

Safety and Efficacy of the Retrograde Pedal Approach for Lower Extremity Revascularization in Chronic Critical Limb-threatening Ischemia

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Abstract

Objective: The aim of this study was to evaluate the technical success, procedural safety, and short-term clinical outcomes of the retrograde pedal approach in patients with chronic limb-threatening ischemia following unsuccessful antegrade revascularization.

Methods: This retrospective study included 68 consecutive patients (mean age, 68.5 ± 8.2 years; 70.6% male) presenting with severe chronic limb-threatening ischemia (Rutherford categories 4–6). All underwent an attempted retrograde pedal or anterior tibial artery (ATA) access after initial antegrade or contralateral crossover approaches proved unfeasible. Ultrasound-guided access was performed via the posterior tibial artery (66.2%) or ATA (33.8%) following failure of conventional routes. Primary endpoints were access success, technical success, clinical success (freedom from major amputation for at least 6 months), and complication rates.

Results: Successful retrograde puncture and target vessel access were achieved in 64 patients (94.1%). Among these, lesion crossing and luminal patency were accomplished in all cases, yielding a 94.1% technical success rate. Interventions included balloon angioplasty (82.3%) and stenting (11.7%), notably including five cases of proximal iliac stenting through distal access. No major access-site complications occurred; minor complications (16.2%) were managed conservatively. Clinical success and symptom improvement were achieved in 88.2% (60/68) of the entire patient cohort. During follow-up, the major amputation rate was 10.3% (7/68), and the mortality rate was 2.9% (2/68).

Conclusion: The retrograde pedal approach represents a safe, versatile, and highly effective bailout strategy for complex lower extremity chronic total occlusions. It provides excellent technical and limb salvage rates with minimal access-site complications when conventional antegrade revascularization strategies prove unsuccessful.

Keywords: Chronic limb-threatening ischemia; endovascular procedures; limb salvage; peripheral arterial disease; retrograde access.

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Kronik Kritik Bacak İskemisinde Alt Ekstremitte Revaskülarizasyonu İçin Retrograd Pedal Yaklaşımın Güvenliği ve Etkinliği

Özet

Amaç: Başarısız antegrad revaskülarizasyon sonrasında kronik ekstremitteyi tehdit eden iskemi bulunan hastalarda retrograd pedal yaklaşımın teknik başarısını, işlem güvenliğini ve kısa dönem klinik sonuçlarını değerlendirmek.

Yöntem: Bu retrospektif çalışmaya, ciddi kronik ekstremitteyi tehdit eden iskemi ile başvuran Rutherford kategori 4–6 düzeyindeki ardışık 68 hasta dahil edildi (ortalama yaş, $68,5 \pm 8,2$ yıl; erkek, %70,6). Tüm hastalarda, başlangıçtaki antegrad veya kontralateral crossover yaklaşımların uygulanabilir olmaması üzerine retrograd pedal ya da anterior tibial arter erişimi denendi. Konvansiyonel erişim yollarının başarısızlığını takiben, ultrasonografi rehberliğinde posterior tibial arter (%66,2) veya anterior tibial arter (%33,8) üzerinden giriş yapıldı. Primer sonlanım noktaları erişim başarısı, teknik başarı, klinik başarı (en az 6 ay süreyle majör amputasyon olmaması) ve komplikasyon oranları olarak belirlendi.

Bulgular: Retrograd ponksiyon ve hedef damara başarılı erişim 64 hastada (%94,1) sağlandı. Bu hastaların tamamında lezyon geçişi ve lümen açıklığının yeniden sağlanması başarıyla gerçekleştirildi ve genel teknik başarı oranı %94,1 olarak bulundu. Uygulanan girişimler arasında balon anjiyoplasti (%82,3) ve stent implantasyonu (%11,7) yer aldı. Dikkat çekici olarak, beş hastada distal erişim yoluyla proksimal iliak arter stentlemesi gerçekleştirildi. Majör erişim yeri komplikasyonu gözlenmedi; minör komplikasyonlar (%16,2) konservatif yöntemlerle başarılı şekilde yönetildi. Tüm hasta kohortunda klinik başarı ve semptomatik iyileşme 60 hastada (%88,2) elde edildi. Takip süresince majör amputasyon oranı %10,3 (7/68), mortalite oranı ise %2,9 (2/68) olarak saptandı.

