Retrograde approach for complex lower limb arterial occlusions

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Introduction
Despite the advancement of endovascular technology, there are complex lesions which cannot be passed through antegrade approach, a retrograde approach to cross the complex lesion was first described by Iyer and colleagues, and it was used in cases where antegrade approach failed to cross the lesion. This promising technique had good results and was done through surgical incision and direct arterial puncture.
Patients and methods
A registry of retrograde approach has been maintained since March 2014, when the first transposterior tibial retrograde recanalization was performed at our institution till March 2016. Thirty-six patients were selected from the registry with age range from 49 to 85 (65.14), male pateints were 21 (58.3%) and female patients were 15 (41.7%). Patients were Rutherford class 4 (six patients), 5 (21 patients) and 6 (nine patients).
Results
After retrograde angioplasty a Kaplan–Meier curve for patency was 77.7% (28 of 36), 63.8% (23 of 36) and 47.2% (17 of 36) at 6, 12 and 24 months, respectively. Limb salvage rates were 97.2, 80.6, and 66.4% at 6, 12, and 24 months, respectively.
Conclusion
Retrograde approach is a safe and effective way to pass a complex lesion and it provides an alternative way to surgery with less complications and faster recovery.

Keywords:
complex lesions, peripheral arterial diseases, retrograde approach

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Introduction

Although clinical success is higher with endovascular intervention for critical limb ischemia (CLI); yet complex, calcified and total obstructing lesions present in some patients are challenging [1]. Endovascular treatment offers multiple strategies to achieve technical and clinical success [2].

Ferraresi *et al*. [2] described the first attempt to below the knee (BTK) arterial lesions which was done through an antegrade common femoral arterial access; either intraluminal or subintimal techniques. The first attempt to cross a chronic total occlusion (CTO) was made by intraluminal approach and when failed they used a subintimal approach which could be successful.

The failure rate associated with antegrade approach to cross the CTO was high; up to 25% in superficial femoral artery (SFA) lesions and 20–40% for infrapopliteal lesions [3–6]. A re-entry device can be used to cross the CTO in case of subintimal passage of a wire but these devices are not always available and costly. Hence, a new and alternative approach (i.e. retrograde approach) emerged allowing for better treatment option for these complex lesions.

The first retrograde approach was described by Iyer *et al*. [7], this promising technique had good results and was done through surgical incision and direct arterial puncture [8–13] which was possible through all BTK arterial levels from the popliteal artery to foot arteries [6].

This technique requires training and has a learning curve. So it was used in difficult cases in which other approaches fail [14].

Patients and methods

We present our experience with the retrograde approach in the last 2 years. A retrospective review of a prospectively maintained database of patients with 150 limbs undergoing endovascular treatment for CLI from March 2014 to March 2016. Patients who failed the conventional antegrade approach underwent retrograde approach to cross the lesion were identified and the data was collected and analyzed, the study also was approved by our institution review board.

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The grading of the ischemia severity was according to Rutherford classification. Although the Rutherford classification [15] remains the standard method it needs to be revised in CLI patients; because, a broad range of foot lesions are incorporated into a single category (category 5).

Indications of retrograde approach

We used retrograde approach when antegrade access failed to cross the lesion, or if there was a difficulty of antegrade femoral access due to SFA flush lesions, groin scars or infections.

