

CASE REPORT

Open Access



# Inframalleolar thrice distal puncture in a single endovascular treatment session for successful revascularization

Issei Ota, Tetsuya Nomura<sup>\*</sup> , Kenshi Ono, Yu Sakaue, Keisuke Shoji and Naotoshi Wada

## Abstract

**Background** Most patients with chronic limb-threatening ischemia (CLTI) have infrapopliteal arterial disease, which are often challenging to treat. In endovascular treatment (EVT) for these complex lesions, establishing retrograde access is an essential option not only for guidewire crossing but also for device delivery. However, no EVT case has yet been reported requiring inframalleolar thrice distal puncture in a single EVT session so far.

**Case presentation** A 60-year-old CLTI patient with grade 3 Wound, Ischemia and foot Infection (WIFI) classification underwent EVT for occluded dorsal artery and posterior tibial artery. First, we conducted successful balloon angioplasty of the posterior tibial artery by establishing a retrograde approach via the lateral plantar artery. To treat the occlusion of the dorsal artery, we punctured the first dorsal metatarsal artery, and retrogradely advanced a guidewire to the dorsal artery occlusion; however, the microcatheter could not follow the guidewire. Therefore, we punctured the occluded distal anterior tibial artery and introduced the retrograde guidewire into the puncture needle. After guidewire externalization, we pulled up the retrograde microcatheter into the occlusion of dorsal artery using the “balloon deployment using forcible manner” technique. Thereafter, we were able to advance the antegrade guidewire into the retrograde microcatheter. After guidewire externalization, an antegrade balloon catheter was delivered and inflated for the purpose of dorsal artery dilation and hemostasis at the “needle rendezvous” point. Consecutively, balloon dilation was performed for puncture site hemostasis of the first dorsal metatarsal artery and complete hemostasis was achieved. Finally, we confirmed good vascular patency and favorable blood flow. After revascularization, transmetatarsal amputation was performed and the wound healed favorably.

**Conclusions** We can markedly increase the success rate of revascularization by effectively utilizing the retrograde approach in EVT for complex chronic total occlusions in infrapopliteal arterial diseases.

**Keywords** Critical limb-threatening ischemia, Infrapopliteal arterial disease, Endovascular treatment, Inframalleolar, Distal puncture

## Introduction

Chronic limb-threatening ischemia (CLTI) is a consequence of the progression of peripheral arterial disease, and has been widely known as a critical pathological entity associated with increased risk of cardiovascular death, myocardial infarction, or ischemic stroke. Most patients with CLTI have infrapopliteal (IP) arterial diseases, which are often challenging to treat (Sato et al. 2022). Development of endovascular treatment (EVT) techniques and devices have facilitated higher rates of

\*Correspondence:

Tetsuya Nomura

t2ya821@yahoo.co.jp

Department of Cardiovascular Medicine, Kyoto Chubu Medical Center, 25, Yagi-Ueno, Yagi-cho, Nantan City, Kyoto 629-0197, Japan

