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Percutaneous Transluminal Angioplasty of Crural Arteries[1]

The authors dilated 103 stenosed crural arteries in 71 patients. Primary success was defined as traversing and reducing the lesion to a residual stenosis of less than 30%. This was achieved in 96% of cases. Complications included one vessel rupture and one occluding intimal flap, which were treated by the vascular surgeon with bypass and venous patch, respectively. One hematoma at the puncture site was treated surgically because of its size. With modern materials such as steerable guide wires and low-profile balloon catheters, dilation of crural arteries has become safe. Until now, the indications for percutaneous transluminal angioplasty (PTA) of crural arteries have been limited to Fontaine stages III and IV disease. The authors believe that the indications for PTA in Fontaine stage IIb disease are justified, especially if intervention improves outflow after a more proximal recanalizing procedure is performed.

Index terms: Arteries, extremities, 92.721 • Arteries, laser angioplasty, 92.128 • Arteries, transluminal angioplasty, 92.128 • Arteries, stenosis or obstruction, 92.721 • Extremities, blood supply

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ARTERIES of the calf have a multitude of physiologic interconnections that, when necessary, develop into efficient collateral vessels. Single or multiple stenoses of single arteries of the calf rarely necessitate invasive therapy; even patients with only one functioning vessel are often free of symptoms. Therefore, treatment with recanalizing procedures is indicated only if total blood supply is diminished; that is, if all three main arteries are stenosed and/or occluded. However, if percutaneous transluminal angioplasty (PTA) fails in these cases, the surgeon faces a difficult situation or might even be unable to help.

With these facts in mind, most authors (1–3) limit the indications for PTA of arteries below the trifurcation to Fontaine stages III and IV disease (Table 1). Indications are further limited by the tendency of crural arteries to develop mechanically induced spasms (4) that necessitate the administration of vasodilators (3,5). Nevertheless, in most studies of PTA in crural arteries, PTA was performed in patients with stage IIb disease (because of high risk at operation) (6), in patients who had a great saphenous vein that was not usable for a bypass graft (6), or to preserve a proximal PTA result by improving the state of the outflow tract (1,5,6). In fact, various studies of long-term results of PTA have shown that the patency rate is highly dependent on the condition of the outflow tract, a factor that is more or less statistically significant (7,8). In a study of PTA, Bollinger et al (9) showed great differences in the long-term results in patients with diabetes, compared with those of metabolically healthy individuals. In addition to an increased rate of acral necrosis and a proneness to infection, they observed insufficient outflow into crural arteries in patients with diabetes (9).

Recent studies of new recanalizing procedures—mainly laser angioplasty—show statistically significant differences in long-term results, depending on the condition of the outflow tract. Results of the Austrian Multicenter Study for Laser Angioplasty 1988 (10) showed a patency rate of 78% after 2 years in patients with good runoff, compared with less than 50% if runoff was poor (good runoff = at least one unobstructed vessel). The success of surgical reconstructions also depends on outflow conditions. Darling and Linton (11) found a patency rate of 77% for saphenous vein bypasses after 3 years if runoff was good, compared with 69% if runoff was poor (good runoff = at least two patent vessels). These figures also seem to justify treatment of crural arteries in cases of Fontaine stage IIb disease—if the success of a more proximal recanalization measure is preserved—provided that the method used is safe. We describe our experience with PTA of crural arteries with use of modern equipment to reevaluate the method.

MATERIALS AND METHODS

From January 1, 1986, to May 31, 1989, we dilated 103 crural arteries in 71 patients. These procedures represented 15.8% of all PTAs performed in this period. The tibiofibular trunk was treated in 43 cases, the anterior tibial artery in 30, the posterior tibial artery in seven, and the fibular artery in 23. Isolated interventions in crural arteries were performed in 28 cases; these cases represented the classic indications for intervention in Fontaine stages IIb–IV disease (Table 2). Crural interventions were done in combination with PTA in the femoropopliteal region in 33 cases, with laser angioplasty in the same region in 15, with local lysis of recent thromboses in 11, and with surgery in 16. These procedures were always

Abbreviations: PTA = percutaneous transluminal angioplasty, PTCA = percutaneous transluminal coronary angioplasty.

