Early outcome of popliteal and tibiopedal retrograde access as a rescue procedure for the endovascular management of complex infrainguinal lesions: a safe and effective technique

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Introduction

Retrograde access has been proposed as an alternative technique after failed antegrade recanalization of peripheral arterial disease. This study aims to evaluate the retrograde access for infrainguinal lesions in terms of indications, safety, feasibility, advantages, disadvantages, precautions, and complications.

Patients and methods

This is a prospective study of peripheral arterial disease patients of Rutherford categories 5 and 6 scheduled for endovascular recanalization in whom antegrade recanalization had failed or there was difficulty in re-entering the true lumen distal to the obstruction, with comorbidities precluding open surgical reconstruction. According to the lesion and the distal runoff, the retrograde access was chosen from either popliteal, posterior tibial, or dorsalis pedis arteries.

Results

Overall 29 patients (22 men and seven women) were included in this study. The popliteal access was adopted in 10 patients. All were performed under fluoroscopic guidance, except in the case of one popliteal artery, which was accessed under sonographic guidance. In one patient there was failure to cross the lesion. In two patients, a double-balloon technique was used. Subintimal arterial flossing antegrade retrograde intervention was resorted to in five patients. Nineteen patients had tibiopedal access. All cases were accessed under fluoroscopic guidance except two cases that were done under the US guidance. We successfully accessed the target vessel in 16 patients. The subintimal arterial flossing antegrade retrograde intervention technique was followed in 14 patients.

Conclusion

Early outcome results for retrograde popliteal and tibiopedal access show that it is feasible and safe, with low 30-day morbidity and mortality. This technique expands revascularization options after failed conventional endovascular antegrade approaches.

Keywords:
popliteal, retrograde, tibiopedal

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Introduction

Peripheral arterial disease (PAD) is increasing worldwide because of increases in life expectancy, obesity, and diabetes. Its higher incidence can also be attributed to improved diagnostic tools [1]. Endovascular therapy is considered a primary therapeutic strategy for critical limb ischemia, especially in patients at high risk for or with contraindications to surgical revascularization. In daily interventional practice, challenging cases are encountered in which innovative technical strategies are required to restore blood flow to the foot when standard technical solutions fail [2]. However, in up to 20% of cases there is a failure of recanalization and/or intervention from the conventional antegrade approach [3]. If the antegrade attempt to re-enter the true lumen with a guidewire fails, retrograde approaches have been reported to facilitate endovascular intervention. Since the first description of retrograde popliteal puncture by Tønnesen *et al.* [4], this approach has proven to be a useful alternative for angioplasty of some superficial femoral artery (SFA) occlusions. Moreover, an alternative technique of retrograde access through pedal vessels has been proposed and was first described by Iyer *et al.* [5]. This study aims to evaluate the retrograde access for complex infrainguinal lesions as regards indications, safety, feasibility, advantages, disadvantages, precautions, and complications.

Subjects and methods

This is a prospective study of consecutive patients who underwent endovascular recanalization of complex infrainguinal lesions at our center between March 2013 and June 2015. Inclusion criteria included

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all PAD patients of Rutherford categories 5 and 6 scheduled for endovascular recanalization in whom antegrade recanalization had failed, with comorbidities precluding open surgical reconstruction, or who refused open surgery.

Technique

For each patient, demographics, symptoms, existing comorbid conditions, and risk factors for atherosclerosis were identified. All patients underwent routine duplex ultrasound, and patients with complex multilevel disease underwent optional CT angiography. All patients were given a 300 mg loading dose of clopidogrel, 6 h or less before the procedure. With patients in the supine position, access to the SFA lesion was achieved from the contralateral or ipsilateral femoral artery, or occasionally from the brachial artery when neither femoral access was available. After the sheath placement, 5000 units of heparin were administered. In all cases, antegrade recanalization was initially attempted, and if recanalization proved to be impossible owing to inability to re-enter the true lumen distal to the occlusion, a retrograde access was considered.

According to the lesion and the distal runoff the retrograde access was chosen through either popliteal, posterior tibial, anterior tibial, peroneal, or dorsalis pedis arteries.

Popliteal access

At the beginning of the study the popliteal artery was accessed while the patient was turned to the prone position. But with study progression, experience has been gained in using the medial approach (Fig. 1), accessing the junction between the SFA and the popliteal artery.

