Retrograde ankle tibial artery approach for endovascular treatment of below-knee chronic critical limb ischemia: appraisal of early outcome and complications

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Background
Infragenicular arterial total occlusion is a major cause of critical ischemia of the lower limbs (CLTI) treated by endovascular intervention. Retrograde pedal artery access is an alternative method to cross total occlusion from below when antegrade passage fails. The aim of this study was to evaluate the short-term outcome in terms of patency, limb salvage, redoangioplasty rate, and complications.
Patients and methods
From June 2018 to July 2019, adult patients who had critical lower limb ischemia (Rutherford 4 and 5) were admitted to the vascular surgery unit of Alexandria main university hospital and department of CLTI clinical and experimental surgery at Alexandria medical research institute. They all were planned to be treated by infragenicular angioplasty. After failure of antegrade lesion crossing, angioplasty was done via retrograde access. Patients were followed for outcome and complications for 6 months.
Results
A total of 20 patients were included, comprising 14 (70%) males and six (30%) females. Mean age±SD was 71±13.5 years. Overall, 85% were diabetic, 75% hypertensive, 30% coronary heart disease, and 80% were smokers. CLTI clinical presentation was ischemic rest pain (20%) and tissue loss and gangrene (80%). Technical success was 85%. There were no procedural mortalities or complications except one case of limited leg hematoma (5%). The 6-month mortality was 5.8%, and major amputation was 5.8%. The 6-month primary and secondary patency rates were 62.5 and 87.5%, respectively, whereas the 6-month limb salvage rate was 93.75%.
Conclusions
Retrograde pedal access angioplasty to treat below-knee CLTI is a safe and feasible alternative to antegrade tibial angioplasty when it fails, with similar limb salvage and acceptable complications, but with possible higher reintervention rate, which needs to be studied further on a larger scale.

Keywords:
below knee, chronic total occlusion, critical limb ischemia, infragenicular angioplasty, retrograde access

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Introduction

Chronic critical limb ischemia (CLTI) imposes an important world-wide health problem. This is attributed to its association with high mortality owing to cardiovascular events (25%) as well as high limb loss rates (25%) in 1 year following its presentation [1,2].

For the sake of limb salvage, patients having infrapopliteal CLTI require revascularization with adequate medical treatment to control atherosclerotic risk factors as well as comorbidities.

Owing to its durability and limb salvage rate, popliteal-to-tibial arterial bypass, with a vein graft, is considered an excellent revascularization procedure to treat popliteal trifurcation and infrapopliteal occlusive disease causing CLTI [3]. However, this is not feasible in all cases owing to the diffuse multistenotic nature of the lesions and unavailability of an adequate vein graft as well [4]. The presence of high operative risk owing to cardiovascular, pulmonary, and renal diseases is another obstacle to surgical bypass. Therefore, endovascular revascularization has been widely used to treat such patients [5].

Endovascular treatment of lower limb lesions is usually done through a contralateral femoral artery approach, ipsilateral antegrade femoral access, or the less commonly used brachial approach. Through these accesses, the lesion wire crossing is tried in an antegrade way, which may fail in up to 20% of the procedures [6].

Percutaneous angioplasty through antegrade femoral approach has been used widely to treat popliteal trifurcation and tibial chronic total arterial occlusions (CTO). However, some popliteal and infrapopliteal occlusions are difficult to be crossed through this approach and subsequently not revascularized. Here, the retrograde pedal access can be used as an adjunctive technique to help crossing such difficult lesions [7]. This leads to increased initial technical success owing to the ease of crossing some tibial arterial lesions from below than from above.

Histologically, CTO lesions are developed on top of severe stenoses with dense fibrosis and calcification proximally more than distally [8]. This might be the cause of success to cross some of these lesions from below while failing using the antegrade access. In such situation, the guide wire passes through the relatively softer distal end of the CTO rather than the proximal difficult cap segment [9,10].

Another advantage of the retrograde pedal artery access is the close proximity of the puncture site to the tibial artery lesion. Being not far from the lesion site, this approach may allow better control and pushability of the wire manipulating the arterial occlusive lesion trying to traverse it.

