Chapter 32
Femoral-Popliteal Bypass Graft

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Introduction

It's estimated that 30 million North Americans are affected by peripheral artery disease (PAD), with a prevalence of almost 30% in people older than 70 years [1–2]. PAD significantly affects the quality of life and constitutes a major burden for healthcare-related expenditures [3–4]. Femoral-popliteal (FP) PAD symptoms can range from asymptomatic to claudication and to critical limb ischemia (CLI) [5]. The optimal approach to treating FP atherosclerotic disease remains controversial [6]. Although the use of endovascular treatment has been increasing over the past decades, there remain a significant number of patients best treated with open surgery. The indications for infrainguinal bypass include the presence of CLI manifested by tissue loss, rest pain, or gangrene. Persistent lifestyle-limiting claudication after medical therapy is also a relative indication.

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Surgical Anatomy

Common Femoral Artery

The common femoral artery (CFA) is the continuation of the external iliac artery at the level of the inguinal ligament. It's located in the femoral triangle, a wedge-shaped area situated within the superomedial aspect of the anterior thigh. The femoral triangle is bounded superiorly by the inguinal ligament, medially by the adductor longus muscle, and laterally by the sartorius muscle (Fig. 32.1). Within the femoral triangle, the anatomical relationship from medial to lateral is femoral vein, CFA, and femoral nerve (Fig. 32.1). The vein and artery are contained within a fascial covering called a fascial sheath while the nerve is not. The CFA branches in the femoral triangle into the profunda femoris and superficial femoral artery (SFA). The latter exits at the adductor hiatus to continue as the popliteal artery.

Popliteal Artery

The popliteal fossa is located at the back of the knee joint defined anteriorly by the upper tibia, femur, and popliteus muscle; laterally by biceps femoris and gastrocnemius muscles; and medially by semitendinosus and semimembranosus muscles.

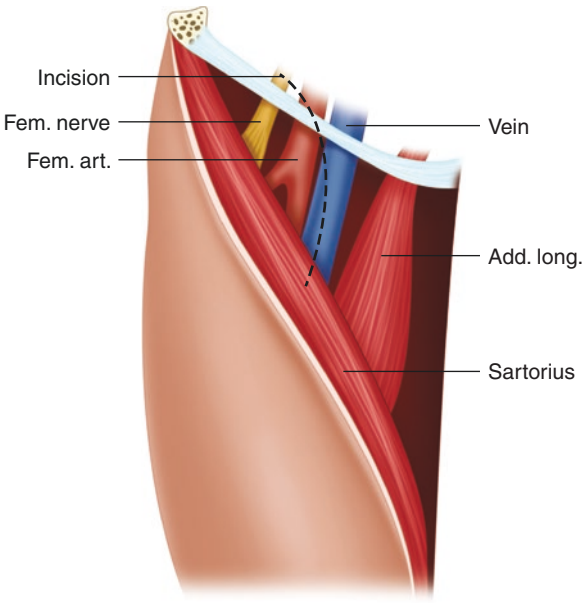

Fig. 32.1 Groin incision in the femoral triangle

The SFA artery exits the adductor hiatus at the apex of the popliteal fossa where it becomes the popliteal artery. The popliteal artery ends at the lower border of the popliteus muscle, where it branches into the anterior tibial artery and the tibioperoneal trunk.

Preoperative Planning

Traditionally, angiography has been the gold standard imaging modality. However, computed tomographic angiography has been used more frequently to assess the thigh vessels.

Proximal Anastomotic Site Assessment and Selection

Traditionally, the CFA is the inflow vessel of choice. If the CFA exhibits significant atherosclerotic disease, consideration of CFA endarterectomy is prudent. The profunda femoris or SFA provide effective sites when appropriately selected and have the added benefit of shortening the conduit length used. In reoperative procedures, access to the CFA may be limited, and the SFA or profunda femoris could serve as alternate inflow site (Figs. 32.2, 32.3, and 32.4).

