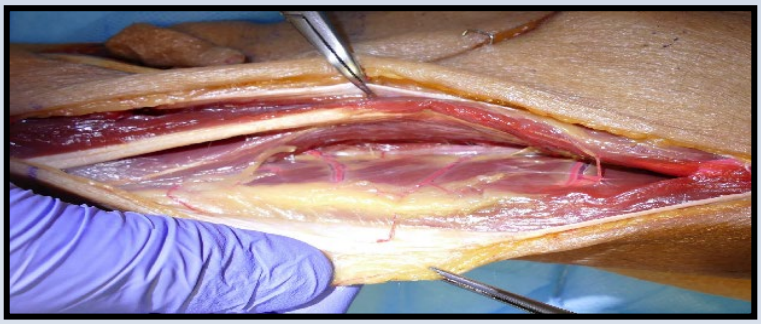
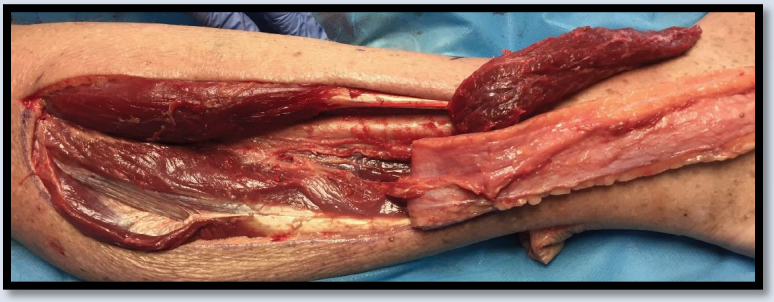
Orthoplastic Surgical Techniques and Considerations for Lower Extremity Muscular Perforator Flaps





Edgardo Rodriguez-Collazo
Arshad A. Khan
Hamid A. Khan
Luis J. Sanchez-Robles
Suhail B. Masadeh

AUTHORS

Edgardo Rodriguez-Collazo, DPM

Director, Chicago Foot & Ankle Deformity Correction Center of Chicago.
Associate Director, Podiatric Medicine & Surgical Residency, Adult and Pediatric Lizarov Lower Limb Correction, Peripheral Nerve and Muscular Microsurgical Reconstruction, Presence Saint Joseph Hospital, Chicago, Illinois.

Arshad A. Khan, DPM

Director of Lower Extremity Limb Salvage and Microsurgical Reconstruction, Pinnacle Hospital, Crown Point, Indiana.
Fellow of the American College of Foot and Ankle Orthopedics and Medicine.
Fellow of the American College of Foot and Ankle Surgeons.
V. Assistant Clinical Professor, Dept. of Orthopedic Surgery, Indiana University Medical School, Northwest.

Hamid A. Khan, M.D.

Research Associate, American Microsurgical Orthoplastic Society, Chicago, Illinois.
Research Associate, Chicago Foot and Ankle Deformity Correction Center, Chicago, Illinois.

Luis J. Sanchez-Robles, MD, DPM

Podiatric Surgery, Florida Hospital, Kissimmee, FL.
Fellow of the American College of Foot and Ankle Surgeons.
Assistant Professor of Surgery at University of Central Florida College of Medicine

Suhail B. Masadeh, DPM

Chief, Podiatric Surgery, Cincinnati VA Hospital
Division Director, Residency Director, Podiatric Surgery, University of Cincinnati Medical Center
Assistant Professor of Surgery, University of Cincinnati Medical Center

CONTRIBUTORS

Bruce A. Bever, DPM
Podiatric Surgical Resident Physician, Presence Saint Joseph Hospital, Chicago, Illinois.

Isra M. Khan, M.D.
Research Associate, Chicago Foot and Ankle Deformity Correction Center, Chicago, Illinois.

Anthony Romano, DPM
Podiatric Resident Physician, Franciscan Foot and Ankle Institute, Federal Way, WA.

Kaitlyn L. Ward, DPM
Podiatric Resident Physician, Franciscan Foot and Ankle Institute, Federal Way, WA.

PREFACE

As a recent medical school graduate and after years of burying myself in textbooks, review books and research articles, I think I can speak for a great majority of physicians and medical professionals when I say that there is nothing more disheartening than a dense and unnecessarily lengthy read.

However, there has always been a sense of immediate elation when at first glance you realize the text which you are about to dive into in is filled with easy to understand key points, concise material, high resolution images and short, detailed explanations that you know will keep you engaged throughout your read and that is exactly what *Orthoplastic Surgical Techniques and Considerations for Lower Extremity Muscular Perforator Flaps* offers.

This visually attractive and well-illustrated E-book on the surgical utilization of lower extremity muscle flaps has been portrayed in an easy to follow step-by-step format, allowing the reader to fully understand each aspect of the surgical techniques mentioned.

I have had the privilege of working alongside distinguished surgeons who have shared their passion and expertise in the growing field of orthoplastic microsurgery with me and will be forever indebted to them and everyone else that has helped me along my medical journey thus far. I am confident that the information found within this book will serve as a vital resource for both orthopedic surgeons and foot and ankle specialists when it comes to exploring these surgical treatment options as a means for resolving lower extremity defects.

On behalf of both the authors and contributors, we would like to thank every member of the American Microsurgical Orthoplastic Society and all medical professionals worldwide who continue to motivate us in wanting to contribute more, learn more, teach more and discover all that medicine has yet to uncover.

Hamid A. Khan, MD

TABLE OF CONTENTS

INTRODUCTION

The implementation of muscle flaps as a method for the surgical treatment of compromised lesions of the lower extremity has proven to show great promise over the years. This versatile approach of using muscle to cover complex wounds, manage osteomyelitis and essentially salvage limbs is gaining well deserved popularity and should be considered in applicable scenarios so long as the surgeon performing the muscle flap is appropriately trained.

The purpose of this E-book is to help physicians establish a foundation of knowledge related to various lower extremity muscle flaps. Using cadavers, the chapters in this book were designed so that along with a detailed explanation of each muscle flap procedure, a comprehensive review of the anatomy, blood supply, actions, and indications for that flap are covered. This approach aids in understanding why certain flaps are utilized over others based on the lower extremity defect involved.

It is important to note that the layout of this book has been set up in a manner that allows for all the mentioned flap procedures to follow the same preoperative protocols and postoperative recommendations. However, in those instances where additional information, key points, or different techniques are necessary, a highlighted box containing that significant addendum has been provided. After reading each of the sections, our hope is that the reader can grasp a clear and concise understanding of how to not only determine which flaps to use for a given situation but also feel confident in their surgical approach, techniques and outcomes.

MATHES & NAHAI CLASSIFICATION

Since the development of the Mathes and Nahai classification system in 1981, surgeons have been able categorize various muscle flaps into distinct, clinically appropriate groups based solely on the involved muscle and its associated vascular anatomy; specifically, the vascular pedicles involved. The Mathes and Nihai classification system requires knowledge of the regional source of pedicle entering the muscle, the size of the pedicle, the location of the pedicle in relation to the muscle's origin and insertion, and the angiographic patterns of the intramuscular vessels. According to the classification system there are five vascular patterns by which muscles are categorized and are briefly explained with examples in the following text.

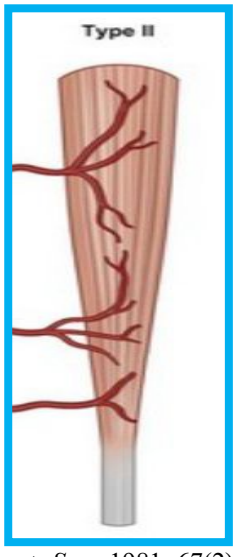
TYPE I: Singular vascular pedicle

- *Gastrocnemius*

Plast Reconstr Surg 1981; 67(2):177-187

TYPE II: One dominant pedicle with minor distant pedicles

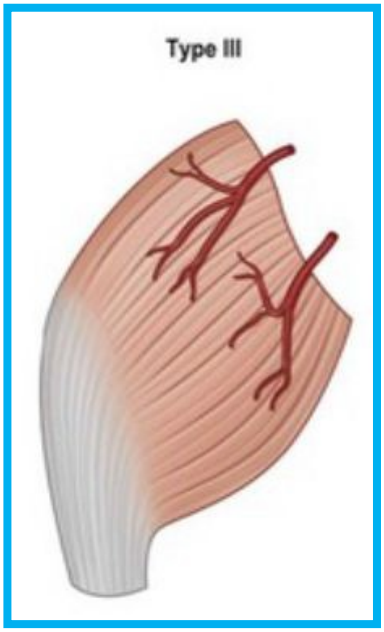
- *Peroneus Longus, Peroneus Brevis, Soleus*



Plast Reconstr Surg 1981; 67(2):177-187

<u>Type III</u>: Two dominant pedicles

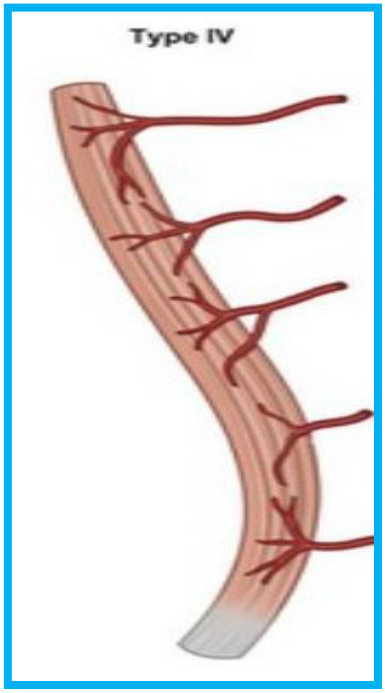
- *Gluteus maximus*



Plast Reconstr Surg 1981; 67(2):177-187

<u>Type IV:</u> Segmental vascular pedicles

- Extensor Digitorum Hallucis, Extensor Hallucis Longus, Flexor Hallucis Longus, Tibialis Anterior