With the patient still in the supine position and the femoral area kept under sterile drapes, the knee was gently flexed and medially rotated to achieve a good approach to the popliteal artery. When the popliteal artery puncture was performed under fluoroscopic guidance, a local anesthetic was injected around the popliteal artery. Contrast was injected from the femoral approach to visualize the popliteal artery or obtain a roadmap. An 18 G needle cannula was inserted. The most suitable puncture point was usually proximal and medial to the knee joint and caudal to the semimembranosus muscle.

To access the popliteal artery under ultrasound guidance, a 3.5 MHz transducer was placed in a transverse position. The needle was inserted where the popliteal artery was visualized without superimposition of the vein. When the needle tip was visualized inside the popliteal artery lumen, a 0.035″, 180 cm angle-tipped standard hydrophilic guidewire (Terumo, Tokyo, Japan) was advanced into the distal patent portion of the SFA. A 6 Fr sheath was then inserted.

Figure 1

Medial supine approach for retrograde popliteal access.

The wire was advanced into the lesion, and a vertebral catheter was advanced over the wire, trying to keep it intraluminal. However, if the approach failed, the subintimal approach was adopted. If the wire crossed the lesion the procedure was continued either by direct engagement of the retrograde wire into the antegrade sheath or, in the event of failure, by snaring the wire from the antegrade sheath. When the hydrophilic guidewire was withdrawn from the femoral sheath, the procedure was completed in a standard manner through the femoral approach. In many instances, the SAFARI technique [6] was followed, allowing great stability, pushability, and trackability. Otherwise, an antegrade wire can be passed in the microchannel produced by the retrograde wire and/or catheter across the lesion, followed by the balloon, and dilatation continues in a standard way.

The popliteal access was managed with manual compression (5–10 min). If extravasation was noted a balloon was inflated inside the artery to seal the puncture site for another 3 min. Technical success was defined as sealing of the puncture of the popliteal artery and achievement of recanalization of the SFA (Figs 2 and 3).

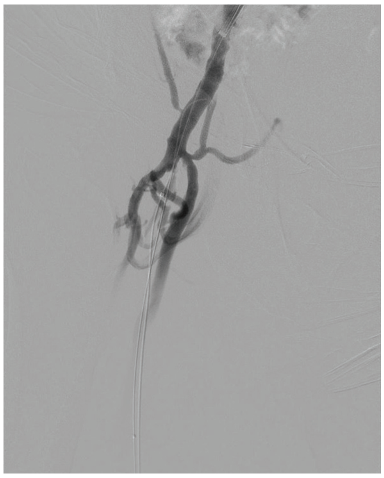
If there was failure to cross the lesion from below, a balloon was passed along the wire and inflated in an attempt to break the intima and let the wire cross through. As a last option in resistant cases, an antegrade and a retrograde balloon is inserted, meeting at their tips while in different planes and then inflated to open the two lumina as a single plane and let the tools pass through and complete the revascularization as mentioned.

Tibiopedal access

For ATA/DP arterial access, the C-arm was adjusted to an anteroposterior and cranial view with respect to the foot. If the PTA was to be punctured, the adjustment was medial to best align the needle to the target vessel. Under roadmapping or contrast angiography, a 20-G radial needle was used to puncture the PTA at the desired, relatively healthy and straight, segment at the level of the ankle. For the anterior tibial artery/dorsalis pedis, the puncture was made at the level of the higher dorsum of the foot or at the distal anterior aspect of the leg. After the puncture was established, a sheathless access was used where a 0.018 wire was advanced, followed by a supporting catheter/balloon to cross the proximal lesion (Fig. 4). The patient is kept anticoagulated. To avoid vasospasm, a solution of nitroglycerin and verapamil in heparinized saline is used to flush the sheathless microcatheter access every 10–15 min. The procedure continued as discussed above with another administration of nitroglycerin shortly before sheath removal and manual compression. As with arterial access in other locations, observation of the puncture site at regular intervals in the recovery area was commenced.

Evaluation of the technique included reporting of the success of access into the runoff artery, success of retrograde crossing of the lesion, technique of angioplasty after success of access and crossing, and identification of any complications at the access site, including bleeding, hematoma, arteriovenous fistula, dissection, and thrombosis.

Figure 2



Antegrade and retrograde wires in the SFA supported by balloons trying to open a common plane. SFA, superficial femoral artery.

Figure 3

Snaring of antegrade wire from below by a snare coming from popliteal access.