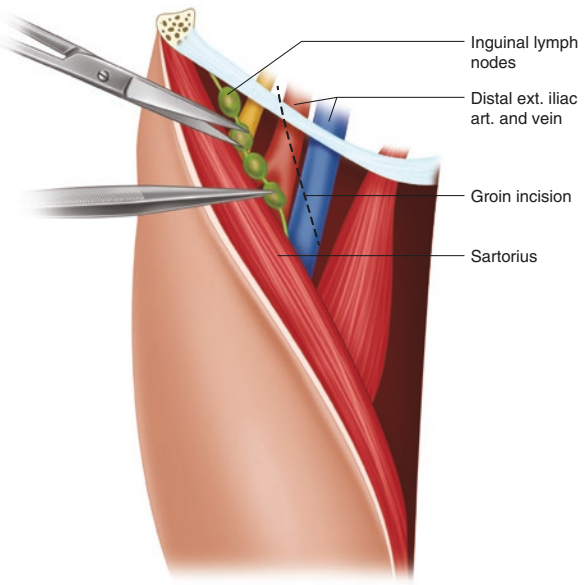

Fig. 32.2 Opening of the deep fascia over the femoral vessels

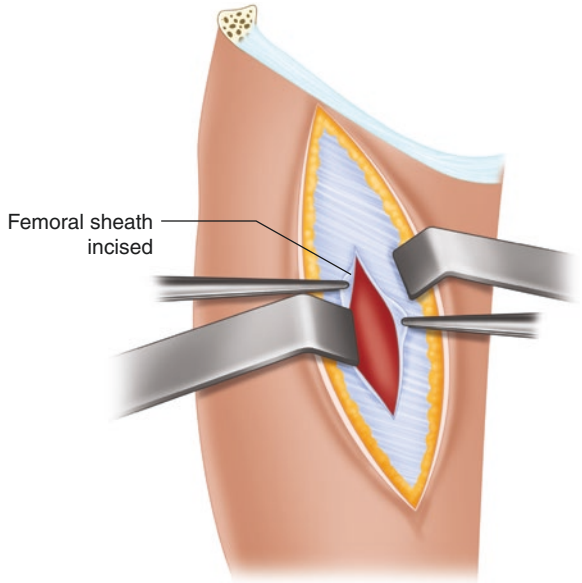

Fig. 32.3 Opening of the femoral sheath

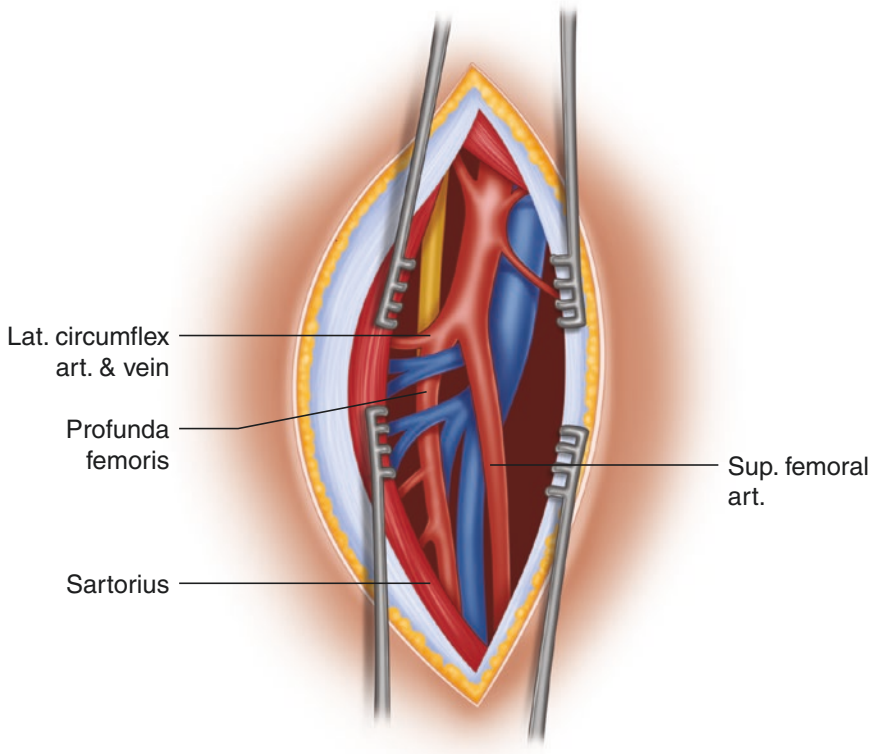

Fig. 32.4 Exposure of the femoral artery, its branches, and accompanying veins

Distal Anastomotic Site Assessment and Selection

The distal anastomotic site should be stenotic free and has at least one runoff artery to the foot. In addition, arteries distal to the outflow vessel should be free of hemodynamically significant atherosclerotic disease.