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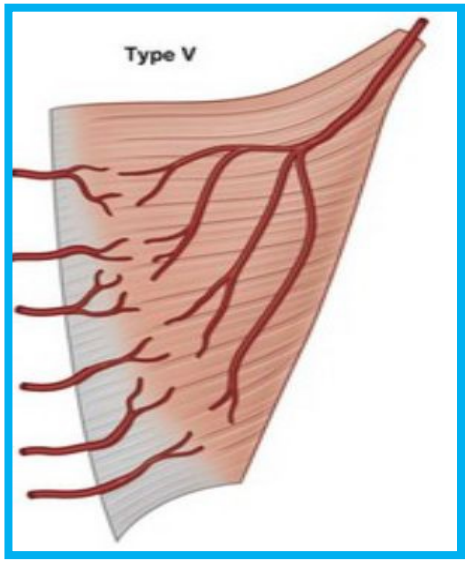
Type V: One dominant pedicle with multiple minor pedicles
Latissimus Dorsi



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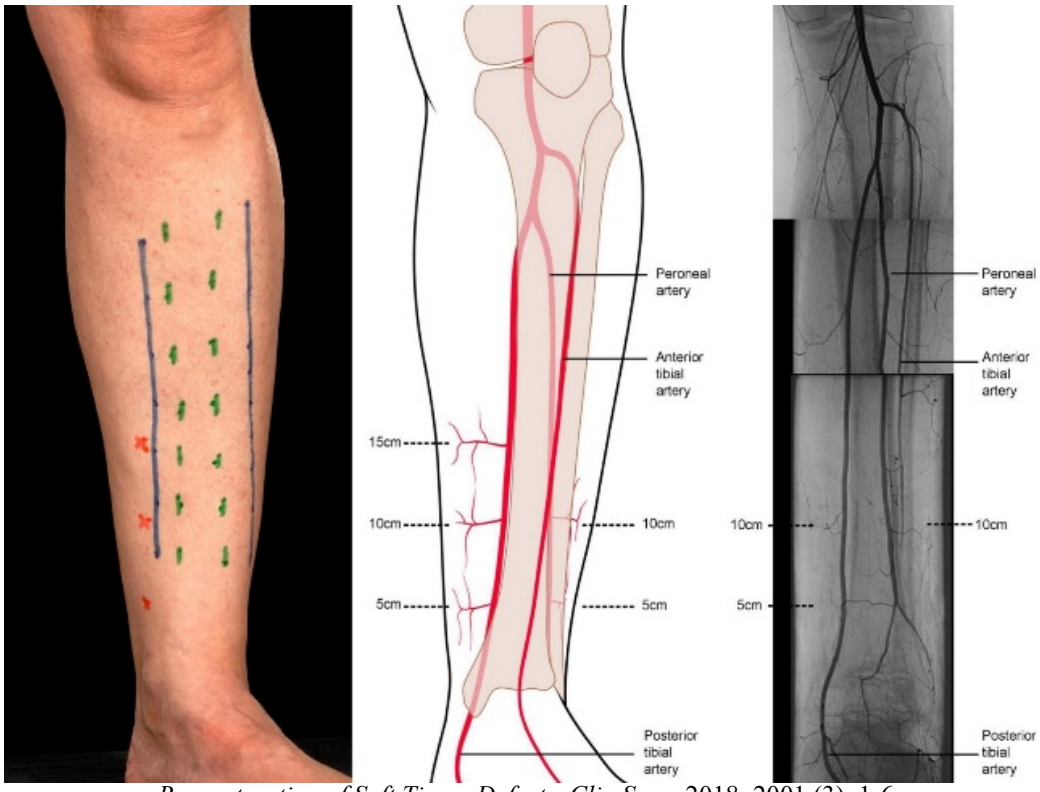
Arterial Perforators and Surface Anatomy

As with all defects and disorders found throughout the body, a strong anatomic understanding of the affected area is crucial for determining both a differential diagnosis and management options. In cases involving the lower extremity, arterial perforators and the associated surface anatomy of that lower limb are of utmost importance when considering a muscle flap for the correction of an underlying defect.



Reconstruction of Soft Tissue Defects. Clin Surg. 2018; 2001 (3): 1-6

The above image helps depict key arteries and their associated perforators which must be located and marked prior to any surgical incisions being made.

The ability to correctly identify the perforators from the anterior tibial, posterior tibial, and peroneal arteries enables surgeons to safely perform pedicled vascular flaps for lower limb defects and thus allows for a procedure that involves minimal donor-site morbidity and rids the need for microvascular anastomoses.

The following section will discuss the pre-operative protocol used for each of the different muscle flaps and includes a detailed explanation of how to locate these critical perforator landmarks and correctly plan for surgical incision and adequate flap exposure.

PRE-OPERATIVE PROTOCOL

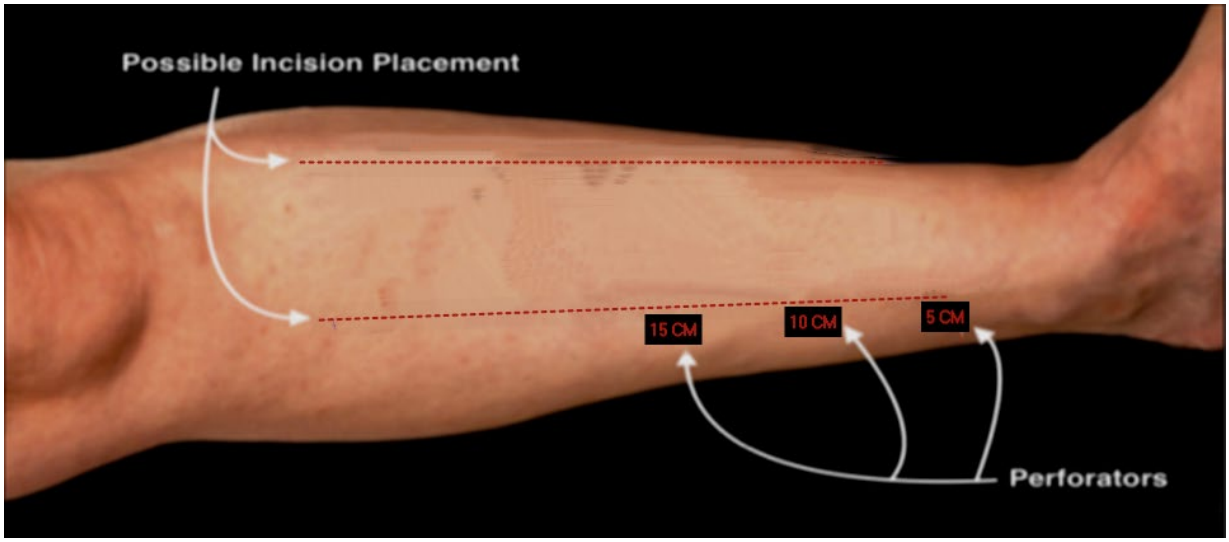
The single most important aspect of a preoperative examination is the determination of any peripheral (PAD). As with any surgical procedure, the lack of blood flow can be detrimental to a muscle flap. This is particularly true when discussing REVERSE transposition of muscle grafts.

In preparation, each patient must undergo rigorous noninvasive testing. This includes ABIs as well as CT angiography to delineate the extent of distal perforators to the muscle bellies. This allows the surgeon to determine which muscle belly to harvest intra-operatively, and how distal the perforating branches can be found, determining how distal a transposition can occur. If need be, preoperative vascular intervention is appropriate to increase blood flow and preserve limb salvage.

For neuropathic patients, pre-operative counseling is less concerning regarding pain. However, all patients must be counseled on the need for an external fixation device. This is not negotiable as the muscle flap will perish with any micro-motion.

Nutrition must be optimized for each patient as well. Each patient's albumin levels are measured, and nutrition counseling is started prior to the date of surgery for all patients and carried through the healing stages. Surgery cannot be performed on any patient that smokes, as it compromises vascular supply to the soft tissues and the harvested muscle flap. Prior to the incision, the CT angiogram is reviewed and perforators are located.

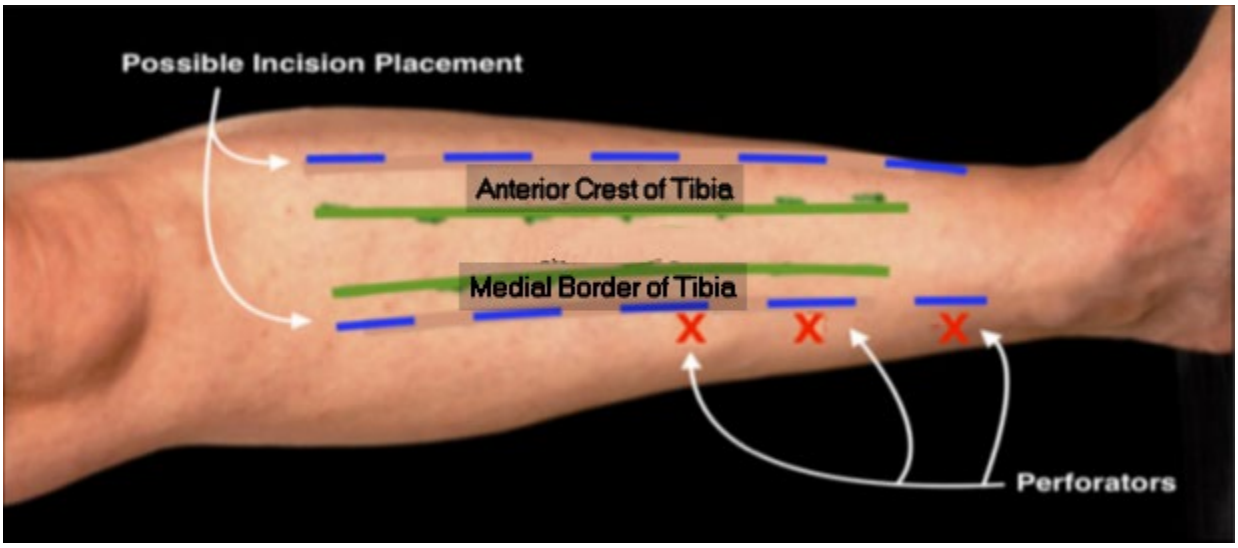
Begin by marking the topographical anatomy of the leg. The primary landmark will be the ankle joint, from which key perforating vessels will be located proximally at approximate intervals of 5,10, and 15cm proximally. These perforators are critical structures as their integrity will largely dictate the success of the flaps discussed in this book.