Figure 4

Dorsalis pedis access with passage of the 0.018” wire out of the antegrade femoral sheath.

Results

Overall 29 patients (22 men and seven women) were included in this study. They were treated between March 2013 and June 2015. Their ages ranged between 40 and 72 years (mean age 59 years). Patient demographic information and risk factors are listed in Table 1.

The presenting symptoms and the indication for PTA are listed in Table 2. All lesions were *de novo* and totally occluded. The site of the lesion and the distal runoff vessels are shown in Table 3.

Retrograde puncture was attempted in 29 cases. According to the site of the retrograde puncture, patients were categorized into a popliteal or a tibiopedal group. The popliteal group comprised 10 patients in whom the contralateral common femoral artery (CFA) was used as an initial retrograde access in eight cases and the

Table 1 Patient demographic information and risk factors

Parameter	Number of patients (*n* (%))
Sex	
Male	22 (76)
Female	7 (24)
Age (mean (range))	59 (40-72)
Risk factors	
IHD	21 (70)
Diabetes mellitus	26 (86.6)
Hypertension	18 (60)
Smoking	17 (56.6)

IHD, ischemic heart disease.

Table 2 The presenting symptoms and the indications for PTA

Presenting symptom	Number of patients
Rest pain	2
Gangrene	15
Tissue loss	12

PTA, posterior tibial artery.

Table 3 The site of the lesion and the state of the distal runoff vessels

Site of lesions	Number of patients
Superficial femoral artery (SFA)	10
Popliteal (POP)	7
Tibioperoneal (TP)	2
SFA+POP	3
POP+TP	1
SFA+TP	4
SFA+POP+TP	2

ipsilateral CFA was the initial access in an antegrade direction in two cases. All cases were accessed under fluoroscopic guidance except for one popliteal artery, which was accessed under sonographic guidance due to accidental popliteal vein puncture at the initial access attempts. In one patient there was failure to reach the true lumen of the popliteal artery despite repeated attempts because of extensive calcifications. A 6 Fr sheath was used after all successful punctures. The wire used for retrograde crossing was a hydrophilic 0.035″ guidewire in six patients and a hydrophilic 0.018″ guidewire in three patients.

Retrograde crossing was tried first in a transluminal plane, but it did not succeed in any patient and the wire was forced as a loop in a subintimal plane. This was successful in seven patients, facilitating re-entry into the proximal true lumen. In two patients the wire did not cross proximal to the lesion except after using the double-balloon (Randevouz) technique. After establishment of a microchannel across the lesion the SAFARI technique was adopted in five patients: in two using a snare and in three by direct engagement of the wire in the proximal sheath.

In the other four patients direct antegrade passage of the proximal wire across the channel was commenced and was successful. Dilatation was performed thereafter, in downward direction in six patients and in upward direction in three patients. Stents were used in six patients because of residual lesions or dissections. The procedure was technically successful in 90% of this group.

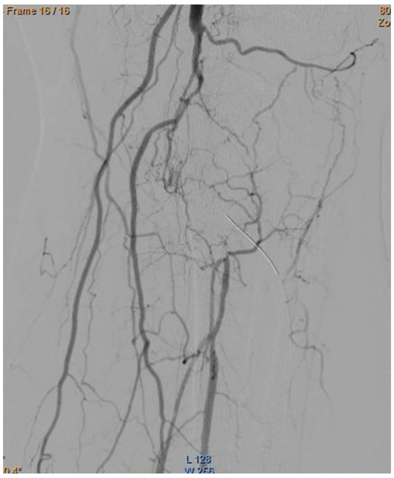
The tibiopedal group consisted of 19 patients in whom the contralateral CFA was used as an initial retrograde access in six cases and the ipsilateral CFA was the initial access in an antegrade direction in 13 cases. All cases were accessed under fluoroscopic guidance except in the case of two patients in whom there was little dye reaching the access vessel, making fluoroscopic visualization difficult. In these two cases the vessel was accessed under ultrasound guidance. We successfully accessed the target vessel in 16 patients. In the remaining three patients the extensive calcifications made access impossible after repeated attempts at different levels of puncture. One of these three cases was under sonographic guidance and the remaining two were under fluoroscopic guidance. After successful access a hydrophilic 0.018″ (n = 13) or 0.014″ (n = 3) wire was passed into the artery without a sheath. A stiff 0.018″ wire was used whenever the lesion was long and required high pushability, whereas a 0.014″ wire was used in shorter lesions.

