MANAGEMENT
OF TIBIOPERONEAL
OCCLUSIVE DISEASE
Christopher K. Zarins, MD, and Christopher K. Zarins, MD

GENERAL CONSIDERATIONS
AND INDICATIONS FOR TREATMENT

Tibioperoneal occlusive disease is among one the most surgically challenging problems in vascular surgery and should be considered when evaluating patients with coexisting medical and functional status. Arterial occlusive disease is rarely an isolated entity and instead is usually accompanied by varying degrees of generalized atherosclerotic disease. Similarly, patients with tibioperoneal disease are predisposed to the risk and poor medical outcomes. Diabetes mellitus is present in approximately 60% of patients with tibioperoneal disease in calcified vessels that increase the difficulty of multifocality of disease. Multilevel disease further augments the complexity, especially where infrapopliteal collateralization prevents earlier surgical intervention. Lastly, the treatment options for this disease are sometimes determined by the need for reintervention and surgical complexity of this disease and the high rates of limb salvage. Patients with tibioperoneal disease may present with signs of impeding limb loss manifested by nonhealing soft-tissue ulceration, gangrene, or an unstable limb. Patients who otherwise maintain a functional status, such as a diabetics, may benefit from tibioperoneal bypass surgery. In the elderly, avoidance of amputation is paramount. Amputation in the elderly is a significant consequence, including loss of independence and quality of life. Furthermore, the medical costs of even the most extensive interventions for tibioperoneal disease are prohibitively expensive. Life expectancy and quality of life in the elderly is limited, and surgical decision making should take these factors into consideration.

Assessment

Preoperative evaluation include identification of patients who may benefit from tibioperoneal intervention, development of treatment options, and consideration of comorbidities to allow medical optimization. Preoperative evaluation should always begin with a thorough history and physical examination that includes assessment of functional status. The presence of diabetes mellitus in this patient population is the rule. Patients are often seen with apparent or occult insufficiency, cardiovascular disease, and cerebrovascular disease. Preoperative optimization of medical comorbidities is important. We do not routinely perform full peroneal artery angiography, but it has been demonstrated that these operations can be safely performed without it. In fact, delay for cardiac evaluation to result in higher amputation rates secondary to progression of ischemia and infection in patients who may have benefited from limb-salvage interventions. Monitoring of renal function is essential, as temporary worsening of renal function associated with contrast nephropathy after angiography is a frequent occurrence. With proper management, however, most renal insufficiency is transient.

TREATMENT

Physical exam should include assessment of bilateral lower extremity pulses, wounds, extent of lower extremity infections, and coexistent venous disease. If intervention is planned, diligent control of foot sepsis with surgical debridement of infected tissue and treatment with antibiotics should be attempted before intervention. Toe amputations may be required and should, in most cases, be left open to drain. Final foot reconstruction can be performed postoperatively, after blood flow is restored.

Noninvasive vascular imaging, including ankle-brachial indexes (ABIs) and toe pressures, should be used to objectively document the degree of ischemia and to serve as a baseline for comparison postoperatively. An ankle pressure below 50 mm Hg with a flat pulse waveform indicates that the patient is unlikely to heal foot wounds without prior revascularization. More detailed imaging that includes conventional angiography, computed tomographic angiography (CTA), or magnetic resonance arteriography (MRA) should be completed and reviewed prior to consideration for intervention. Delayed images may be helpful in patients with poor runoff, and CTA and MRA may provide more detailed imaging of the distal circulation than routine angiography, thus it is our preferred method for preoperative assessment. Imaging should be obtained from the aorta distal to the renal arteries through the pedal vessels, with attention paid to the quality of inflow vessels, degree of multifocality of disease, vessel calcification, and vessel runoff. The number of patent tibial vessels is an important consideration as improved success of revascularization. At a minimum, restoration of blood flow for wound healing or resolution of rest pain typically requires at least one continuous vessel to provide in-line flow to the foot. If this is not possible, revascularization is indicated to restore the vessel most likely to provide flow to the wound.