Sonuç: Retrograd pedal yaklaşım, kompleks alt ekstremité kronik total oklüzyonlarının tedavisinde güvenli, çok yönlü ve yüksek etkinliğe sahip bir kurtarıcı stratejidir. Konvansiyonel antegrad revaskülarizasyon yöntemlerinin başarısız olduğu durumlarda, düşük erişim yeri komplikasyonu oranlarıyla yüksek teknik başarı ve ekstremité kurtarma oranları sağlamaktadır.

Anahtar sözcükler: Kronik bacak iskemisi; endovasküler işlemler; ekstremité kurtarma; periferik arter hastalığı; retrograd erişim.

Introduction

Critical limb ischemia (CLI) is a severe clinical manifestation of peripheral artery disease (PAD), predominantly characterized by ischemic rest pain with or without accompanying distinct ischemic tissue loss, such as non-healing ulcers or gangrene of the toes.^[1] Representing the most advanced and end stage presentation of PAD, CLI is associated with grave prognostic implications, carrying a daunting 1-year mortality rate of up to 20% and a major amputation rate approximating 30%.^[2,3]

In recent years, endovascular therapy has emerged as a cornerstone in CLI management. This paradigm shift is largely driven by continuous advancements in endovascular techniques and devices, coupled with the high prevalence of prohibitive surgical comorbidities commonly encountered in frail patient populations.^[4,5]

Conventionally, the ipsilateral antegrade and contralateral retrograde crossover approaches through the common femoral artery (CFA) have been the standard access routes for endovascular interventions. However, these conventional modalities can be technically challenging and are associated with a procedural failure rate of up to 20%, often due to heavily calcified occlusions or complex multi-level disease.^[6] In cases where traditional femoral access strategies fail or are deemed anatomically unfeasible, pedal access has become a critical and highly viable alternative for achieving successful revascularization.

Previous studies have documented the safety and feasibility of the retrograde pedal approach. Although it has historically been reserved as a bail out strategy following a failed antegrade attempt, emerging evidence indicates that retrograde pedal access can yield highly favorable procedural outcomes, facilitating successful crossing of complex lesions where standard approaches fall short.^[7,8]

Therefore, to further validate the utility of this alternative access, the present study was designed to assess the technical success, procedural safety, and short to midterm clinical outcomes associated with the retrograde pedal approach in patients treated for CLI at our center.

Materials and Methods

Study Design

This retrospective, single-center study included consecutive patients who underwent retrograde pedal or anterior tibial artery (ATA) access for lower extremity revascularization between

January 2024 and June 2026. This study was approved by the İstanbul Training and Research Hospital (Date: 10.07.2026, Decision no: 225), and the requirement for written informed consent was waived due to the retrospective nature of the study.

The study was conducted in accordance with the ethical principles of the Declaration of Helsinki.

Patients were included if they met the following criteria:

- Presence of chronic limb-threatening ischemia corresponding to Rutherford categories 4, 5, or 6,
- Presence of femoropopliteal and/or infrapopliteal chronic total occlusion,
- Failure of an initial ipsilateral antegrade or contralateral retrograde recanalization attempt,
- Performance of retrograde access through posterior tibial or ATA,
- Availability of procedural and follow-up data.

Conversely, patients were excluded from the analysis if they presented with acute limb ischemia, had non atherosclerotic vascular disease, or had incomplete procedural or inadequate follow-up records.

Clinical and procedural variables were systematically recorded for the study cohort, including demographics, cardiovascular risk factors, comorbidities, and a history of revascularization. In addition, the Rutherford clinical stage, target vessel details, specific endovascular procedural data, and long-term follow-up outcomes were meticulously documented.

Procedure

All procedures were performed by interventional radiologists who were highly experienced in peripheral vascular interventions. Initial arterial access was obtained through the ipsilateral antegrade CFA, contralateral cross over CFA, or another suitable access site. Systemic anticoagulation was achieved with an initial intravenous bolus of 5,000 IU unfractionated heparin, followed by supplemental doses of 1,000 IU/h throughout the procedure. For the initial antegrade recanalization attempts, standard guidewires, support catheters, and conventional crossing techniques were utilized.

