

Cadaveric Atlas for Orthoplastic Lower Limb and Foot Reconstruction of Soft Tissue Defects

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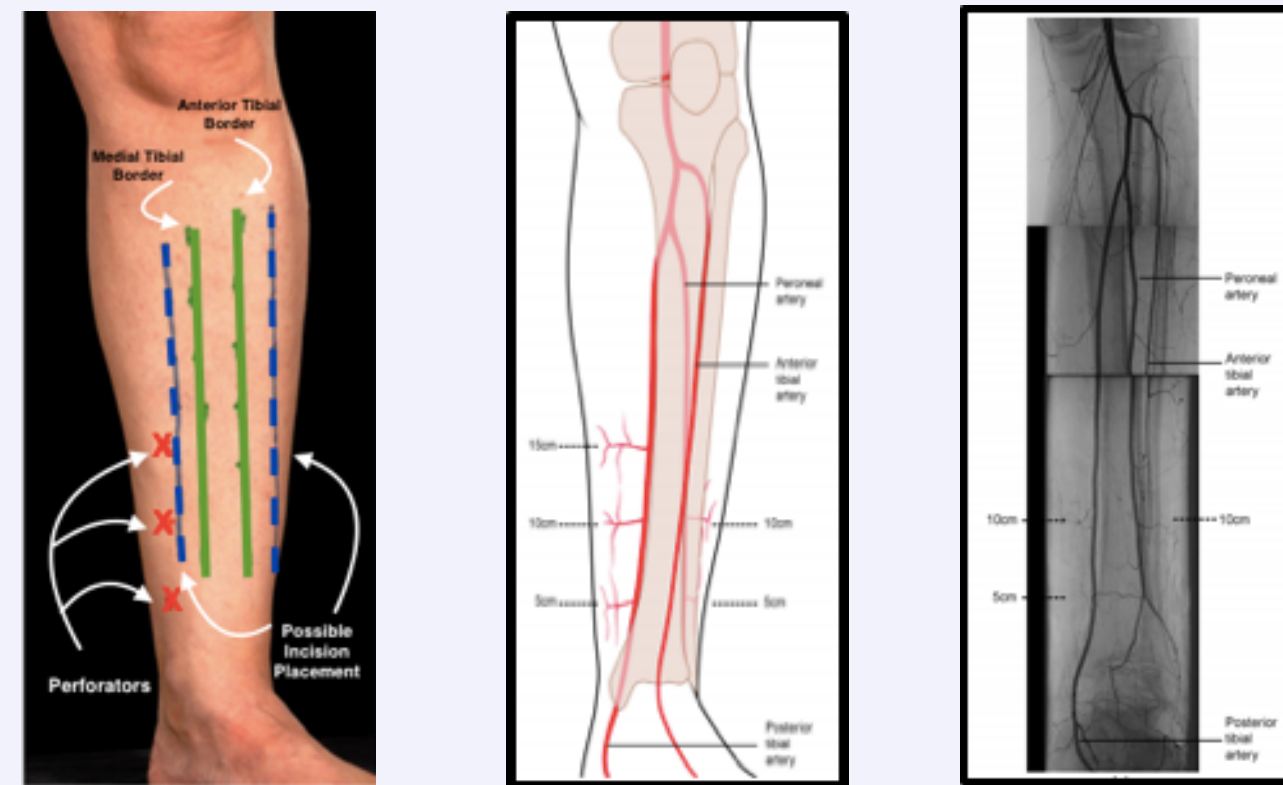
Statement of Purpose

Soft tissue deficits or non-healing wounds are a common and challenging problem faced by the lower extremity reconstructive surgeon. These cases often end in proximal amputation, especially in those with co-morbidities, compromised angiosomes, or following significant trauma. This atlas therefore is to be used as a comprehensive resource for basic lower extremity flaps for soft tissue defects to assist in limb salvage.

Methodology

This atlas provides a guide for surgeons to understand and treat soft tissue lower extremity defects and complications. We discuss basic orthoplastic reconstructive principles and patient work-up; thus, alleviating the need to refer to a plastic or microsurgical specialist. Additionally, incision placement, anatomy of perforators, axial flow and arc of rotation for flaps are shown for medial, lateral and anterior compartments of the lower leg as well as the foot.

Introduction and Preoperative Planning



The first step in preparation for performing any flap is precise preoperative planning. Anatomic landmarks should be utilized to map out major neurovascular structures and perforating vessels. Locations and patency of said vessels can be further confirmed with the use of Doppler ultrasound and/or angiography if necessary.

A typical map of such structures in the lower extremity is shown in the figures above. Figure 1a shows the major landmarks that should be drawn out preoperatively. The green lines represent the anterior and medial borders of the tibia.

The dashed blue lines represent proper incision placement. They are drawn 1 cm posterior and 1 cm anterior to the medial and anterior tibial borders respectively. Perforating vessels lie along these blue lines and are marked by the red X's. They correlate with the anatomic map of perforating vessels at approximately 5 cm, 10 cm, and 15 cm proximal to the ankle joint as shown in Figure 1b. Figure 1c shows a contrast angiogram confirming adequate blood flow to the perforators stemming from the major vascular structures of the lower extremity.

