Extraordinary approaches for treatment of complex tibial and popliteal arterial occlusions

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Objective
The purpose of this study is to evaluate the efficacy and safety of different tibiopedal approaches as alternative methods for failed antegrade recanalization of popliteal and infrapopliteal arterial occlusions.
Patients and methods
A prospective study was done at Vascular Surgery Department, Zagazig University Hospitals, from February 2015 to June 2018. During this period, 73 patients with critical lower limb ischemia with popliteal and/or infrapopliteal lesions underwent endovascular intervention. Antegrade recanalization failed in 17 patients (nine males and eight females with the mean age 68.6±9.8 years). Retrograde tibiopedal approach was tried in them. Six patients were Rutherford category 4 (complaining of rest pain), eight patients were Rutherford category 5 (had ischemic ulcers), and three patients were Rutherford category 6 (had gangrene). The mean ankle brachial index was 0.39±0.11. Three patients had occlusions in the popliteal artery only, 11 patients had tibial occlusions, and three patients had combined popliteal and tibial occlusions. The mean length of lesions was 9.7±2.8 cm. Eleven (64.8%) patients had Trans-Atlantic Inter-Society Consensus II C lesions and six (35.2%) patients had Trans-Atlantic Inter-Society Consensus II D lesions.
Results
We succeeded in 13 (76.5%) patients to cross the occlusion and recanalyze the target vessel [completing the procedure from the antegrade approach in eight (47.1%) patients, and completing the procedure from the retrograde approach in five (29.4%) patients]. The mean ankle brachial index was improved significantly from 0.39±0.11 before to 0.78±0.12 after the intervention ($P<0.01$).
Conclusion
Retrograde tibiopedal approach can be used safely as a bailout to increase the technical success rate and limb salvage for failed antegrade recanalization of popliteal and infrapopliteal arterial occlusions.

Keywords:
critical limb ischemia, infrapopliteal arterial occlusions, retrograde angioplasty

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Introduction

Many patients with critical limb ischemia have cardiac or chest diseases that make them unfit for infrainguinal bypass [1], so endovascular management of infrainguinal Trans-Atlantic Inter-Society Consensus (TASC) C and D lesions is widely used [2]. However, chronic total occlusions (CTOs) are the main cause of failure [3], where antegrade recanalization of long CTOs of the femoro-popliteal territory succeeds only in 60–80% of cases [4], and the failure for antegrade recanalization of tibial arteries with CTO lesions is 20–40%, according to length of lesions, calcification, and experience [5].

Failure of antegrade recanalization is owing to inability to cross the lesion or to re-enter the true lumen distal to the lesion. Re-entry devices are a good solution and have a rate of success exceeding 80% [6]. However, the re-entry devices are very expensive, do not succeed in all patients, carry possible complications, have slow learning curve, and no dedicated re-entry device for tibial arteries. The retrograde approach is a good solution for failed antegrade recanalization in these patients [7].

The purpose of this study was to evaluate the retrograde approach for failed antegrade recanalization of popliteal and infrapopliteal arterial occlusions.

Patients and methods

We conducted our prospective study at the Vascular Surgery Department, Zagazig University Hospitals

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from February 2015 to June 2018. All steps of the intervention, including type of anesthesia and possible complications which might be acquired were discussed carefully with all patients and written consents were obtained from all patients which were approved by the Institutional Review Board. Our patients underwent thorough history taking, physical examination, laboratory investigations, and arterial duplex, and computed tomography angiography.

Our inclusion criteria were patients with critical lower limb ischemia with CTOs involving popliteal and/or infrapopliteal lesions (TASC II C or D) in whom antegrade recanalization failed. Exclusion criteria were angiography with iliac or femoral arteries CTOs and acute limb ischemia.

During this period, 73 patients with critical lower limb ischemia with popliteal and/or infrapopliteal lesions underwent endovascular intervention. Antegrade recanalization failed in 17 patients (nine males and eight females, with the mean age of 68.6±9.8 years). In these patients, we tried retrograde tibiopedal approach.