Despite being close to infragenicular lesions and giving better chance to cross difficult ones, retrograde pedal access can be difficult to do percutaneously owing to distal tibial and pedal artery dense calcification. However, this difficulty can be overcome when tibial artery is exposed at the ankle through a cut down with direct needle puncture [11].

Retrograde pedal revascularization allows a single tibial artery in-line flow to the foot. Hence, the proper artery supplying the affected angiosome should be chosen carefully, if more than one pedal artery is available for puncture [12,13]. However, in many cases, the operator may find only a single vessel runoff after the CTO, regardless of the angiosome.

In such situation, retrograde revascularization is used to improve the foot perfusion through indirect flow rather than in-line flow which is a desperate maneuver that may help but with questionable clinical effect.

Aim

The aim of the work was to evaluate the early results of retrograde transtibial endovascular approach as an alternative vascular access in the treatment of below the knee (BTK) arterial occlusive disease in patients with chronic limb-threatening ischemia in a period of 1 year from June 2018 to July 2019 in the surgical department of Alexandria main university hospital, Faculty of Medicine, and department of CLTI clinical and experimental surgery, Medical Research Institute, Alexandria, Egypt.

Patients and methods

IBR ethical approval and patient consents obtained in Alexandria University Faculty of Medicine. Adult patients were included in this study between June 2018 and July 2019 fulfilling the following inclusion criteria:

(1) Patients with CLTI having rest pain (Rutherford class 4) and/or tissue loss (Rutherford class 5).
(2) Patients with angiographic evidence of the presence of CTO lesions involving the distal popliteal artery and/or infrapopliteal arterial segment with at least one tibial artery adequate run off at the ankle.
(3) Failure of antegrade transfemoral approach to cross the occlusion.

Exclusion criteria

The following were the exclusion criteria:

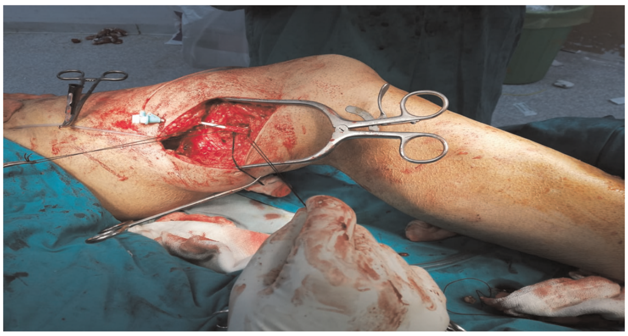
(1) Patients with chronic ischemia who are asymptomatic or claudicant.
(2) Patients who had successful antegrade transfemoral endovascular approach in crossing the occlusion.
(3) Absent adequate distal run off either by duplex or angiography whether done preoperatively or in the catheter laboratory.
(4) Patients presenting with chronic limb ischemia Rutherford grade 6 or life-threatening infection indicated for primary major amputation.

Methods: The patients of this study were subjected to the following:

(1) Full history taking.
(2) Thorough CLTI clinical evaluation including ankle blood pressure index measurement.