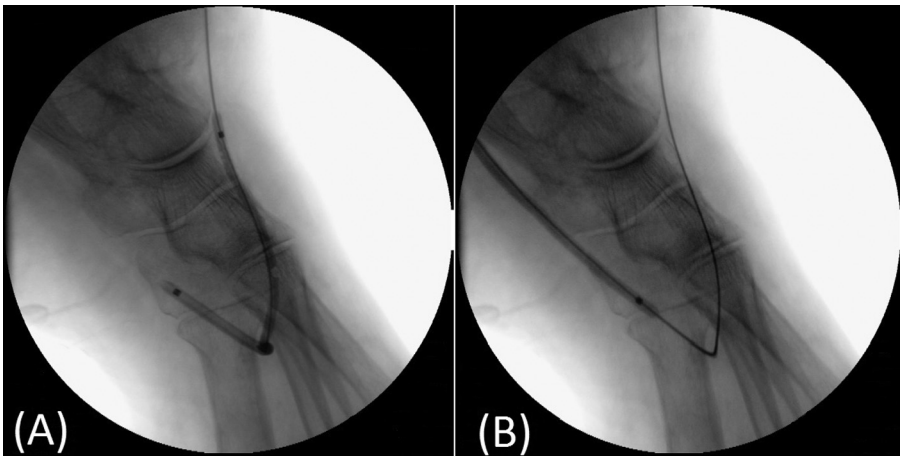
The techniques of retrograde approaches

All patients underwent full medical therapy and all had a trial of antegrade approach to cross the CTO. There were three techniques used for the retrograde approach the first is pedal-plantar loop technique which involves the passage of a wire from the Anterior tibial artery (ATA) to Posterior tibial artery (PTA) (or vice versa) through the pedal arch of the foot (Fig. 1).

The second is the transcollateral approach which uses a collateral artery suitable for guide wire passage to recanalize the tibials or foot arteries (Fig. 2).

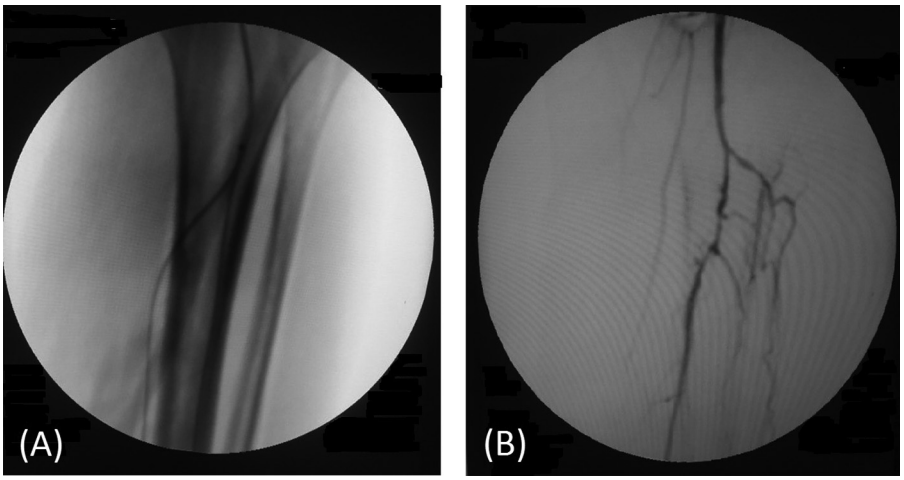
The third is the retrograde percutaneous access which is done by direct puncture of a distal patent artery followed by passage of the wire in a retrograde direction then dilatation of the CTO followed by the standard antegrade angioplasty (Fig. 3).