Procedures

We started antegrade recanalization in all patients through the 6-Fr sheath in ipsilateral common femoral artery. After many trials, if we failed to cross the occlusion or to re-enter the true lumen distal to the occlusion, retrograde approach was decided as long as there was distal reconstruction of posterior tibial artery (PTA) or the anterior tibial artery (ATA). Nitroglycerin (0.2 mg) is injected through the antegrade sheath. We used the 4 Fr MAK Mini Access Kit (Merit, Merit medical system, Inc, south Jordan, Utah, USA); using its 21-G micropuncture needle, the punture was guided by roadmapping the reformed vessels after injecting contrast from antegrade sheath or the calcification shadow of vessels or duplex guided using the hockey stick or linear probe. When puncturing dorsalis pedis or ATA, the C-arm was made antero-posterior, but for the PTA, the C-arm was made lateral. The puncture of dorsalis pedis was 3–4 cm below the ankle, whereas the puncture of ATA was 2–3 cm above the ankle while making passive plantar flexion. The puncture of PTA was at or just above the ankle while making passive eversion and dorsi-flexion.

After the puncture, we used more than 1 technique, in some cases 0.018-inch short guide wire, included within the kit, was inserted and the needle was removed, then inserting only the dilator and then the wire was exchanged by either 0.018-inch wire V-18 (Boston Scientific, Natick, MA, USA) or Nitrex (ev3 Inc, Plymouth, Minnesota, USA), and then removing the dilator and inserting 3×80 mm Pacific Plus (Invatec S.P.A. Roncadelle B.S. Italy) over the wire 0.018-inch balloon as a support catheter and as angioplasty balloon. In other cases, 0.014-inch wire Nitrex was used then removing the dilator and inserting (2–3)×(80–120) mm Amphirion Deep (Invatec S.P.A. Roncadelle B.S. Italy) over the wire balloon as a support catheter and as angioplasty balloon. Also in some cases, the procedure was done completely sheathless by inserting the 0.018-inch wire V-18 or Nitrex directly through the micropuncture needle, then the needle was removed then inserting 3×80 mm Pacific Plus over the wire balloon directly through the skin. Then after any one of the 3 techniques, both the wire and balloon were advanced crossing the lesions, and then wire was removed and contrast was injected through the balloon to be sure of crossing the lesion and being intraluminally then reinserting the wire. Then we dilated the lesion from the retrograde approach in five patients with isolated tibial lesions. But we dilated the lesions through the antegrade sheath in eight patients, by manipulating the wire to tip of straight catheter, inserted from the antegrade sheath, then the wire is extracted and catheter is removed, then the balloon was removed from the retrograde approach and reinserted through the antegrade sheath crossing the lesion, then the wire was removed from retrograde puncture and contrast injection was done through the balloon to be sure that the balloon has successfully crossed the lesion and its tip is intraluminally, then 10 min digital compression and 1 h mild crepe bandage compression, during this the wire was reinserted through the hub of the balloon through the antegrade sheath, then dilating the popliteal and or tibial lesions from the antegrade approach then injecting 0.2 mg nitroglycerin through the antegrade sheath, then completion angiogram was done.

In two cases, percutaneous access failed, and a small incision was made exposing the PTA with a loop made around it and then the procedure continued sheathless.

In two patients, the wire could not cross the occlusion (mostly due to severe calcification); in one patient, the wire made perforation; and in two patients, the retrograde wire could not re-enter the lumen proximal to the occlusion or pass through the same subintimal track made by the antegrade wire, so two balloons were inflated at the same time with 5 mm between the tips of balloons with both wires are slightly retracted before tips of balloons. This technique succeeded in one patient then manipulating the antegrade or retrograde wire to continue the procedure, but failed in the other patient because the retrograde wire failed to renter the true lumen proximal to the occlusion and also failed to enter the subintimal track made by the antegrade wire.

The patients were given enoxaparin (40 mg, four times daily) for 2 days and cilostazol (100 mg, twice daily), acetylsalicylic acid (100 mg, four times daily), and clopidogrel (75 mg, four times daily).

All our patients were encouraged to come to us on monthly visits, and they were thoroughly examined; in addition, ankle brachial index calculation and radiological studies were performed when needed.

The collected data were computerized and statistically analyzed using statistical package for the social science program (SPSS for Windows, version 20.0, SPSS Inc., Chicago, Illinois, USA), version 20.0. Continuous variables were reported as mean±SD. For technical success, we used paired *t* test to compare values before and after procedure. *P* value less than 0.05 was considered statistically significant. For limb salvage rate, we used Kaplan–Meier survival curve.

