Ultra-distal bypasses — when and how to perform a pedal bypass

Feras Abdallah, Alison Phair, Paul Chadwick, Naseer Ahmad

Surgical bypasses onto the pedal vessels, although technically demanding, are being increasingly performed by vascular surgeons. The main indication for the procedure is either rest pain or ulceration associated with crural vessel disease. This article describes the principles underlying the procedure, as well as its technical aspects.

Since Jean Kunlin performed the first lower-limb bypass in 1948, the boundaries of surgical possibility have been pushed ever further (Menzoian et al, 2011). Bypasses onto the pedal vessels are being increasingly performed by specialist vascular surgeons and pose many challenges due to their technically demanding nature.

When and on whom to perform pedal bypasses

Pedal bypasses are only performed on patients who have critical limb ischaemia, for example, rest pain or tissue loss. They should also have a reasonable quality of life, be fit for a general anaesthetic and have a vein that is suitable for a bypass.

The decision to perform a bypass is made based on clinical examination, duplex imaging and angiograms. Duplex imaging is used to measure the diameter and quality of the great saphenous vein in the ipsilateral leg. It is preferable that veins are at least 3 mm in diameter and have no evidence of phlebitis or thrombosis. If no ipsilateral vein is suitable, the contralateral great saphenous is examined, as well as arm veins and short saphenous veins. Prosthetic grafts are not used for these ultra-distal bypasses due to the higher risk of infection and greater flow rates required for patency.

Digital subtraction angiograms are used to delineate anatomy and plan the bypass. Patients who do not have inline flow to the foot — i.e. no named vessel from the superficial femoral artery to either of the pedal arteries — are candidates. It is preferable that the pedal vessels have a luminal diameter of 2 mm on angiogram or 1.5 mm on duplex to be considered for bypass.

Choice of bypass landing vessel: the concept of angiosomes

There are two vessels on the foot that generally are bypassed onto — dorsalis pedis (DP) and the posterior tibial (PT). There is often no choice as most patients only have one viable option. If there is a choice, the vessel supplying the angiosome containing the lesion is chosen.

An angiosome is an anatomical unit of tissue (skin, subcutaneous tissue, fascia, tendon, muscle and bone) which is supplied and drained by one specific artery and vein (Taylor et al, 1987) (*Figure 1*). For example, an ulcer on the dorsal surface of the hallux is likely to be related to a DP angiosome, whereas a fifth-digit ulcer is likely related to the lateral plantar; a branch of the PT. In practice, choice is rare and there is significant overlap in angiosomal supply, thus improving blood supply to any available vessel should improve perfusion to the whole foot.

How to perform a popliteal pedal bypass

A pedal bypass takes at least 4 hours to perform

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Article points

1. Pedal bypasses are technically demanding as vessels are only 1 mm in diameter.
2. They are performed for critical ischaemia i.e. rest pain and tissue loss using native vein.
3. Only a handful of vascular surgeons regularly perform these procedures in England.
4. Five-year limb salvage rates of around 80% are reported.

Key words

- Angiosomes
- Critical limb ischaemia
- Pedal bypass

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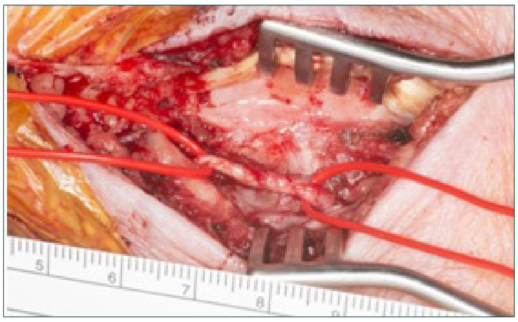
Figure 1. Angiosomes of the foot; from left to right — posterior tibial artery, peroneal artery, and anterior tibial artery.

in our centre and includes a completion angiogram. The procedure can take considerably longer if an on table angioplasty is additionally performed. The procedure commences with exposure of the target vessel (*Figure 2*).

Once this has been achieved, assessment of the quality and patency of the target vessel is needed. An orange needle can be inserted to confirm patency. In some cases, the procedure may be abandoned at this stage as the target vessel may have occluded in the run up to the procedure. The proximal vessel can be exposed simultaneously and, in the same fashion, by another surgeon. The preferred inflow vessel is either the above- or below-knee segment of the popliteal artery (*Figure 3*). The best quality vessel should be selected to maximise inflow and reduce the technical difficulty of this anastomosis. The great saphenous vein is then exposed and harvested. It is the authors' practice to reverse the vein.

Once the proximal anastomosis is performed (*Figure 4*), the graft is tunnelled subfascially and brought out at the site of the distal anastomosis. This is a demanding step as the graft should not be compromised by surrounding tissue, twisted or damaged.

