# Pedal-Plantar Loop Technique

A new method for revascularization of foot vessels.

BY MARCO MANZI, MD

Chronic critical limb ischemia (CLI) is due to extensive atherosclerotic occlusive disease of the lower limb arteries. This condition, typical of diabetic patients, is often associated with ulceration and/or gangrene of the foot and represents the main cause of nontraumatic lower limb amputation.[1] Restoring adequate blood flow to the foot is essential to promote healing of trophic changes and to provide relief from pain.[2]

Given the mean age and high comorbidity rate of CLI patients,[2] percutaneous transluminal angioplasty (PTA) has emerged as a valid alternative to the more invasive traditional bypass surgery.[3] Indeed, the TASC recommendations[2] to use either the endovascular or surgical approach—based on the extent of obstructive disease—are routinely overcome by the improved quality of available materials and increased experience of endovascular specialists in current daily practice. As a result, PTA is often the first choice for lower limb revascularization, and only patients who failed treatment with PTA are referred to surgery.[3]

Nevertheless, PTA in CLI patients may be very challenging. It is often necessary to treat very long occlusions of below-the-knee (BTK) vessels. Furthermore, in most patients, foot vessels are also examined during macroangiopathy.[4]

Because a patent plantar arch is essential to provide blood flow to both the forefoot and the calcanear region, we conceived the pedal-plantar loop technique, which consists of the recanalization of both pedal and plantar arteries and their anatomical anastomoses.[5,6] This technique is ideal in patients with extensive trophic alteration of the foot requiring the maximum improvement in blood flow support. It might also be useful in cases in which it is necessary to use the retrograde approach coming from the plantar arch to treat the target vessel (anterior or posterior tibial artery) because of the impossibility of antegrade crossing.

In our institution between January 2007 and September 2008, the pedal-plantar loop technique was performed in 114 patients among a total of 1,331 CLI diabetic patients with BTK disease undergoing PTA (Rutherford category 4–6). CLI was documented on the basis of nonhealing gangrene and/or ulceration of the foot associated with a critically low level of oxygen tension ($TcPO_2$). After exclusion of aortoiliac disease by noninvasive examinations (mainly duplex scan), patients were sent to the catheterization laboratory for invasive angiography and PTA. Ninety-five percent of patients were diabetic (20% type 1, 75% type 2). Acute success for the pedal-plantar loop technique was achieved in 84.2% of cases. No clinically relevant complications were observed.

## DESCRIPTION OF THE TECHNIQUE

Antegrade femoral puncture is essential for performing complex BTK procedures. The puncture is echo-guided, and the preferred entry sites are the common femoral artery (85%) and the proximal (maximum 2 cm from the origin) superficial femoral artery (15%). We use a single-piece 18-gauge needle. After selective wiring of the superficial femoral artery, an 11-cm-long, 5-F Terumo introducer sheath (Terumo Interventional Systems, Somerset, NJ) is placed. Baseline angiography is performed to obtain pictures of the femoropopliteal tract, as well as BTK and foot vessels. Given the high prevalence of chronic kidney disease in CLI diabetic patients, we prefer to use a 50% diluted iso-osmolar contrast media. Once baseline angiography is obtained, the revascularization strategy is planned. In most patients, the pedal-plantar loop technique was the elective planned strategy; in some cases, it was a bailout procedure.

Specifically, two approaches could be attempted in each patient: (1) antegrade recanalization of the anterior tibial artery and the dorsalis pedis followed by retrograde recanalization of the plantar artery and then of the distal

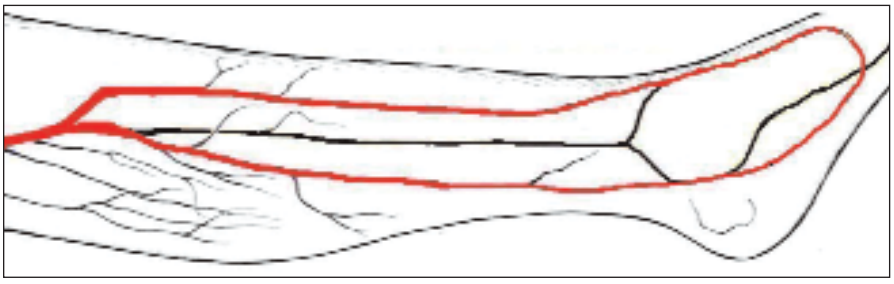

**Figure 1. Line drawing of the foot showing the connections that would be suitable for this technique.**

posterior tibial artery or (2) antegrade recanalization of the posterior tibial artery and the plantar artery followed by retrograde recanalization of the dorsalis pedis and then of the distal anterior tibial artery.

