Variables	All patients (*n* = 152)
DVT/PE	0 (0%)
Coagulopathy	0 (0%
Allergic	0 (0%)
Radiation-induced	0 (0%)
Others	0 (0%)
Grading, according to SVS reporting standards	
Mild/moderate/severe	11 (7.2%)/2 (1.3%)/3 (2%)
Grading, according to CIRSE classification system	
1/2/3/4/5/6	10 (6.6%)/0 (0%)/3 (2%)/3 (2%)/0 (0%)/0 (0%)
Required treatment, no/yes	136 (89.5%)/16 (10.5%)
Medical/interventional/surgery	11 (7.2%)/5 (3.3%)/0 (0%)
Procedural success rate	130 (85.5%)
30-day MACE	5 (3.3%)
30-day MALE	3 (2%)
Primary (≤30 days) conversion to open surgery	3 (2%)
6-Min Walk test—at 30 days	454.7 (±14.9)
VascuQOL test—at 30 days	10.4 (±14.9)

Abbreviations: MACE, major adverse cardiovascular events; MALE, major adverse limb events.

TABLE 5 Logistic regression analysis of predictive factors affecting successful retrograde crossing (simple/multiple/multiple II).

Predictors	Coeff.	Standard error	Z	p>|z|
Lesion length (cm)	−0.76/−1.37/−1.41	9.45/1.12/1.05	2.95/−1.22/−1.34	0.003/0.223/0.180
Calcium score groups (1–2; 3)	−16.72/3.72	2467.14/11050.92	−0.01/<0.01	0.994/0.999
PACSS groups (1–3; 4)	−18.47/−5.49	2075.18/6325.26	−0.01/<−0.01	0.992/0.999
Modified SVS Runoff score	−1.48/−3.47/−3.59	0.53/2.88/2.66	−2.79/−1.20/−1.35	0.005/0.228/0.178
Vascular access-site	−0.57/−0.12/	0.53/1.23	−1.07/−0.10	0.282/0.921
Rutherford category	−4.16/−1.53/−1.60	1.16/2.29/2.20	−3.60/−0.67/−0.73	<0.001/0.502/0.468

Abbreviation: PACSS, peripheral arterial calcium scoring system.

published studies in the endovascular field related to both femoral and radial access.[46–50] Patel et al.[51] compared the transradial and tibio-pedal approach in femoro-popliteal CTOs, highlighting higher major adverse events at 30 days in the transradial access arm (5% vs. 0%). Shah et al.[52] reported a comparison between transfemoral and tibio-pedal access showing a comparable lesion crossing rate but with fewer access site complications (14% vs. 0%). Ultrasound was our preferred method of guiding percutaneous vascular access. It limits radiation exposure and the amount of contrast medium, and it allows real-time visualization of the vessel, avoiding the puncture of wall plaques thus minimizing the occurrence of VASCs.[15,53–55] Furthermore, the use of low-profile devices, vasodilators and heparinization was preferred to decrease the risk of injury to the vessel, vasospasm and thromboses.[15,36,53,55,56] Hence, the arterial puncture of tibial vessels is a safe approach to performing the retrograde crossing of femoro-popliteal occlusions.

The total procedure duration and fluoroscopy time don't differ from similar procedures performed with retrograde vascular access sites.[12,14] Giusca and Leon[12,14] reported similar results with 44% of distal accesses gained in the distal SFA and 35% in the popliteal artery, respectively. Htun et al.[13] observed a shorter fluoroscopy time, as expected, when retrograde tibio-pedal access is performed as the primary approach. The dose-area product and the cumulative air kerma don't differ from that of other investigations in this field in which different distal access sites were used.[12,14] Retrograde crossing of femoro-popliteal occlusions with tibial access is associated with similar procedure duration, fluoroscopy time and radiation exposure, compared to other distal vascular access sites. The administered dose of contrast medium was not higher than that recorded in other studies for the antegrade crossing of femoro-popliteal occlusions.[14]

Limitations of the study are the lack of a control group to directly compare retrograde and antegrade approaches, the single-centre setting, the retrospectivity of the analysis and the scarcity of data in the literature, necessary to evaluate the congruence and the consistency of the data presented. Moreover, endpoints were evaluated in terms of acute outcomes only.

5 | CONCLUSION

The results of our study indicate that retrograde crossing of femoro-popliteal occlusions with tibial access is a feasible, effective and safe approach in case of failed antegrade approach. Moreover, it can be an interesting alternative strategy to more complex combined approaches such as SAFARI and CART. The results presented represent one of the largest investigations ever published on retrograde tibial access and contribute to the small body of literature on this topic to date.

Further randomized, prospective, multicenter controlled trials with a longer follow-up are warranted to evaluate the congruence of our data and validate our findings.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

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