Figure 1



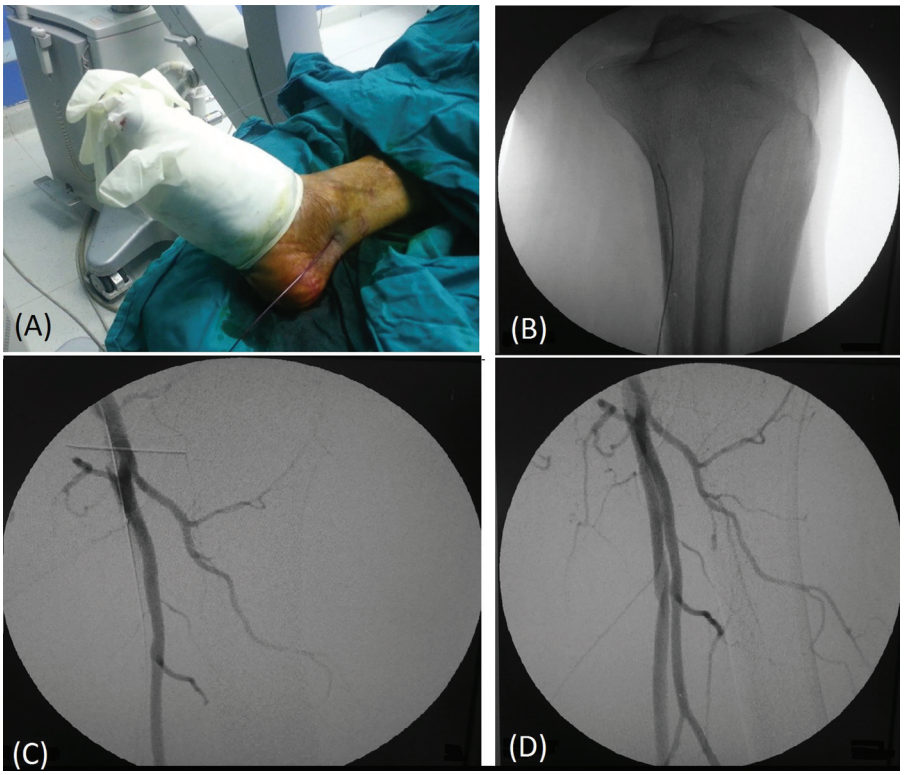
A representation of pedal-plantar loop technique (a) a balloon over the wire used to dilate the plantar arch. (b) Balloon over the wire passed into the posterior tibial artery through the plantar arch from the anterior tibial artery.

Figure 2



A representation of transcollateral artery approach (a) wire passes through suitable collateral from the peroneal into the posterior tibial artery upward into the popliteal artery. (b) The popliteal artery after dilatation with the balloon.

Figure 3



Direct puncture of the posterior tibial artery to cross the chronic total occlusion followed by standard antegrade approach.

Guidance for access

Historically, Iyer *et al*. [7] described surgical incision (cutdown) as the first technique used but currently less invasive methods are used.

Two methods are now used for arterial access, the first one is fluoroscopy which is now widely used as it does not need extra instruments thus it is easy to use, also it can be done even without contrast in case of severe calcification. But, it has several drawbacks such as multiple punctures trials which might increase the risk of local complications, extra contrast will be used during the puncture trials. Also, the patient will move his foot due to pain so the road-mapping is difficult.

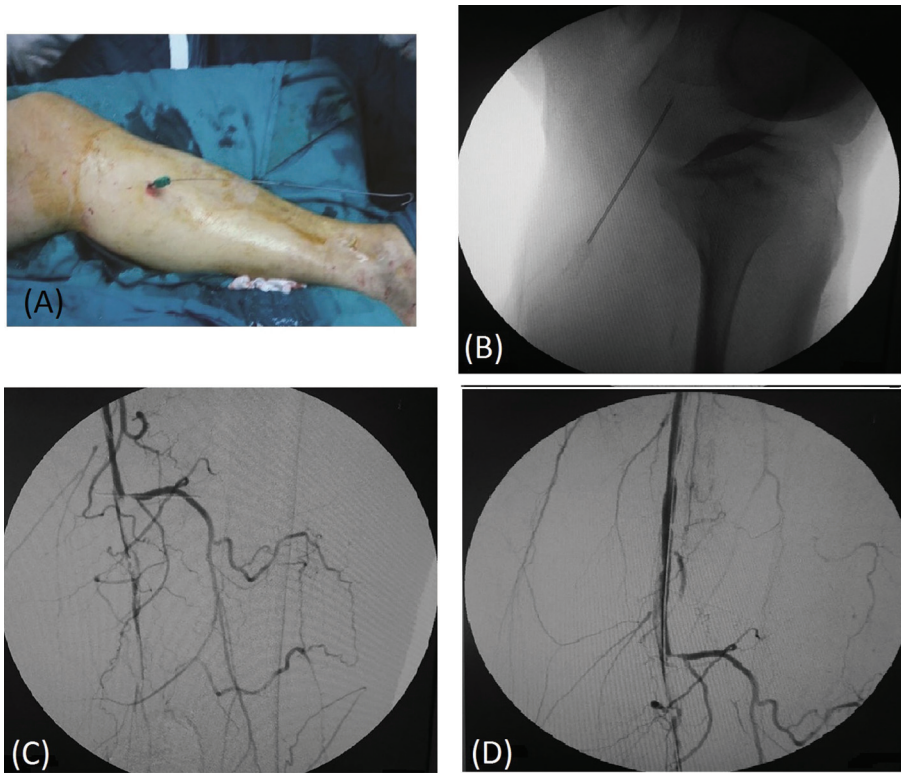
The second method used for retrograde approach arterial access is ultrasound guidance which gives a real time visualization of the arteries, less punctures so this would decrease pain and foot movement, no use of contrast and radiation exposure is decreased leading to less local complications and higher success rates. Access can be done in a few minutes as the learning curve is short.