(3) Laboratory investigations, including the following:
   (a) Complete blood count.
   (b) Blood glucose level.
   (c) Renal and liver function tests.
   (d) Plasma lipid profile.
(4) ECG and plain chest radiogram.
(5) Respiratory function tests when indicated.
(6) Duplex ultrasound examination of the complaining limb for arterial tree evaluation including inflow and runoff segments.
(7) Computed tomography angiography of the abdominal aorta of both lower limbs arterial trees unless the patients had palpable popliteal pulse in whom diagnostic catheter angiography was done in the same session with angioplasty.
(8) Procedure: all patients were loaded with clopidogrel 75 mg (four to six tablet) before the procedure.
   (a) Transfemoral ipsilateral antegrade approach was tried in 19 patients, whereas ipsilateral transpopliteal open access approach was attempted in one patient as part of hybrid femoropopliteal bypass with tibial angioplasty (Fig. 1). Failure to cross the lesion was reported in 20 patients with subsequent tibial arterial puncture at the ankle through posterior tibial artery (PTA), in 18 patients (Fig. 2), and anterior tibial artery (ATA), in two patients (Fig. 3). All tibial arterial ankle punctures were done under guidance of fluoroscopy and road map imaging.
   (b) After successful tibial arterial puncture, retrograde advancement of the glide wire was done using 0.35-inch hydrophilic Tueromo TM wire in 18 patients, whereas 0.18 floppy tip V18 TM wire was used in the remaining two patients. Crossing the lesions was accomplished in all patients, with the wire supported by a percutaneous sheath (in two patients) (Fig. 4), sheathless wire passage (in 14 patients), sheathless wire passage with a guiding catheter support (in two patients), and sheathless passage with low profile balloon support (in two patients) (Fig. 5).
   (c) Wire retrieval through the antegrade sheath was done either after engagement by an antegrade Bernstein catheter (17 patients), or directly through the sheath opening (three patients).
   (d) Transluminal angioplasty was then accomplished through antegrade balloons without stenting.
   (e) Wires were withdrawn away from distal puncture sites with compression to control bleeding and no occlusion balloons applied.
   (f) Diluted nitroglycerine preparation was injected through the angioplasty balloon lumen to avoid and treat arterial spasm, and control angiography was done to assess technical success in all cases.
   (g) Postoperative ankle blood pressure index measurement was done in all patients to assess hemodynamic success.
   (h) At 3–5 days after a hemodynamically successful procedure, ulcer debridement and functional foot amputations were done as complementary procedures after revascularization.
(9) Follow-up: all patients were followed for the following 6 months for outcome and complications.

Figure 1



Open popliteal antegrade access.

Results

The current study included 20 patients, comprising 14 (70%) males and six (30%) females. Their ages ranged from 50 to 88 years, with a mean age±SD of 71±13.5 years. Of 20 patients, 17 (85%) were diabetic, whereas 15 (75%) patients had essential hypertension, and six (30%) patients had proved coronary heart disease, with four of them having previous coronary stenting and one had coronary bypass surgery (CABG). Overall, 16 (80%) patients were smokers. All patients presented clinically with CLTI of the lower limb in the form of either ischemic rest pain (four patients) or minor tissue loss and gangrene (16 patients) (Table 1).

Infrapopliteal CTO was the lesion nature found in all the current study cases with single suitable tibial artery run-off at the ankle level as seen in catheter angiograms. Concomitant popliteal artery stenosis was encountered in four (20%) patients, popliteal occlusion in one (5%) patient, superficial femoral

Figure 2

(a) PTA puncture under fluoroscopic road map. (b) ATA puncture under fluoroscopic road map. ATA, anterior tibial artery; PTA, posterior tibial artery.

artery (SFA) stenosis in four (20%) patients, and SFA occasion in one (5%) patient (Table 2). The initial step in the study patients was percutaneous transfemoral antegrade approach in all studied patients except one (5%) patient, who was offered an open transpopliteal antegrade approach to optimize a better tibial runoff for a planned femoropopliteal bypass in the same session, that is, a hybrid procedure (Table 3).

Failure of antegrade crossing of the infrapopliteal occlusive lesions was encountered in all cases except one patient, in whom, successful crossing of proximal peroneal stenosis was gained, but a distal one-third occlusion was found. Hence, an alternative PTA retrograde access was secured through an ankle puncture, and both proximal peroneal and PTA balloon dilatations were done through the antegrade access.

Procedural technical success: In this study, technical success was 85% (17 patients). The three technical failure cases were owing to inability to cross the tibial occlusion in retrograde fashion. In these three patients, the indication of intervention was two

Figure 3

(a) PTA retrograde sheath. (b) Sheathless wire passage with balloon support. PTA, posterior tibial artery.

cases of foot gangrene and ischemic rest pain in one. The two patients with ischemic gangrene of the foot had major amputation (below the knee), and the patients with rest pain were offered popliteal-posterior tibial bypass with a reversed vein graft, and they improved well. No periprocedural complications were reported except a limited noncommunicating ankle hematoma, which resolved completely on conservative measures.