If the patient is a potential distal bypass candidate, noninvasive evaluation of the bilateral lower extremity venous systems should be done to evaluate for bypass conduits. Upper extremity duplex ultrasonography (DUS) may also reveal suitable veins for bypass procedures, should the greater or lesser saphenous veins prove unusable. During the evaluation it should be remembered that primary amputation may be more advisable in patients who are nonambulatory, of limited functional status, or in those who have severe flexion contractures, predetermined prohibitive medical risks, and unsalvageable lower extremity infections. However, advanced age, most medical problems, incurable malignancy, and a contralateral amputation should be considered to allow limb-salvage interventions. We preferentially use clopidogrel in our patients. In those who require more urgent intervention, or in those who did not complete their course of clopidogrel as instructed, clopidogrel loading can be done the same day. When elective circumstances prevail, we also routinely start our bypass patients on aspirin and clopidogrel preoperatively. However, it is not our routine practice to use clopidogrel loading on bypass patients who have not already been taking this medication.

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Tibial Artery Bypass

Outflow: Distal Bypass Target
Distal bypasses may be performed to the posterior tibial, anterior tibial, or peroneal arteries. Alternatively, bypass may be performed to the pedal vessels of the foot. All things considered, the most disease-free proximal vessel that can provide in-line flow to the foot is chosen.

Inflow Vessels
Choice of inflow vessel is determined by prior surgical interventions, characteristics of the inflow vessel, and length of available autogenous vein. The common femoral artery is a popular location for the inflow anastomosis. If this vessel is heavily calcified or scarred from prior surgery, the surgeon can alternatively utilize the distal external iliac, profundap femoris, superficial femoral, or above-the-knee popliteal arteries. The profundap femoris, superficial femoral, and popliteal arteries may also be used if the length of the available conduit is limited. It is paramount to construct a tension-free anastomosis to avoid future pseudoaneurysms. Alternatively, a previous bypass conduit used for a femoral-femoral, axillofemoral, or aortofemoral bypass may be used for a proximal anastomosis.

Conduits
Autogenous vein is the preferred conduit for distal bypass. The order of preference is greater saphenous vein, lesser saphenous vein, followed by arm vein. Although the cephalic and basilic veins are definite options for bypass, we have listed them last because they are generally thin walled, often have fibrotic segments following venipuncture, and have lower patency rates compared with extremity veins. The venous segment may be used (Figure 1) or in situ fashion. Regardless of the vein source, vein diameters of at least 3 mm are recommended. Both require ligation of venous side branches, and the in situ vein requires lysing of venous valves. Veins with a single kink may still be used, but they require intraoperative repair prior to use.

Use of expanded polytetrafluoroethylene (ePTFE) is discouraged when alternatives exist, because both patency and limb-salvage rates using this material lag significantly behind rates performed using autogenous vein. Segments of vein may be used together if a single, long, continuous vein is unavailable. Even if a single, long, continuous vein is unavailable in patients with critical limb ischemia, distal bypasses may still be considered using autogenous vein segments. Patency rates using such multisegment bypass grafts have decreased, and it is unclear how much benefit is gained from a long prosthetic graft. Thus, if autogenous vein is unavailable in patients with critical limb ischemia, distal bypasses may still be considered using autogenous vein segments.
Inflow and outflow vessels should be exposed, and the vein graft prepped, prior to anticoagulation and arterial clamping.

Surgical exposure varies depending on the target vessel and location of the distal anastomosis. The tibioperoneal trunk and proximal tibial vessels are exposed through a medial approach below the knee, avoiding injury to the greater saphenous vein during the skin incision. The muscular fascia is incised, and the medial head of the gastrocnemius muscle is retracted posteriorly. If exposure is insufficient, the medial head of the gastrocnemius may be divided at the medial femoral condyle. The proximal tibial arteries are exposed by separation of the soleus muscle from the tibia. The mid posterior tibial artery, the preferred target for distal bypass, runs between the tibialis posterior and the flexor digitorum longus muscles (Figure 2). Distally the posterior tibial artery is exposed through a longitudinal incision posterior to the medial malleolus, splitting the distance between the
ial, and the Achilles tendon. The flexor retinaculum must be divided to expose the posterior tibial artery at this location. Exposure may be continued to the medial and lateral plantar arteries in the foot by continuing the dissection of the flexor retinaculum distally.