Retrograde access through the ATA or posterior tibial artery (PTA) was attempted following the failure of the antegrade approach. Antegrade failure was defined as: the inability to ad-

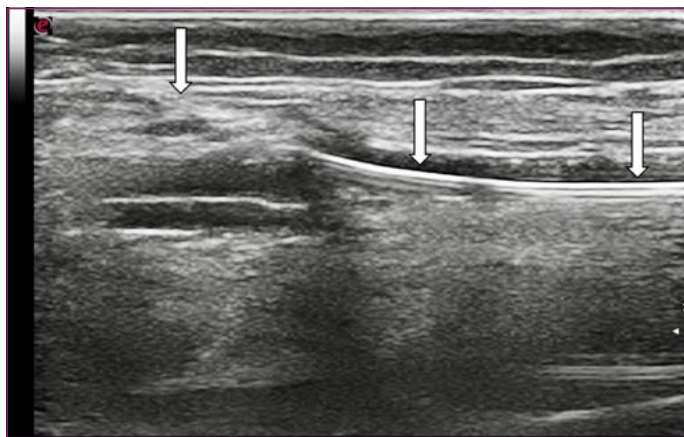


Figure 1. Ultrasound-guided pedal access demonstrating target artery puncture and guidewire advancement.

vance a guidewire across the total occlusion, subintimal tracking without successful distal true lumen re-entry, or the inability to deliver a balloon or support catheter to the target lesion despite extensive manipulation.

For the retrograde approach, access to the ATA or PTA was performed at the most optimal arterial segment under continuous ultrasound guidance using a 7.5-MHz linear transducer (MyLab X9; Esaote SpA, Genoa, Italy). Puncture was achieved using a dedicated micropuncture set (Micropuncture Pedal Access Set; Cook Medical, Bloomington, IN, USA) (Fig. 1). Following successful entry, the intraluminal position was confirmed through contrast injection, and a 1-cc bolus of tirofiban (Aggrastat; Correvio International, Geneva, Switzerland) was locally administered.

Subsequently, the occluded segment was navigated retrogradely to reach the proximal patent true lumen using a 0.018-inch guidewire (V-18 ControlWire; Boston Scientific, Marlborough, MA, USA, or Asahi Gladius; Asahi Intecc, Aichi, Japan) supported by a 2.6-Fr support catheter (NaviCross; Terumo Corporation, Tokyo, Japan).

On successful lesion crossing, either a rendezvous technique (Fig. 2) or a through and through wire technique was employed. Following successful wire externalization or rendezvous, standard balloon angioplasty was performed. The adjunctive use of drug coated balloons (DCBs) or stents was determined on a case by case basis, depending on lesion characteristics, the presence of significant residual stenosis, or the development of flow limiting dissections. When stent implantation was required, deployment was performed either through the antegrade access or retrogradely following the up sizing of the pedal sheath. At the end of the procedure, hemostasis was achieved at the retrograde access site using manual compression.

Study Endpoints and Definitions

Retrograde Access Success

Defined as the successful puncture of the target distal artery and the advancement of a guidewire or micropuncture sheath into the true vessel lumen.



Figure 2. Retrograde revascularization through the rendezvous technique for complex lesion crossing.

Crossing Success

Defined as the successful passage of a guidewire and catheter across the target lesion with confirmed re-entry into the true lumen.

Angiographic Success

Defined as the restoration of continuous antegrade flow with <30% residual stenosis and the absence of any flow-limiting dissection within the treated segment.

Clinical Success

Defined as limb salvage, specifically freedom from major amputation (above the ankle level), for a minimum follow-up period of 6 months.

Complications

Procedural complications were categorized as either access site related or non-access site related and were evaluated and graded according to the society of interventional radiology classification system.^[9]

Statistical analysis

Statistical analysis was performed using the Statistical Package for the Social Sciences software, version 26.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean $\pm$ standard deviation along with their minimum and maximum ranges. Categorical variables were presented as frequencies and percentages. Given the single arm and retrospective design of the study, data were primarily evaluated using descriptive statistics to report procedural efficacy, safety, and clinical outcomes.