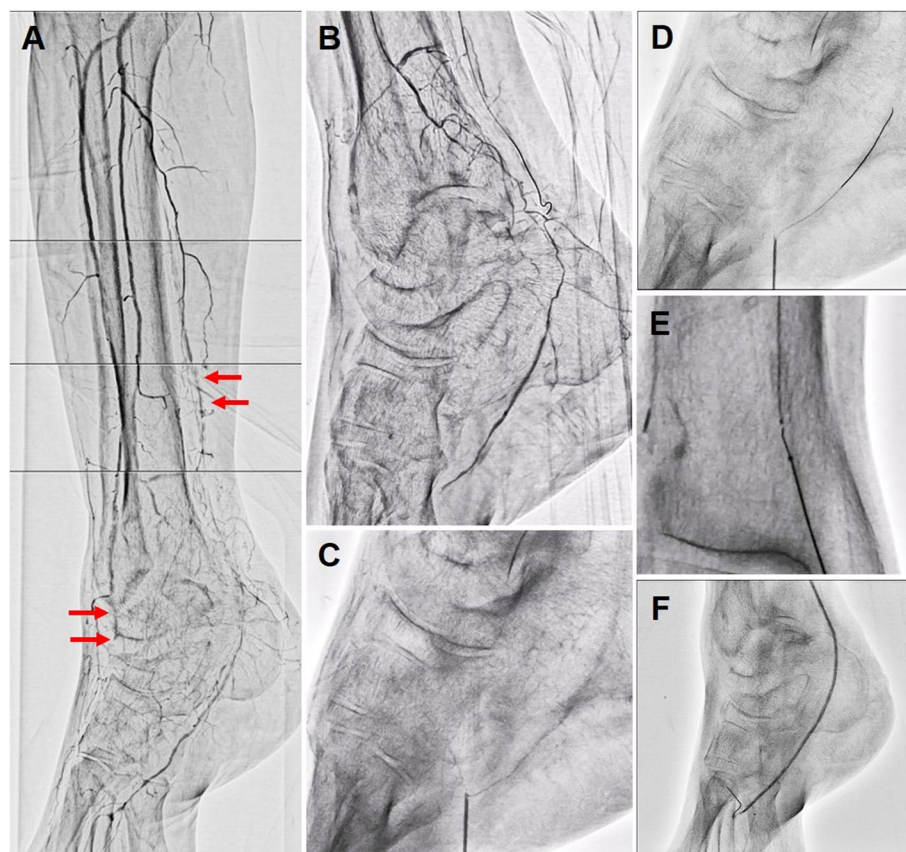
successful revascularization. Particularly, establishing retrograde access after failure of the antegrade approach is a useful option not only for guidewire crossing but also for device delivery.

### Case presentation

A 60-year-old man who had been undergoing intermittent chronic hemodialysis for 35 years developed severe gangrene in all the digits of his right foot (Rutherford 5). Skin perfusion pressure (SPP) demonstrated 23 and 3 mmHg at dorsal and bottom of the foot, respectively. The Wound, Ischemia and foot Infection (WIFI) classification was stage 3 with W-1, I-3, fI-1. Medical treatment was not effective for the severe ischemic gangrene of this patient. Since non-invasive imaging findings revealed severe IP arterial diseases, we performed angiography. The patient received 100 mg aspirin and 75 mg clopidogrel prior to catheterization. We opted for antegrade puncture of the right common femoral artery and inserted a 4-Fr 10-cm long regular sheath (Terumo, Tokyo, Japan) into the right superficial femoral artery. Immediately after sheath

insertion, an intra-arterial bolus of 5,000 units of unfractionated heparin was administered, and the activated clotting time was controlled to  $\geq 250$  s during the procedure. Angiography of the right lower extremity revealed occlusion of the distal anterior tibial artery (ATA) and mid posterior tibial artery (PTA) with severe calcification (Fig. 1a). The Global Limb Anatomic Staging System (GLASS) classification was stage III with femoropopliteal grade 0 and IP grade 4; inframalleolar (IM) disease with GLASS IM P2 was also present. Since optimal great saphenous vein (GSV) for bypass grafting was not available in this patient, we implemented EVT for limb salvage.

We exchanged the 4-Fr regular sheath for a 4.5-Fr Parent Plus 45 guide sheath (Medikit, Tokyo, Japan). The initial antegrade guidewire for the occluded PTA advanced into the subintimal space due to severe calcification, and we could not intentionally manipulate the guidewire anymore. At that point, as the lateral plantar artery was perfused by collateral blood flow from the peroneal artery (Fig. 1b), we established a retrograde approach by angiographically puncturing the