Outcome and complications

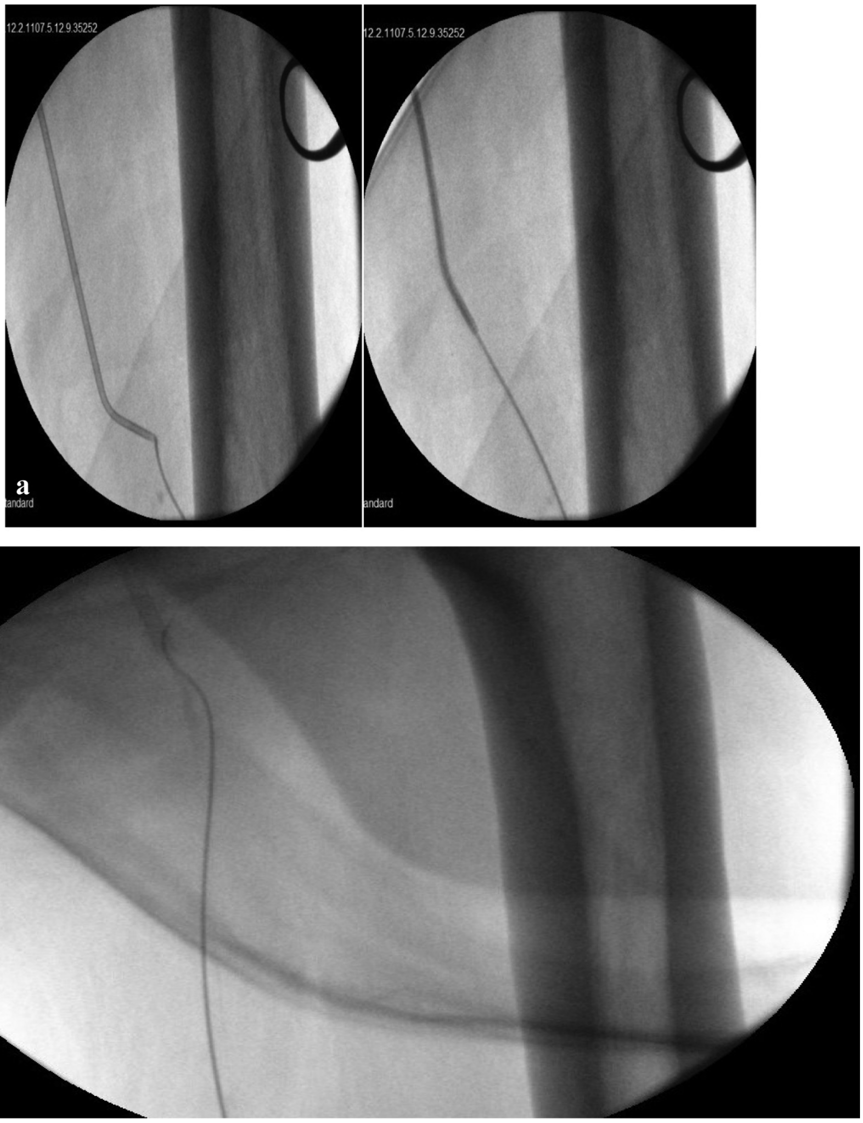
During follow-up after successful retrograde tibial angioplasty, mortality in one (5.8%) patient, owing to myocardial infarction, and major amputation (below the knee) in one (5.8%) were reported in 6 months (Table 4).

The 6-month primary patency was 62.5% (10 patients) owing to reported reocclusion, evidenced by duplex follow-up in five patients (one patient with rest pain and four patients with ischemic tissue loss). The patient with rest pain responded well to aggressive medical treatment and his rest pain improved. The other four (25%) patients having tissue loss required redo angioplasty after aggressive medical treatment and wound care for more than 4 months. Surprisingly, they had successful tibial angioplasty through an antegrade access with a 100% technical success and improved CLTI clinical response with limb salvage. This rendered an estimated 6-month secondary patency of 87.5%. Through the 6-month follow-up period, complete healing of minor ischemic tissue loss was reported in 12 (75%) patients and improvement of rest pain in three (18.75%). Hence, the limb salvage rate of the studied procedure was reported to be 93.75% (15 out of 16 patients) in the 6-month follow-up period.