The anterior tibial artery may be exposed along its length by an incision 2 cm lateral to the tibia. The anterior tibial artery is found by dividing the fascia overlying the anterior compartment and bluntly separating the tibialis anterior muscle and the flexor digitorum longus. The anterior tibial artery is usually associated with two overlying veins and the deep peroneal nerve. The dorsalis pedis artery is a continuation of the anterior tibial artery after crossing the ankle joint. This artery is exposed via a 2 cm incision lateral to the extensor hallucis longus tendon on the dorsum of the foot.

The peroneal artery can be exposed through a medial or lateral incision on the calf. A medial approach is best suited for access of the superior two thirds of this vessel. The distal peroneal artery is exposed though a lateral incision over the fibula, with excision of a segment of the fibula to reveal the underlying peroneal artery, which is on the flexor hallucis longus muscle posterior to the intramuscular septum.

After target vessel exposure and vein harvest, intravenous heparin is given prior to arterial clamping, at a dose of 70 to 100 U/kg, and is redosed at 45-minute intervals as needed to maintain an activated clotting time (ACT) of 250 to 300 seconds. Gentle clamping techniques should be used and antegrade perfusion performed. Atraumatic vascular clamps to minimize the possibility of clamp injury. Anastomoses are performed using small diameter (6-0 or 7-0) monofilament suture with good lighting and magnification. The proximal anastomosis is usually performed first. When using the nonreversed in situ technique, the saphenous vein is left in place, and the most proximal valve is lysed under direct vision; after the proximal anastomosis is complete, the remainder of the valves are lysed using a valvulotome. Reversed saphenous vein bypasses are usually tunneled in the subcutaneous plane but may be tunneled in the deeper anatomic plane. Regardless of the plane chosen, attention must be paid to avoid graft twisting or kinking.

A number of techniques can be used to enhance the distal anastomosis to improve outflow. The Linton patch enlarges the distal anastomosis by sewing a vein patch onto the tibial artery and then anastomosing the bypass graft onto the vein patch in an end-to-side fashion. Miller described a method of constructing a vein cuff secured to the distal target vessel, thus allowing the bypass graft to be anastomosed to the vein cuff end-to-end. This method is particularly useful for prosthetic ePTFE tibial artery bypasses. The Taylor patch utilizes a vein patch to widen the distal graft anastomosis. Alternatively, Dardik has described the creation of a side-to-side fistula between the distal target vessel and adjacent vein by opening both, sewing the back wall of the vein and artery together, and then anastomosing the vein graft to the anterior wall of both the artery and vein. These techniques should be considered when the tibial arteries are small, and the outflow is poor with high arterial resistance.

After completion of the anastomoses and flow restoration, the adequacy of perfusion is assessed by inspection of the foot and toes, palpation of distal pulses, and Doppler flow assessment in the bypass graft and outflow artery. We also perform intraoperative angiographic evaluation of the bypass and distal anastomosis to ensure there are no technical defects. Noninfected foot wounds greater than 2 cm may be debrided at the end of the operation after arterial reconstruction. Debridement may include toe amputations, which may be loosely closed. Skin grafts should be postponed until wounds are granulating.

**Endovascular Treatment**

**General Considerations**

The indications for endovascular interventions for tibioperoneal occlusive disease are similar to those for surgical bypass. Significant advances in imaging and endovascular technology and improved proficiency of interventionalists have resulted in improved outcomes after peripheral vascular endovascular interventions advocate extending the indications to intervene in occlusive disease, evidence suggests that endovascular procedures should be reserved for limb salvage in appropriate patients.

Endovascular treatment of tibioperoneal disease should be avoided. Early intervention may place rely medical comorbidities at risk from complex interventions and early treatment failure. Endovascular treatment may result in worsening of symptoms to critical limb ischemia and a potentially uncontrolled loss situation.