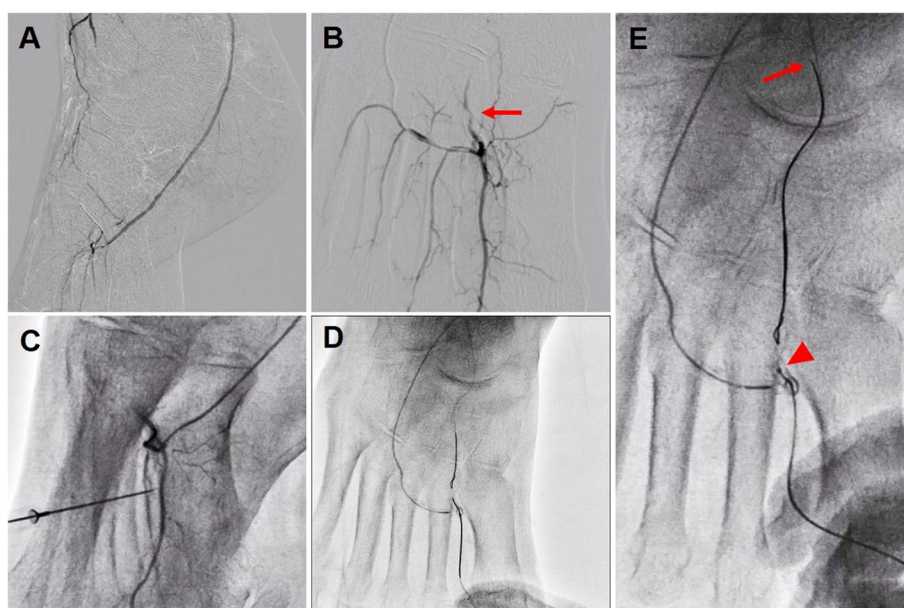
**Fig. 1** **a** Initial angiography showing occlusions of the distal anterior tibial artery (ATA) and mid posterior tibial artery (PTA) with severe calcification (Arrows). **b** The lateral plantar artery was perfused by collateral blood flow from the peroneal artery. **c** First distal puncture of the lateral plantar artery with angiographical guidance. **d** Gladius MG guidewire advancement into the lateral plantar artery. **e** Retrograde guidewire insertion into the antegrade microcatheter. **f** Successful balloon angioplasty of the occluded PTA.

lateral plantar artery with a 20-gauge puncture needle (Medikit, Tokyo, Japan) (Fig. 1c) and introduced the retrograde guidewire (Gladius MG: ASAHI INTECC, Aichi, Japan) into the antegrade microcatheter (Fig. 1d, e). After first guidewire externalization, we conducted successful balloon (Coyote 2.0-mm/150-mm: Boston Scientific, MA, USA) angioplasty of the PTA for 10 min, simultaneously completing hemostasis of the puncture point by balloon tamponade (Fig. 1f).

Next, since the antegrade guidewire via ATA could not pass through the occluded dorsal artery (DA), we tried to establish trans-pedal arch approach from the revascularized PTA. Microcatheter tip injection of contrast medium enabled clear visualization of distal end of the occluded DA (Fig. 2a,b). However, acute bend of the pedal arch hampered the guidewire penetration retrogradely into the DA occlusion. Therefore, we retrogradely punctured the first dorsal metatarsal artery under the angiographical guidance with 22-gauge indwelling needle (Surf flow: Terumo, Tokyo, Japan) (Fig. 2c) and advanced a guidewire (Gladius MG: ASAHI INTECC, Aichi, Japan) to the occluded DA (Fig. 2d). The retrograde guidewire (Naveed Hard30: Terumo, Tokyo, Japan) could advance as far as distal ATA along with the course of antegrade guidewire, but the microcatheter (Corsair Armet: ASAHI INTECC, Aichi, Japan) could not follow the guidewire (Fig. 2e).