We used different sites to access the artery using the retrograde approach; this was either transpedal access at any level of the leg (lower third, middle third or upper third), if there was a complex SFA, popliteal and tibioperonial occlusions and there was distal reconstitution of the tibial arteries, or by the distal SFA in patients with CTOs affecting the SFA in whom antegrade recanalization failed and the occluding lesion did not cross the level of the adductor canal (Fig. 4).

Percutaneous retrograde approach technique

(1) First the antegrade access was used with a 6-Fr ipsilateral (Radiofocus Introducer II; Terumo, Tokyo, Japan) or 6-Fr contralateral (Balkin; Cook, Bloomington, Indiana, USA) sheath or from a left brachial approach using a 5-Fr, 110-cm long sheath (Cook Inc., Bloomington, USA).
(2) After the placement of sheath 5000 U of Unfractionated heparin (UFH) given intravenously and additional 1000 U every 1 h for interventions that lasted longer than 1 h.
(3) The needle puncture of arteries in the retrograde approach is done either under fluoroscopic guidance or duplex guided (noncalcified vessels).
    (a) For the retrograde approach by the distal SFA, the C-arm was positioned into a contralateral oblique (30–45° for the right SFA (i.e. left oblique) and vice versa to facilitate puncture.
(4) The needle was introduced distal to the occlusion into the medial area of the thigh in a direct line with

Figure 4



An illustration of a retrograde superficial femoral artery approach. (a) Direct puncture through percutaneous approach. (b) Fluoroscopic position of the needle after puncture. (c) Passing the wire through the lesion. (d) Postdilatation angiogram.

the SFA. Oftentimes, contrast had to be injected through the antegrade sheath to visualize the distal SFA target.

(5) After arterial puncture, a guide wire was passed in the needle then a 5 or 6-Fr sheath was introduced.

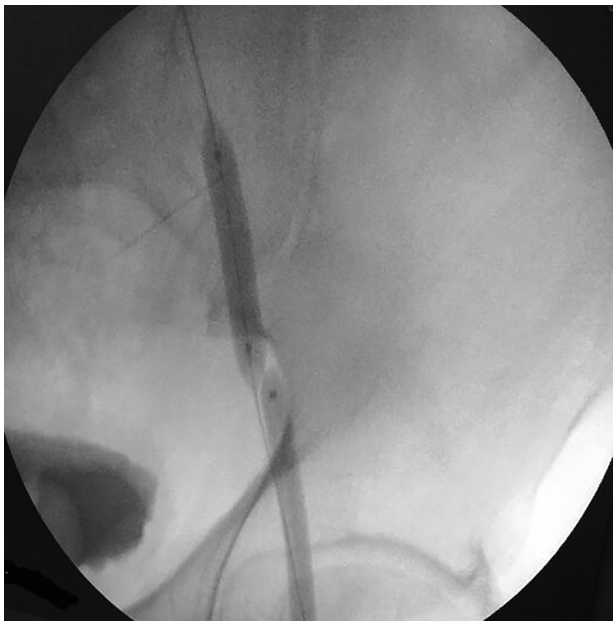
(6) If the wire cannot cross the lesion through the retrograde approach, a 'double-balloon' technique was used in which two balloons were used at the same time both in an antegrade and retrograde manner into the occlusion.