The distal anastomosis is the main area of challenge. When performing an anastomosis it is usual to clamp the vessels proximally and distally so suturing can be performed in a bloodless field. However, this option is not available because of the delicate nature of the vessels and significant calcification. Many surgeons complete the anastomosis while bleeding continues. The authors insert size matched coronary shunts into the vessels to facilitate the anastomosis. This also reduces the patient's overall blood loss during the procedure. The coronary shunt must be removed before completion of the anastomosis. The actual anastomosis is performed using a 7/0 prolene



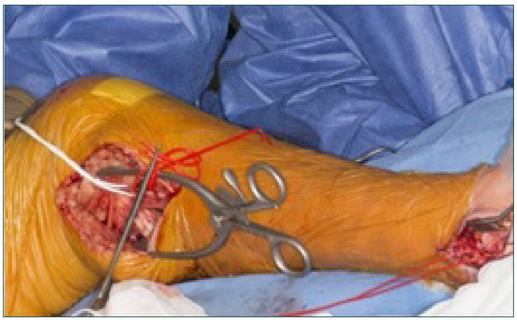


Figure 2 (left). Exposure of a 2 mm posterior tibial artery at the level of the medial malleolus. Figure 3 (right). Exposure of the below-knee popliteal artery.

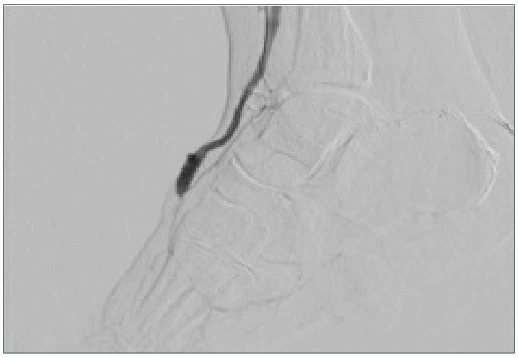


Figure 4 (above left). Harvest of the below-knee long saphenous vein for conduit for pedal bypass. Figure 5 (above right). Completion on table angiogram of a pedal bypass with anastomosis to the dorsalis pedis artery.

suture on a Everpoint® (Ethicon) needle. This is a significantly tougher needle than normal sutures and less readily deforms on passing through these calcified arteries. A completion angiogram is then performed (*Figures 5 and 6*). This will help to assess the anastomoses, the vein and the run off. Postoperatively, the patients are usually managed on a high dependency unit.

Following any kind of limb revascularisation, reperfusion oedema can be seen and patients are advised to keep the leg elevated. Patients are sat out the following day, with mobilisation led by physiotherapists commenced as soon as practicable, (day 3-4 usually). It is the authors' standard practice to remove foot sutures (interrupted prolene) after 3 weeks, whereas those in the rest of the leg are usually subcuticular and do not require removal.

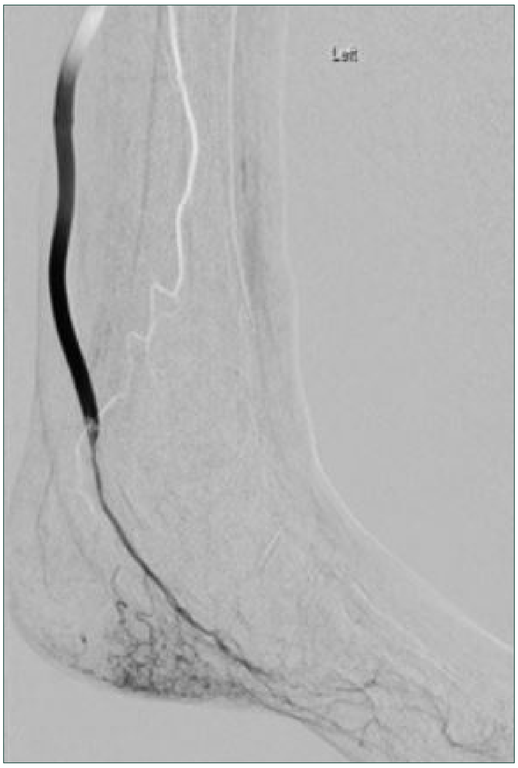


Figure 6. Completion on table angiogram of a pedal bypass onto the Posterior Tibial Artery.

All patients have a duplex scan with toe pressures or TcPO2 prior to discharge. These grafts are monitored closely with graft scans repeated at three-monthly intervals for the first year.

Evidence for effectiveness of pedal bypasses — literature review

Pedal bypass grafting became an accepted form of treatment for critical limb ischemia in the late 1990s. The assembled literature reports rates of limb salvage at 3 to 5 years of around 80% (Kalra et al, 2001; Uhl et al, 2014). A more recent study has shown patency rates after 5 years to be up to 85% in patients who had a bypass to a branch of the pedal artery (Dünschede et al, 2016). Morbidity and mortality rates are also sufficiently low to be accepted in this group of comorbid patients (Kalra et al, 2001).

Direct angiosomal revascularisation is supported by a recent systemic review that showed improved wound healing and limb salvage when the correct angiosome is targeted, compared with indirect revascularisation. This included all bypasses and endovascular treatment (Bosanquet et al, 2014).

In this new era of advancement of endovascular techniques, it is still unclear whether surgical bypass or endovascular treatment represents the most clinically beneficial and cost-effective treatment for severe limb ischaemia. The BASIL-2 trial is currently under way, which aimed to assess what is the optimal revascularisation modality in infra-popliteal disease. It is hoped that the conclusions of this trial will go some way towards answering this question (Popplewell et al, 2016).

Conclusion

Ultra-distal bypasses are being increasingly performed in tertiary units by specialist vascular surgeons. Multiple patient and disease factors must be considered prior to performing these technically demanding procedures. A multidisciplinary approach is key as many patients are frail, comorbid and the active involvement of several specialities is required to ensure excellent pre-, intra- and postoperative care. ■

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