Discussion

For peripheral arterial disease (PAD), age is the strongest risk factor. The mean age of patients included in the current study was 71 years. Many studies stated that PAD is more prevalent in population aging 50–70 s and accounts for ∼25% in population over 80 years [14–16].

Figure 4



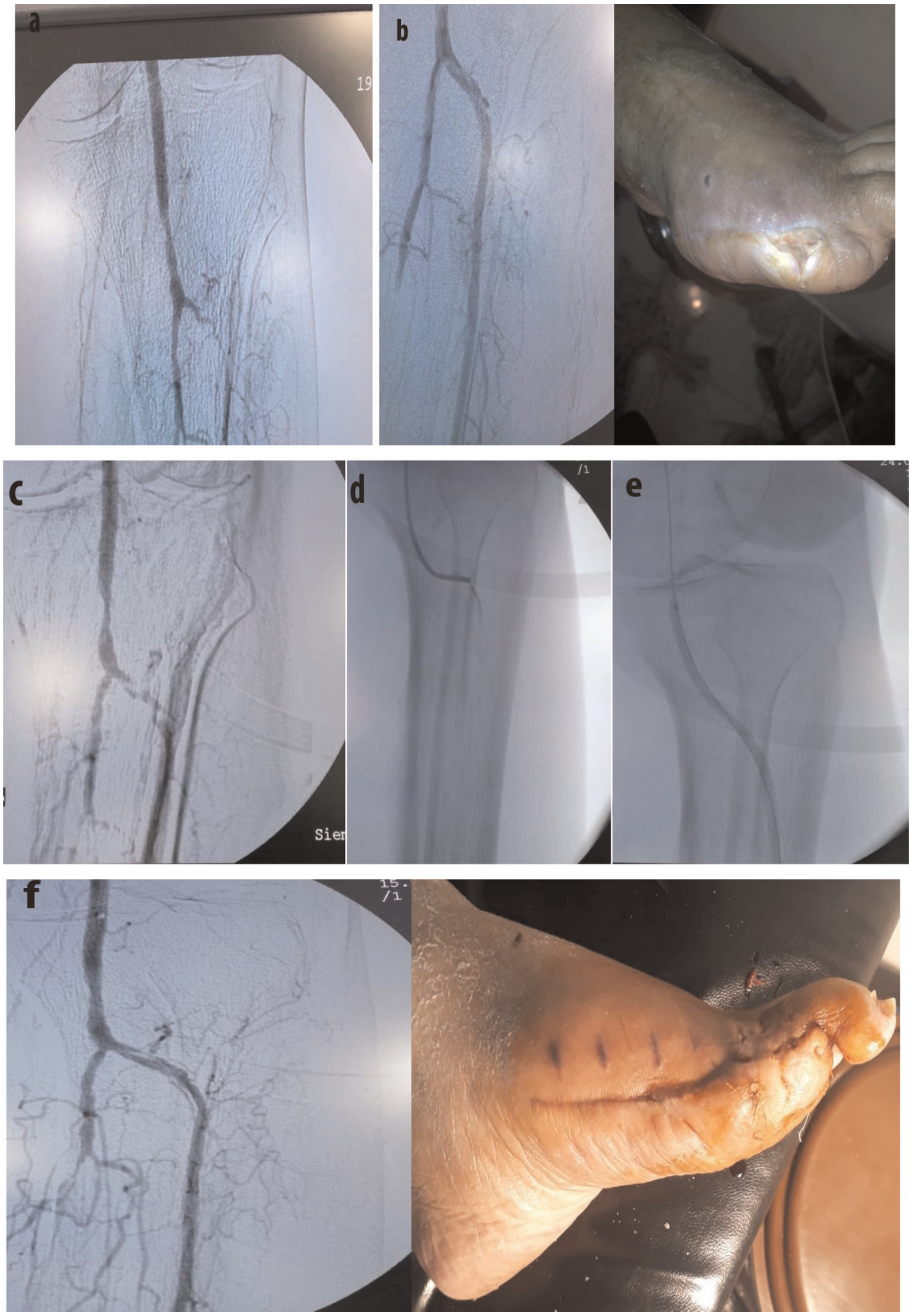
(a) Engagement of the retrograde wire by Bernstein catheter for retrieval through antegrade sheath. (b) Retrieval of the retrograde wire through the femoral antegrade sheath without engagement.