Despite the aforementioned concerns, the armamentarium of endovascular options provides excellent options for patients who are not suitable candidates for bypass surgery, inadequate vein conduits or patients at high risk who may benefit endovascular procedures with lower complication rates and low morbidity and mortality compared to surgical procedures. Endovascular procedures may also be performed for bypass surgery, by augmenting inflow or outflow. This procedure is particularly useful for healing ischemic ulcers and toe amputations, and can result in improved limb salvage, even if the endovascular intervention is not successful. It is well known that limb-salvage rates exceed 90% for endovascular interventions. During the past decade, we have witnessed a dramatic increase in the number of endovascular procedures performed for lower extremity ischemia, and this has been achieved by a decrease in the overall major amputation rate.

**Access**

Endovascular interventions are typically performed via a femoral, or local anesthesia combined with sedation. Tibial interventions may be obtained from the ipsilateral external iliac artery. A long guidewire may be required for occlusive disease or patients at high risk. A 5 or 6 Fr multipurpose catheter, is introduced into the common femoral or popliteal artery to provide support during interventions. The crossover technique is best used for complex interventions to treat long stenoses. Complex interventions to treat long stenoses, with or without distal lesions may require antegrade access from the femoral or popliteal artery. This approach allows access for interventions and allows the operator to perform antegrade opacification of the distal circulation with minimal nephrotoxic contrast.

**Imaging**

Infra-popliteal interventions require high-resolution imaging. The use of low-osmolar contrast will be less painful for the patient, and less nephrotoxic. Sedation and local anesthesia is usually obtained using a straight anterior-posterior 5 Fr diagnostic catheter. Additional views using a craniocaudal or a true lateral view may better delineate the tibial artery and distal popliteal arteries.

**Procedural Details**

Heparin is administered at the start of intervention, maintaining an activated clotting time of 250 to 300 seconds. Most tibial interventions for stenosis are performed over a 0.014 inch guidewire. A 0.018 inch guidewire may be required for occlusive lesions, and can be used to traverse calcified or long lesions. Crossing of an occluded tibial artery can be achieved using a straight guidewire, allowing antegrade performance of the remainder of the intervention.
of stenotic lesions is the most common tibial intervention. Balloon angioplasty alone is not the treatment of single, short-segment stenoses (<1 mm) to respond to angioplasty include occlusive stenosis, multiple lesions, and heavily calcified vessels. The results of balloon angioplasty are useful to correct abnormalities such as vessel recoil and arterial dissection. Inconsistent, the endovascular treatment of occlusive lesions has been reported to be successful in up to 90%. Although treatment options include the use of cutting or laser balloons, rotational atherectomy, and laser atherectomy appear disappointing but may be improved with use of glycoprotein IIb/IIIa inhibitors. Cryoplpasty has shown little benefit over routine angioplasty and adjunctive stenting, but investigation into the use of this technology in the tibial vessels is currently underway. Some encouraging results have been demonstrated with laser atherectomy, but these reports are early.

**POSTINTERVENTION TREATMENT AND SURVEILLANCE**

Aspirin and ADP-receptor inhibitors should be continued after lower extremity endovascular interventions and should strongly be considered after distal bypass. The use of clopidogrel compared with aspirin alone has been demonstrated to decrease the incidence of vascular events in patients with peripheral artery disease. Antiplatelet drugs have further been shown to improve the patency of infrapopliteal grafts. Warfarin therapy should be considered in patients after bypass with prosthetic conduits, because this may improve patency rates, particularly in patients with failed previous bypass. Finally, statins should be considered for all patients unless contraindicated. In addition to the medical benefits of statins, recent trials indicate a cholesterol-independent improvement in graft patency after bypass.
Surveillance of patients with saphenous vein bypass grafts should include DUS of the bypass along with measurement of ABIs postoperatively at 1 month, 3 months, 6 months, 1 year, and annually thereafter. Patients with prosthetic grafts are followed at similar time frames with the exception of biannual follow-up after the first year, instead of continuing with annual follow-up. A decrease in the ABI of 0.15 or greater, increased focal velocity at the anastomoses or within the bypass, or increases in mean graft velocity are suggestive of early graft failure and should prompt further imaging with CTA, MRA, or angiography.