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Table 1
Clinical Stages of Peripheral Arterial Occlusive Disease, Modified Fontaine Classification

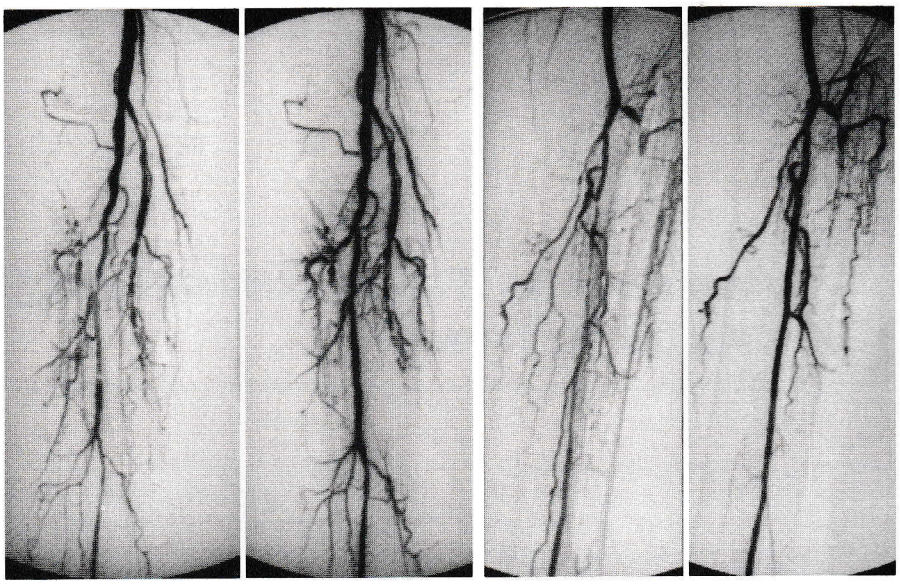
Stage	Condition
I	Stenosis or occlusion without symptoms
II	Intermittent claudication
IIa	Walking distance of more than 100 m
IIb	Walking distance of less than 100 m
III	Rest pain
IV	Gangrene

performed to improve outflow (Table 3). The mean patient age was 70.2 years ± 9.6. The youngest patient was 44 years of age, and the oldest was 92. Forty-seven patients were men and 24 women. Thirty-nine of the vessels were in 25 patients with diabetes, and 64 vessels were in 46 patients without diabetes. Five of the vessels were treated repeatedly because of recurrent stenoses.

The interventions were mainly performed with 5-F Schneider-Shiley balloon catheters (Zurich) with balloon diameters ranging from 3 to 5 mm. These were inserted over steerable 0.020-inch guide wires with floppy tips (Schneider-Shiley golden tip; Cordis platinum tip [Brussels]) via sheaths placed into the common femoral artery in almost all cases. In selected cases, special percutaneous transluminal coronary angioplasty (PTCA) catheters were used (Orion steerable PTCA balloon catheter [Cordis], balloon size of 2–3 mm). As protective measures in dilation, heparin was administered (mean dose, 5,000 U; intraarterial bolus; weight dependent), and 20 mg of nifedipine was given by mouth to prevent spasm. For high-risk procedures (eg, PTA in the distal third of the calf), nitroglycerin infusions were given, starting 1 hour before PTA (mean dose, 1.2 mg/h). Therefore, intraarterial nitroglycerin was unnecessary. Acetylsalicylic acid was given twice daily (500 mg), starting preferably 1 day before the intervention. After the procedure, the patients were given heparin subcutaneously four times a day; in some cases, 1,000 U/h were given intravenously for 24–48 hours after local lysis or laser angioplasty. Some patients, especially those also treated surgically, received anticoagulative therapy with coumarin instead of acetylsalicylic acid for long-term prophylaxis.