Results

Demographic and Clinical Characteristics

The demographic and clinical characteristics of the study cohort are detailed in Table 1. A total of 68 patients were in-

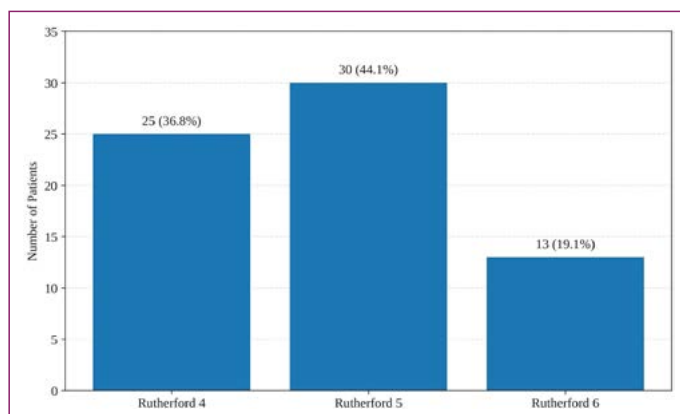
Table 1. Demographic and clinical characteristics

Variable	Value (n=68)
Age, years (mean±SD)	68.5±8.2
Age range (years)	52–85
Gender (%)	
Male	48 (70.6)
Female	20 (29.4)

SD: Standard deviation.

cluded in this retrospective study. The mean age was 68.5±8.2 years (range, 52–85 years), comprising 48 males (70.6%) and 20 females (29.4%). The distribution of Rutherford clinical categories at the time of presentation is illustrated in Figure 3. Assessment of medical history and comorbidities revealed prominent cardiovascular risk factors, which are summarized in Figure 4. Active or former smoking was noted in 55 cases (80.9%), hypertension (HTN) in 50 (73.5%), diabetes mellitus (DM) in 45 (66.2%), hyperlipidemia in 40 (58.8%), and heart failure in 15 (22.1%). Furthermore, 25 patients (36.8%) presented with the high-risk triad of concurrent smoking, DM, and HTN. Eighteen patients (26.5%) had a history of previous revascularization in the index limb, either through endovascular angioplasty or open surgery.

Procedural access details and anatomical involvement of target lesions are presented in Tables 2 and 3. Successful retrograde puncture and target vessel access were achieved in 64 patients (94.1%). Lesion crossing and luminal patency were accomplished in all 64 cases, yielding a 94.1% technical success rate. Interventions included balloon angioplasty (82.3%) and stenting (11.7%), notably including five cases of proximal iliac stenting facilitated through distal access. The distribution of target lesion involvements across different arterial segments is visually depicted in Figure 5. No major access-site complications occurred; minor complications (16.2%) were successfully managed with conservative measures. Clinical success and symptom improvement were achieved in 88.2% (60/68) of the cohort. During a 6-month follow-up, the major amputation rate was 10.3% (7/68), and the mortality rate was 2.9% (2/68).

**Figure 3.** Rutherford classification of the patients at presentation.**Table 2. Procedural access and lesion characteristics**

Distal puncture site (n=68)	n (%)
PTA	45 (66.2)
ATA	23 (33.8)
Target vessel involvement (Number of lesions)	
PTA	45
Superficial femoral artery	42
ATA	40
Peroneal artery	38
Popliteal artery	35
Procedural access success	
Successful access	64 (94.1)
Failed access	4 (5.9)

PTA: Posterior tibial artery; ATA: Anterior tibial artery.

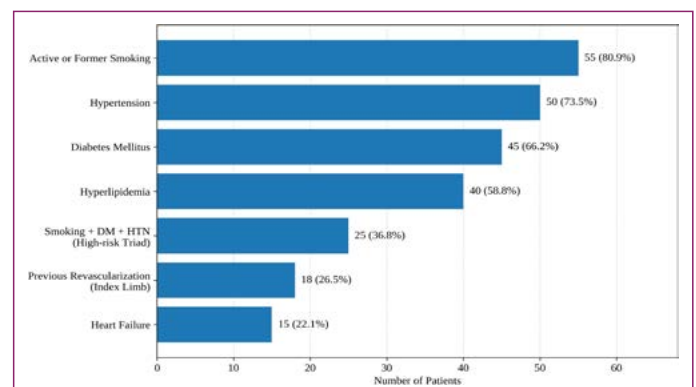
Table 3. Procedural details and clinical outcomes

	n (%)
Overall technical success	64 (94.1)
Endovascular modality (Among technically successful cases, n=64)	
Plain old balloon angioplasty	42 (65.6)
Drug-coated balloon	14 (21.9)
Stent implantation	8 (12.5)
Common iliac artery stent	5
SFA bail-out stent	3
Access site complications (n=68)	
None	57 (83.8)
Minor (Vasospasm/Localized perforation)	11 (16.2)
Major	0 (0)
Clinical Outcomes (n=68)	
Clinical success (symptomatic improvement)	60 (88.2)
Clinical failure (includes 4 initial access failures)	8 (11.8)
Major amputation	7 (10.3)
Mortality (early follow-up)	2 (2.9)

SFA: Superficial femoral artery.