The occlusion is approached by a system consisting of a hydrophilic .014-inch-long, 300-cm Pilot 200 guidewire (Abbott Vascular, Santa Clara, CA) supported by an over-the-wire low-profile Amphirion Deep balloon catheter (Invatec S.p.A., Roncadelle, Italy), specifically designed for BTK interventions. The use of appropriate x-ray equipment capable of subtraction angiography and magnification is crucial to carefully navigate the wire through the anastomotic connections between the dorsalis pedis and plantar artery (Figure 1). A very useful trick is to bring the balloon catheter to the distal dorsalis pedis or plantar artery and then to inject contrast locally to assess a possible road of connection. The availability of a low-profile, dedicated balloon catheter is then very important to follow the wire through tortuous vessels. Local injection through the balloon catheter can also be used to confirm the correct intraluminal position before inflation.

The inflation should last between 60 and 180 seconds. The balloon size for foot vessels and plantar arch is usually 2 to 3 mm. The inflation pressure ranges between 7 and 10 atm, and the anastomotic region is included in the target segment undergoing dilatation. After several inflations, the balloon is retrieved, while leaving the guidewire in place, to perform digital subtraction angiography and appraise post-PTA results. If angiographic success is apparent, the guidewire is retrieved, and final control angiography is performed. Otherwise, subsequent inflations at higher pressure or with larger balloons are performed. The goal of PTA is to achieve a diameter stenosis <50% in all treated segments in the absence of flow-limiting dissections. All patients were pretreated with aspirin (75–160 mg), ticlopidine (500 mg), or clopidogrel (300 mg), and were periprocedurally managed with 3,000 to 5,000 units of intravenous unfractionated heparin. After the procedure, hemostasis was achieved with manual compression or, more frequently, with the Angio-Seal device (St. Jude Medical, St Paul, MN). Both aspirin and ticlopidine/clopidogrel were then continued for 4 weeks. After discharge,