Retrograde crossing was tried initially through the true lumen in all patients, but eventually this was successful in only six of the 16 patients. In nine patients crossing proceeded in a subintimal plane with re-entry proximal to the lesion, and in one patient crossing failed and the wire could not re-enter the lumen proximal to the lesion inspite of different attempts with different techniques. A 0.018″ support catheter or a 0.018″ balloon was used whenever the wire was not able to cross alone.

After successful crossing the SAFARI technique was used in 14 patients using a snare (n = 3) or by direct engagement into the proximal sheath or catheters (n = 11). In one patient the proximal wire passed in an antegrade direction into the channel created by the retrograde wire and the procedure continued in a standard way from above. Dilatation was performed thereafter in a downward direction in all patients. No stents were used in this subset of patients. There was technical success in 79% of the patients in this group (Figs 5–8).

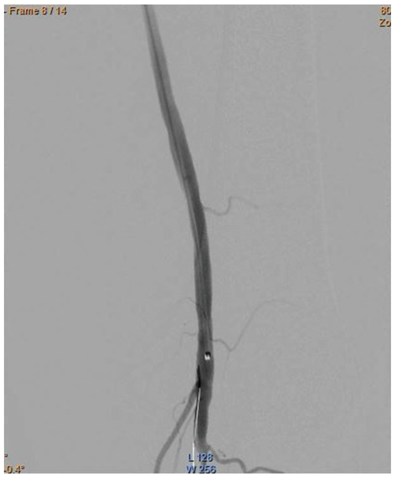
The details of the procedure in both groups are listed in Table 4. No patient in any of the two groups developed thrombosis or dissection of the distal access. Dye extravasation was noticed in two patients in the tibial access group and in one patient in the popliteal access group, all of which were sealed by balloon inflation (Fig. 9). All successfully managed patients achieved clinical success and there was improvement in

Figure 5



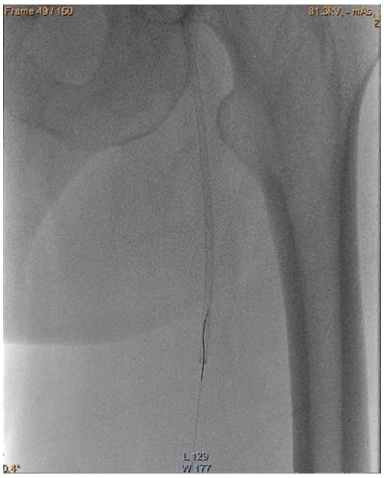
A 0.018” wire passing upward through an ATA access trying to cross a popliteal lesion. ATA, anterior tibial artery.

Figure 6



Angiographic confirmation that the wire is now intraluminal after crossing.

Figure 7



Direct engagement of the retrograde wire into the antegrade sheath.

Figure 8

After successful revascularization.

Table 4 Tibiopedal access site

Tibiopedal access sites	Number of patients
Anterior tibial artery (ATA)	8
Posterior tibial artery (PTA)	9
Peroneal artery (PA)	1
Dorsalis pedis (DP)	1

their symptoms at early outcome assessment with no limb loss. One failed popliteal access did not improve clinically and was scheduled for a femoro-lower popliteal bypass, with no compromise in runoff. The three failed tibial accesses were followed up for wound healing, and eventually all of them required a major amputation in the following 6 months. None of them underwent an open bypass due to poor runoff (Table 5).

Discussion

The retrograde access is considered an alternative tool in endovascular management of infrainguinal lesions. It is well known that the cap at the cephalad end of an SFA occlusion is more resistant to wire navigation. Consequently, there may be a better chance of finding the softest tract through the occlusion from the distal end. In addition, as the initial cap presents a convex shape and a smooth surface, the guidewire coming from above may slide over the cap, entering the subintimal space [7]. In this study, we showed the indications, safety, feasibility, advantages, disadvantages, precautions, and complications of this alternative technique.

We selected all PAD patients of Rutherford categories 5 and 6 scheduled for endovascular recanalization in whom antegrade recanalization had failed, with comorbidities precluding open surgical reconstruction.

Situations where retrograde puncture may be considered include SFA origin occlusion, adverse collateral anatomy, severe scarring in the groin after surgery, and obesity that hinders antegrade puncture of the common femoral artery [8,9]. The contralateral

Figure 9

Final angiogram following removal of DP access showing preserved runoff with minimal dye extravasation managed by gentle balloon dilatation. DP, dorsalis pedis.

approach can be challenging in patients with a narrow aortic bifurcation and impossible in patients previously treated for an abdominal aortic aneurysm [10].