(7) The balloons were positioned with a 5 mm distance between their tips (no overlap) then the wires are retracted from the balloons followed by inflating the balloons for few seconds (Fig. 5).

(8) Balloons were inflated to break the dissection membrane separating the two balloons, then the balloons were pulled back for several centimeters, and another trial to pass the wire from both directions was reattempted.

   (a) The transpopliteal (face down) approach is the alternative [16] but it has many disadvantages: It has many drawbacks as the patient is put in a prone position, time-consuming and not convenient for both patient and interventionist and if the trial to pass the occlusion from a retrograde failed, no other access can be used in this prone patient [14].

Figure 5



Double balloon technique to break the fibrous cap in case of failure to pass the lesion through a retrograde approach only.

   (b) For pedal artery access if the ATA is the targeted vessel the C-arm was adjusted to an anteroposterior and cranial view with respect to the foot; if the PTA was the

artery to be punctured, the view was lateral to adjust the needle to the PTA.
After puncturing the tibial artery by the needle we use the sheath wire then the dilator to dilate the subcutaneous tissue especially when the artery is deep and also to exchange the wire then thread the wire upwards to cross the lesion and we prefer to continue the procedure sheathless by advancing the ballon over the wire (sheathless approach).

(c) After successful dilatation of the CTO we continue through the antegrade femoral sheath and sealing of the puncture site in the tibial artery by inflating balloon for 5 min and also with external compression.
(d) Antegrade administration of NTG 200 μg, prevent vasospasm in the retrograde approach.

Follow-up

After the procedure dual antiplatelet given with aspirin (150 mg/day) and cilostazol (100 mg twice/day) for 3 months and then lifelong daily aspirin thereafter.

Duplex ultrasound was done 1 day after the procedure to assess patency and detect the complications at puncture sites if present. Clinical follow-up took place every 1 month for at least 3 months (Tables 1–4).

A well maintained registry for patient with CLI was treated from March 2014 to March 2016, 150 limbs undergone angioplasty revascularization procedure of whom antegrade revascularization failed in 39 (26%) patients with complex CTOs.

Hence those 36 (21 males and 15 females) patients were suitable for retrograde approach, the success means the ability to cross the occlusion not only gaining an access. All lesions were CTO with a technical success rate of 92.3% (failed three cases); one case had a major amputation (below knee amputation), another case had femoroposterior tibial bypass by in-situ long saphenous vein using valvutom and one the third case was managed conservatively by medical treatment. The cause of failure was small tortious arteries (absence of sufficiently developed tibial vessels) in one case so that we could not get access and also the wire could not cross the lesion in two cases.

Many comorbidities in these patients was mainly diabetes mellitus in 75%, hypertension 61.1% and smoking 36.1% (Table 1). Postprocedure complications was bleeding, thrombosis, and vasospasm, all of which were managed successfully (Table 4); the occurrence of thrombi during the procedure was treated by infusion of urokinase at doses ranging from 25 000 to 200 000 IU. If vasospasm occurred, antegrade administration of nitroglycerine 200 μg was used which was an effective strategy to prevent vasospasm.

Considering that the below-the-ankle arteries were small and previous stenosis or occlusion existed, no treatment in case of bleeding was required.

Table 1 Patient characteristic, comorbidities and clinical condition (Rutherford classification)

Number of patients (*N*)	36
Age [mean (range)] (years)	65.14 (49–85)
Sex [*n* (%)]	
Male	21 (58.3)
Female	15 (41.7)
Medical comorbidities [*n* (%)]	
Smoking	13 (36.1)
CRF	6 (16.6)
Diabetes mellitus	27 (75)
Hypertension	22 (61.1)
IHD	7 (19.4)
Hyperlipidemia (*n*)	15 (41.7)
Clinical condition of treated limb [*n* (%)]	
Rutherford class 4	6 (16.7)
Rutherford class 5	21 (58.3)
Rutherford class 6	9 (25)

CRF, Chronic renal failure; IHD, ischemic heart disease.