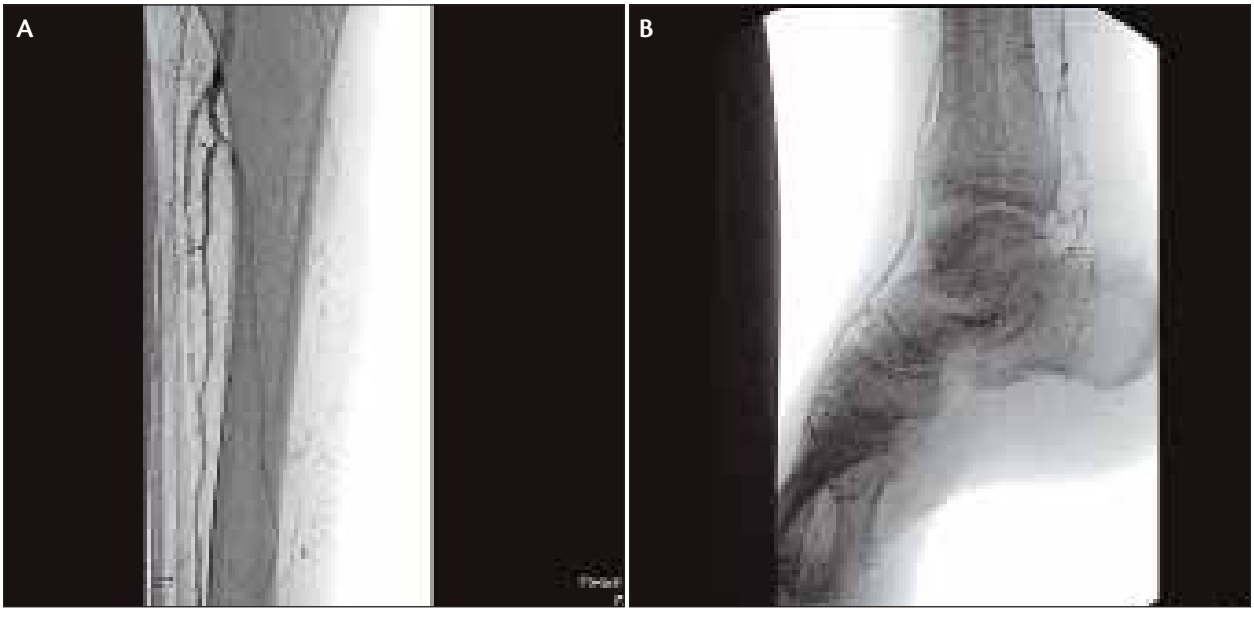


**Figure 2. Tibioperoneal trunk with diffuse stenosis in the anterior tibial artery. Severe occlusive lesion in the anterior and posterior tibial arteries (A). Severe occlusion in malleolar and plantar arteries (B).**

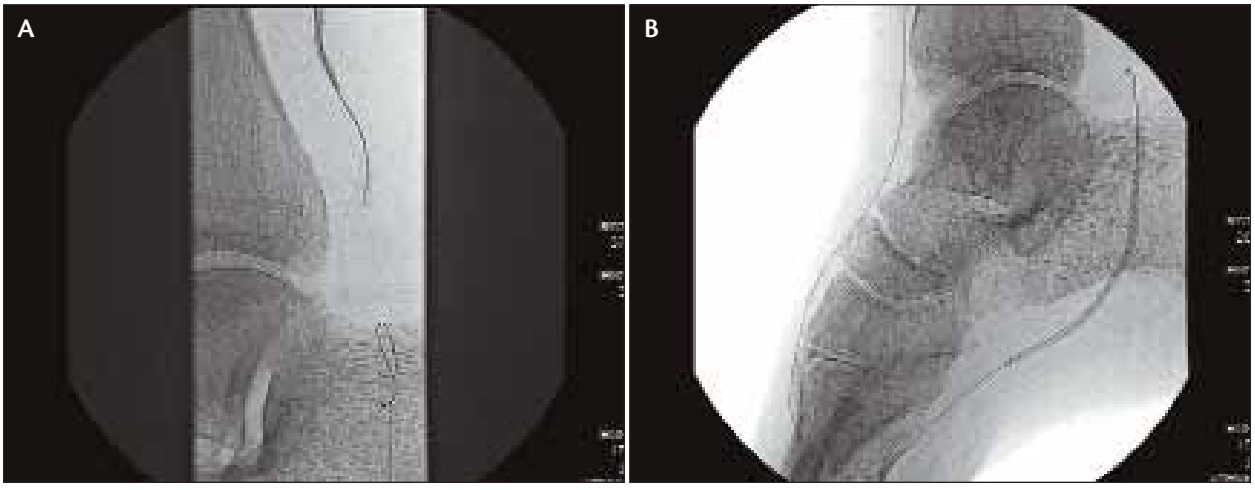


**Figure 3. Three- X 80-mm posterior tibial balloon angioplasty (A). Loop of the guidewire from dorsalis pedis to plantar and malleolar arteries with a 2.5- X 120-mm inflated Amphirion Deep balloon (B).**

clinical follow-up was routinely performed at 1 month and then at 3-month intervals for the duration of recovery, including assessment of vital status and duplex ultrasound imaging of the affected limb. If patients showed little clinical improvement, clinical recurrence of disease (eg, foot ulcer), or ultrasound evidence of restenosis/reocclusion, patients underwent repeat lower limb angiography followed by revascularization when appropriate.