The steps of retrograde ATA angioplasty are explained in Figs 1–4.

Results

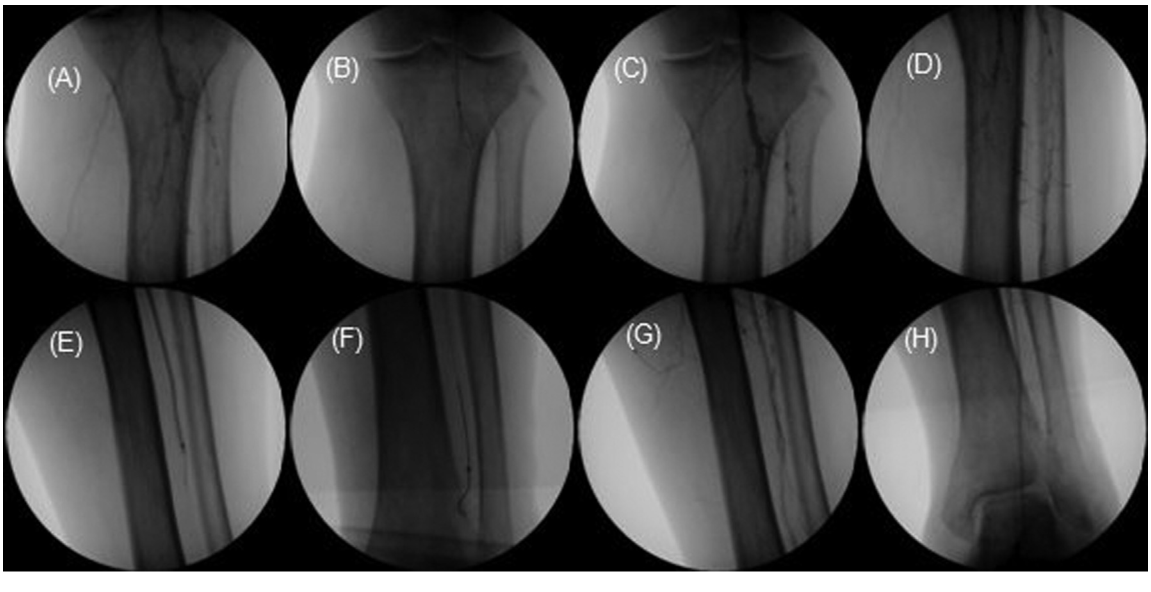
Our prospectivestudy was conducted at Vascular Surgery Department, Zagazig University Hospitals, from February 2015 to June 2018. A total of 17 patients underwent retrograde tibiopedal approach. Patient's characteristics are summarized in Table 1.

Six patients were Rutherford category 4 (complaining of rest pain), eight patients were Rutherford category 5 (had ischemic ulcers), and three patients were Rutherford category 6 (had gangrene). Three (17.6%) patients had occlusions in the popliteal artery only, 11 (64.8%) patients had tibial occlusions, and three patients had combined popliteal and tibial occlusions. The mean length of lesions was 9.7±2.8 cm.

Eleven (64.8%) patients had TASC II C lesions and six (35.2%) patients had TASC II D lesions. Percutaneous puncture was made in 15 patients (eight for ATA, one for dorsalis pedis artery, and six for PTA), but two patients underwent a small incision exposing PTA (Table 2).