Reconstruction of Soft Tissue Defects. Clin Surg. 2018; 2001 (3): 1-6

In all cases, the perforators will be located and marked prior to incision, it also goes without saying that meticulous instrument dissection will be required for the highest rates of success.

Topographical Notes:

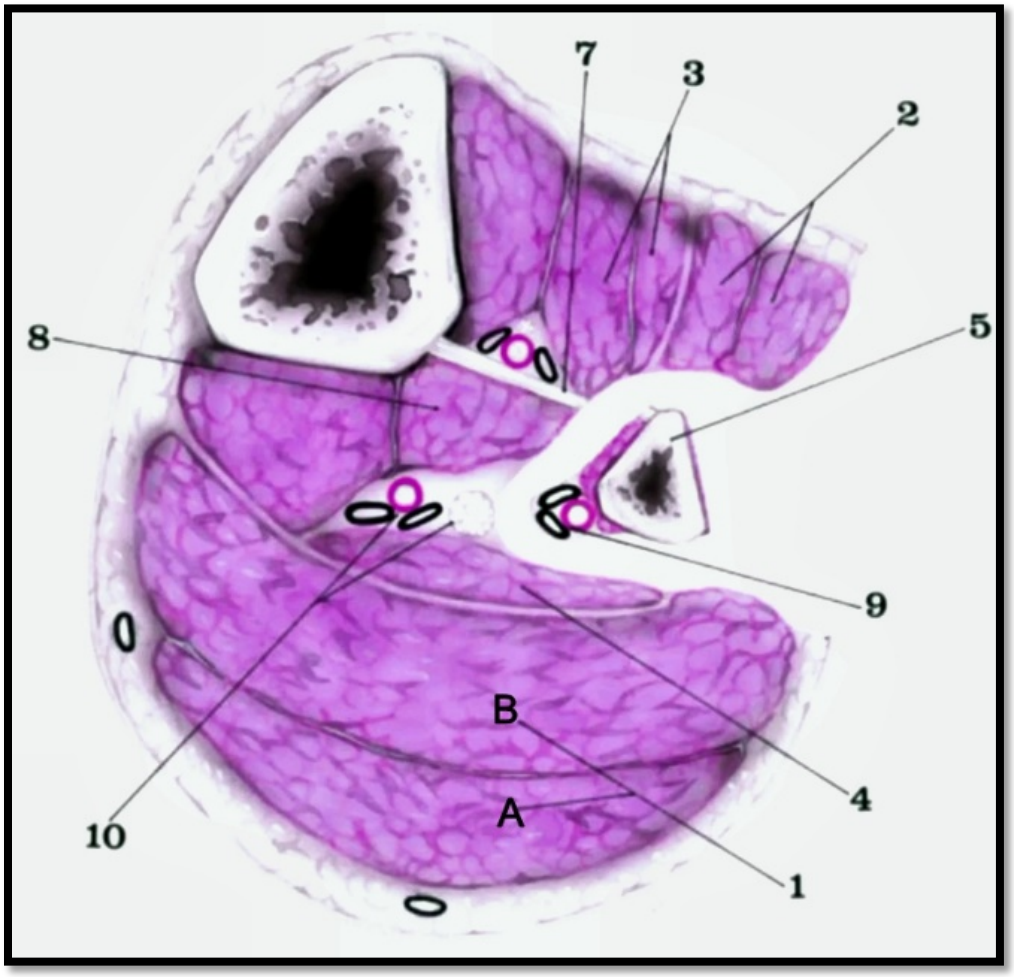


Reconstruction of Soft Tissue Defects. Clin Surg. 2018; 2001 (3): 1-6

The following landmarks are of valuable importance as they help aid in creating the surgical markings necessary for all the lower extremity flaps mentioned within the text.

- Transverse line through the ankle joint
- Anterior Crest of tibia *(superior green line)*
- Medial border of tibia *(inferior green line)*
- Axial line, 1cm posterior to medial border
- Final pre-incision mark-up demonstrating location of perforating vessels at 5, 10, and15cm proximally from the ankle joint. *(Red 'X' markings)*; Always remember to use a handheld doppler to pinpoint these locations.

CROSS-SECTIONAL DIAGRAM OF MAJOR MUSCLES AND VASCULATURE

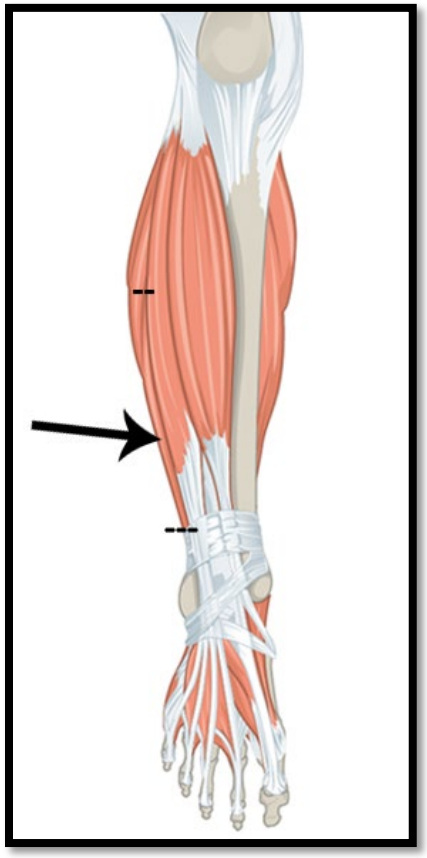


Berish Strauch, M.D. *Atlas of Microvasular Anatomy and Operative Techniques 2nd Ed.* 2006

(CROSS-SECTION: MID TIBIA)

1A. Gastrocnemius
1B. Soleus muscles
2. Peroneus Brevis and Longus muscles
3. Extensor Hallucis Longus and Digitorum muscles
4. Flexor Hallucis Longus muscle
5. Fibula
7. Interosseus membrane
8. Posterior Tibialis muscle
9. Pernoneal artery and veins
10. Posterior Tibial artery. Nerve and vein

PERONEUS BREVIS MUSCLE



Origin:
-Mid to lower two-thirds of fibula, lateral surface

Insertion:
-Tuberosity of 5thmetatarsal base

Innervation:
-Superficial Peroneal Nerve (L5-S1)

Blood supply:
-Fibular Artery, and occasionally Anterior tibial artery[7]

Action:
- Everts, pronates and plantar flexes foot

Indications:

- Small and medium sized defects involving: The ankle. the hindfoot, and both the distal and or middle third of the lower leg.

Physical Examination:

- Visually asses for any obvious signs of vascular insufficiency.
- Palpate both legs and make note of ROM and muscle strength.
-

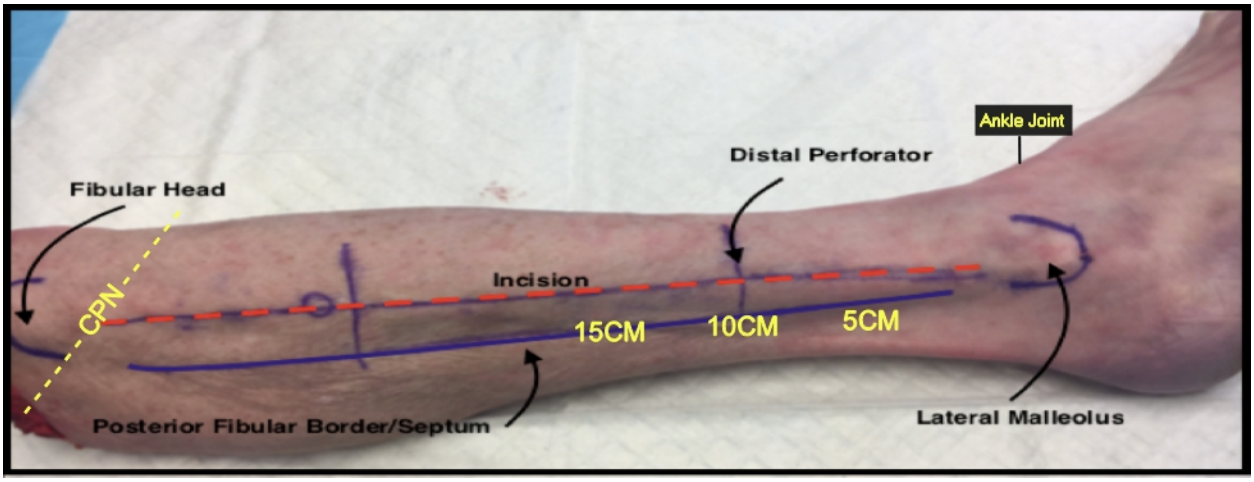
Patient Positioning:

- Lateral Decubitus.
- General anesthesia with peripheral nerve block.