Conduit Selection

The two primary types of conduit available for bypass are autogenous and prosthetic. Autogenous conduits include the aforementioned veins, whereas prosthetic conduits include Dacron, polytetrafluoroethylene (PTFE), expanded PTFE, and polyester.

Autogenous Conduit

In general, autogenous veins are preferred due to their higher patency and limb salvage rates in infrainguinal bypass procedures [7–10]. The GSV is the most used and best-performing autogenous conduit, providing 70% for above the knee and 50–70% below the knee patency at 5 and 3 years postoperatively, respectively [7, 8, 11, 12]. The GSV could be used in either reversed or in situ configurations, with equal effectiveness [13, 14]. In the absence of appropriate GSV, alternative sources of veins could be used, including harvesting the cephalic or basilic veins, or connecting spliced short segments of veins with venovenostomies to achieve appropriate graft length. These alternative veins may also be used in reversed or in situ configurations; however, due to their smaller size and thinner walls, they are more prone to injury and hence are more commonly used as reversed grafts.

Preoperative Vein Assessment

Preoperative vein mapping is done via duplex imaging to determine the quality of the vein conduit. Namely, the vein diameter, flow, compressibility, and wall thickness are evaluated. For optimal patency, the diameter of the vein should be at least 3 mm.

Prosthetic Conduit

For patients with no suitable autogenous conduits, prosthetic grafts are used. The expanded PTFE is (ePTFE) is the most used prosthetic graft for lower extremity bypasses. It provides slightly lower patency than autogenous graft in above-knee

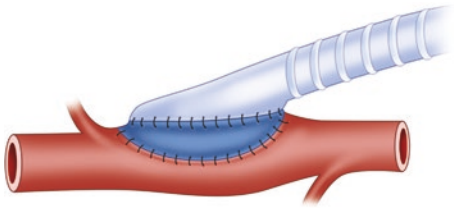

Fig. 32.5 Miller vein cuff

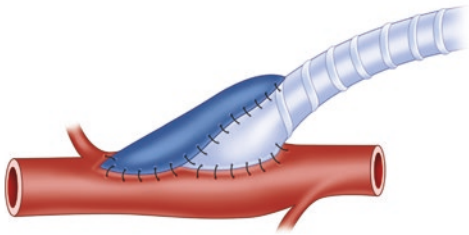

Fig. 32.6 Taylor vein patch

popliteal bypasses [8, 15]. In below-the-knee popliteal bypasses, prosthetic bypasses have uniformly poor patencies [12]. Adjunctive Miller vein cuff (Fig. 32.5) or Taylor vein patch (Fig. 32.6) could be used to further improve the patency of below-the-knee prosthetic bypasses [16]. Prosthetic grafts do have some advantages, including decreased operative time, spare vein harvesting with its associated potential wound complications, and provide better size match to the inflow and outflow arteries.

Operative Technique

Vein Harvesting

The GSV is found on the medial aspect on the femoral triangle. Preoperative vein mapping can be used to delineate the GSV pathway.

Incision

1. Using a #10 blade, an oblique incision directly overlying the GSV is made to prevent subcutaneous skin flaps. The GSV can be identified in the fossa ovalis as it enters the common femoral vein.
2. Once the GSV is identified, distal circumferential dissection directly over the vein is made. To avoid direct grasping of the vein with forceps, silicone elastomer loops can be used.