The reported male predominance in the study patients (70%) can be explained, possibly, by the increased PAD incidence among Egyptian male sex than females, increased smoking among males more than females resulting in more PAD, or the more severe form of PAD, that is, CLTI, is found more in males. Many studies reported different sex incidence of PAD in different communities and socio-economic classes. However, they stated that the severe form of PAD is more common in males [17].

Regarding anatomical pattern of the arterial lesion and its relation to risk factors, it was found that aortoiliac and femoropopliteal diseases are more related to smoking, whereas tibial and pedal affections are to old age, male sex, and diabetes mellitus [18,19]. Overall, 85% of the study patients had diabetes mellitus, whereas 80% were smokers, and all of them had tibial artery (infrapopliteal)-predominant lesions.

CLTI as the severe form of PAD has an intimate relation to the anatomical form of the arterial lesions and consequently to their related risk factor predominance, as mentioned before. It was found that CLTI is there when the patient has at least two levels of arterial disease affection, or when he/she has severe infrapopliteal disease [20,21]. The current study patients had CLTI as their clinical presentation, and this was attributed to affection of infrapopliteal arterial tree by CTO in all of them. In 50% of the study patients, the tibial artery CTO was the sole arterial lesion, whereas it was found in combination with other popliteal and SFA lesions in the remaining 50%.

Figure 5



Redo case: (a) ATA lesion treated via retrograde access, (b) after initial angioplasty with incomplete toes amputation healing, (c) recurrent ATA lesion, (d) antegrade lesion manipulation, (e) antegrade redoangioplasty, (f) after redo dilatation with completion of foot lesion healing in 3 weeks. ATA, anterior tibial artery.

Table 1 Patients' comorbidities and clinical presentations

Patients' comorbidities and presentation	*n* (%)
Diabetes mellitus	17 (85)
Essential hypertension	15 (75)
Heart disease (ischemic)	6 (30)
Rest pain (Rutherford 4)	4 (20)
Limited tissue loss and gangrene	
Rutherford 5	16 (80)
Total number	20 (100)

In this study, retrograde access was gained through ATA ankle puncture in 18 (90%) patients and PTA puncture in two (10%). No peroneal artery puncture was attempted in this study. The initial cause of puncture site choice was the availability of suitable ankle pedal artery run-off for access regardless of the angiosomal distribution of the tibial vessels. This suitability was assessed by the use of diagnostic angiography done during intervention, and the ankle tibial puncture was

Table 2 Number of treated arteries and their procedures

No. of managed arteries	Procedures	*n* (%)
Single tibial artery	Balloon angioplasty	9 (45)
Two tibial arteries	Balloon angioplasty	1 (5)
Single tibial+popliteal stenosis	Balloon angioplasty	4 (20)
Single tibial+popliteal occlusion	Balloon angioplasty	1 (5)
Single tibial+SFA stenosis	Balloon angioplasty	4 (20)
Single tibial+SFA occlusion	Hybrid femoropopliteal bypass + tibial balloon angioplasty	1 (5)
Total number of patients		20 (100)

SFA, superficial femoral artery.

Table 3 Type of access used and its guidance

Initial failed access	Number of patients (%)	Alternative retrograde access	Number of patients (%)	Retrograde guidance	Number of patients (%)
Ipsilateral antegrade femoral	19 (95)	Posterior tibial artery	18 (90)	Fluoroscopic guidance	20 (100)
Open antegrade popliteal	1 (5)	Anterior tibial artery	2 (10)	ultrasonography	0
Total number	20 (100)	Total number	20 (100)	Open access (ankle cut down)	0

performed under fluoroscopic road map guidance as well. No ultrasound duplex guidance was used in all study patients despite the availability of the technique. The study working group found fluoroscopy guidance feasible and efficient in all study patients, and hence, they did not attempt any alternative.