For the popliteal access, we adopted prone position in three cases in the early period of the study. This was the same technique adopted by Noory *et al.* [8] and Younes *et al.* [3]. The latter required popliteal artery longer than 5 mm, not heavily calcified, with more than one distal runoff vessel as a prerequisite.

We shifted to the supine position technique – as described by many studies – because we found that the patients were not comfortable with the prone position and that the procedure was time-consuming [10–12]. Schmidt and colleagues mentioned that, most importantly, the supine position allows simultaneous manipulation of guidewires and balloon catheters from above and below. They considered the SAFARI technique highly successful, as it enables high degree of pushability and trackability, allowing easy recanalization. The 'double-balloon' maneuver, when used as an adjunct to the SAFARI technique, has been extremely useful in facilitating wire passage when there is an inability to pass the occlusion from either direction. This is not possible with the patient is lying prone in the transpopliteal approach [11].

We preferred to follow the medial supine approach for the popliteal artery under fluoroscopic guidance as we were more familiar with this technique while still improving the learning curve. However, other studies used ultrasound-guided puncture as it minimizes radiation hazards and avoids fistula formation between the popliteal artery and the vein [3,9,10]. This technique was used in one case because of accidental popliteal vein puncture at the initial access attempts.

Table 5 Details of the procedure

Groups (number)	Popliteal (10)	Tibiopedal (19)
Initial access		
Ipsilateral antegrade SFA	2	13
Contralateral retrograde SFA	8	6
Guiding image		
Fluoroscopic	9	17
Ultrasound	1	2
Sheath		
6 Fr	9	0
Sheathless	0	16
Failed puncture	1	3
Wire diameter used to cross the lesion		
0.018	3	10
0.035	7	0
0.018+0.035	0	3
0.014	0	3
Transluminal crossing	0	6
Subintimal crossing	10	9
Failed crossing	0	1
Crossing the lesion using a wire		
Successful	9	15
Failed	1	1
SAFARI technique		
Yes	7	14
No	2	1
Use of snare	2	3
Direct engagement	5	11
Direction of angioblasty from		
Above	6	15
Below	2	0
Below and above	1	0
Stents used	6	0

SAFARI, subintimal arterial flossing antegrade retrograde intervention; SFA, superficial femoral artery.

Once popliteal access had been established, a 6 Fr sheath was inserted to allow exchange of different tools used to negotiate the lesion. Some authors described the use of a 4 Fr sheath and others adopted sheathless access. The decision on the type of access to be followed depended on the degree of stenosis in the PA access, the possibility of pushing the low-profile balloon through the lesion without the sheath, and whether stent implantation was needed from the PA, especially in cases in which the antegrade procedure was performed from the brachial artery [10,11,13].

After successful crossing, angioplasty was carried out from above to minimize the adoption of retrograde access, which in turn minimizes its complications. However, two cases required angioplasty from below and one case had angioplasty done from below and above. In this case angioplasty started first from below through a popliteal sheath due to failure of crossing of the antegrade balloon (from above). But after establishment of a lumen across the lesion, a larger balloon introduced from above was used to continue the dilatation.

Manual compression was used to control the access site after removal of the sheath except in three cases where we used mild balloon dilatation to seal the access opening after dye extravasation. Balloon dilatation, crepe bandage, and closure devices were also described to control access site bleeding. Dilatation is suspected to cause dissection and could induce intimal hyperplasia in the long term [11].

As regards tibiopedal access, all cases were accessed under fluoroscopic guidance except two cases where there was little dye reaching the access vessel, making fluoroscopic visualization difficult. In these two cases the vessel was accessed under ultrasound guidance and the procedure was successful. Wiechmann recommended the US guidance to avoid excess radiation exposure, that to get a 'workingroom' we need to raise the intensifier thus increasing the source-to-image distance, which in turn increases radiation scatter. Although calcifications make puncture difficult, it may map the site of puncture. Roadmapping is an alternative to real-time fluoroscopy but this technique is subject to patient motion [14].