3. Skip incisions are preferred over continuous incision to minimize wound complications. Typically, three incisions are made each extended for 8 to 10 cm with two intervening skin bridges of around 4 cm. The proximal incision is used for exposure of the femoral vessels and to harvest the proximal great saphenous vein. If performing a below-the-knee bypass, a fourth incision is made below the knee.
4. 3-0 silk sutures are used to ligate small vein tributaries. It's advisable to leave a short stump when tying next to the vein to prevent graft stenosis.
5. Dissection is continued distally until adequate vein length is achieved.
6. A small clamp is placed flush with the common femoral vein. The GSV is then ligated proximally, and two layers of monofilaments are used to oversaw the stump.
7. A bulldog clamp is used to clamp the proximal aspect of the graft, and heparinized blood with papaverine is flushed under gentle pressure from the distal end to identify untied branches or tears. Avoid overdistention of the vein.
8. 6-0 propylene sutures can be used to repair any leak due to tears or small, untied branches. Any focal areas with stenosis are resected.
9. Graft is then temporarily stored in a chilled, heparinized blood until creation of the tunnel.

Femoral to Above-Knee Popliteal Bypass

CFA Exposure

Incision

1. A vertical incision is made 1 to 2 cm proximal to the inguinal crease directly over the femoral pulse and continued 3 to 4 cm distally (Fig. 32.1). If the pulse is absent, the common femoral artery can be located two fingerbreadths lateral to the pubic tubercle.
2. Electrocautery is used to deepen the dissection and expose the femoral artery in a longitudinal fashion to avoid lymphatic disruption (Figs. 32.2 and 32.3). Lymphoadipose tissue (inguinal lymph nodes) is mobilized medially. The deep fascia is incised, and the femoral sheath can be adequately exposed using self-retraining retractors (Fig. 32.4). Any bleeding or lymphatic disruption is controlled with ligation.
3. The dissection is carried proximally to the level of the inguinal ligament and distally to the level of the SFA and profunda femoris on the anterior surface of the CFA. Dissection of the profunda femoris at its origin should be done carefully to avoid disrupting collateral branches and the one or two satellite vein branches crossing at its initial anterior segment.
4. Silastic vessel loops are placed around each vessel using a right-angled clamp to establish vessel control.

Above-Knee Popliteal Artery Exposure

Incision

1. With the knee flexed at 30° and leg externally rotated, an incision is made anterior to the sartorius muscle in the lower third of the thigh and extended to the medial aspect of the knee (Fig. 32.7).
2. Electrocautery is used to dissect the deeper tissue and fascia anterior to the sartorius muscle, and the sartorius is retracted posteriorly.
3. The popliteal fossa is entered, and the popliteal artery can be identified with palpation. The sheath of the artery is opened, and division of the adductor magnus tendon may be required to achieve adequate exposure.
4. Venous network on the surface of the artery is separated from the adventitia, and the branches are divided and ligated.
5. The artery is carefully mobilized from the popliteal vein. The popliteal artery is then freed for an appropriate healthy length, and vessel loops are placed around it proximally and distally (Fig. 32.8).

Conduit Tunneling

A tunneling device is passed from the femoral incision to the popliteal fossa below the sartorius muscle. A red rubber catheter attached to an aortic clamp can be used as a tunneling device as well.

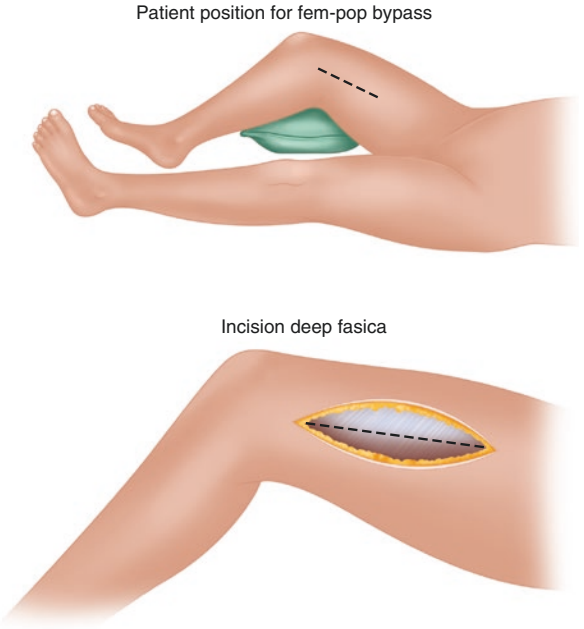

Fig. 32.7 Patient positioning and distal incision with opening of deep fascia for AK femoral-popliteal bypass