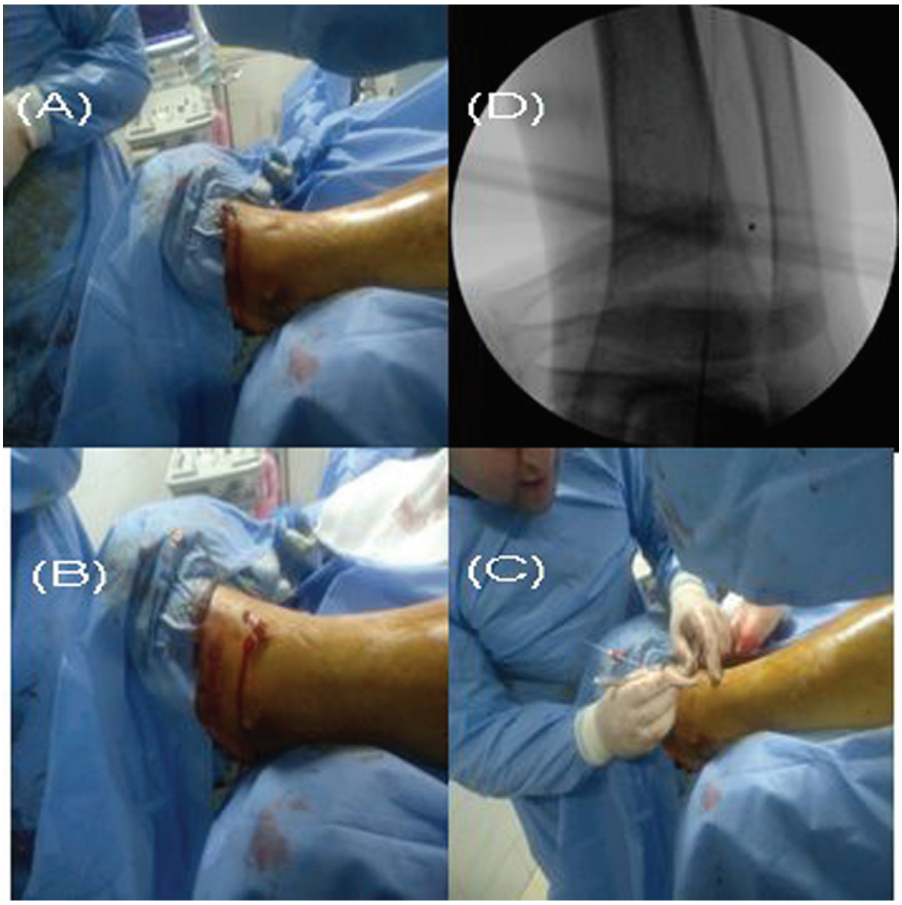
We succeeded in 13 (76.5%) patients to cross the occlusion and recanalyze the target vessel [completing the procedure from the antegrade approach in eight (47.1%) patients, and completing the procedure from the retrograde approach in five (29.4%) patients].

Figure 1



(a) Injected contrast from antegrade sheath showing stenosis at junction of popliteal artery behind (P2) and below the knee (P3) with near-total occlusion of the three tibial vessels. (b) 0.014 wire supported by balloon at P3. (c, d) Injected contrast from the balloon showing proximal part of peroneal artery and reformation of lower ATA. (e, f) Antegrade balloon dilatation of peroneal artery. (g, h) Injected contrast from the balloon showing recanalization of the peroneal artery. ATA, anterior tibial artery.

Figure 2



(a) Retrograde puncture of ATA. (b) Advancement of the short 0.018-inch wire. (c) Inserting the dilator and removal of wire. (d) Advancement of 0.014-inch wire supported by Pacific deep balloon 3×80 mm. ATA, anterior tibial artery.

The mean ankle brachial index was significantly increased, from 0.39±0.11 before the intervention to 0.78±0.12 after the intervention, with *P* value less than 0.01.

However, we failed in four (23.5%) patients. In two patients, the wire could not cross the occlusion (and the patients underwent popliteodistal bypass later, but one of them underwent above-knee amputation later), in one patient the wire made perforation (and this patient also performed below-knee amputation), and in one patient the retrograde wire failed to re-enter the true lumen proximal to the occlusion and also failed to enter the subintimal track made by the antegrade wire even after simultaneous balloon dilatation (and the patient underwent above-knee amputation later) (Table 3).

Apart from two patients who developed mild hematoma at the site of PTA puncture that was treated conservatively, there were no puncture site complications (Table 4).