Procedure: Incision planning, exposure and flap placement:

- A lateral incision approach will be used

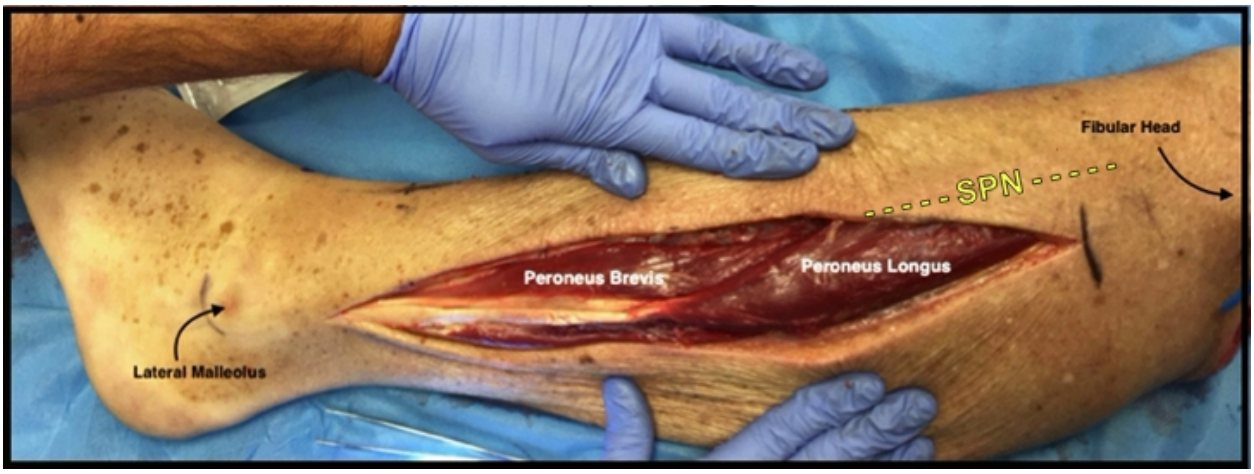
- Begin by marking the both the fibular head and the distal tip of the fibula.
- Palpate the anterior and posterior borders of the fibula and mark each border.
- Palpate the Groove between the tibia and fibula at the anterior aspect of the fibula.
- Just posterior to the posterior border up the fibula, push down into the tissue this is the septal area. The perforators will be located along this border, from proximal to distal. Mark an 'X' to the center of this area for identification of the muscular septal perforators along this margin.
- Extend the ankle and palpate the medial and lateral gutters, this will help to identify the anterior joint line. Mark the point over the medial and lateral gutters.
- Next, mark a line approximately 1cm posterior to the medial tibial line.
- Using a ruler and beginning at the ankle joint line, make marks at the levels of 5cm, 10 cm, and 15cm proximally. At this point, a hand-held doppler should be used to identify and confirm the position of the perforators at the marked levels.



- Start incising over the center of the lateral compartment of the fibula. Deepen the incision through the skin and subcutaneous tissue until you can identify the fascia of the lateral compartment.

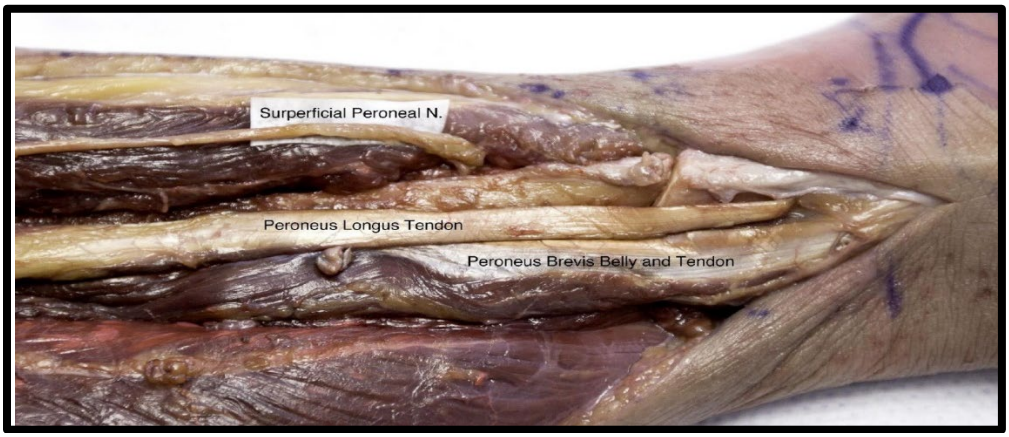
NOTE: It is imperative that you do not enter the anterior compartment of the patient's leg.

- An incision is now created through the fascia entering the lateral compartment of the leg.



- Using 2 hemostats, carefully begin to peel the fascia from the muscle by creating traction with the hemostats.

- At this point, make sure to identify the superficial peroneal nerve. We recommend that the superficial peroneal nerve at this level necessitates the need for a double axonal crush to be performed.



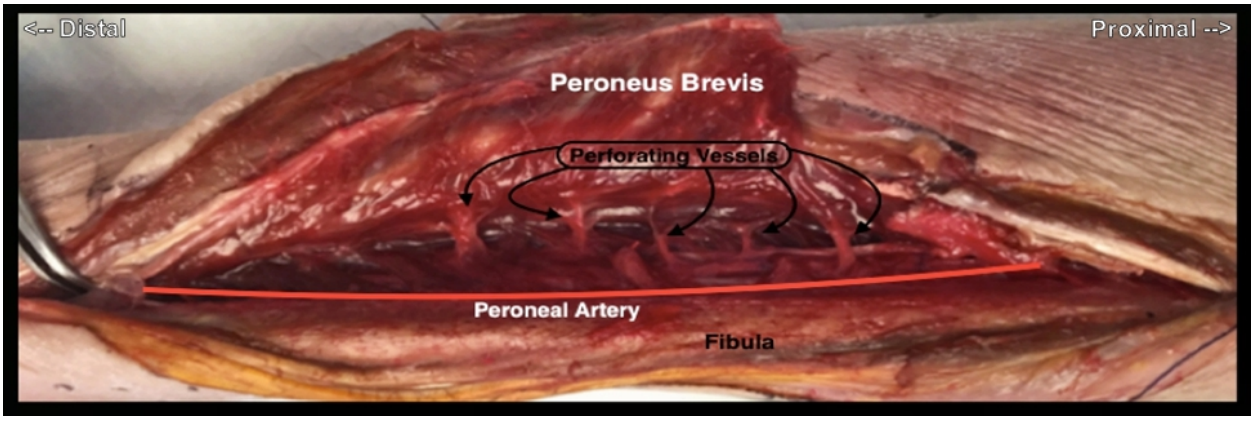
Reconstruction of Soft Tissue Defects. Clin Surg. 2018; 2001 (3): 1-6

NOTE: The superficial peroneal nerve is found on the lateral aspect of the patient's lower leg, approximately mid-level and just anterior to the border of the fibula.

- Expose the conjoined tendon of the Peroneus Longus and Peroneus Brevis and identify the fat line which demarcates the two muscles from one another. Note that the Peroneus Brevis will be underneath.

- Dissect down and tease away the fascia, exposing the Peroneus Brevis muscle. The anterior compartment of the lower leg and floor of the fibula should be identifiable.

- Once the fibula has been acknowledged, you can appreciate the flat surface found in the middle third of the bone; this is one of the origins of the Peroneus Brevis.
- Using a sharp blade, begin careful dissection of the Peroneus Brevis from the fibula laterally, making sure to avoid injury to the perforators found both posterior and anterior to the fibula bone.



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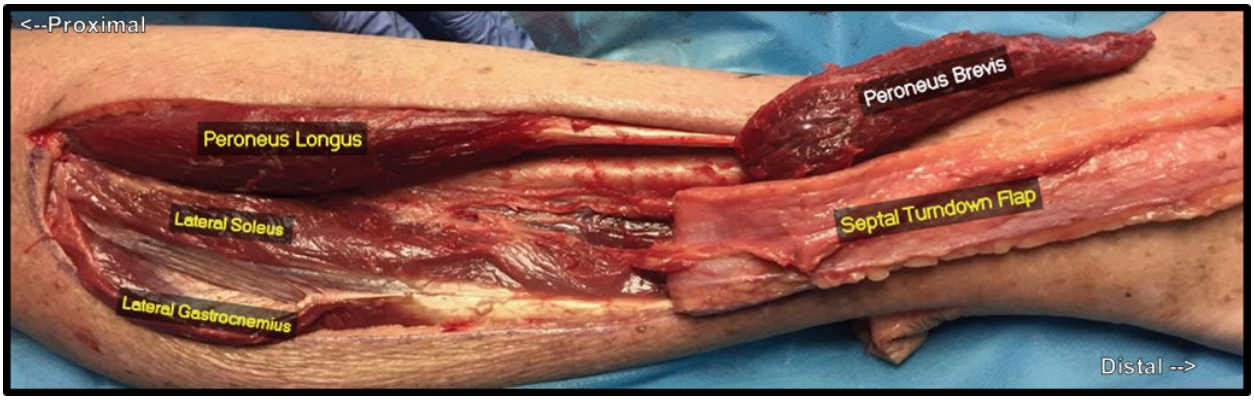
- After the Peroneus Brevis has been dissected off the fibula, identify the fat line. The fat line will be found proximally and is what demarcates the Peroneus Brevis from the Peroneus Longus.
- Carefully separate the 2 muscle bellies away each other and begin separating the Peroneus Brevis from the conjoined tendon.
- Now that the Peroneus Brevis has been dissected, determine the length and arc of rotation needed to cover the associated deficit and transect the Peroneus Brevis proximally.