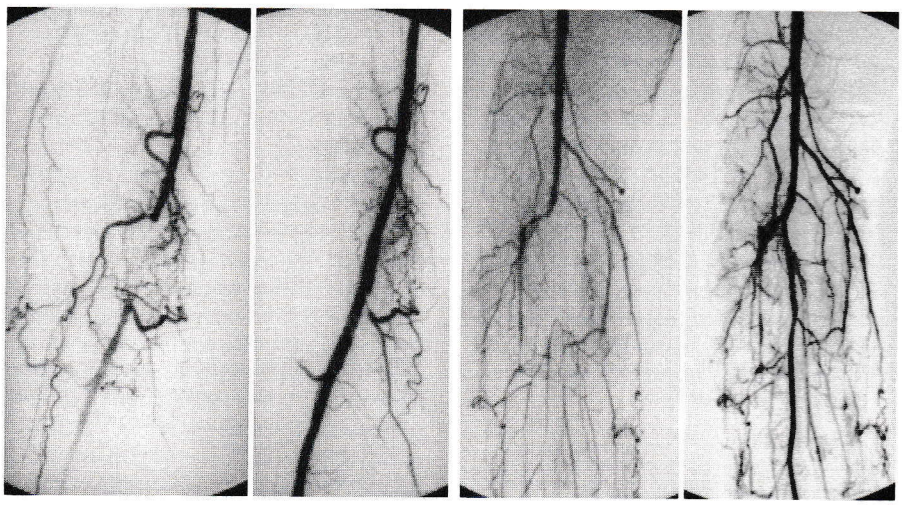
Primary success was defined as traversing and reducing the lesion to a residual stenosis of less than 30%.

Follow-up was basically done with Doppler ultrasound (ankle-brachial indexes, segmental wave form, and color analysis) every 3 months. When recurrent stenosis or occlusion was suspected or clinical symptoms deteriorated, angiography was performed, either intraarterial (most cases) or intravenous (some cases) digital subtraction angiography. Data were collected retrospectively and computed according to a modified Kaplan-Meier life table analysis.



1. 2.

Figures 1, 2. **(1)** Stenoses of the fibular artery before (left) and after (right) PTA. The anterior and posterior tibial arteries are occluded. The fibular artery was the only supply for collateral vessels of the foot. **(2)** Multiple high-grade stenoses of the tibiofibular trunk and fibular artery before (left) and after (right) PTA. The anterior and posterior tibial arteries are occluded. The treated vessel supplied the anterior and posterior arch of the foot.

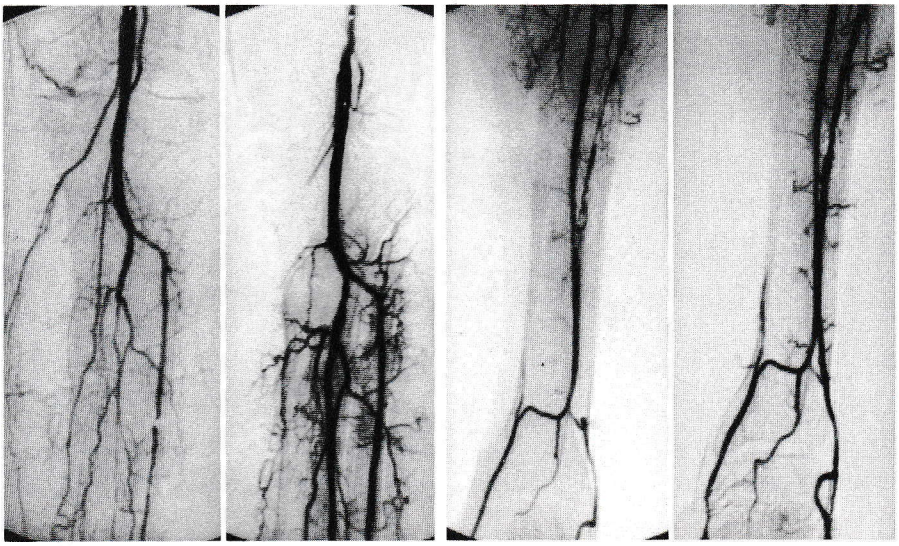


a. b.

Figure 3. **(a)** Occlusion of the superficial femoral artery before (left) and after (right) laser angioplasty and PTA. The defect at the angioplasty site was interpreted as an intimal cleft. Stenosis recurred at this site 2 months later and was successfully dilated. **(b)** Outflow results in the same patient before (left) and after (right) laser angioplasty and PTA. The anterior tibial artery is occluded. Recanalization of the tibiofibular trunk was successful.