Medial Gastrocnemius and Medial Soleal Flap

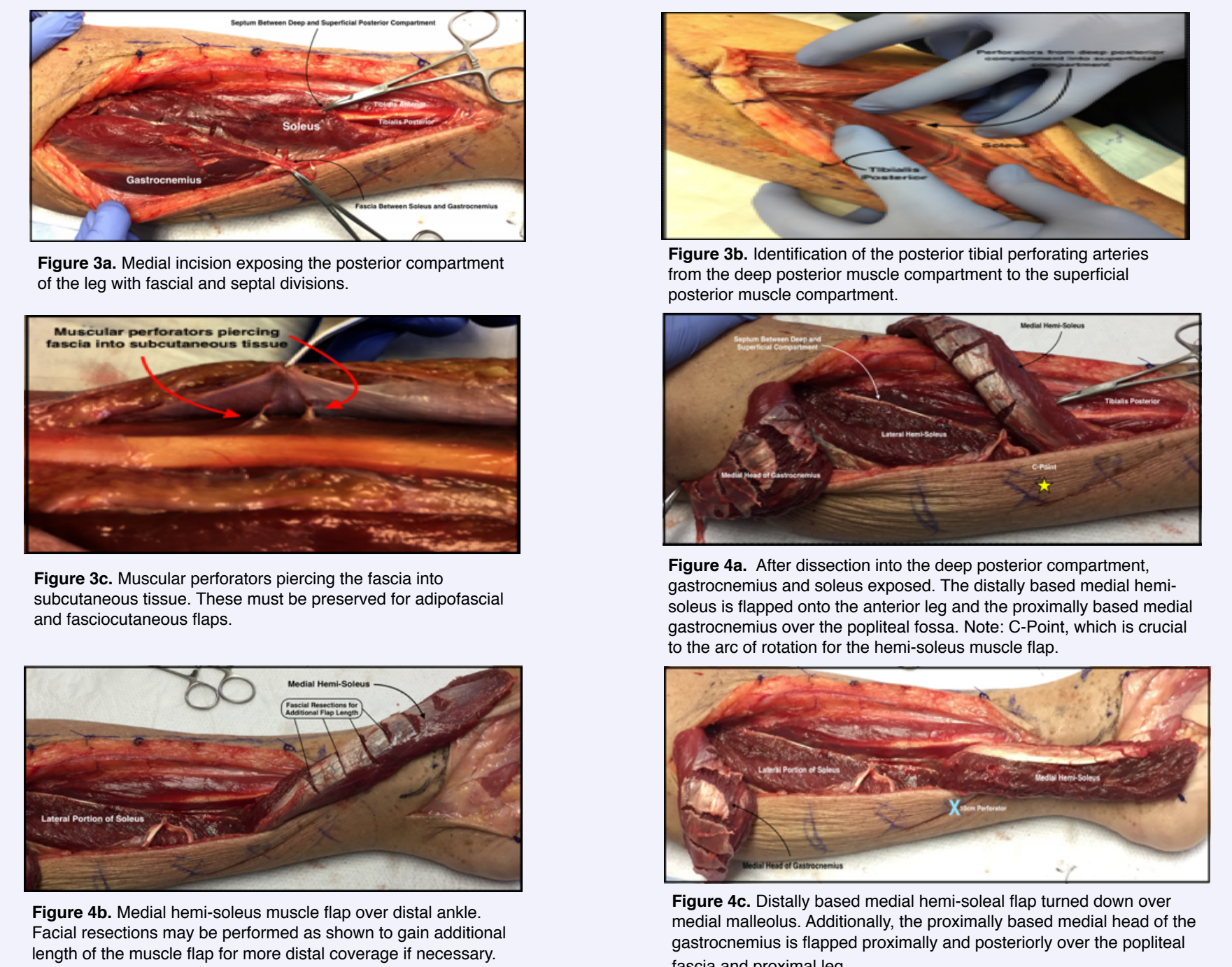


Figure 3a. Medial incision exposing the posterior compartment of the leg with fascial and septal divisions.
Figure 3b. Identification of the posterior tibial perforating arteries from the deep posterior muscle compartment to the superficial posterior muscle compartment.
Figure 3c. Muscular perforators piercing the fascia into subcutaneous tissue. These must be preserved for adipofascial and fasciocutaneous flaps.
Figure 3d. Medial hemi-soleus muscle flap over distal ankle. Facial resections may be performed as shown to gain additional length of the muscle flap for more distal coverage if necessary.
Figure 4a. After dissection into the deep posterior compartment, gastrocnemius and soleus exposed. The distally based medial hemi-soleus is flapped onto the anterior leg and the proximally based medial gastrocnemius over the popliteal fossa. Note: C-Point, which is crucial to the arc of rotation for the hemi-soleus muscle flap.
Figure 4b. Medial hemi-soleus muscle flap turned down over medial malleolus. Additionally, the proximally based medial head of the gastrocnemius is flapped proximally and posteriorly over the popliteal fossa and proximal leg.
Figure 4c. Distally based medial hemi-soleal flap turned down over medial malleolus. Additionally, the proximally based medial head of the gastrocnemius is flapped proximally and posteriorly over the popliteal fossa and proximal leg.