Similarly, Ruzsa *et al.* [22] used ATA and PTA access guided by fluoroscopy and did not attempt peroneal artery access. Bazan *et al.* [7] also used ATA and PTA ankle access and did not used peroneal access similar to the current study. However, duplex ultrasound was the guidance in their study. They explained abandoning peroneal access by its deep location in posterior leg compartment, its difficult control by external pressure, and therefore the possibility of postprocedural hematoma and compartmental hypertension when using it.

On the contrary, El-Sayed *et al.* [6] used ATA, PTA, and peroneal artery as a retrograde access, in their study guided by duplex ultrasound scanning. They made their access site puncture choice according to angiosome distribution principle.

In the current study, in a similar way to many studies evaluating this type of intervention [6,7,22,23], retrograde access was done percutaneously. However, it was described to access the tibial arteries using surgical cut down either as a case report [11] or as a routine procedure [24].

In the current study, the procedural technical success was reported in 85% of cases in the form of successful lesion crossing and final in-line flow to the ankle with no significant residual stenosis. Failed cases were owing to inability to cross the lesion in the retrograde trial after failure of antegrade passage trial. Bazan *et al.* [7] reported 69% technical success in their study but also this study included fewer number of patients than the current one (13 patients and 20 patients, respectively). Similar technical success was encountered in other studies which included similar number of studied patients in relation to the study duration [9,25,26].

Table 4 Outcome and complications

Outcome and complications	*n* (%)
Access pedal arteries thrombosis	0
Access site leg hematoma	1 (5): mild did not require intervention
Procedural mortality	0
Procedural failure	3 (15) 2 had BKA and 1 patient offered popliteal tibial bypass
Follow-up mortality	1 (5.8) due to myocardial infarction
Postprocedural major amputation	1 (5.8)
Postprocedural reocclusion	5 (31.25)
6-month primary patency	10 (62.5)
6-month secondary patency	14 (87.5)
6-month limb salvage rate	15 (93.75)

BKA, below the knee.

The current study reported a single case of retrograde access site hemorrhagic complication and no other reported procedural complications. Similar to the current study, Chou *et al*. [23] reported a retrograde access site hemorrhagic complication in the form of limited ankle hematoma in two (2.7%) patients and no tibial access arterial thrombosis. However, they reported multiple procedural complications in the form of perforation, dissection, and embolization from groin access site. This remarkable difference can be explained by the larger number of their study patients over a 6-year period comparing the conventional retrograde technique with controlled and reversed controlled antegrade retrograde subintimal tracking (CART and rCART) techniques. Other studies revealed the same principles of infrequent retrograde percutaneous access site complications [22,25,27,28].

Retrograde access site complications were believed to be more whenever the open surgical access was adopted owing to surgical wound problems, mainly. However, Liang *et al*. [24], in their study that evaluated tibial artery cut down as a routine retrograde access for endovascular treatment reported no access site complications in their 14 studied patients. They stated that decreased risk of tibial artery injury, taking under vision artery control, and decreased fluoroscopic exposure are advantages of the open method. However, the current study working group believe that the possibility to apply the open technique as an alternative to a failed percutaneous retrograde puncture is the main advantage of this method.

In the current study, 6-month postoperative mortality was estimated to be 5.8% owing to myocardial infarction as a major adverse cardiac event (MACE). Studying 58 patients who underwent conventional retrograde angioplasty for infrainguinal arterial lesions, Chou *et al*. [23] reported a 24-month mortality of 31% in this patients group, but their study included all causes including MACE and others. In another study on 21 retrograde angioplasty cases for complex tibial artery disease, the reported mortality was 5% due to MACE [6].

In the current study, the 6-month primary patency was 62.5%, with a reintervention rate of 25% due to occlusion with nonhealed ischemic foot lesions, rendering a secondary patency rate of 87.5%. These results are equivalent to other research studies investigating retrograde tibial access for infragenicular arterial insufficiency. El-Sayed *et al*. [6] reported an assisted primary patency of 84% and a secondary patency of 94% but with a redoangioplasty in only 9.5%. The reintervention was done in a conventional antegrade way similar to the current study. On a larger number of patients, for a longer time period, Chou *et al*. [23], in the conventional retrograde group, reported similar 6-month primary patency (62%), assisted primary patency (83%), and target vessel revascularization (TVR) of 18.4%.