RESULTS

Figures 1 and 2 show the initial findings in cases of occlusion of the anterior and posterior tibial arteries and stenoses of the tibiofibular trunk and fibular artery. In both cases, satisfactory results were achieved. These cases demonstrate the classic indications for crural PTA, stenoses of the crural arteries with a patent femoropopliteal axis and Fontaine stages III–IV disease. In a different case (Fig 3a), the superficial femoral artery had a distal occlusion of 4 cm that was recanalized with a combination of laser and balloon angioplasty. Below the knee in the same patient, there was an occlusion of the anterior tibial artery, as well as the tibiofibular trunk. The latter was recanalized with laser angioplasty and dilated with a 3-mm balloon, so that good runoff was achieved into at least the fibular artery (Fig 3b). Figure 4



a. b.

Figure 4. **(a)** Outflow results in a patient after laser angioplasty of the thigh. There are multiple stenoses of the anterior tibial and filiform fibular arteries and occlusion of the posterior tibial artery (left). Results after PTA are seen on the right. **(b)** Distal calf of the same patient. There are more high-grade stenoses of the anterior tibial artery, which does not opacify in the supramalleolar region. Results after PTA are seen on the right.

Table 2
Indications for Isolated Interventions in Fontaine Stages IIb-IV Disease in 103 Vessels

Indication	Stage IIb (n = 60)	Stage III–IV (n = 43)
Unsuccessful intervention	2	2
Complications necessitating surgery	1*	1

* In another case, a hematoma developed at the puncture site.

Table 3
Interventions in Arteries of the Calf in Patients with Fontaine Stages IIb-IV Disease

Type of Intervention	No. of Vessels
PTA of femoropopliteal region	33
Laser angioplasty of femoropopliteal region	15
Local lysis	11
Intraoperative therapy as adjunct to bypass surgery or distal to an existing bypass	16

shows outflow into the calf of a patient after laser angioplasty of the femoropoliteal segment. There was a proximal occlusion of the posterior tibial artery, the anterior tibial artery had multiple high-grade stenoses, and the fibular artery was exceptionally thin (Fig 4a). More distally, there was another high-grade stenosis of the anterior tibial artery, which did not opacify in the supramalleolar region (Fig 4b). Both of the patent arteries were successfully dilated.

In 150 laser angioplasties performed in 120 patients in our institution, the arteries of the calf were stenosed in such a way in 15 cases that PTA improved the outflow (12). In a similar way, 33 of 651 cases were treated with PTA. After recanalization in the femoral or popliteal region, PTA of stenosed arteries of the calf was performed to maintain the result more proximally by improving the outflow. For example, in one case in our study, there were multiple stenoses of the superficial femoral artery (Fig 5a), a high-grade stenosis of the fibular artery, and occlusion of the anterior and posterior tibial artery (Fig 5b).

PTA of crural arteries may also be necessary if, after local lysis, a stenosis is found to have caused the thrombotic occlusion (Fig 6). Figure 6b shows results after successful lysis and PTA. There were 11 similar cases in our study (among 80 lysis therapies or thrombus aspirations).

The state of outflow is especially important for maintaining a surgical vessel reconstruction. Figure 7 shows that a femorocrural jump graft bypass was acutely endangered by a stenosis distally and by stenoses of the receiving vessels (anterior tibial artery and tibiofibular trunk). The right image in Figure 7 shows the morphology after dilation of both grafts and the receiving arteries. A similar case is shown in Figure 8. There was a femoropopliteal bypass, the fibular artery was occluded proximally, the posterior tibial artery was occluded as a whole, and the anterior tibial artery was highly stenosed. With a 3-mm balloon, the main path of flow was reestablished. PTA of crural arteries was performed in 16 cases in connection with bypass operations to improve runoff.

Of 103 dilations of crural arteries, 99 were successful (primary success rate, 96%) (Table 2).

Figures 9 and 10 show long-term results. Figure 9a shows a femoropopliteal composite bypass in a patient with diabetes. Stenoses developed at the anastomosis between the vein and synthetic graft, as well as in the crural arteries. The right image in Figure 9a shows the results immediately after PTA. Figure 9b shows results 6 months later. Outflow is still satisfactory. Figure 10a depicts an occlusion of the popliteal artery that continued into the trifurcation, tibiofibular trunk, and proximal anterior tibial artery. Laser angioplasty and balloon dilation reestablished patency of the popliteal artery and tibiofibular trunk, with main runoff into the fibular artery. This region was still open 15 months later. The untreated anterior tibial artery also recanalized spontaneously, although a stenosis remained.