Section II: Approach to the Lateral and Anterior Compartment of the Lower Leg

- Peroneus Brevis Flap
- Septal Peroneal Perforator Flap
- Lateral Compartment Options
- Common Peroneal Nerve Exposure
- Proximal Based Lateral Gastrocnemius Muscle Flap

Peroneus Brevis Flap

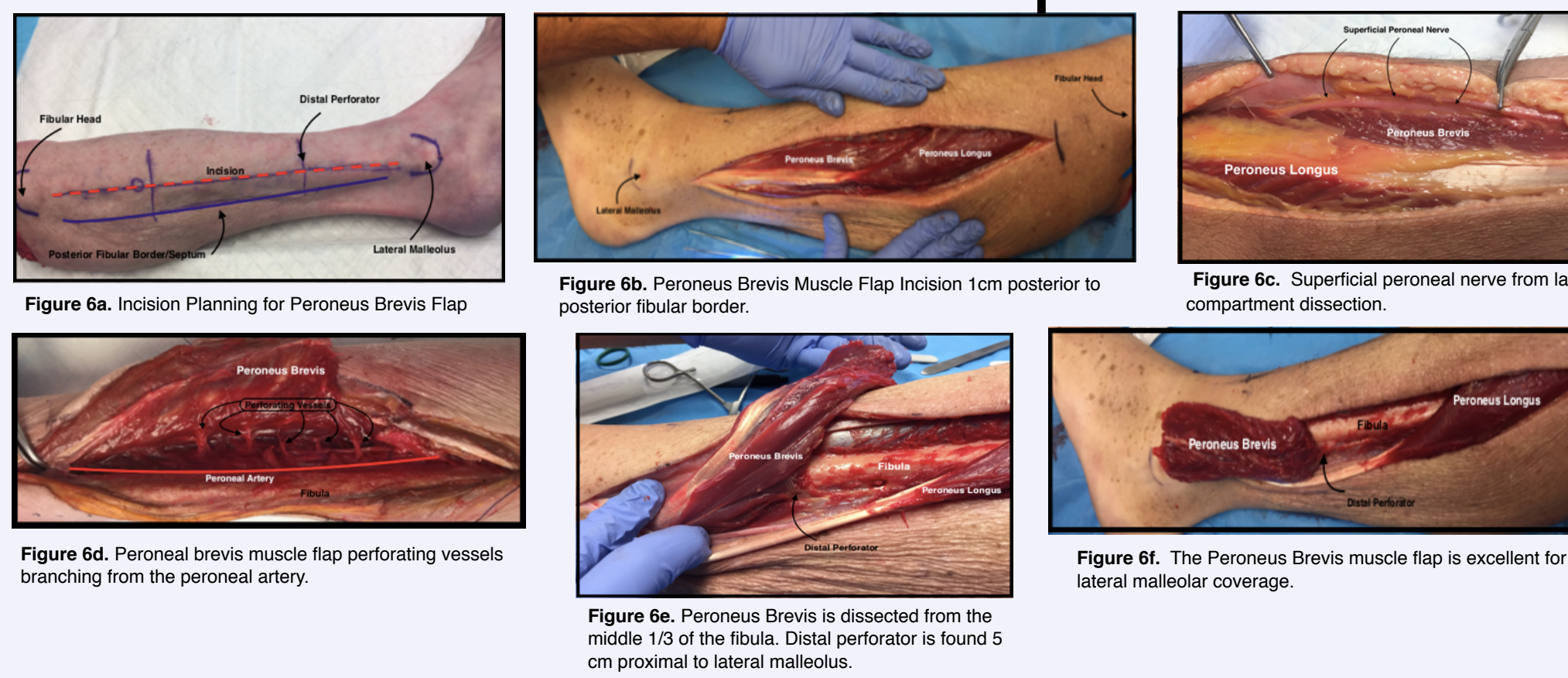


Figure 6a. Incision Planning for Peroneus Brevis Flap
Figure 6b. Peroneus Brevis Muscle Flap Incision 1cm posterior to posterior fibular border.
Figure 6c. Superficial peroneal nerve from lateral compartment dissection.
Figure 6d. Peroneus brevis muscle flap perforating vessels branching from the peroneal artery.
Figure 6e. Peroneus Brevis is dissected from the middle 1/3 of the fibula. Distal perforator is found 5 cm proximal to lateral malleolus.
Figure 6f. The Peroneus Brevis muscle flap is excellent for lateral malleolar coverage.