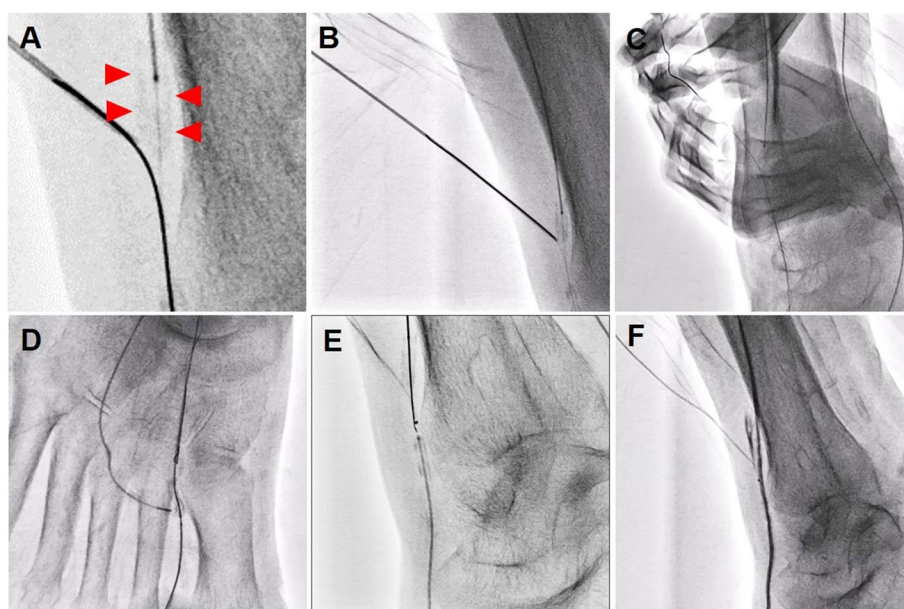
To make pull-through formation using Rendezvous technique in occluded DA, retrograde microcatheter advancement into the DA occlusion was mandatory. For that purpose, we punctured the occluded distal ATA with 20-gauge puncture needle (Medikit, Tokyo, Japan) making the vessel calcification as a target under fluoroscopy guidance (Fig. 3a) and introduced the retrograde Naveed Hard30 guidewire into the puncture needle (Fig. 3b). After the second time guidewire externalization (Fig. 3c), the puncture needle was exchanged for Ichibanyari PAD microcatheter (KANEKA: Osaka, Japan) and we pulled up the retrograde Corsair Armet microcatheter into the occluded DA using the Balloon Deployment using Forcible Manner (BADFORM) technique (Nakabayashi et al. 2017) (Fig. 3d). Thereafter, we were able to advance the antegrade guidewire (AstatoXS 9–40: ASAHI INTECC, Aichi, Japan) into the retrograde microcatheter (Fig. 3e). After the third guidewire externalization, a Coyote antegrade balloon catheter was delivered into the occluded DA using the BADFORM technique and was inflated to dilate the vessel and for hemostasis at the distal ATA puncture site for approximately 10 min (Fig. 3f).

Subsequently, antegrade guidewire was advanced to the first digital artery after releasing guidewire externalization (Fig. 4a). Subsequently, Coyote balloon dilation for about 5 min was added for puncture site hemostasis of the first dorsal metatarsal artery (Fig. 4b) and complete hemostasis was achieved (Fig. 4c). Finally, we confirmed



**Fig. 2** **a, b** Visualization of the pedal arch by microcatheter tip injection. Arrow indicating the distal end of the dorsal artery (DA) occlusion. **c** Second distal puncture of the first dorsal metatarsal artery for retrograde access. **d** Gladius MG guidewire penetration into the occluded DA. **e** The retrograde Naveed Hard30 guidewire advancement as far as distal ATA (Arrow). However, Corsair Armet microcatheter could not follow the guidewire (Arrowhead)





**Fig. 3** **a** Third distal puncture of the distal ATA occlusion making the vessel calcification as a target under fluoroscopy guidance (Arrowheads). **b** The retrograde Naveed Hard30 guidewire insertion into the puncture needle. **c** Second guidewire externalization. **d** Successful retrograde Corsair Armet microcatheter advancement into the occluded DA using the balloon deployment using forcible manner technique. **e** Antegrade AstatoXS 9–40 guidewire insertion into the retrograde microcatheter. **f** Prolonged balloon inflation for DA vessel dilation and hemostasis of the distal ATA puncture site

good vascular patency and favorable blood flow (Fig. 4d). SPP restored to 47 and 39 mmHg at dorsal and bottom of the foot, respectively. Two weeks after revascularization, transmetatarsal amputation (TMA) was performed and the wound finally healed favorably (Fig. 4e).