Early failures after open interventions are usually the result of technical errors, which can result in vessel recoil, dissection, and perioperative plaque embolization. Early failures may be prevented by intraoperative imaging and recognition of the defect before leaving the operating room. Most patients with early graft failure will require surgical reintervention and reconstruction, typically with vein patch angioplasty. However, short-segment stenoses of less than 1.5 cm may be amendable to percutaneous angioplasty provided the vein diameter is of adequate caliber (>3 mm).

Treatment failures after 1 month but before 2 years are most often attributable to neointimal hyperplasia. Failures after more than 2 years are most often secondary to progression of atherosclerotic disease. In either case, these later failures are best treated with early recognition and reintervention. Early reintervention is often much simpler than the treatment required for complete thrombosis and is associated with improved long-term outcomes.

Patients treated with endovascular interventions should be followed with clinical examination, DUS imaging of the treated artery, and ABIs. Reintervention for these patients is reserved for recurrence of critical limb ischemia.

**SUMMARY**

The management of iliofemoral occlusive disease relies on the primary goal of limb salvage. Patients with complete thrombosis should be managed conservatively, but patients with critical limb ischemia most often require intervention. Treatment options include conventional techniques, postoperative surveillance, medical therapy, and reintervention. With optimal care the majority of patients will achieve limb salvage, resulting in improved quality of life and overall cost savings for society.

**SUGGESTED READINGS**


**PROFUNDA FEMORIS RECONSTRUCTION**

Evan C. Lipsitz, MD, and Amit Shah, MD

**OVERVIEW**

The importance of adequate profunda femoris flow in the setting of lower extremity occlusive disease cannot be underscored enough. Although the primary function of the profunda femoris artery is to provide blood flow to the large muscles of the thigh, it also provides flow to the lower leg via numerous collateral vessels. When there is occlusion or extensive stenotic disease of the superficial femoral artery, the profunda femoris provides flow to the entire lower extremity.

**ANATOMIC CONSIDERATIONS**

The profunda femoris originates at the femoral bifurcation, which is generally located from 3 to 5 cm below the inguinal ligament (Figure 1). However, the bifurcation may be located at the level of the inguinal ligament or more than 5 cm below it. It is useful for operative planning to note the location of the profunda femoris origin preoperatively, based on any imaging studies that have been performed. The profunda femoris branches off the femoral bifurcation in a posterolateral direction, forming an acute angle with the superficial femoral artery. When dissecting the femoral vessels from the anterior approach, the location of the profunda origin can be ascertained by change in caliber from the larger, common femoral artery. The profunda femoris is located anteriorly, deep to the sartorius and vastus medialis, crossed anteriorly by the circumflex femoral vessel, and is formed at the femoral bifurcation. This vein is a potential site of anastomosis with geniculate collaterals when the puncture is located at the level of the profunda takeoff. When there is femoropopliteal occlusive disease, the profunda femoris provides collateral flow to the lower leg via anastomosis with geniculate collaterals, and also serves as an important source of retrograde flow through hypogastric occlusion via circumflex arteries.

The profunda femoris can be divided into anatomic landmarks. The **proximal zone** begins at the profunda takeoff and extends to the lateral femoral circumflex. The **middle zone** begins at the lateral femoral circumflex to the takeoff of the second perforating artery anterior to the adductor longus muscle and sartorius brevis and magnus. The **distal zone** begins at the adductor longus muscle and extends to the fourth perforating artery.

**EVALUATION AND IMAGING**

It is difficult to evaluate the status of the profunda femoris exam alone. The presence of a femoral pulse and the palpability of the profunda femoris. This is especially true when a femoral pulse may be palpable, even when a thrombus occluding the femoral bifurcation. Revascularization via profunda femoris collaterals will allow for limb salvage in the setting of a superficial femoral artery occlusion.