Table 2 Outcomes

Overall outcome	*n* (%)
Technical failure	3 (7.6)
Death	2 (5.1)
Lost follow-up	3 (7.6)
Outcome of treated limb	
Wound healing	27(69.2)
Improved	4 (10.2)

Table 3 Access artery during retrograde approach

Superficial femoral artery [*n* (%)]	5 (13.8)
Tibioperoneal access [*n* (%)]	1 (2.7)
PTA [*n* (%)]	16 (44.4)
ATA [*n* (%)]	10 (27.7)
Peronieal access [*n* (%)]	4 (11.1)

Table 4 Incidence of postoperative complications

Complications	*N*=7 [*n* (%)]
Surgical site infection	0 (0)
Myocardial infarction	2 (28.5)
Deep vein thrombosis	0 (0)
Pulmonary embolism	0 (0)
Acute kidney injury	0 (0)
Unplanned readmission within 30 days	3 (43)
Postoperative groin hematoma that did not require readmission	2 (28.50)

A Kaplan–Meier curve was done to compare primary patency rates after retrograde angioplasty which was 77.7% (28 of 36), 63.8% (23 of 36) and 47.2% (17 of 36) at 6, 12 and 24 months, respectively. Limb salvage rates were 97.2, 80.6, and 66.4% at 6, 12, and 24 months, respectively (Fig. 6).

Discussion

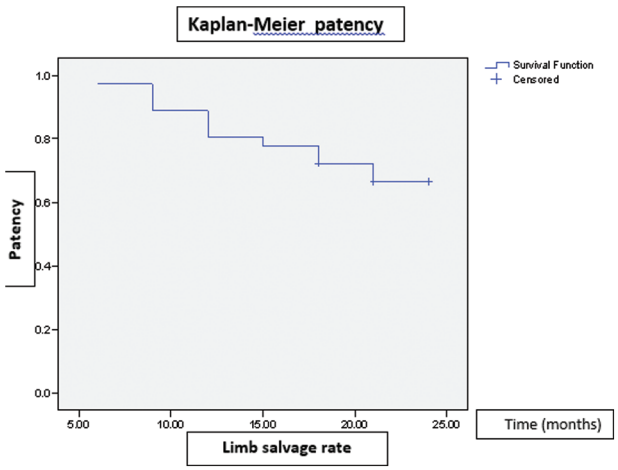
Previously antegrade approach was the only solution used to bypass a CTO affecting the lower limb arteries, with advances in technology a new method was used to cross the CTO requiring a subintimal passage of the wires with a re-entry device need to get back into the actual arterial lumen, these re-entry devices are not always available and costly to be used.

A newer technique emerged with a greater success rate of passing the CTO which proved effective as the CTO lesion cap was higher in density at its upper end than its lower end, also the wire will not enter side branches through a retrograde approach due to the direction of collaterals [17]. Also stronger wire push ability due to short distance between the puncture site and the occlusion and small size of access artery [18].

Retrograde pedal access can be used even without failure of antegrade approach and usually associated with shorter time of the procedure [19]. Lupattelli *et al.* [20] did not advice using the retrograde pedal access from the start to avoid serious access site complications.

In our study we used the retrograde approach to treat limb ischaemia and to avoid its complications we used this approach only as a backup method in case of failure of an antegrade access to cross the lesion or cannot be done due to flash CTO of SFA.

Figure 6



Kaplan–Meier patency curve for the retrograde approach.

This retrograde approach became possible with the availability of smaller catheters and balloons.

The use of sheath is well established in the femoral access, but in retrograde tibial is still controversial. Bazan *et al.* [17] and Yeh *et al.* [21] advised against the use of a sheath because of increased risk of local complications due to small tibial arteries diameter.