Keeping in consideration the short follow-up period of the current study, there was no observed big difference regarding the limb salvage rate comparing the current study 6-month limb salvage rate with many other reports concerning retrograde infragenicular angioplasty in literature review, for example, Bazan *et al*. [7] (77% in 17 moths), El-Sayed *et al*. [6] (88% in 1 year), Ruzsa *et al*. [22] (93% in 2 months), and Chou *et al*. [23] (52% sustained CLTI clinical success in 2 years).

Regarding the differences in limb salvage in patients with CLTI treated by lower extremity bypass and angioplasty, Schamp *et al*. [29] reported similar 3-year limb salvage in both groups and suggested both treatment modalities to be complementary.

Limb salvage rate of BTK angioplasty by retrograde access is not far from rates of the same treatment modality but via antegrade access, for example, Tefera *et al*. [30] reported 83.5% in 33-month follow-up and Bosier *et al*. [31] reported 89.3% in 1 year.The adopted concept of the working group of the current study is to recanalize as many tibial arteries as they can in BTK angioplasty. This concept is used to improve pedal flow to the maximum helping ischemic foot lesions to heal more rapidly and efficiently. It was reported that there is better limb salvage in reciprocal relation to the number of recanalized tibial vessels. Moreover, significantly more ischemic pedal lesion healing in significantly shorter time was reported in relation to increased numbery of axial leg arteries opened successfully [32,33]. This is not the condition when using retrograde access which allows single tibial arterial flow to the treated foot. In few instances, retrograde angioplasty can be used as a complementary maneuver to antegrade angioplasty with the risk of antegrade recanalized artery reocclusion risk. Hence, a big disadvantage of the technique is the limitation of the number of revascularized tibial arteries.

Reintervention rate is reported to be higher in patients undergoing endovascular treatment than in patients treated by surgery. In a large study included 883 patients treated by endovascular procedures and 975 patients offered lower extremity bypass surgery in 6 years study duration, it was concluded that there a statistically significant higher rates of reintervention and TVR in patients treated by peripheral intervention than in those offered a bypass [34]. Reintervention rate increases with age and related much to complexity of the disease. Klaphake *et al.* [35] studied 263 patients treated by endovascular procedures between 2006 and 2013 and revealed that in population aged over 70 years, reintervention was reported in 32% of them. Overall, 48% of reinterventions were reported within the first 3 months, that is, early reintervention. This might be related to complexity of the lesions managed.

From the more complex nature of the lesions that required retrograde access to enable crossing and the relation between restenosis and lesion pathology, the working group of the current study believes that lesions requiring retrograde access might be associated with a higher incidence of reintervention and TVR. However, on literature review, we found no dedicated studies comparing this issue in patients treated with retrograde access intervention and those offered antegrade conventional interventions. Thus, we need to conduct studies comparing the two groups with a larger number of patients over a longer time period. The observation of successful reintervention via antegrade access raised the concept of paving the way by the initial retrograde access for the second intervention when happened.

Conclusions

(1) Percutaneous angioplasty for below-knee CTO through retrograde tibial artery access is a feasible and easily applicable endovascular maneuver carrying many advantages, for example the small caliber of tibial arteries offers better pushability of the retrograde wire.
   (a) Better penetration of the distal fibrous cap of the CTO which is histologically softer than the proximal one.
   (b) The short distance from the ankle to CTO may offer better wire control, that is shorter distance gives better control.

(2) The use of fluoroscopic guidance to puncture ATA and PTA allows an easy and efficient alternative to ankle cut down with its wound complications and to ultrasound guidance as well.

(3) Puncturing the small diameter tibial arteries may have the disadvantages of being more liable to arterial spasm, occlusion, or even injury.

(4) Because more difficult lesions necessitate retrograde crossing of CTO, the study working group had the impression that retrograde angioplasty might be associated with higher rates of early reintervention. Larger studies are required to verify this issue.

However, the study working group recommends this technique as a secondary or bailout maneuver when antegrade lesion crossing fails and not as a primary maneuver unless the patient has a hostile groin or other antegrade access contraindications.

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Conflicts of interest
There are no conflicts of interest.

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