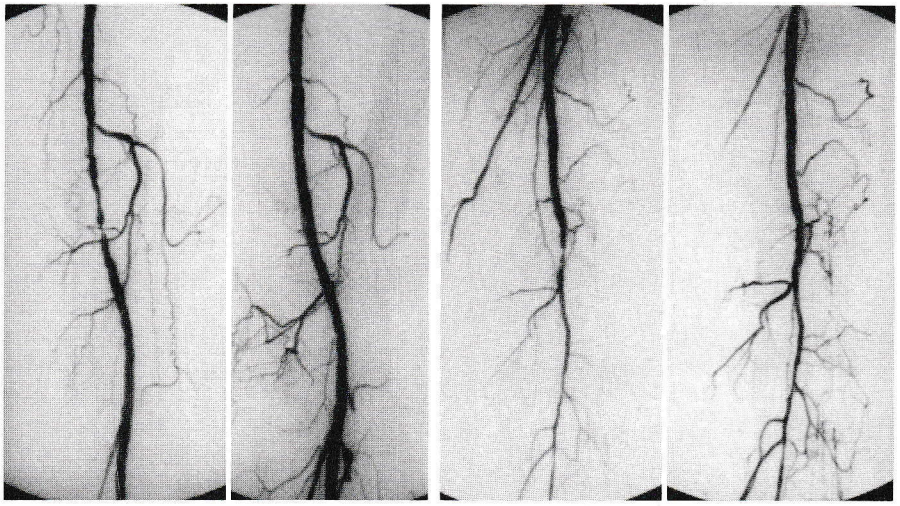
The maximum follow-up time was 38 months. Angiograms obtained in 29 cases revealed seven recurrent stenoses and 12 occlusions (Table 4). All stenoses were successfully dilated again, and one occlusion was reopened with local lysis. Amputation of the calf was unavoidable in two cases. In five cases, the additional therapy (PTA, bypass, laser angioplasty) was so successful that despite recurrent occlusion in the calf, clinical improvement was achieved and no further therapy was necessary. In four cases, conservative therapy was

sufficient, and no clinical deterioration occurred. Life table analysis for single vessels showed a cumulative patency rate of 92.5% after 1 month (n = 63), 87.4% after 6 months (n = 45), 79.8% after 1 year (n = 27), 75.3% after 2 years (n = 12), and 64.6% after 3 years, although the low number of control cases in this group (n = 3) makes the results somewhat unreliable (Fig 11). Surprisingly, there was no statistically significant difference between the results achieved in patients with and without diabetes. This is not true for the amputation rate. Despite successful PTA, amputation was performed in one patient with diabetes. In two more patients with diabetes, the amputation area was probably decreased because of successful PTA (forefoot). Because of recurrent occlusions, the calf of one patient with diabetes and of one patient without diabetes had to be amputated. During the follow-up period, two patients with diabetes died of cardiac and cerebral diseases, and two without diabetes died because of cardiovascular and cardiopulmonary diseases.

Complications included one rupture of a fibular artery, treated with surgical bypass, and one intimal flap causing occlusion of the corresponding vessel. This complication occurred during intraoperative PTA and was treated by the vascular surgeon, with the patient under the same anesthesia. In one case, a hematoma at the puncture site was evacuated because of its size (Table 2).

DISCUSSION

PTA of the crural arteries has become a safe procedure with improvements in catheters, guide wires, and contrast media (low osmolality); availability of arterial digital subtraction angiography with road mapping; reduced contrast material doses; and cumulative experience in the treatment of complications (spasm prophylaxis, local lysis). This corresponds well with the results of Schwarten and Cutcliff (13), who also used low-profile balloon catheters and steerable guide wires and discussed PTA of the calf for Fontaine stage IIb disease. On the other hand, much is expected from the vascular surgeon in case the method fails or complications cannot be resolved by the interventional radiologist. This is why the indications for dilation of crural arteries must still be restrictive. When the femoropopliteal axis is open, only Fontaine stages III and IV disease should be treated. However, because long-term results of various recanalizing procedures of the upper thigh are dependent on the distal runoff (7–11), treatment of crural arteries in this context seems to be justified also when claudication is less severe, mainly in stage IIb disease. The data show that primary success is even better in patients with stage IIb disease, compared with that in patients with stages III–IV disease, and that the risk of a major complication is less. The long-term results,



a. b.