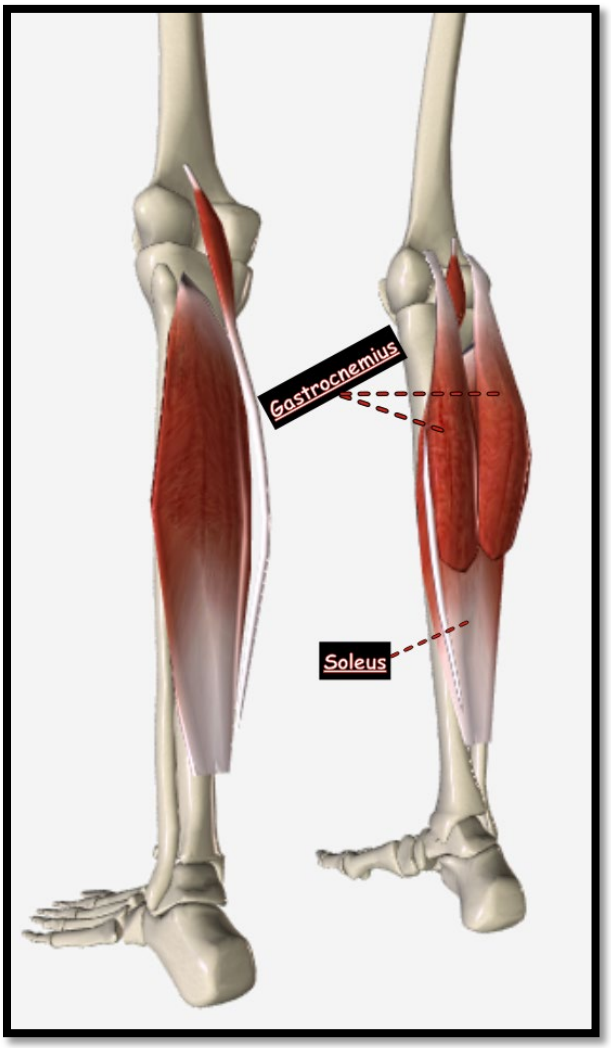
NOTE: The Peroneus Longus and Peroneus Brevis tendons must have a tenodesis performed. This will aid in avoiding overpowering of the posterior tibial tendon and the tibialis anterior tendon which may very likely result in causing an unwanted varus deformity.

Post-Operative Care:

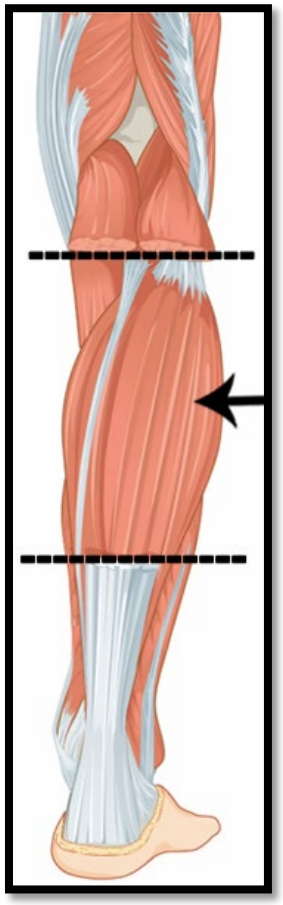
Please refer to the post-operative care chapter found on page 41.

SOLEUS & GASTROCNEMIUS MUCSCLES

READING NOTE: In our attempt to keep this text as simple and concise as possible, we have elected to use the same 'Procedure: incision planning and flap placement' methods for both the Soleus and Gastrocnemius sections as they are almost identical. In instances where variances between the two flaps are present, these differences will be pointed out and explained.



SOLEUS MUCSCLE



ORIGIN:
Proximal 1/3 of posterior fibular shaft/head; Soleal line of tibia; Posterior peroneal septa

INSERTION:
Forms aponeurosis with Gastrocnemius; Inserts on Calcaneus as tendoachilles

INNERVATION:
Tibial nerve

BLOOD SUPPLY:
Sural, Peroneal and Posterior Tibial arteries

ACTION:
Plantarflexion of foot

Indications:

- Small and medium sized defects involving: The hindfoot, and both the distal and or middle third of the lower leg.

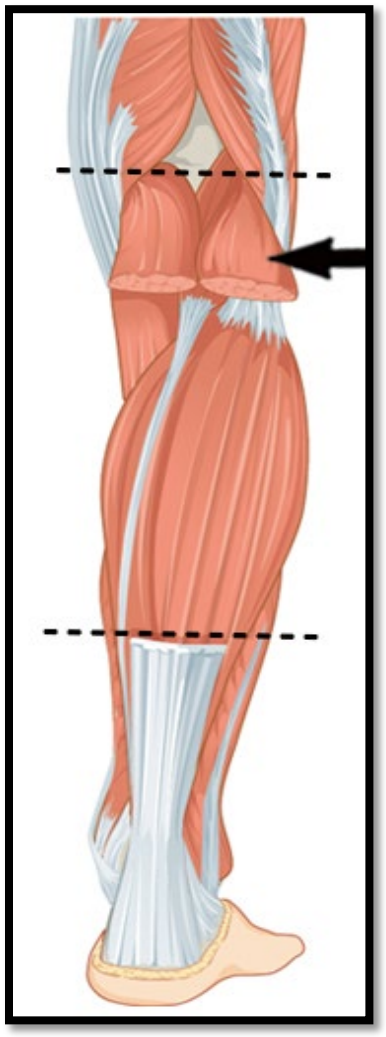
Physical examination:

- Visually asses for any obvious signs of vascular insufficiency.
- Palpate both legs and note ROM and muscle strength of posterior compartment of leg.

Positioning:

- Lateral Decubitus.
- General anesthesia with peripheral nerve block.

GASTROCNEMIUS MUSCSLE



ORIGIN:

Medial and lateral condyles of Femur

INSERTION:

Aponeurosis blends with Soleal aponeurosis to form the Achilles tendon. Inserts on the middle portion of the posterior Calcaneus.

INNERVATION:

Tibial nerve

BLOOD SUPPLY:

Medial Gastrocnemius= medial Sural Artery

Lateral Gastrocnemius= lateral Sural artery and vein

ACTION:

Flexes leg at the knee

Plantarflexes foot

Indications:

- Small and medium sized defects involving: The hindfoot, and both the distal and or middle third of the lower leg.

Physical Examination:

- Visually asses for any obvious signs of vascular insufficiency.
- Palpate both legs and note ROM and muscle strength of posterior compartment of leg.

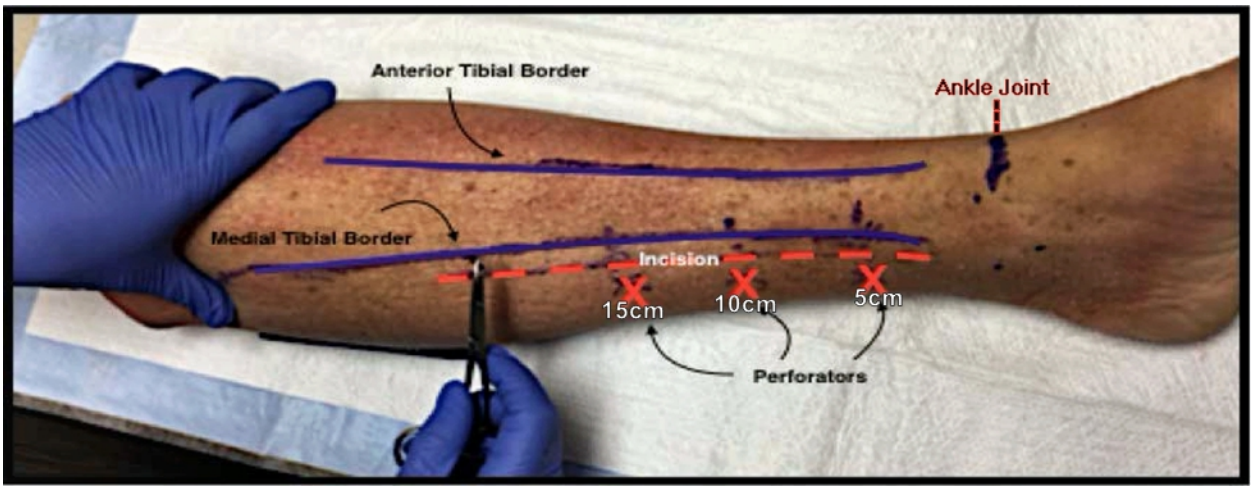
Position:

- Lateral Decubitus
- General anesthesia with peripheral nerve block.

Procedure: Incision planning, exposure and flap placement:
[Applies to both Soleal and Gastrocnemius flaps]

- A medial incision approach will be used

- Begin by palpating the tibial crest and marking it on the lower leg.
- Extend the ankle and palpate the medial and lateral gutters, this will help identify the anterior joint line. Mark the areas over the medial and lateral gutters.
- Proceed to the medial aspect of the patient's leg and palpate the medial aspect of the tibia bone. Mark this anatomical land mark.
- Draw a line approximately 1cm posterior to the medial tibial line. This line will serve as a safe zone of dissection to access the medial compartment of the lower leg. By performing the dissection at this line, unwanted injury to perforators can be avoided.
- Next, using a ruler and beginning at the ankle joint line, make marks at the levels of 5cm, 10 cm, and 15cm proximally. At this point, a hand-held doppler should be used to identify and confirm the position of the perforators at the marked levels.
- Mark the Medial Malleolus.
- Palpate the Achilles tendon and draw a line anterior to the tendon distally. Follow the tendon proximally and mark your path. As you move proximally, you will encounter the medial head of the Gastrocnemius muscle.