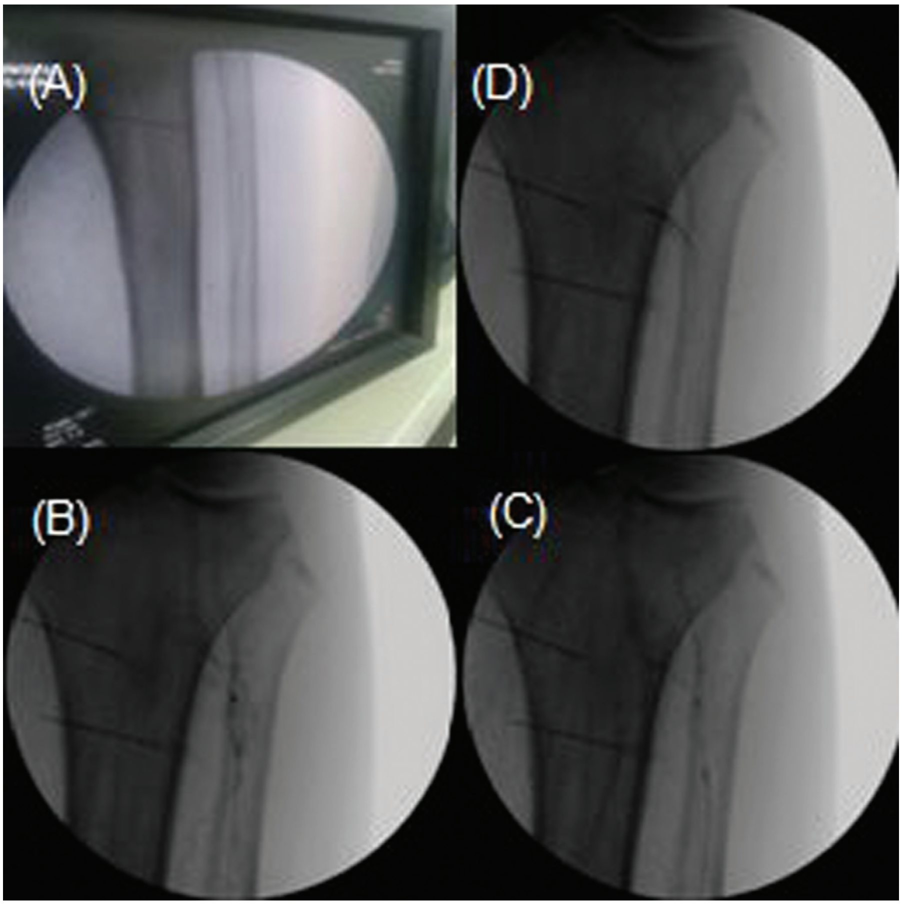
At a mean follow-up of 12.3±4.8 months, three patients (of the four technically failed patients) underwent above-knee amputation and two patients (of the 13 technically succeeded patients) underwent below-knee amputation because of infection of the foot and so the limb salvage rate was 70.5% (12 of 17 patients) (Fig. 5).

Discussion

Most patients with critical limb ischemia with popliteal and or infrapopliteal CTOs undergo endovascular interventions because of high risk for surgery, no available leg vein, or no available runoff vessel. However, endovascular interventions fail in 10–40% of cases. So retrograde tibiopedal approach was described as a bailout technique [8]. Retrograde approach success may be owing to much more nearer distance between access and CTO, giving the guiding wire and supporting balloon more push-ability, less fibrosis and calcification of the distal cap of CTO and avoiding passage of the guide wire through collaterals arising caudally just proximal to the lesions [9].

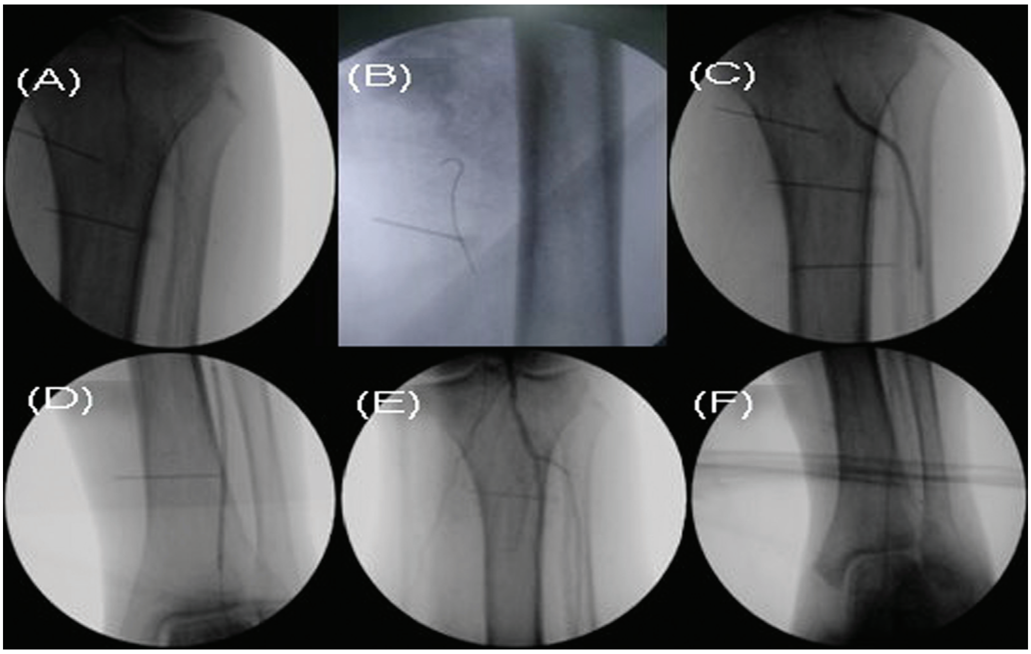
Our technical success rate was 76.5%, lower than (100%) of Fusaro *et al.* [10] and (86%) of Montero-