Septal Peroneal Perforator Flap

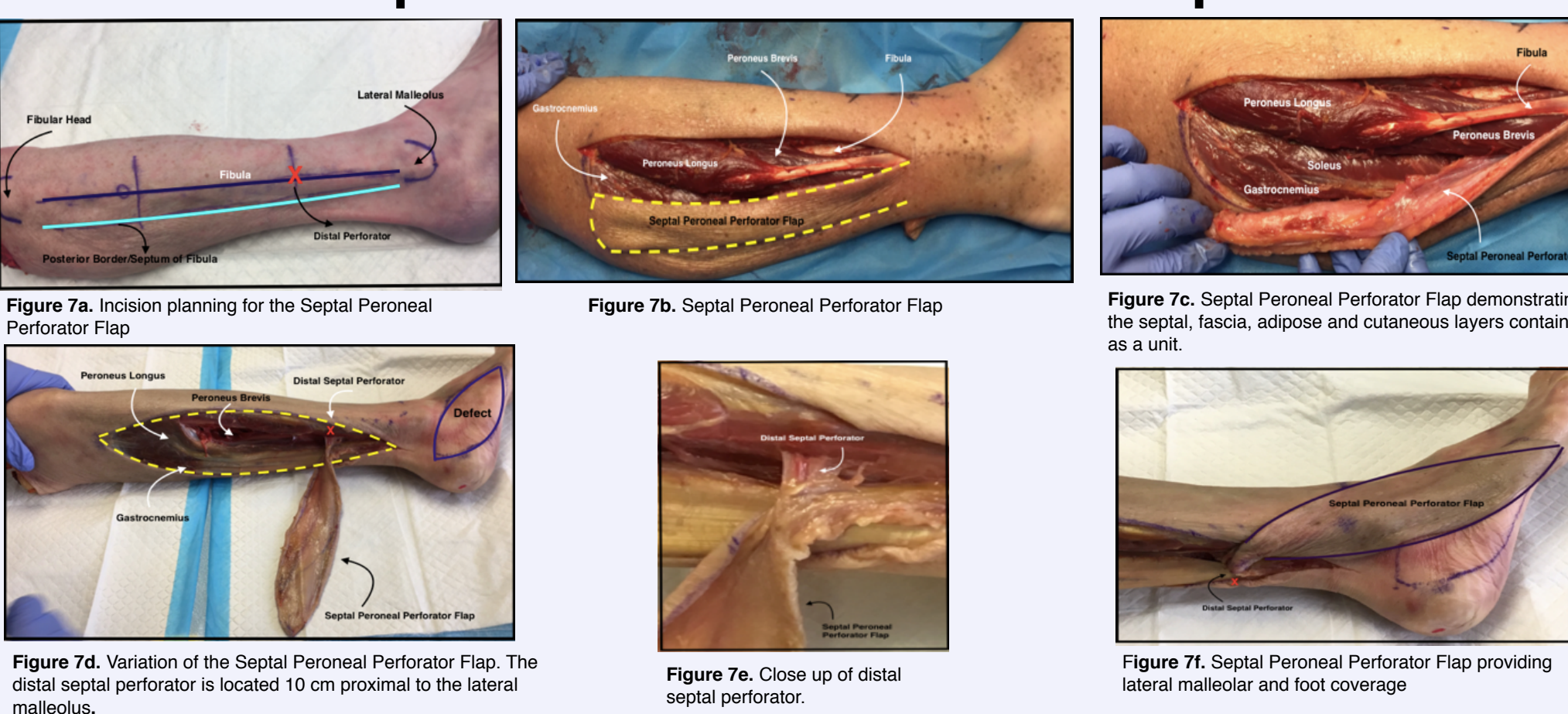


Figure 7a. Incision planning for the Septal Peroneal Perforator Flap
Figure 7b. Septal Peroneal Perforator Flap
Figure 7c. Septal Peroneal Perforator Flap demonstrating the septal, fascia, adipose and cutaneous layers contained as a unit.
Figure 7d. Variation of the Septal Peroneal Perforator Flap. The distal septal perforator is located 10 cm proximal to the lateral malleolus.
Figure 7e. Close up of distal septal perforator.
Figure 7f. Septal Peroneal Perforator Flap providing lateral malleolar and foot coverage