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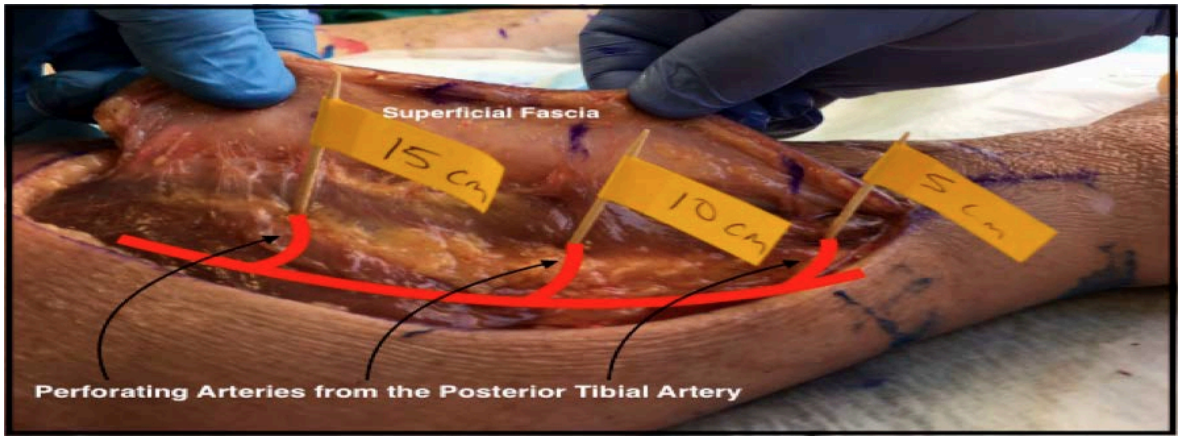
- Prior to making the initial incision, remember to stay along the safe zone as mentioned above. 2 other key points to recall are that deep to the Achilles tendon will be the superficial posterior compartment and that the area of the medial tibia is where the posterior compartment is found. This area is to be avoided.

- Begin the incision distally at the 5cm mark and incise proceeding proximally, just inferior of the knee medially. The incision is made down to the level of the fascia avoiding any neural and vascular structures.



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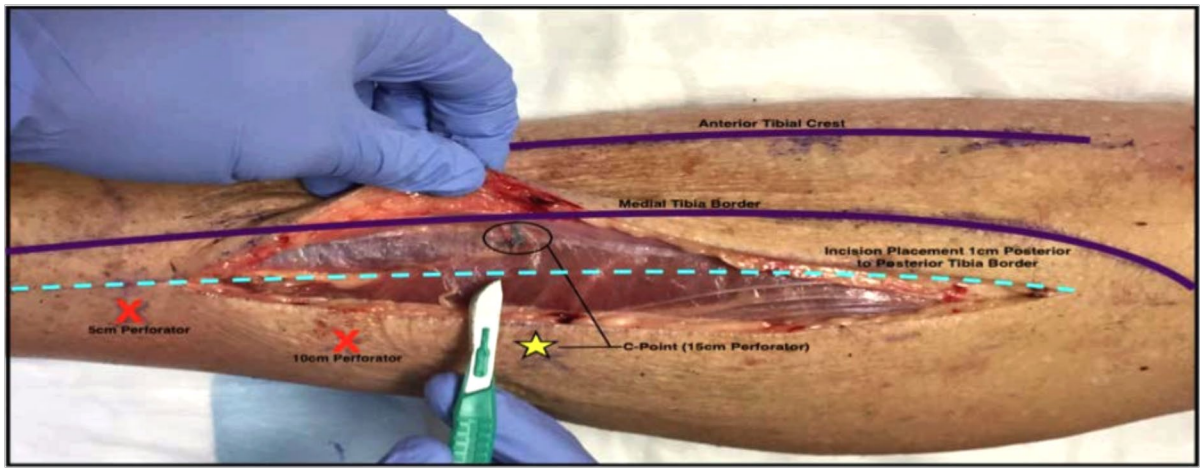
- Once the fascia is identified, a fasciotomy is performed, allowing the muscle to bulge out. Some of the fascial perforators will be cut at this point. After the incision and fasciotomy, apply Allis clamps to the fascia and have your assistant pull up and away, the Gastrocnemius muscle will be identified superiorly.



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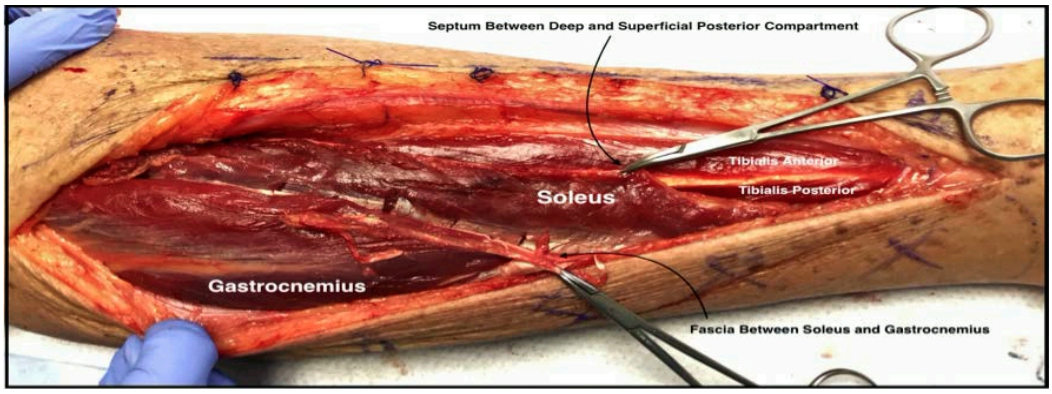
One important landmark to make note of is that of what we like to call the 'C-Point'. This is the anatomical point where the dense attachment of the soleus muscle to the tibia eases and forms a tunnel. This point, the 'C-Point' defines the space between the soleus muscle and the deep posterior compartment. A perforator will almost always be found there.



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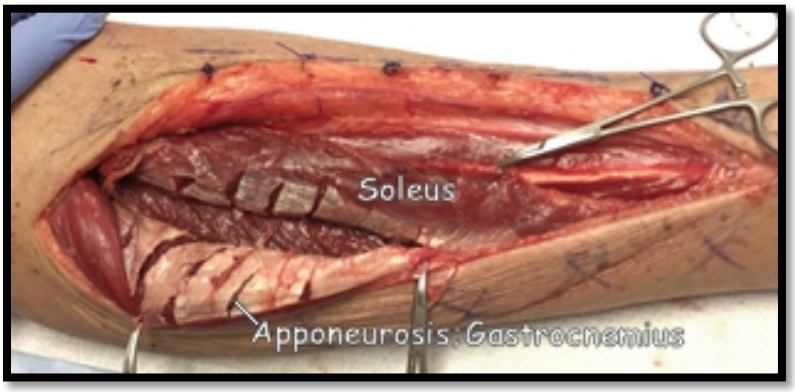
- Following the incision and fasciotomy, move the Gastrocnemius muscle away from you to appreciate the soleus fibers found below this layer. A fat line will distinguish the separation between the Gastrocnemius and Soleus muscles.

Note: The perforators to the Soleus muscle are deep proximally and become superficial as you move distally. Therefore, as the dissection is carried out distally care must be taken to avoid injury to these perforators.

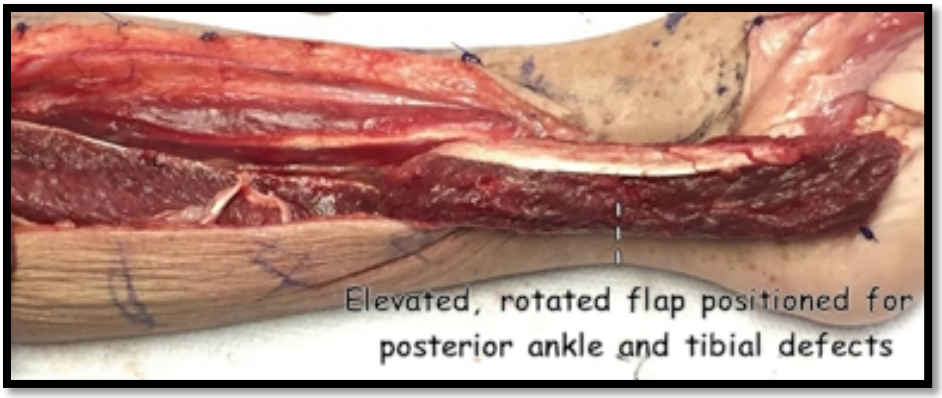
- Beginning proximally, dissect the soleus away from the medial aspect of the tibia, creating a deep plane. This is of great importance because if a plane is developed superficially, you will lose traction counter-traction movement.