Procedural Access and Lesion Characteristics

Regarding the selection of the distal puncture site, retrograde access was attempted through the posterior tibial artery in 45 (66.2%) patients and the ATA in 23 (33.8%) patients. Doppler

**Figure 4.** Cardiovascular risk factors and comorbidities among the study population.

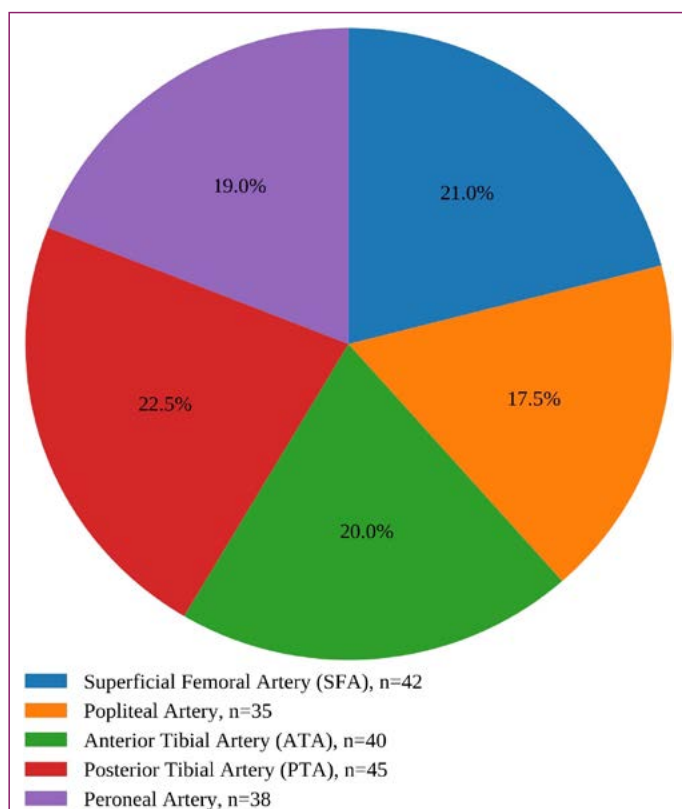


Figure 5. Distribution of target lesion involvement by arterial segment.

ultrasonography guidance was routinely utilized in all cases to maximize procedural safety. These attempts resulted in successful puncture and target vessel access in 64 cases (94.1%); however, access was deemed unsuccessful in 4 cases (5.9%) due to an inability to advance the needle into the target vessel lumen. Angiographic evaluation of the target lesions, which exhibited occlusions or critical stenoses, revealed the following anatomical distribution: Superficial femoral artery (SFA) involvement in 42 cases, popliteal artery involvement in 35 cases, ATA involvement in 40 cases, PTA involvement in 45 cases, and peroneal artery involvement in 38 cases (Table 2).

Procedural Details and Endovascular Treatment

Overall technical success, defined as successful lesion crossing and restoration of luminal patency, was achieved in the 64 patients (94.1%) who had successful initial puncture. The four cases with failed vascular access were recorded as technical failures. Among the 64 patients with technical success, adequate patency was established solely by percutaneous transluminal angioplasty in 56 (82.3%). Of these, the procedure was completed using standard plain old balloon angioplasty in 42 patients, while 14 underwent DCB angioplasty following predilatation with a standard balloon. Stent implantation was required in eight patients (11.7%). Five of these cases involved common iliac artery occlusions, which were successfully stented retrogradely through a 6-Fr short vascular sheath placed through distal PTA access. In the remaining three patients, bail-out stenting was performed in the SFA segment due to the presence of balloon resistant lesions or the development of flow limiting dissections (Table 2).