Proximal & Distal Cutaneous Sural Perforator Flap

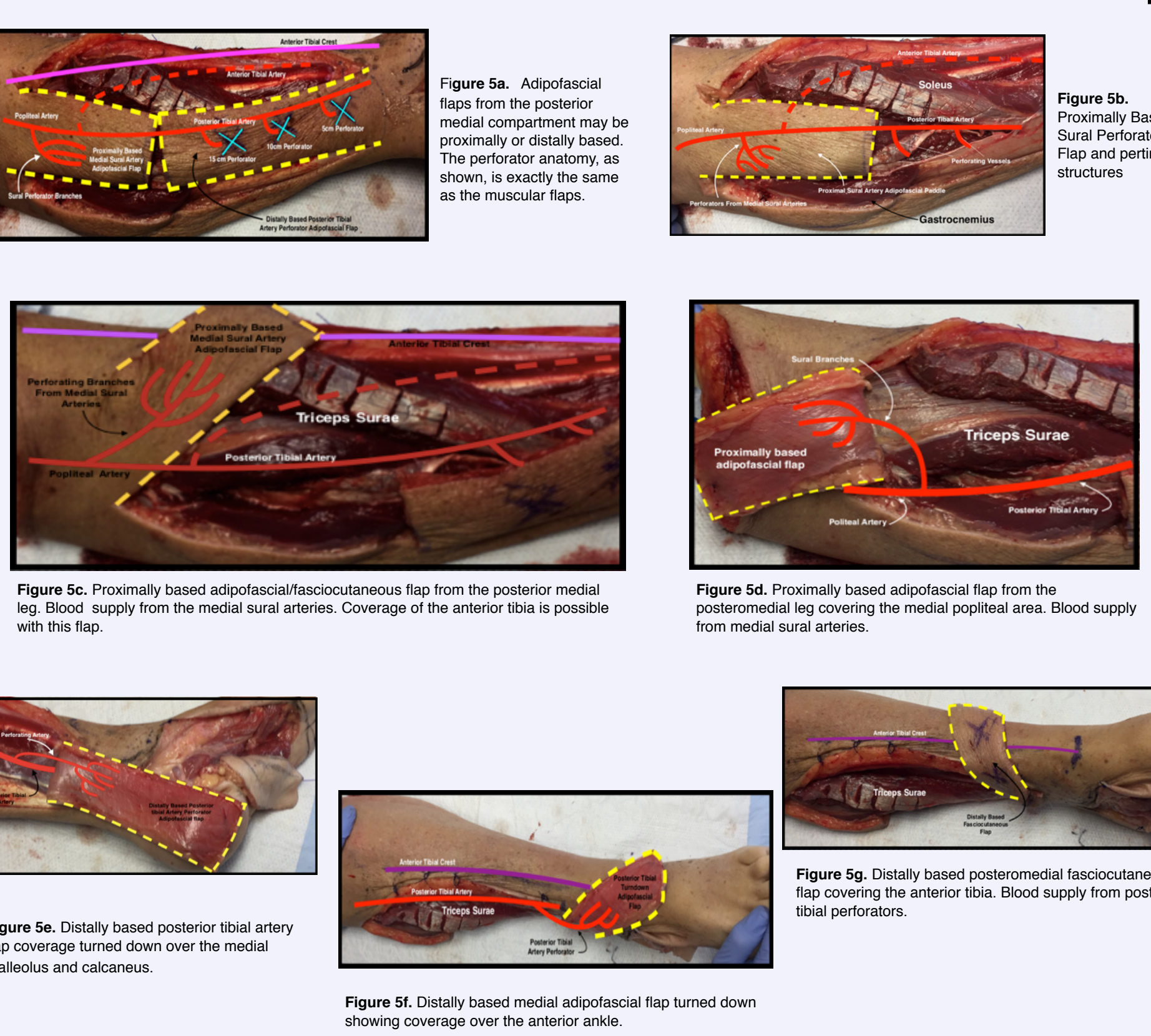


Figure 5a. Adipofascial flaps from the posterior medial compartment may be proximally or distally based. The perforator anatomy, as shown, is exactly the same as the muscular flaps.
Figure 5b. Proximally Based Sural Perforator Flap and pertinent structures
Figure 5c. Proximally based adipofascial/fasciocutaneous flap from the posterior medial leg. Blood supply from the medial sural arteries. Coverage of the anterior tibia is possible with this flap.
Figure 5d. Proximally based adipofascial flap from the posteromedial leg covering the medial popliteal area. Blood supply from medial sural arteries.
Figure 5e. Distally based posterior tibial artery flap coverage turned down over the medial malleolus and calcaneus.
Figure 5f. Distally based medial adipofascial flap turned down showing coverage over the anterior ankle.

Section I: Medial Approach to the Superficial and Deep Compartment of the Lower Leg

- Tibial Exposure
- Medial Gastrocnemius Flap
- Medial Soleal Flap
- Proximal cutaneous sural perforator flap