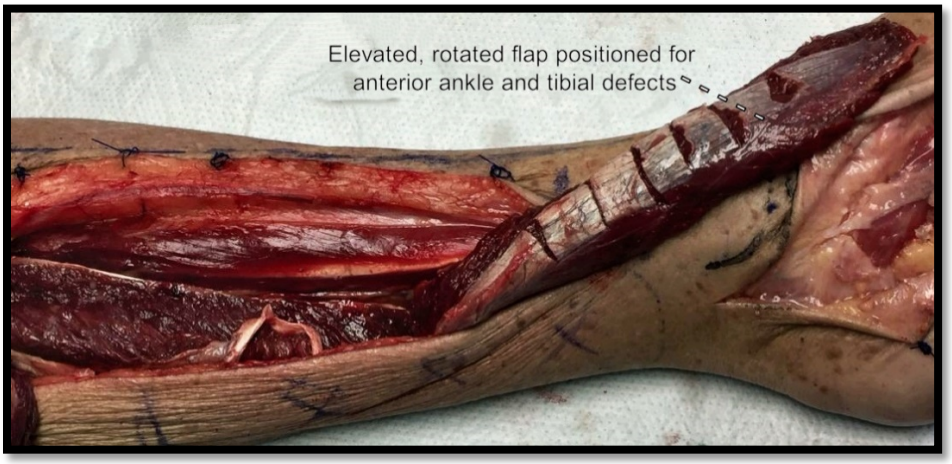
- Complete the fasciotomy distally, remembering to be cautious as the perforators to the Soleus become superficial as you move distally.



- Identify the aponeurosis and begin to develop a plane between the Gastrocnemius and Soleus muscle. At this point the Plantaris tendon will be encountered and as you follow your dissection from proximal to distal in direction, it will become evident that there is a transition point where the perforators become more superficial. It is important the we do not go pass this point when rotating the muscle.

- Determine what arc of rotation you will need based on the location of the defect and complete your flap.



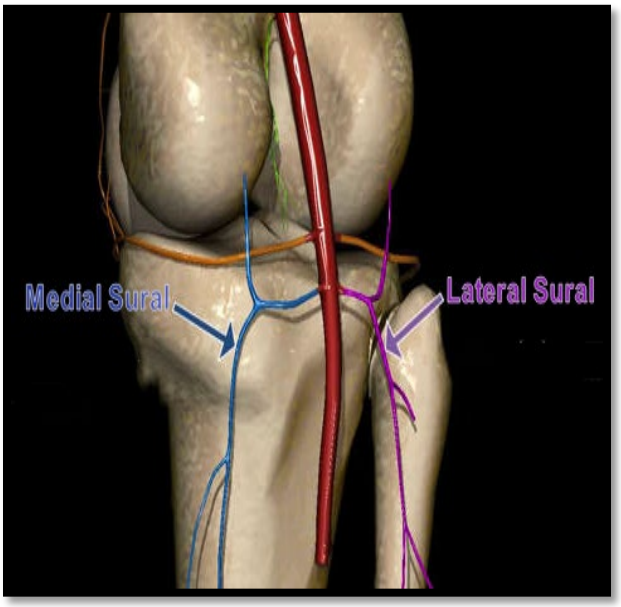


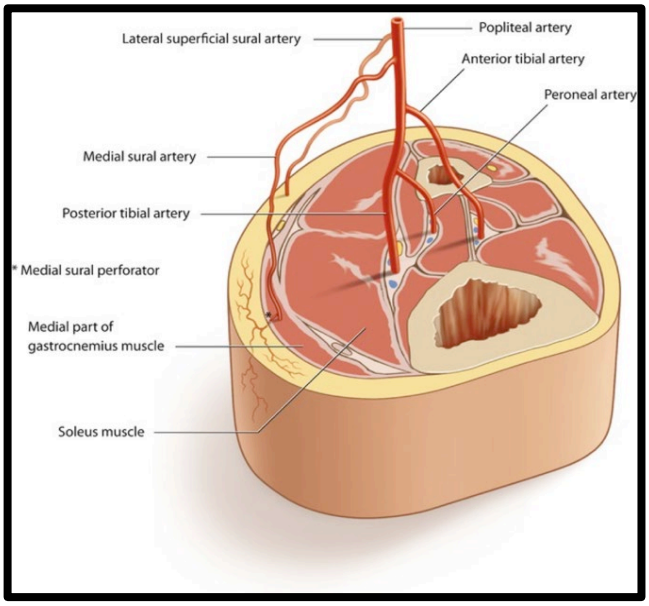
Post-Operative Care:

Please refer to the post-operative care chapter found on page 41.

REVERSE SURAL ARTERY FLAP

NOTE: Since the reverse sural artery flap is not a typical 'muscle flap', the layout for this portion of the E-book is different than the others. To simplify the information involved with the reverse sural artery flap, a detailed explanation of the anatomy and blood flow is given first. This is then followed by key surgical techniques and begins with 'pivot point'. This was done so that the reader can easily differentiate the variances between this type of flap and the other muscle flaps previously discussed.





Anatomy

- The Sural arteries: A pair of blood vessels, originating from the popliteal artery. They supply the Soleus, Gastrocnemeus, and plantaris muscles.
- The sural nerve proper is formed by union of the medial sural cutaneous nerve and the lateral sural cutaneous nerve (AKA the peroneal communicating branch).
- Due to the presence of variability the union site, the reverse sural artery flap (RSAF) is often referred to as the medial sural cutaneous flap.
  - Union of the medial sural cutaneous nerve and the lateral sural cutaneous nerve does not occur 33% of the time.
  - The sural nerve proper is most commonly a continuation of the medial sural cutaneous nerve.

Various Nomenclature of the RSAF

- Distally based sural flap
- Sural neuro-veno-fasciocutaneous flap
- Reverse sural island flap
- Median sural flap

Indications

-Soft-tissue defects 10x12 cm in size at distal third of the leg, proximal third of the foot and posterior heel

***Note**: defects >6 cm wide require skin grafting for donor site closure*

-Reconstructive option for coverage of exposed vessels, tendons, bones and internal fixation hardware.

Advantages:

- Ease of Dissection
- Primary closure at donor site
- Versatile and pliable in nature allowing for an increased reach and ability to cover a larger surface
- Provides gliding surface for tendons
- Better shoe fit with an acceptable aesthetic result

Disadvantages:

- Possible to lesion subdermal plexus
- Functional result at weight-bearing surfaces is not as suitable
- Requires a split thickness skin graft

Defects that have been reconstructed using the RSAF

- Non-healing skin wounds/ulcers
- Chronic venous ulcers
- Soft-tissue injury secondary to open fractures
- Chronic osteomyelitis
- Gangrene
- Contractures and unstable scars
- Electrical burns
- Cancer resection

A Closer Look at The Anatomy around the Sural Artery:

Anterograde Arterial Supply:

- Involves the sural artery, musculocutaneous perforators, and gastrocnemius muscle
- 1-3 fasciocutaneous arteries named the medial, median and lateral superficial sural arteries (also called the sural cutaneous arteries; based on their relationship to the medial and

lateral heads of the gastrocnemius muscle) comprise the dense arterial network known as the sural angiosome.

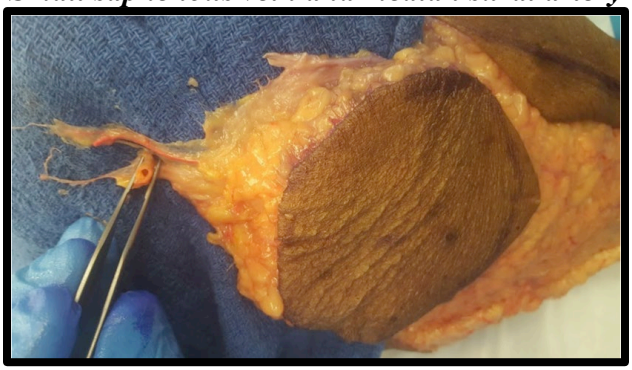
- The largest of the three is generally the median superficial sural artery (0.9 - 2.6 mm in diameter)

- Superficial sural arteries form an anastomosis with perforators of the gastrocnemius muscle

- Provides vascular supply to the skin and fascia

- Musculocutaneous perforators of the gastrocnemius provide vascular supply to the overlying skin, more concentrated over the medial head

Small saphenous vein and median sural artery

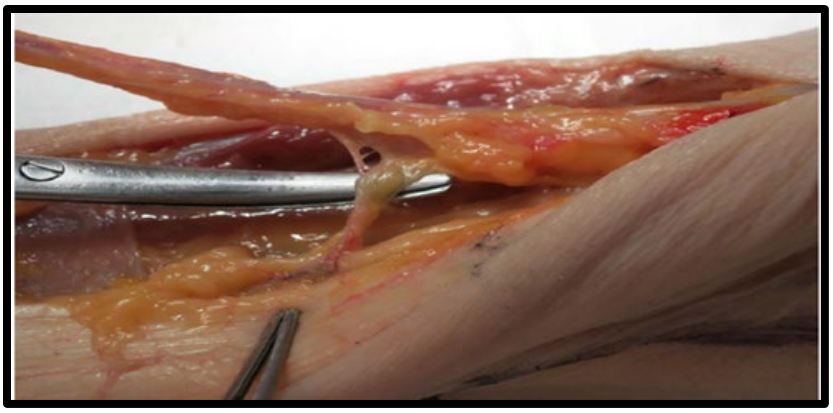


<u>Retrograde blood flow</u>

- Peroneal artery fasciocutaneous perforators
- Posterior tibial artery fasciocutaneous perforators
- Lesser saphenous vein- venocutaneous perforators
- Sural nerve- neurocutaneous perforators