## CLINICAL CASE

A 74-year-old man with a 23-year history of type 2 diabetes mellitus was admitted for right limb angiography because of a nonhealing calcanear foot ulcer. Baseline angiography showed occlusion of the anterior tibial artery (Figure 2A) and of the distal posterior tibial artery and plantar artery (Figure 2B). The target vessel for recanalization was the posterior tibial plantar artery because of the site of the ulcer. The occlusion was approached with a .014-inch 300-cm Pilot 200 hydrophilic wire and a 3- X 120-mm Amphirion Deep balloon catheter. Antegrade crossing was not possible, and perforation of the artery occurred. A pedal-plantar loop technique was then attempted. The anterior tibial artery was engaged with a .014-inch hydrophilic guidewire and dilated with a 3- X 80-mm balloon catheter. The wire was then navigated from the dorsalis pedis to the plantar artery, up to the distal posterior tibial artery (Figure 3A), and dilatation was performed with a 2.5- X 120-mm Amphirion Deep balloon catheter (Figure 3B). The wire then could be advanced in an antegrade fashion from the distal posterior tibial artery to the plantar artery. The result was optimized by another dilatation of the distal posterior tibial


**Figure 4. Postangioplasty results showing revascularization of anterior and posterior tibial arteries (A, B) and complete recanalization of the loop from a dorsalis pedis to plantar and malleolar arteries (C).**

artery and proximal plantar artery. It is very useful to simultaneously dilate long segments with long low-profile balloons ensuring consistent time saving. An excellent final angiographic result was achieved (Figure 4).

## DISCUSSION

Since its initial applications, PTA of BTK arteries has proven to be feasible and safe, becoming particularly useful in diabetic patients with CLI. However, in the setting in which endovascular treatment of BTK artery disease is more valuable (eg, CLI diabetic patients), PTA seems to be technically more demanding because of the typical pattern of macroangiopathy in these patients, which is characterized by long calcified occlusions involving BTK arteries. Thus, the technical success rate with conventional approaches is not satisfactory. For these reasons, different techniques have been developed, such as subintimal angioplasty, the SAFARI technique,[7] and transpedal access techniques. Since its first description, the pedal-plantar loop technique has been extensively applied in our center.

The experience we gained in the last year on the pedal-plantar loop indicates that this technique is useful and safe, and it could be an important instrument for endovascular specialists approaching BTK artery disease. Whenever feasible, the pedal-plantar loop technique improves angiographic results, local oxygen tension, and, most likely, clinical results, and thus its application should be considered whenever the foot is in jeopardy and angiographic and/or clinical results of above-the-ankle PTA remain suboptimal or insufficient to achieve limb salvage. The availability of very low-profile balloon catheters (eg, the over-the-wire Amphirion Deep balloon) is crucial to perform this technique because it helps to tackle very challenging angles and tortuosities in the foot.

In most patients, the pedal-plantar loop technique was applied electively, as intention-to-treat, because it may guarantee a faster ulcer healing as compared to conventional PTA. This is because the improvement in blood flow supply is more relevant, and the reconstitution of appropriate outflow may even improve patency duration of the treated artery. In some cases, it was used as a bailout procedure because of unavailable proximal occlusion stump, huge iatrogenic dissection, or perforation of the target vessel needing a retrograde approach. Noteworthy, a retrograde approach by direct puncture of pedal vessels[8] is not possible in cases of occlusive disease of those vessels, and pedal-plantar loop becomes the unique usable technique.

An important difference as compared to the first description of this technique[5] is that in our current practice, we do not use the anastomotic connections between the dorsalis pedis and plantar artery as a route for retrograde approach, for instance, in coronary chronic total occlusion treatment.[9] We do perform dilatation of those anastomotic connections to create a conduit between the dorsal and plantar foot circulation. For this reason, the pedal-plantar loop should not only be considered an alternative technique in the case of failed antegrade crossing but also as an approach potentially able to increase the clinical benefit from endovascular therapy in CLI patients with severe foot trophic changes needing the maximal improvement in blood supply.

## CONCLUSIONS

The pedal-plantar loop technique is feasible and safe in a good number of patients; it permits an almost-complete revascularization of the foot arteries leading to a good inflow and outflow from both anterior and posterior tibial vessels. This technique should be considered whenever the foot is in jeopardy and angiographic and/or clinical results of above-the-ankle PTA remain suboptimal or insufficient to achieve limb salvage.

Furthermore, our preliminary data demonstrate a significant clinical improvement in terms of wound-healing time and in the level of oxygen tension in the patients successfully treated.

Thus, the pedal-plantar loop technique has been largely dependent on technical and technological advancements and dedicated devices, such as the introduction of low-profile long balloon catheters giving high conformability. These improvements have made PTA for critical limb ischemia a reasonable alternative to the standard treatment, bypass surgery. ■

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