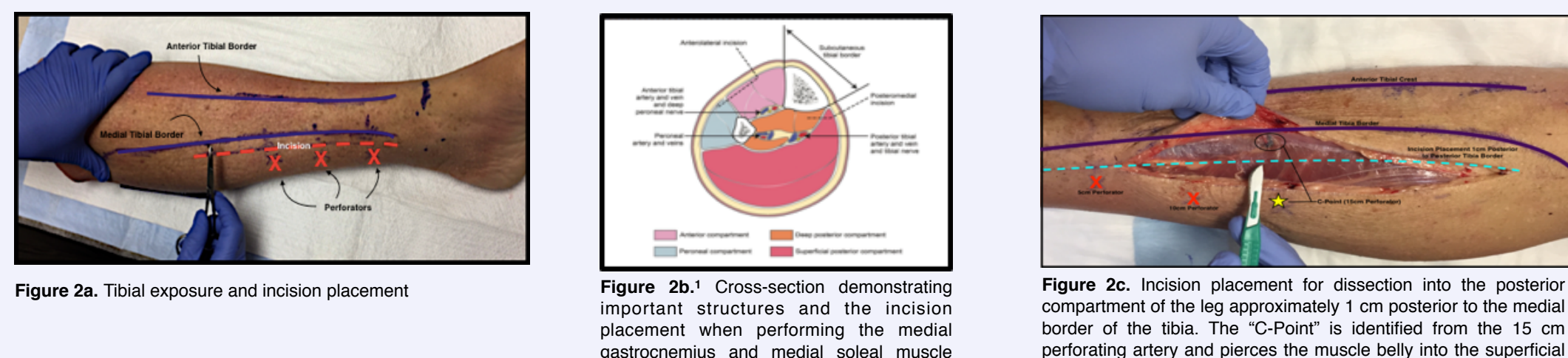


Figure 2a. Tibial exposure and incision placement
Figure 2b. Cross-section demonstrating important structures and the incision placement when performing the medial gastrocnemius and medial soleal muscle flaps
Figure 2c. Incision placement for dissection into the posterior compartment of the leg approximately 1 cm posterior to the medial border of the tibia. The "C-Point" is identified from the 15 cm perforating artery and pierces the muscle belly into the superficial fascia.

Section III: Medial Arch Approach to the Foot

- Medial Plantar Artery Cutaneous Adipofascia Flap
- Abductor Hallucis Muscle Flap
- Flexor Digitorum Brevis Muscle Flap
- Flexor Hallucis Brevis Muscle Flap
- Plantar Fasciocutaneous Flap

Medial Plantar Artery Cutaneous Adipofascia Flap

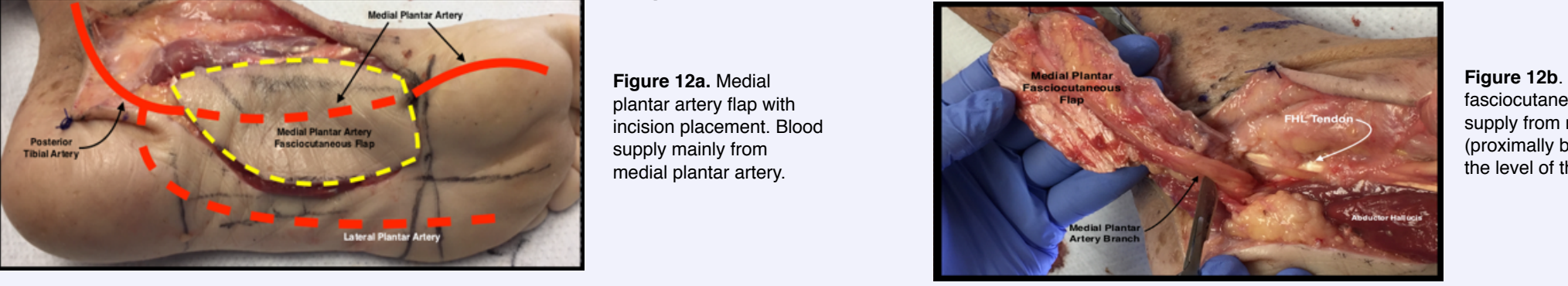


Figure 12a. Medial plantar artery flap with incision placement. Blood supply mainly from medial plantar artery.
Figure 12b. Medial plantar artery fasciocutaneous flap with blood supply from medial plantar artery (proximally based) with dissection at the level of the tarsal tunnel

Abductor Hallucis Muscle Flap

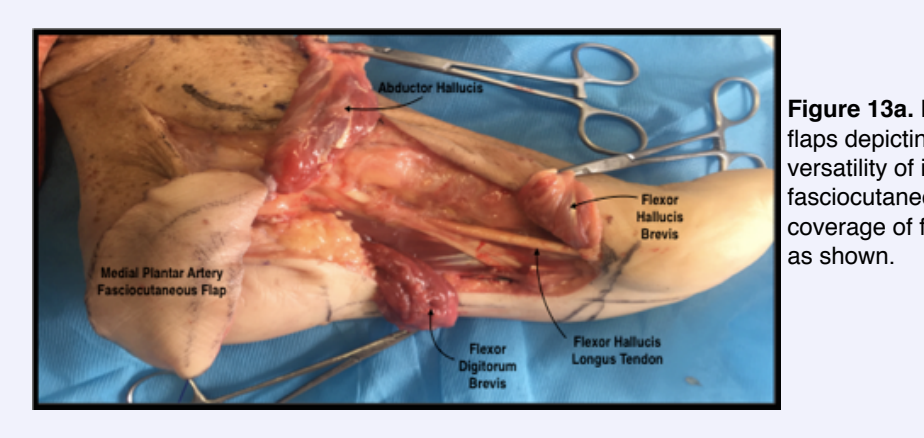


Figure 13a. Medial foot flaps depicting the versatility of intrinsic and fasciocutaneous flaps coverage of foot defects as shown.