Figure 5. **(a)** Numerous stenoses of the superficial femoral artery before (right) and after (left) PTA. **(b)** Calf of the same patient. The anterior and posterior tibial arteries are occluded. The stenosed tibiofibular trunk is seen before (left) and after (right) PTA.

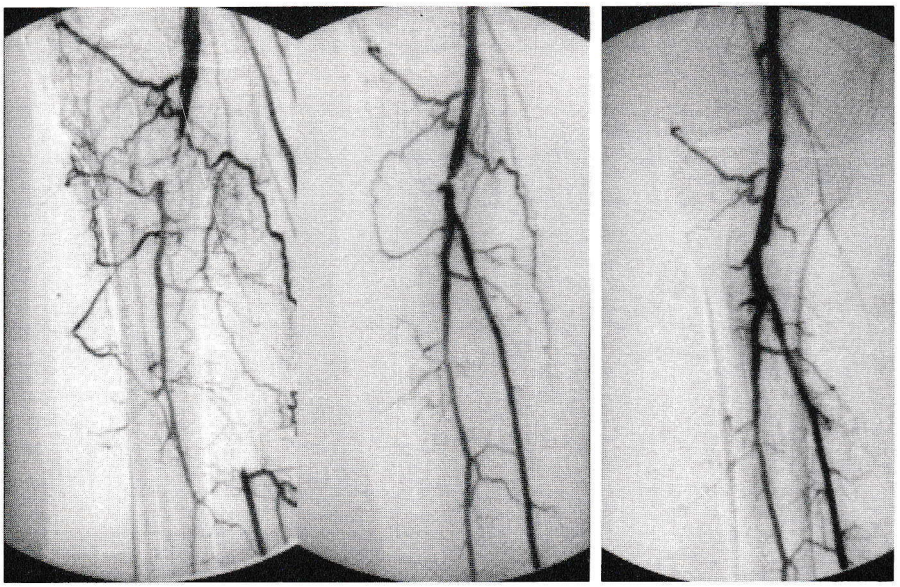


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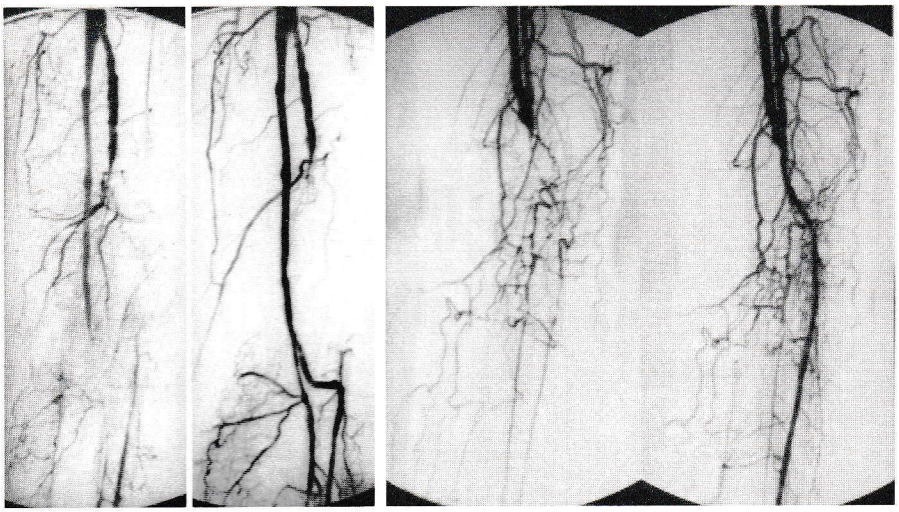
Figure 6. **(a)** Popliteal occlusion continuing into the trifurcation and proximal arteries of the calf before (left) and after (right) local lysis. The stenosis causing the occlusion is seen. **(b)** Trifurcation in the same patient after PTA.