Clinical Outcomes and Complications

Evaluation of access site complications at the pedal puncture location revealed no major or minor complications in 57 patients (83.8%). In 11 cases (16.2%), minor intraprocedural complications, such as localized perforation or vasospasm, occurred; however, these were successfully managed with minimal interventions. Long-term follow-up of the cohort demonstrated that targeted clinical success and symptomatic improvement were achieved in 60 patients (88.2%). An adequate clinical response was not obtained in 8 cases (11.8%), a cohort that inherently included the four patients who experienced initial access failure. During the early follow-up period, mortality secondary to cardiac and infective etiologies was observed in 2 patients (2.9%). In addition, limb salvage could not be maintained in 7 cases (10.3%), ultimately necessitating major amputation (Table 3).

Discussion

The principal finding of this study demonstrates that retrograde pedal and ATA access serves as a highly effective bailout strategy for complex femoropopliteal and infrapopliteal chronic total occlusions when antegrade recanalization is unsuccessful. Demonstrating high procedural viability, both retrograde access and overall technical success were achieved in 94.1% of the procedures. This technical achievement translated into a robust clinical success rate of 88.2%, marked by significant symptomatic relief and a notably low major amputation rate, even within a high-risk demographic presenting with advanced Rutherford stages and severe comorbidities. Furthermore, the distal approach proved to be exceptionally safe; it was devoid of major access site complications, with only minor, conservatively managed instances of spasm or perforation (16.2%). Ultimately, these findings reaffirm the retrograde pedal approach as a safe, efficacious, and indispensable alternative when conventional antegrade strategies are exhausted.

Chronic limb-threatening ischemia (CLTI) carries a staggeringly high risk of major limb loss and cardiovascular related death. The clinical prognosis is exceptionally dire among patients with coexisting diabetes mellitus and chronic kidney disease, as these systemic comorbidities synergistically accelerate vascular calcification, precipitate aggressive infrapopliteal disease, and ultimately lead to significantly elevated morbidity and mortality rates. Preventing major amputation is a critical cornerstone of treatment strategies, as limb loss frequently triggers a rapid downward clinical spiral and substantially increases long-term mortality.^[1,10]

Effective revascularization of the pedal vasculature in patients with Rutherford 4 and 5 clinical categories serves as a cornerstone therapy, demonstrating pronounced clinical benefits that substantially mitigate morbidity and mortality risks.^[11–13] Similarly, in our cohort, successful distal revascularization demonstrated favorable outcomes in mitigating systemic morbidity and mortality risks associated with CLI.

The successful crossing of chronic total occlusions through a retrograde distal pedal approach, particularly following a failed antegrade attempt, can be largely attributed to the morpho-

logical asymmetry of the occlusive lesion. Pathophysiologically, structures such as densely calcified atheromatous plaques tend to be significantly more severe, hardened, and organized at the proximal cap of the occlusion. Furthermore, morphologically, the distal cap tends to be softer; consequently, guidewire penetration into this region is often significantly facilitated, particularly when it exhibits a concave configuration.^[14,15]

Severe arterial calcification at the targeted access site and the inability to re-enter the true lumen following subintimal wire passage are widely recognized as the primary contributing factors to technical failure in the retrograde pedal approach. Notably, a dense calcific burden frequently precludes the initial needle puncture, rendering vascular access impossible. Aligning closely with the existing literature regarding access site limitations, our cohort experienced similar procedural challenges; specifically, initial vascular puncture could not be achieved in four of our 68 patients. This complete inability to access the vessel, primarily driven by heavy localized calcification, reinforces that entry site characteristics remain a significant procedural barrier.^[16,17]

Minor complications associated with retrograde pedal access most commonly include access site hematoma, arterial dissection, and vasospasm. These events are generally self-limiting or can be successfully managed with conservative measures, prolonged manual compression, intra-arterial vasodilator administration, or limited endovascular treatment when necessary. Previous studies have similarly reported low rates of minor access-related complications, with findings comparable to those observed in our cohort.^[18,19] Although these complications rarely result in significant clinical deterioration, careful puncture site selection, ultrasound guided access, the use of low-profile devices, and meticulous hemostasis are essential to minimize distal vessel injury. More severe access-related events, including pedal artery occlusion and arteriovenous fistula formation, have also been described in the literature, although they appear to occur infrequently.^[20,21] Pedal artery occlusion may result from local thrombosis, intimal injury, severe vasospasm, or impaired baseline arterial flow, whereas arteriovenous fistula formation may occur due to simultaneous puncture of adjacent arteries and veins. These complications are of particular concern in patients with CLTA because the accessed vessel may represent an important component of the limited blood supply to the foot. Notably, pedal artery occlusion or arteriovenous fistula was not observed in our study. This finding supports the relative safety of the retrograde pedal approach when performed with appropriate imaging guidance, careful patient selection, atraumatic access techniques, and close post-procedural monitoring.