Flexor Digitorum Brevis Flap

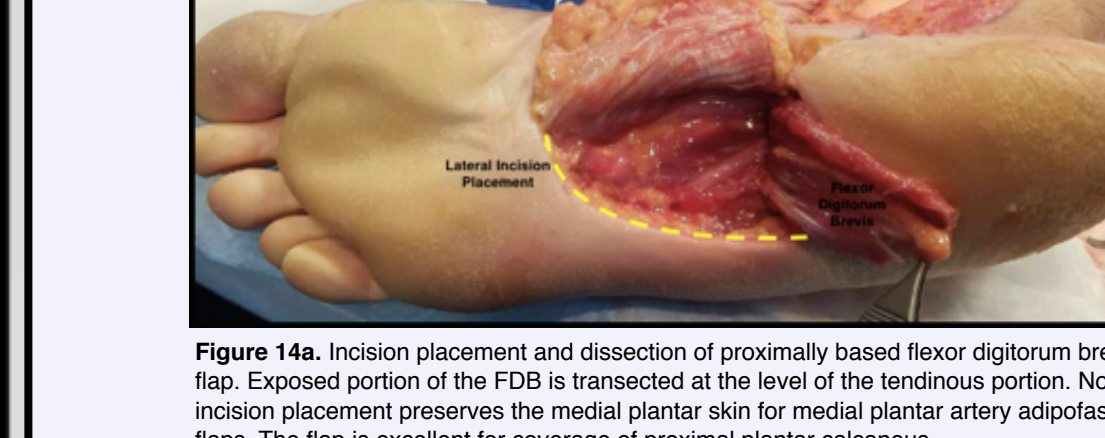


Figure 14a. Incision placement and dissection of proximally based flexor digitorum brevis flap. Exposed portion of the FDB is transected at the level of the tendinous portion. Note the incision placement preserves the medial plantar skin for medial plantar artery adipofascial flaps. The flap is excellent for coverage of proximal plantar calcaneus.

Flexor Hallucis Brevis Flap

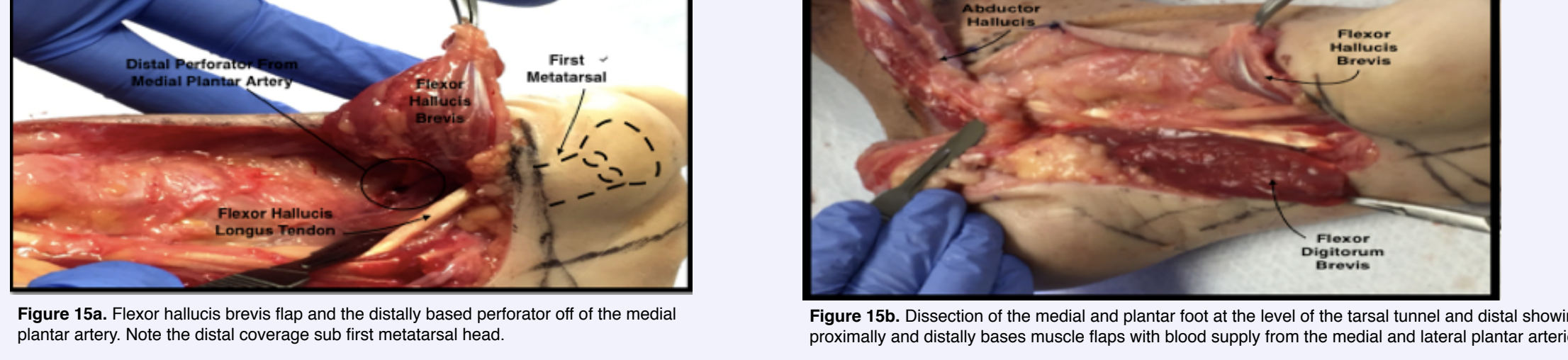


Figure 15a. Flexor hallucis brevis flap and the distally based perforator off of the medial plantar artery. Note the distal coverage sub first metatarsal head.
Figure 15b. Dissection of the medial and plantar foot at the level of the tarsal tunnel and distal showing proximally and distally based muscle flaps with blood supply from the medial and lateral plantar arteries.

Plantar Fasciocutaneous Flap

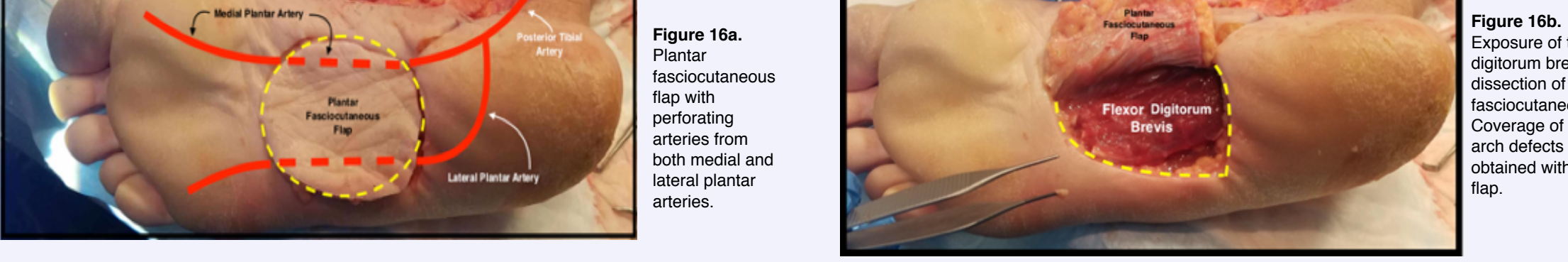


Figure 16a. Plantar fasciocutaneous flap with perforating arteries from both medial and lateral plantar arteries.
Figure 16b. Exposure of the flexor digitorum brevis and dissection of plantar fasciocutaneous flap. Coverage of medial arch defects can be obtained with this flap.