Figure 3



(a) Inserting 0.014-inch wire with antegrade balloon in peroneal artery. (b) Advancement of 0.014-inch wire supported by Pacific deep balloon 3×80 mm in the ATA (c) Advancement of 0.014-inch wire supported by Pacific deep balloon 3×80mm till the mouth of ATA. (d)The wire made a loop transversing the origin of ATA. ATA, anterior tibial artery.

Figure 4



(a) Inserting with antegrade balloon in peroneal artery. (b) Advancement of 0.014-inch wire supported by Pacific deep balloon 3×80 mm till SFA. (c, d) Balloon dilatation of ATA. (e, f) Completion angiogram from antegrade sheath. ATA, anterior tibial artery.

Baker *et al.* [11]. This lower success may be owing to our learning curve and more advanced Rutherford category of our patients, as our patients were categories 4, 5, and 6, whereas their categories 3, 4, and 5 (part of their patients were claudicant and no patients with gangrene).

Table 1 Patient characteristics

Age (mean±SD) (years)	68.6±9.8
Sex (female/male)	8/9
Diabetes mellitus [*N* (%)]	16 (94.1)
Smoking [*N* (%)]	7 (41.2)
Ischemic heart disease [*N* (%)]	12 (70.6)
Hyperlipidemia [*N* (%)]	14 (84)
Hypertension [*N* (%)]	11 (64.8)
Rutherford category 4 [*N* (%)]	6 (35.3)
Rutherford category 5 [*N* (%)]	8 (47.1)
Rutherford category 6 [*N* (%)]	3 (17.6)

Table 2 Lesions and approaches

	N (%)
Lesions of popliteal artery only	3 (17.6)
Lesions of tibial arteries only	11 (64.8)
Lesions of both popliteal and tibial arteries	3 (17.6)
TASC II C lesions	11 (64.8)
TASC II D lesions	6 (35.2)
Percutaneous ATA access	8 (47.1)
Percutaneous dorsalis pedis access	1 (5.9)
Percutaneous PTA access	6 (35.2)
Open PTA access	2 (11.8)

ATA, anterior tibial artery; PTA, posterior tibial artery; TASC, Trans-Atlantic Inter-Society Consensus.

At a mean follow-up of 12.3±4.8 months, the limb salvage rate was 70.5% (12 of 17 patients), whereas Bazan *et al.* [9] found at a mean follow-up of 17.1±10.3 months, the limb salvage rate was 77% (10 of 13 patients) and Gandini *et al.* [12] found the limb-salvage rate was 83% at 6-month follow-up.

Our strategy was gentle manipulation of the wire trying first to keep it intraluminal by unfolding loop in its