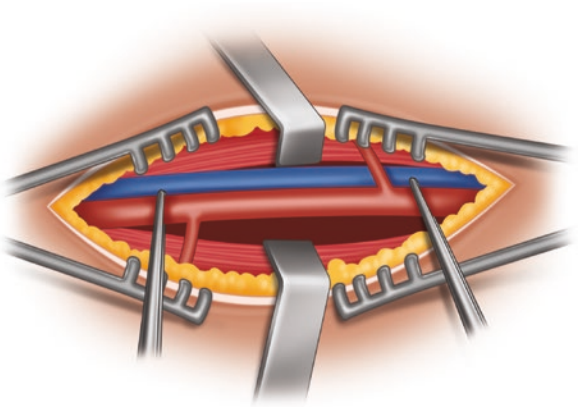

Fig. 32.8 Exposure of the popliteal artery above the knee

Proximal and Distal Anastomosis

Heparin is administered at least 5 min before arterial clamping. Usually 100 U of heparin are given for each kg of body weight. Activated clotting times are monitored, and the anticoagulation is adjusted appropriately. Proximal anastomosis is typically performed first after the clamps are applied to the inflow vessels.

Incision

1. A #11 knife blade is used to perform a longitudinal arteriotomy on the anterior wall of the CFA. Arteriotomy is then enlarged with a scalpel or Potts angled scissors to achieve an opening length of approximately twice the vessel diameter.
2. A longitudinal incision over the end of the graft is made. If using a reversed GSV technique, the segment is reversed so that its proximal end becomes its distal end for anastomosis.
3. 5-0 polypropylene continuous suture starting at the heel of the graft and proceeding toward the toe is made in an end-to-side fashion.
4. The clamps are released after flushing, and if a vein graft is used, it is distended and checked for bleeding.
5. The graft is then tunneled. The graft is marked for orientation and then attached to the obturator of the tunneler and pulled into position.
6. The tunneler is removed, and graft orientation is checked and insured not to be twisted.
7. A soft clamp is placed on the proximal end of the graft until the distal anastomosis is complete.
8. Vessel clamps or loops are used to control the above-knee popliteal artery. After the arteriotomy is performed, any atheromatous or calcified edges are excised with scissors.

9. The orientation of the graft is rechecked, and the bulldog clamp is released and should result in a highly pulsatile flow through the graft.
10. The distal anastomosis is sewn in place using 6-0 prolene in an end-to-side anastomosis.

In Situ Vein Grafts

1. The proximal GSV is identified as described previously. The distal segment is then mobilized in the projected anastomotic location.
2. The saphenofemoral junction is divided, and the first venous valves are removed with Potts scissors under direct visualization.
3. The proximal anastomosis is performed next in an end-to-side fashion. Valvulotomies are then created starting from the distal GSV and advanced proximally. Blood flow through the vein is then analyzed and should be pulsatile.
4. Distal anastomosis is performed, and the graft is evaluated with Doppler ultrasound to exclude any continuous flow indicating an arteriovenous fistula (AV). Ligation of any AV fistula identified should be done before closure.

Femoral to Below-Knee Popliteal Bypass

If the upper and middle portion of the popliteal artery exhibit significant atherosclerosis, the lower portion is used instead.

Below-Knee Popliteal Artery Exposure

Incision

1. With the knee flexed at 30° and leg externally rotated, a vertical incision is made 1–2 cm behind the posteromedial surface of the tibia and extended one third of the way down the calf (Fig. 32.9). Care must be taken to avoid injury to the GSV. If a GSV is to be used, the same incision can be made for artery exposure and vein harvesting.
2. The crural fascia is exposed and opened along its fibers. The sartorius, gracilis, and semitendinosus tendons are mobilized and divided if more proximal exposure is needed (Fig. 32.10).
3. The medial head of the gastrocnemius muscle is mobilized and retracted posteriorly, exposing the neurovascular structures within the popliteal fossa (Fig. 32.11).