Table 4
Recurrent Lesions after Intervention

Intervention	Stenosis	Occlusion
Isolated PTA of the calf	...	2
PTA and proximal intervention	5	6
PTA and bypass	2	4



7. 8.

Figures 7, 8. **(7)** Femorocrural jump graft bypass before (left) and after (right) PTA of both segments and of the receiving crural arteries. **(8)** Diminished outflow of a femoropopliteal bypass due to completely occluded posterior tibial, proximally occluded fibular, and stenosed anterior tibial arteries (left). Results after PTA are seen on the right.

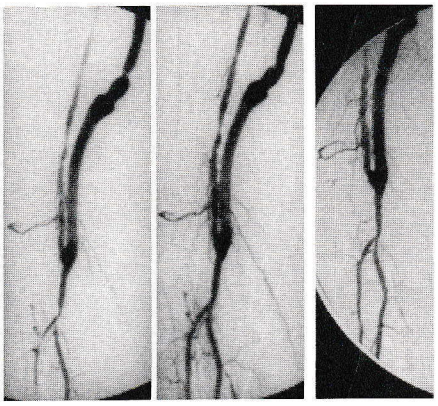


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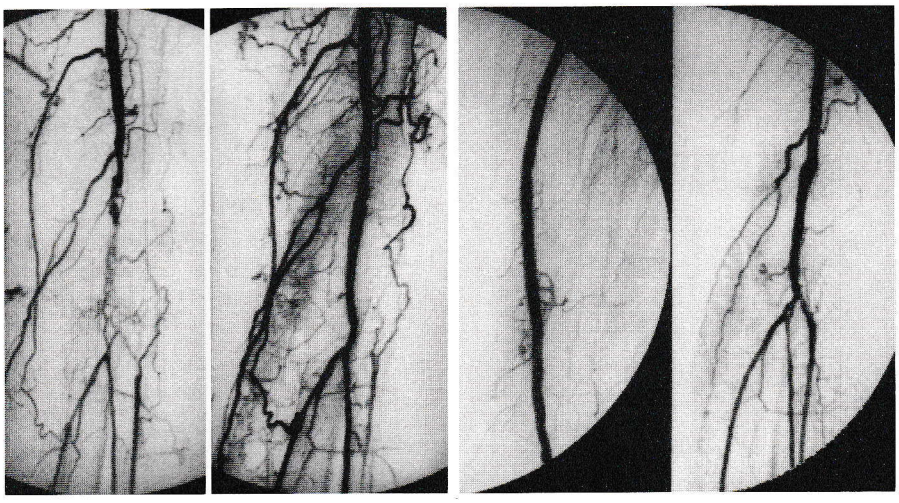
Figure 9. **(a)** Femoropopliteal composite bypass (polytetrafluorethylene-vein) with a stenosis at the anastomosis between the polytetrafluorethylene and venous grafts. There are stenoses in the outflow tract, as well as in the anterior tibial artery and tibiofibular trunk (left). Results after PTA are seen on the right. **(b)** Follow-up image of the same patient 6 months later.



a. b.

Figure 10. **(a)** Occlusion of the popliteal artery, tibiofibular trunk, and proximal anterior tibial artery before (left) and after (right) laser angioplasty and PTA. **(b)** Follow-up images 15 months after the intervention.

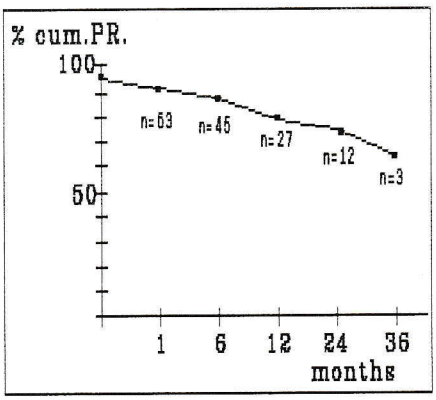


Figure 11. Life table analysis. *cum. PR.* = cumulative patency rate.

which often equal those of surgical successes, especially substantiate this view. Nevertheless, close teamwork between the interventional radiologist and vascular surgeon is of paramount importance and begins with determining the indication. ■

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