In contrast, other operators like Rutherford *et al.* [15] Montero-Baker *et al.* [22] preferred to use the sheath because it gives strong push ability, which would increase the success rate of passing the lesion, also with small (4 Fr microsheath or radial sheath) local access site complication become infrequent [21,23].

In our study we prefer sheathless approach because of its minimal complications and also due to less availability of microsheath in our hospital.

Thrombosis is usually high with retrograde access due to double access and the presence of CTO lesions compromising both the inflow and the outflow (especially during hemostasis of access site) [8].

So antithrombotic drugs should be used but no uniform regimens are established; most operators use UFH alone as we did with our cases, we gave the patients loading dose of 5000 UFH then 1000 µm every 1 h.

In spite of paucity of data. Kristić and Lukenda [24] tell that spasm of the radial artery access occurred with small artery, multiple attempt of punctures, diabetes mellitus and especially in females and young age. Despite the frequent occurrence of tibial and pedal arteries vasospasms no standardized protocols to prevent its occurrence [25].

Currently, nitroglycerine (NTG) is the commonly used agent to prevent arterial spasm. Walker and colleagues [19] give 200–400 NTG by the antegrade sheath and 1 : 1 mixed solution of 1% lidocaine and NTG subcutaneously at the retrograde puncture. In our cases we give 200 NTG routinely in all cases to avoid arterial spasm.

Hemostasis in retrograde access differ according to the technique used; in case surgical exposure was used fine stitches was needed. In percutaneous approach Werner *et al.* [26] used external compression for 5–10 min or intra-arterial balloon inflation for 10–15 min.

In our cases manual compression was effective for hemostasis in the ATA and PTA but not enough in

peroneal or tibioperonial access so we inflated the balloon for 5 min inside the artery at the retrograde puncture.

In a series of Walker *et al.* [18], he published 95% success of access puncture but crossing the occlusion was 87.2%. Failure of access was common in female, chronic renal failure (CRF) patients and small arteries.

In our study we had success rate in crossing the lesion of 92.3% (only three cases failed) which is very good as regard to the complexity of the lesions, diffuse disease and failure of the antegrade access in most cases.

With revascularization in CLI patency rate and limb salvage are the most important results and according to Romiti *et al.* [27] bypass surgery have higher patency than endovascular procedures but rates of limb salvage were similar.

According to many authors results of endovascular interventions using retrograde approach are similar to an antegrade approach [8,17,21,28].

The advantages and success rates of the pedal access approach for intervention and recanalization of BTK arteries for treatment of CLI overweighs that of the antegrade approach and can replace bypass surgery for tibial arteries which failed conventional antegrade approach [29].

In our study primary patency rates at 6, 12, and 24 months after retrograde angioplasty were 77.7% (28 of 36), 63.8% (23 of 36) and 47.2% (17 of 36), respectively. Limb salvage rates were 97.2%, 80.6%, and 66.4% at 6, 12, and 24 months, respectively. These results are comparable to the antegrade approach, thus this method can treat patients with complex lesions before shifting to any bypass surgery.

Some authors published a new technique using the first metatarsal artery which is connected to lateral plantar artery through the plantar arch and can be used to recanalize the tibial arteries [14,30,31]. We did not use this technique yet, but it may be tried in the next cases of failed retrograde approach.

Retrograde popliteal artery access need the patient to be prone so we need turn the patient [32] these maneuvers make the patient irritable and uncomfortable.

On the other hand, the operator needs to use the guide wire in the femoral and popliteal sheath in the same time which is difficult. Also popliteal access cannot be used in obese patients or those whom have cardiac, respiratory failure and severe rest pain. Popliteal access is also not used for patients with popliteal artery lesions [33]. So we did not use this technique in our study.

Conclusion

Retrograde approach can be used in failure of antegrade recanalization with the patient in the same supine position. Retrograde access for complex CTO disease has proven to be an easy and successful technique for treatment of patients with poor options or failed previous attempts. Interventionists should be encouraged to use this technique in their daily practices. This technique also preferred in cases when a re-entry device is not available.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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