We successfully accessed the target vessel in 16 patients. In the remaining three patients the extensive calcifications made access impossible after repeated attempts at different levels of puncture. Repeated attempts at puncture may result in spasms, which should be avoided, and we were able to avoid injuries or thrombosis in the vessels that we could not access. Continuous intraprocedural anticoagulation by means of nitroglycerin (200–300 mg) was routinely administered to avoid spasm. Open surgical exposure of the puncture site was adopted by Hua *et al.* [15] to avoid spasm.

All the procedures were managed without a sheath to minimize the access site complications. Montero-Baker *et al.* [13] adopted the use of a wire and balloon only, whereas Gandini *et al.* [6] used a 4 Fr sheath, Botti *et al.* [16] introduced only the dilator of a 4 Fr sheath, and Spinosa *et al.* [17] used a 3 Fr sheath and 3 Fr catheter or only a 3-Fr dilator. Fusaro *et al.* [18] described a sheathless approach introducing only a 0.018 guidewire through the puncture needle for passing the lesion followed by an over-the-wire balloon. In most cases, a 0.018″ guidewire has better pushability than a 0.014″ guidewire.

We used low-profile balloons and all the angioplasties were carried out from antegrade direction to minimize retrograde access site complications. As a balloon after inflation has a larger diameter than an unused balloon, there is a potential risk of increasing the trauma to the pedal artery during retrieval [13].

In our study transluminal wire passage was successful only in six of the tibiopedal patients (less than half of the patients). This can be explained by the fact that the included patients in this study had complex and difficult lesions, rendering them difficult to cross in an antegrade direction from the start. This was more pronounced in the popliteal group, where the pathologic and morphologic nature of the SFA lesions made transluminal crossing almost impossible. This is in contrast to the case of tibial disease where transluminal is frequently successful.

The success rate in this study was 79% in tibiopedal access and 90% in popliteal access. This is comparable to the success rates reported in the literature: 86% by Montero-Baker *et al.* [13], 96% by Schmidt *et al.* [11], 89.5% by Sangiorgi *et al.* [1], 91.6% by Fanelli *et al.* [10], 67% by El-Sayed *et al.* [19], and 94% by Younes *et al.* [3].

In 2012, Sangiorgi and colleagues described the retrograde popliteal access as a 'bail out strategy' and considered it safe and effective. However, selected patients with extremely complex lesions still fare better with bypass surgery. Nonetheless, several patients are not candidates for bypass surgery because of comorbidities, or because of patients' preferral for endovascular therapy [1]. In 2015, Younes *et al.* [3] stated that retrograde popliteal access should be added to the vascular surgeon's portfolio. Tibiopedal access was greatly encouraged in a recent study by El-Sayed and colleagues. They stated that this technique lowered the threshold for a distal bypass, as there was no possibility of jeopardizing the possibility of a bypass should the technique fail. The technique avoided a major vascular procedure in a cohort with multiple major comorbidities. It is also evident that the industry is starting to introduce more devices that are specifically designed to facilitate the procedure – for example, the dedicated micropuncture pedal access kit, the pedal micropuncture sheath with the check-flo hemostasis valve, and the ultra-low-profile microballoon catheter, which refines the performance of the procedure and further reduces the risk for access site complications [19].

This study is limited primarily by its retrospective, nonrandomized design, and the potentially biased selection of the group of patients undergoing the retrograde approach. There was no comparison group of patients undergoing alternate treatment for their critical limb ischemia and tissue loss. Also, the relatively small number of patients in the group and the lack of a long follow-up make our results rather early outcomes only. Nevertheless, this study is relevant in that it demonstrates a realistic picture of the efficacy of this technique in a complex, high-risk patient population when conventional endovascular therapy techniques are unsuccessful in recanalizing the diseased segment. Retrograde revascularization may lead to avoidance of more invasive vascular procedures.

Conclusion

Early outcomes for retrograde popliteal and tibiopedal access show that it is feasible and safe, with low 30-day mortality, morbidity, and major adverse limb events. This technique expands revascularization options after failed conventional endovascular antegrade approaches.

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Conflicts of interest

There are no conflicts of interest.

References

1 Sangiorgi G, Lauria G, Airoldi F, Godino C, Politi L, Colombo A, *et al.* Retrograde popliteal access as bail-out strategy for challenging occlusions of the superficial femoral artery: a multicenter registry. Catheter Cardiovasc Interv 2012; 79(7): 1188–1193.

2 Palena LM, Garcia LF, Brigato C, Sultato E, Candeo A, Baccaglini T, Manzi M. Angiosomes: how do they affect my treatment? Tech Vasc Interv Radiol 2014; 17(3): 155–169.