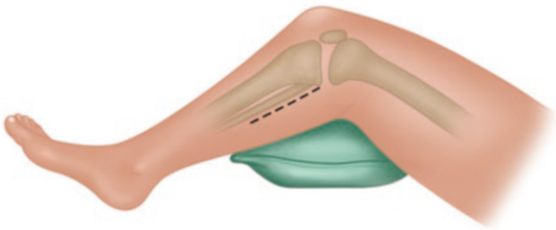

Fig. 32.9 Patient position and incision line for below-the-knee femoral-popliteal bypass

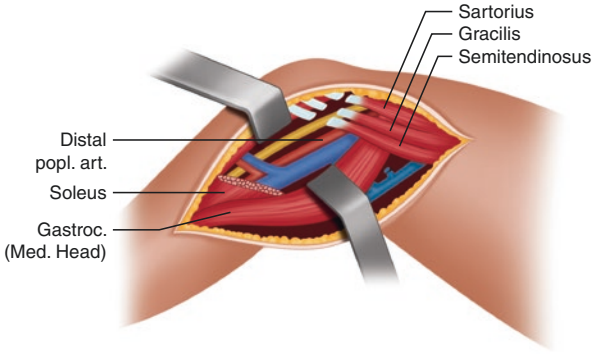

Fig. 32.10 Exposure of the distal popliteal artery

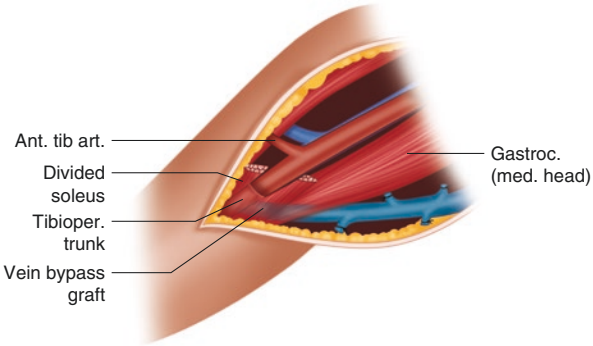

Fig. 32.11 Exposure of the popliteal artery bifurcation with a partial takedown of the soleus from the soleal line

4. Metzenbaum or tenotomy scissors are used to enter the fascial sheath. The popliteal veins are carefully dissected from the artery, and associated bridging veins are divided with 3-0 silk sutures.
5. Vessel loops are used to obtain proximal and distal control.

Tunneling

The tunneling device is passed through the two heads of the gastrocnemius muscle in the popliteal fossa, advanced posterior to the knee between the femoral condyles, and then through the subsartorial space to the groin incision. The graft is passed through the tunnel while maintaining proper orientation.

Proximal and Distal Anastomosis

Same steps are performed for the proximal and distal anastomosis as described in the femoral to above-knee popliteal bypass section.

Intraoperative Assessment of Femoral-Popliteal Bypass

A Doppler probe can be used to check for the presence and quality of blood flow to the foot. Duplex imaging of the graft is used to assess any stenosis, outflow obstruction, or other potential conduit defects. Similarly, intraoperative angiogram can be performed.

Wound Closure

The wound can be closed once the bypass is determined to be successful. Hemostasis is then achieved with reversal of heparin. Absorbable sutures are used to approximate the fascia, taking care not to close the deep fascia of the popliteal fossa. Subcutaneous tissue is then closed in layers, and the skin is finally closed subcuticularly. Skin closure in an interrupted fashion using running nylon sutures is done for patients with significant edema or diabetes. If there are any concerns for lymphatic leak, closed suction drains may be placed in the groin incision.

Complications

1. Possible early complications include postoperative bleeding, wound infection and dehiscence, lymphedema, and early graft thrombosis (<30 days).
2. Possible late complications include late graft thrombosis, arterial aneurysms, infection, and persistent lymphedema.

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