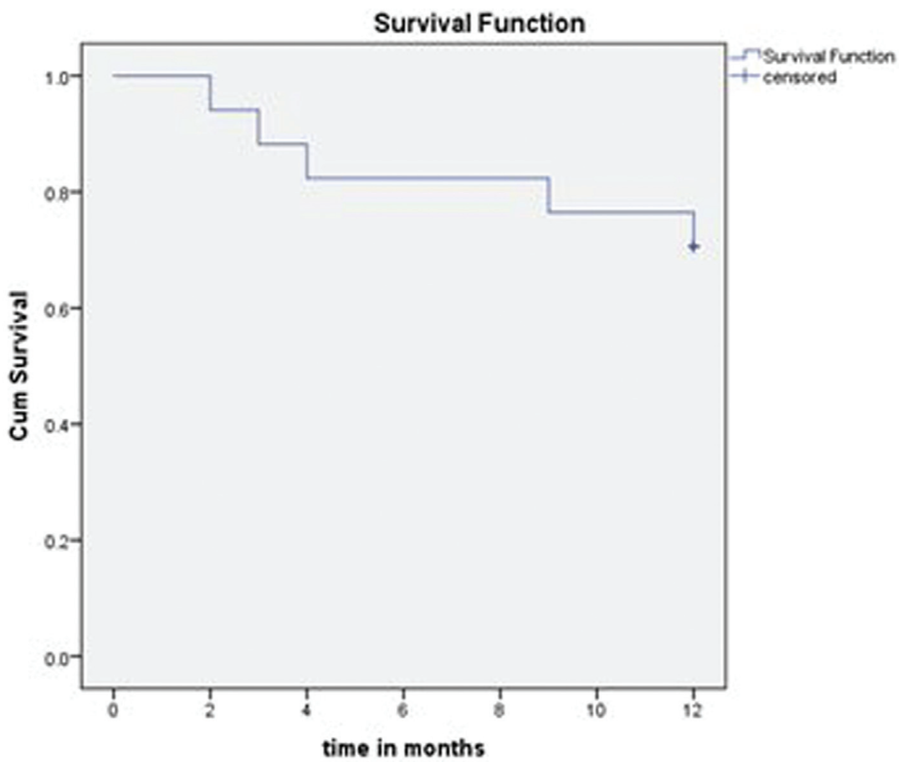
Table 3 Technical success rate

	N (%)
Technical success of the procedures	13 (76.5)
Failed cases	4 (23.5)
Completing the procedure from antegrade approach	8 (47.1)
Completing the procedure from retrograde approach	5 (29.4)

Table 4 Puncture site complications

	N (%)
Hematoma	2 (11.8)
Pseudoaneurysm	0 (0)
Arteriovenous fistula	0 (0)
Infection of incision	0 (0)

Figure 5



Kaplan–Meier survival curve for limb salvage.

leading part, but if failed allowing it to pass through the least resistant track even it made a loop. This is also adopted by Montero-Baker *et al.* [11], but differs from Spinosa *et al.* [13] in that they intended subintimal track, Percutaneous Intentional Extraluminal Recanalization.

Our strategy was to decrease trauma to the access vessel by avoiding introducing the sheath itself, like the first group of Montero-Baker *et al.* [11] and Gandini *et al.* [12], by only using the dilator part to exchange the wire, like Botti *et al.* [14], or completely sheathless by inserting the long 0.018-inch guide wire directly through the micropuncture needle, like Fusaro *et al.* [10]. Moreover we had no significant access site complications like previous authors and most of literature, apart from acute occlusion of access vessel in one patient of the first group of Montero-Baker *et al.* [11] that required urgent pedal bypass.

Our technique was like almost all of the literature and all previously mentioned authors to start by antegrade femoral approach, and only if failed, we go for retrograde tibiopedal approach, but that was different from Amro *et al.* [15] that they used retrograde approach as a primary approach without antegrade femoral approach. However, Amro *et al.* [15] encouraged us to complete the procedure from below (ballooning the lesion from retrograde approach) for five patients with isolated infrapopliteal lesions to avoid extraction of the retrograde wire from the antegrade femoral sheath, which is a difficult step or needs an expensive snare kit. Moreover, Fusaro *et al.* [10] and Amro *et al.* [15] dilated the lesions from the retrograde approach, and then Fusaro *et al.* [10] extracted the wire from the antegrade approach and completed the procedure from above, but Amro *et al.* [15] did all the procedure from primary retrograde approach. Montero-Baker *et al.* [11] criticized dilatation from retrograde approach claiming that extracting an inflated balloon may traumatize the access tibial vessel more than unused balloon.

In the other successful eight patients, we extracted the wire from the antegrade femoral sheath without using a snare kit, by guiding the wire into the tip of a straight catheter inserted from the antegrade sheath, like Montero-Baker *et al.* [11] and Spinosa *et al.* [13]. That differs from Fusaro *et al.* [10], Gandini *et al.* [13], Botti *et al.* [14], and Norgren *et al.* [16] who used a snare kit.

Conclusion

Retrograde tibiopedal approach can be used safely as a bailout option to increase the technical success rate and limb salvage for failed antegrade recanalization of popliteal and infrapopliteal arterial occlusions.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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