The prevention of major amputations remains a paramount objective in the management of CLI, and our findings are highly consistent with several pivotal studies that underscore the value of distal access. El-Sayed et al.^[22] reported that in patients with failed antegrade approaches, retrograde interventions yielded a 67% revascularization success rate and an 88% major amputation free survival rate at 1 year. Corroborating these findings, a retrospective study by Kaushal et al.^[23] demonstrated a 79% limb salvage rate at 6 months, while Perry et al.^[24] observed an 86% success

rate in preventing major amputations at the 1 year follow-up. In the present study, we achieved a remarkably high limb salvage rate of 89.7%, effectively preventing major limb loss in a challenging patient demographic. This superior clinical outcome not only compares favorably with previously published data but also robustly highlights the critical role of retrograde pedal access. Our results clearly demonstrate that when standard antegrade recanalization strategies are unfeasible, a distal approach serves as an indispensable and highly effective alternative for limb preservation.

Several previous studies^[25–27] have demonstrated the feasibility of performing iliac artery stenting utilizing a retrograde pedal approach. In accordance with these findings, our study successfully achieved stent implantation in both the iliac artery and the SFA through this distal route. Such procedural success not only validates the high efficacy of pedal access but also underscores its indispensable role as a bailout strategy in clinical scenarios, in which conventional vascular pathways are exhausted.

This study has several limitations. Despite the relatively high technical and clinical success rates observed in our cohort, the single center and retrospective design, together with the limited sample size and relatively short follow-up period, may restrict the generalizability of our findings. In addition, the absence of a control group treated with conventional surgical or alternative endovascular approaches precluded direct comparison of procedural efficacy, safety, and durability. Longer term follow-up is required to determine sustained vessel patency, freedom from reintervention, wound healing, limb salvage, and persistent functional improvement. Further prospective, multicenter studies with larger patient populations, and standardized follow-up protocols are therefore warranted to more accurately establish the long-term durability and clinical value of the retrograde pedal approach in comparison with conventional surgical and endovascular treatment strategies.

Conclusion

Retrograde pedal and ATA access represents an effective, safe, and versatile bailout strategy for patients with CLTA. When conventional antegrade recanalization attempts are unsuccessful, these distal access routes can provide high technical success rates and favorable clinical outcomes, particularly in terms of limb salvage and the low incidence of access site complications. The feasibility of performing more proximal interventions, including superficial femoral and iliac artery stenting, through these access sites further highlights the broad applicability of the technique within contemporary endovascular practice. Although severe calcification at the intended puncture site remains an important anatomical limitation and may prevent successful initial access, the overall safety profile of the procedure is favorable, particularly when puncture is performed under ultrasound guidance. Therefore, our findings support the integration of retrograde pedal and ATA access into the treatment algorithm for complex revascularization procedures after failed antegrade attempts. Nevertheless, prospective multicenter studies with larger patient populations and longer follow-up periods are required to establish the long-term durability, patency outcomes, and comparative clinical effectiveness of this approach.

Disclosures

Ethics Committee Approval: The study was approved by the the İstanbul Training and Research Hospital Ethics Committee (no: 225, date: 10/07/2026).

Informed Consent: Retrospective study.

Conflict of Interest Statement: The authors have no conflicts of interest to declare.

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Author Contributions: Concept – M.Ö., E.Ö.; Design – M.Ö.; Supervision – E.Ö.; Data collection and/or processing – E.Ö.; Data analysis and/or interpretation – M.Ö., E.Ö.; Literature search – M.Ö., E.Ö.; Writing – M.Ö., E.Ö.; Critical review – M.Ö.

Peer-review: Externally peer-reviewed.

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