## Discussion

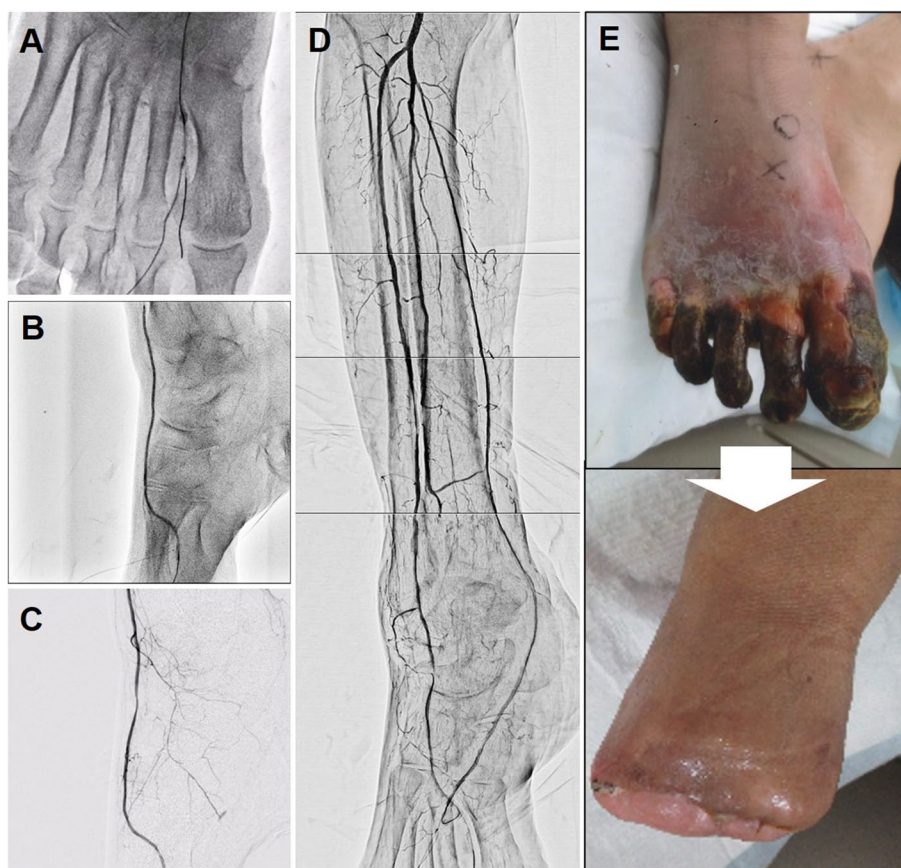
The Global Vascular Guidelines (GVGs) recommend the preferred method of initial revascularization for CLTI to be based on assessment of anatomical complexity (GLASS stage) and limb severity (WIFI stage) (Conte et al. 2019). The IM anatomic modifier is also defined in the GVGs, but this modifier is not relevant to the GLASS stage or the recommendation for initial revascularization method. For bypass surgery in CLTI, appropriate arterial runoff to the lower limb and foot for wound perfusion and good-quality GSV for optimal autologous conduit are necessary conditions (Kobayashi et al. 2021). Unfortunately, our case did not satisfy either of these conditions.