3 Younes HK, El-Sayed HF, Davies MG. Retrograde transpopliteal access is safe and effective-it should be added to the vascular surgeon's portfolio. Ann Vasc Surg 2015; 29(2): 260–265.

4 Tønnesen KH, Sager P, Karle A, Henriksen L, Jørgensen B. Percutaneous transluminal angioplasty of the superficial femoral artery by retrograde catheterization via the popliteal artery. Cardiovasc Intervent Radiol 1988; 11(3): 127–131.

5 Iyer SS, Dorros G, Zaitoun R, Lewin RF. Retrograde recanalization of an occluded posterior tibial artery by using a posterior tibial cutdown: two case reports. Cathet Cardiovasc Diagn 1990; 20(4): 251–253.

6 Gandini R, Pipitone V, Stefanini M, Maresca L, Spinelli A, Colangelo V, *et al.* The 'Safari' technique to perform difficult subintimal infragenicular vessels. Cardiovasc Intervent Radiol 2007; 30(3): 469–473.

7 Fanelli F, Lucatelli P, Allegritti M, Corona M, Rossi P, Passariello R. Retrograde popliteal access in the supine patient for recanalization of the superficial femoral artery: initial results. J Endovasc Ther 2011; 18(4): 503–509.

8 Noory E, Rastan A, Schwarzwälder U, Sixt S, Beschorner U, Bürgelin K, *et al.* Retrograde transpopliteal recanalization of chronic superficial femoral artery occlusion after failed re-entry during antegrade subintimal angioplasty. J Endovasc Ther 2009; 16(5): 619–623.

9 Brountzos EN, Moulakakis KG, Avgerinos ED, Dalainas I, G Giannakopoulos T, Kakisis J, *et al.* Retrograde transpopliteal approach of iliofemoral lesions. Vasc Endovascular Surg 2011; 45(7): 646–650.

10 Fanelli F, Cannavale A. Retrograde recanalization of complex SFA lesions indications and techniques. J Cardiovasc Surg (Torino) 2014; 55(4): 465–471.

11 Schmidt A, Bausback Y, Piorkowski M, Werner M, Bräunlich S, Ulrich M, *et al.* Retrograde recanalization technique for use after failed antegrade angioplasty in chronic femoral artery occlusions. J Endovasc Ther 2012; 19(1): 23–29.

12 Kawarada O, Yasuda S, Nishimura K, Sakamoto S, Noguchi M, Takahi Y, *et al.* Effect of single tibial artery revascularization on microcirculation in the setting of critical limb ischemia. Circ Cardiovasc Interv 2014; 7(5): 684–691.

13 Montero-Baker M, Schmidt A, Bräunlich S, Ulrich M, Thieme M, Biamino G, *et al.* Retrograde approach for complex popliteal and tibioperoneal occlusions. J Endovasc Ther 2008; 15(5): 594–604.

14 Wiechmann BN. Tibiopedal access for lower extremity arterial intervention: when to use and how to perform. Tech Vasc Interv Radiol 2014; 17(3): 197–202.

15 Hua WR, Yi MQ, Min TL, Feng SN, Xuan LZ, Xing J. Popliteal versus tibial retrograde access for subintimal arterial flossing with antegrade-retrograde intervention (SAFARI) technique. Eur J Vasc Endovasc Surg 2013; 46(2): 249–254.

16 Botti CF Jr, Ansel GM, Silver MJ, Barker BJ, South S. Percutaneous retrograde tibial access in limb salvage. J Endovasc Ther 2003; 10(3): 614–618.

17 Spinosa DJ, Harthun NL, Bissonette EA, Cage D, Leung DA, Angle JF, *et al.* Subintimal arterial flossing with antegrade-retrograde intervention (SAFARI) for subintimal recanalization to treat chronic critical limb ischemia. J Vasc Interv Radiol 2005; 16(1): 37–44.

18 Fusaro M, Dalla Paola L, Biondi-Zoccai GG. Retrograde posterior tibial artery access for below-the-knee percutaneous revascularization by means of sheathless approach and double wire technique. Minerva Cardioangiol 2006; 54(6): 773–777.

19 El-Sayed H, Bennett ME, Loh TM, Davies MG. Retrograde pedal access and endovascular revascularization: a safe and effective technique for high-risk patients with complex tibial vessel disease. Ann Vasc Surg 2016; 31:91–98.