Other Lateral & Anterior Compartment Flap Options

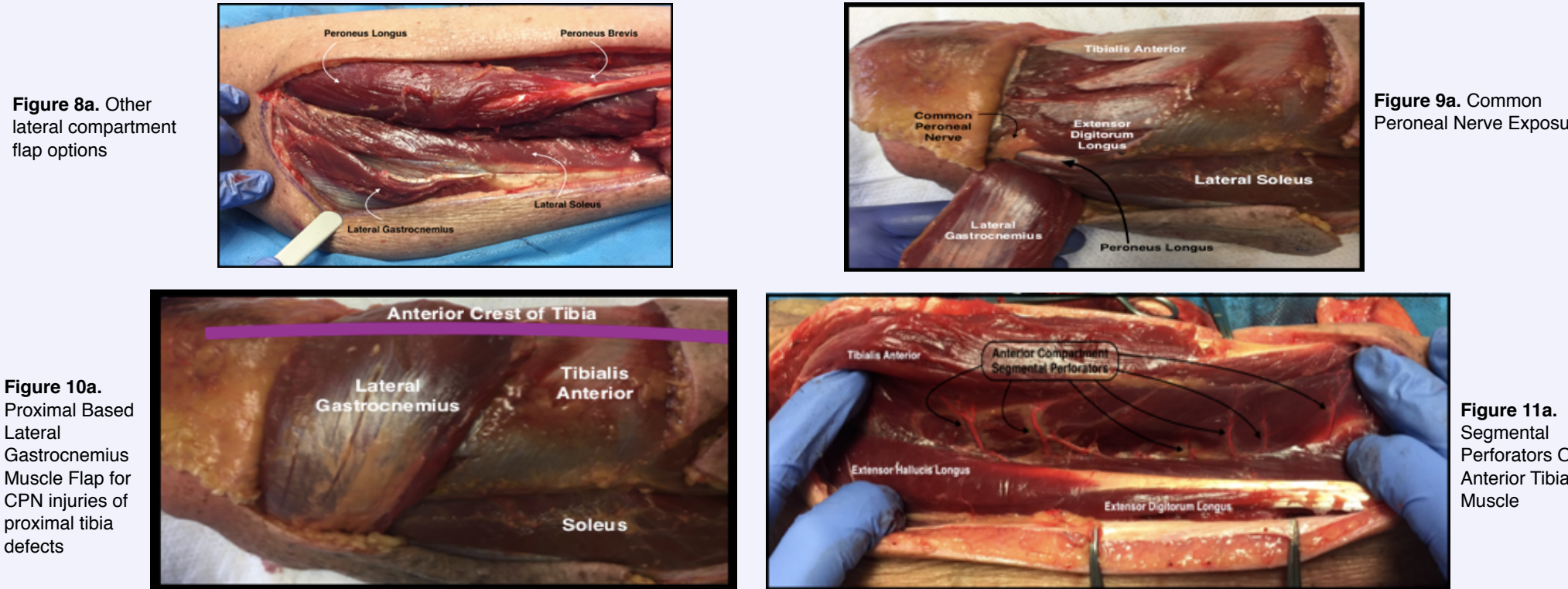


Figure 8a. Other lateral compartment flap options
Figure 8b. Proximally Based Lateral Gastrocnemius Muscle Flap for CPN injuries of proximal tibia defects
Figure 8c. Common Peroneal Nerve Exposure
Figure 10a. Proximally Based Lateral Gastrocnemius Muscle Flap for CPN injuries of proximal tibia defects
Figure 11a. Segmental Perforators Over the Anterior Tibial Muscle

Analysis & Discussion

The purpose of this atlas is to serve as a guide for surgeons to more effectively treat these soft tissue defects without the need for amputation. The muscular and fasciocutaneous flaps in this atlas can be used to cover almost all areas of the lower extremity from the knee distally to the digits.

References

- 1.Nanchahal J, Nayagam S, Khan U, Moran C, Barrett S, Sanderson F, et al. Standards for the Management of Open Fractures of the Lower Limb. Royal Society of Medicine Press Ltd. 2009.
- 2.Ward KL, Romano A, Rodriguez Collazo ER. Cadaveric Atlas for Orthoplastic Lower Limb and Foot Reconstruction of Soft Tissue Defects. Clin Surg. 2018; 3: 2001.