Advancements in EVT include improved wires, sophisticated catheters, and multi-site retrograde access to allow therapy for complex disease patterns down to the foot (Machin et al. 2022). Retrograde access by distal puncture with either fluoroscopic or ultrasound guidance can certainly increase the ability to cross chronic total occlusions in IP arterial diseases. Moreover, the pedal artery angioplasty has been described as a salvage

procedure for patients with CLTI in the presence of IM disease (Nakama et al. 2017a, b). Although hemodynamic stability remains the primary limitation of EVT for highly complex IP lesions, some CLTI patients can benefit from these procedures.

Our patient had severe gangrene in all the digits of his right foot, and TMA was an inevitable option from the beginning (Fig. 4e). Although our case showed IP grade 4 with multiple target vessels, the current version of GLASS does not consider multivessel IP revascularization due to lack of the evidence. Therefore, it is controversial how far we should revascularize in these types of IP diseases. We recognized the importance of pedal artery angioplasty for wound healing and believed that as much revascularization, if possible, would be beneficial for wound healing after TMA, and completed all the procedures as described above.

Multiple distal puncture sites have been developed for vascular access to-date, and their safety and efficacy have been demonstrated in clinical settings (Palena and Manzi, 2012; Nakama et al. 2017a, b; Schmidt et al. 2019). To be noted, distal puncture is not a method only for retrograde access. We can utilize the distal puncture site for both, entry and exit of a guidewire as shown in Fig. 3a and b (Needle Rendezvous technique) (Haraguchi et al. 2021). Moreover, by making pull-through formation, we can establish stronger back-up



**Fig. 4** **a** Antegrade guidewire advancement to the first digital artery. **b** Balloon dilation to hemostat the puncture site of the first dorsal metatarsal artery. **c** Confirmation of complete hemostasis. **d** Final angiography showing good vascular patency and favorable blood flow. **e** (Upper panel) Severe gangrene in all the digits of the right foot before endovascular treatment. (Lower panel) Favorable wound healing after transmetatarsal amputation

support for device delivery. We can also take advantage of BADFORM technique. In general, techniques associated with distal puncture are indispensable for successful EVT procedures especially in IP lesions.

At the same time, we also should consider some of the disadvantages of this method. One of them is a potential risk of causing vessel injury. Therefore, we should avoid applying this maneuver if there is only one artery remaining. Additionally, it is important to ensure the hemostasis management at the distal puncture sites. Some of them such as peroneal or metatarsal artery cannot be directly compressed from the body surface due to their anatomies. In those cases, we must successfully complete revascularization and balloon tamponade inside the vessel which is mandatory for hemostasis. We usually conduct balloon inflation for hemostasis for 10 min at the puncture sites of IM area concurrently performing vessel dilation. The shorter time may be sufficient for more distal puncture point such as dorsal metatarsal artery.

Thus, we have described a CLTI case with severely calcified IP disease in which successful revascularization was achieved by IM thrice distal puncture in a single EVT session. Individual techniques such as multi-site distal puncture in IM area, needle rendezvous technique, and BADFORM technique utilized in this case are previously reported, and are widely prevalent in daily clinical settings of EVT for IP lesions. However, the strategies adapted to pursue revascularization for severely calcified obstruction in the IP area is variable among the interventionists all over the world. Through our case, we have demonstrated the possibility of using different EVT techniques and strategies for limb salvage.

## Conclusions

The success rate of revascularization can be substantially increased by effectively utilizing the retrograde approach in EVT for complex chronic total occlusions in IP arterial diseases.

## Abbreviations

ATA	Anterior tibial artery
BADFORM	Balloon deployment using forcible manner
CLTI	Critical limb threatening ischemia
DA	Dorsal artery
EVT	Endovascular treatment
GLASS	Global limb anatomic staging system
GSV	Great saphenous vein
GVG	Global vascular guideline
IM	Inframalleolar
IP	Infrapopliteal
PTA	Posterior tibial artery
SPP	Skin perfusion pressure
TMA	Transmetatarsal amputation
WIFI	Wound, Ischemia and foot Infection

## Acknowledgements

We thank Editage ([www.Editage.com](http://www.Editage.com)) for the English language editing.

## Authors' contributions

IO and TN were the primary authors of this study. These authors contributed equally to this work. KO, YS, KS, and NW made substantial editorial revisions to this manuscript. NW contributed significantly to the study conception and design. All authors read and approved the final manuscript.

## Funding

Not applicable.

## Availability of data and materials

Not applicable.

## Declarations

### Ethics approval and consent to participate

All procedures were performed in accordance with the ethical standards of the institution and with the 1964 Helsinki Declaration. Informed consent was obtained from the patient.

### Consent for publication

Written informed consent was obtained from the patient for publication of this case report and any accompanying images.

### Competing interests

The authors declare that they have no competing interests.

Received: 7 January 2023 Accepted: 18 March 2023

Published online: 29 March 2023

## References

- Conte MS, Bradbury AW, Kolh P, White JV, Dick F, Fitridge R et al (2019) Global vascular guidelines on the management of chronic limb-threatening ischemia. *Eur J Vasc Endovasc Surg* 58:S1–S109
- Haraguchi T, Tsujimoto M, Kashima Y, Takeuchi T, Tadano Y, Hachinohe D et al (2021) The "Needle bypass" technique: percutaneous anatomical bypass with needle rendezvous for patients with peripheral arterial disease that have no other surgical options. *CVIR Endovasc* 4:66
- Kobayashi T, Hamamoto M, Okazaki T, Hasegawa M, Takahashi S (2021) Does the global limb anatomic staging system inframalleolar modifier influence long term outcomes of chronic limb threatening ischaemia after distal bypass? *Eur J Vasc Endovasc Surg* 62:590–596
- Machin M, Younan HC, Gueroult AM, Onida S, Shalhoub J, Davies AH (2022) Systematic review of inframalleolar endovascular interventions and rates of limb salvage, wound healing, restenosis, rest pain, reintervention and complications. *Vascular* 30:105–114
- Nakabayashi K, Ando H, Kaneko N, Shiozaki M, Sunaga D, Matsui A et al (2017) A novel lesion crossing technique: balloon deployment using FORcible manner (BADFORM) technique. *Catheter Cardiovasc Interv* 90:1161–1165

- Nakama T, Ando H, Watanabe N, Ogata K, Takei T, Shibata Y (2017a) Novel retrograde puncture technique for infrapopliteal artery revascularization: transplantar retrograde access. *Cardiovasc Interv Ther* 32:287–293
- Nakama T, Watanabe N, Haraguchi T, Sakamoto H, Kamoi D, Tsubakimoto Y et al (2017b) Clinical outcomes of pedal artery angioplasty for patients with ischemic wounds: results from the multicenter RENDEZVOUS registry. *JACC Cardiovasc Interv* 10:79–90
- Palena LM, Manzi M (2012) Extreme below-the-knee interventions: retrograde transmetatarsal or transplantar arch access for foot salvage in challenging cases of critical limb ischemia. *J Endovasc Ther* 19:805–811
- Sato Y, Morishita T, Tan M, Hayashi T, Miwa T, Hieda S et al (2022) Prediction of technical failure of inframalleolar angioplasty in patients with chronic limb threatening ischaemia. *Eur J Vasc Endovasc Surg* 63:852–863
- Schmidt A, Bausback Y, Piorkowski M, Wittig T, Banning-Eichenseer U, Thiele H et al (2019) Retrograde tibioperoneal access for complex infrainguinal occlusions: short- and long-term outcomes of 554 endovascular interventions. *JACC Cardiovasc Interv* 12:1714–1726

## Publisher's Note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

**Submit your manuscript to a SpringerOpen<sup>®</sup> journal and benefit from:**

- Convenient online submission
- Rigorous peer review
- Open access: articles freely available online
- High visibility within the field
- Retaining the copyright to your article

Submit your next manuscript at ► [springeropen.com](http://springeropen.com)