<u>Classically: The Peroneal artery</u>

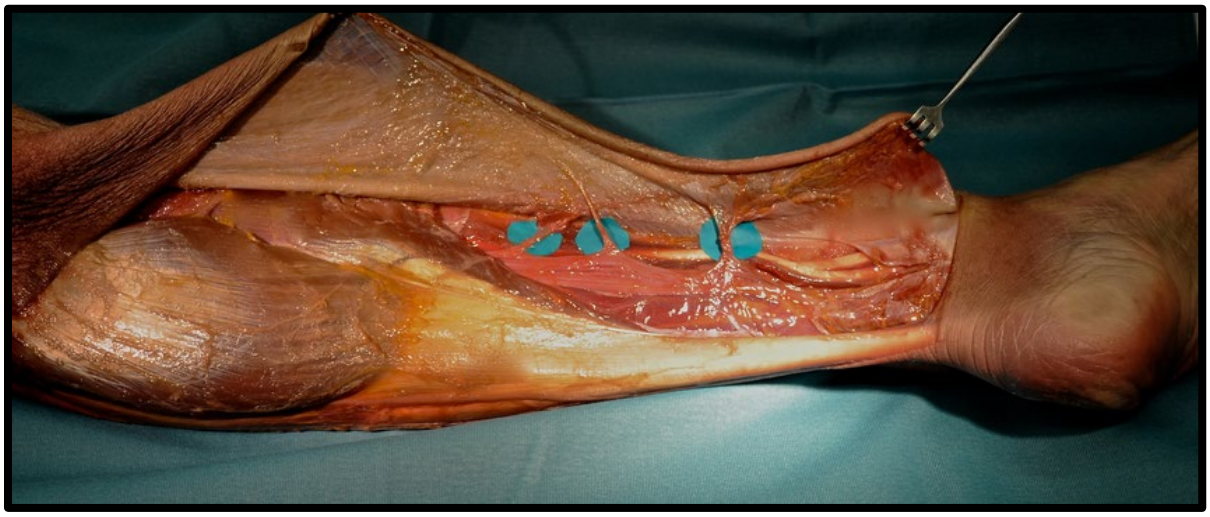
- The leg usually consists of three to six septocutaneous perforators arising from the peroneal artery
- Run proximally between the fibula and flexor hallucis longus
- More distally run between the soleus and peroneus longus
- The most distal of the peroneal septocutaneous perforators is located 4 to 7 cm proximal to the lateral malleolus
- Directly connect with the superficial sural arteries



- *The peroneal septocutaneous perforator is located 5-7 cm proximal to the tip of the fibula posteriorly*
- *At the midline between the fibular shaft and Achilles*
- *This is the pivot point of the pedicle*

Retrograde blood flow: Posterior Tibial artery

- Consists of four to five septocutaneous perforators
- Proximally run between the tibia and soleus
- More distally run between the flexor digitorum longus and soleus
- The most distal of posterior tibial septocutaneous perforators is located 4 to 10 cm above the tip of the medial malleolus

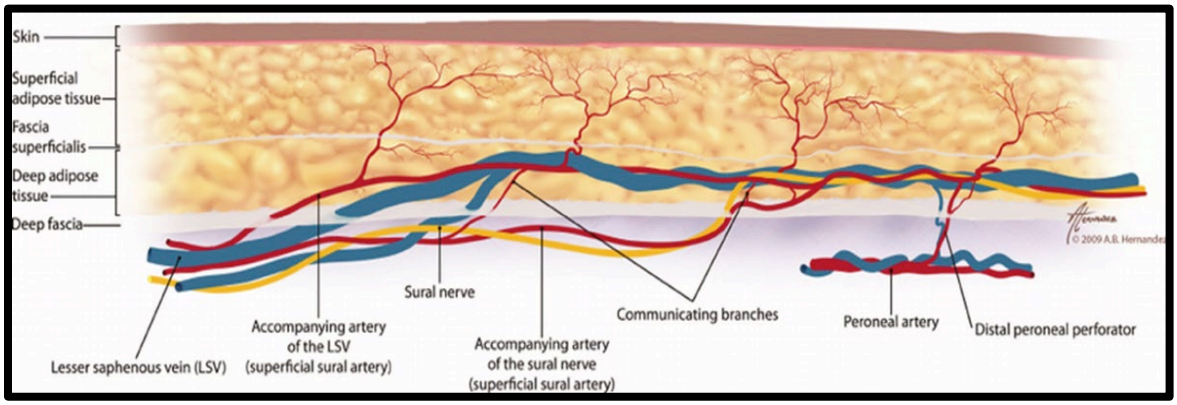


Three septocutaneous perforators originating from the posterior tibial artery

Neurocutaneous perforators and venocutaneous perforators

- Network of small arteries that accompany the sural nerve and the lesser saphenous vein
- Accompanying alongside their length is the intrinsic vascular supply and extrinsic vascular plexus

Venous Drainage



- The skin and fascia of the RSAF is primarily drained by the lesser saphenous vein (also called the small saphenous vein)
- The lesser saphenous vein prevents retrograde blood flow via the numerous valves it contains
- Running parallel to the lesser saphenous vein are one or more smaller collateral veins which have anastomotic connections to it and may allow for blood to bypass its valves flowing in a retrograde fashion.

Anatomical Relationship of Nerve, Artery and Vein

- **The lesser saphenous vein**
  - Begins its course at the lateral border of the dorsum of the foot
  - Passes below the lateral malleolus and continues its course along its posterior border
  - It then crosses the sural nerve after coursing approximately one-third of the length of the lower leg
  - The lesser saphenous vein is more proximally located between the two heads of the gastrocnemius muscle
  - It is important to note that the lesser saphenous vein remains superficial to the deep fascia until it passes through the popliteal fossa to drain into the popliteal vein
  - ✶ Remains in superficial fascia

- **The medial superficial sural artery**
  - Pierces the popliteal fossa, traveling between the two heads of the gastrocnemius muscle
  - Proximally, it runs deep to the deep fascia
  - Pierces the deep fascia and courses to the superficial fascia at the inferior margin of the upper one third of the leg
  - Travels just medial to the lesser saphenous vein toward the lateral malleolus after piercing the fascia
  - ✶ Deep to superficial

- **The median cutaneous sural nerve**
  - Courses between the median superficial sural artery and the lesser saphenous vein
  - Pierces the deep fascia after connecting with the lateral cutaneous sural nerve to become the sural nerve.
  - In the distal leg, the sural nerve is located between the median superficial sural artery and the Achilles tendon
  - ✶ Deep to Superficial

  - *The medial sural nerve pierces the fascia to course superficially with the saphenous vein, typically at the inferior aspect and midline of the gastrocnemius heads.*

Flap composition:

- **Fasciocutaneous**
  - Traditional flap
    - Skin, subcutaneous tissue, underlying fascia

- **Adipofascial**
  - No skin with flap; only subcutaneous tissue and underlying fascia
  - Allows for primary closure of the donor site to be obtained
  - Does not require 180 degree turn

- **Myocutaneous**
  - Includes part of the gastrocnemius muscle to provide bulk
    - Different from the gastrocnemius muscle cuff which protects mesentery.

Surgical Technique:

Pivot point

- Identification of the pivot point for the RSAF is located between the Achilles tendon and posterior border of the fibula
- It is said by most authors that the pivot point must be a minimum of *approximately 5 cm proximal to the lateral malleolus*
- Some authors claim that in order to achieve consistent flap survival, a minimum distance as large as 10 to 11 cm is required
- In young healthy patients, presence of the posterior lateral malleolar artery and the lateral calcaneal artery allow for the pivot point to be as close as 1.5 cm from the lateral malleolus
- ✶ To aid in the planning of a pivot point, a thorough Doppler exam is key to identify perforating vessels

Skin Island and Incision

- Outline the skin island to match the recipient site defect

- Low pivot point
  - Fascial pedicle can be kept short.
  - Flap can be harvested from the distal two-thirds of the posterior lower leg.

- High pivot point
  - Allows for preservation of any potential perforating vessels.
  - Fascial pedicle must be longer to reach the defect site.
  - Flap may be taken to within 1 to 2 cm of the popliteal crease.

- Under tourniquet control, the skin is then incised to the level of the fascia

Incorrect

Correct

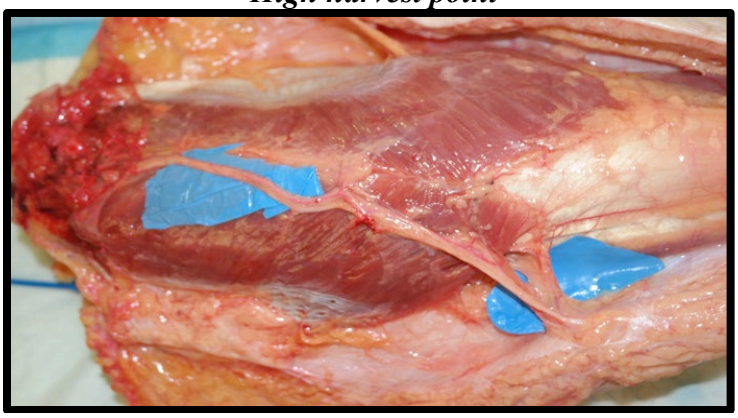
- To ensure proper level and subfascial dissection you must visualize the gastrocnemius muscle belly with medial and lateral incisions.
- Avoid retraction on flap.
- Identify your neurovascular pedicle and vein
- Harvest the vein so that its longer than the flap to allow for supercharging or catheter draining; These terms will be discussed later.

- Due to the suprafascial location of the median sural nerve, superficial sural artery, and lesser saphenous vein in a low harvest technique, they are generally transected in the course of this incision.

- Then, the median superficial sural artery and lesser saphenous vein can be ligated as a single unit or individually.

- If the proximal border of the flap is taken closer to the popliteal fossa, where the subfascially located sural nerve and lesser saphenous vein are, carefully preserve the adipofascial connections between the fascia and the proximal portions of these structures to maintain the venocutaneous and neurocutaneous perforators that arise from their extrinsic vasculature.

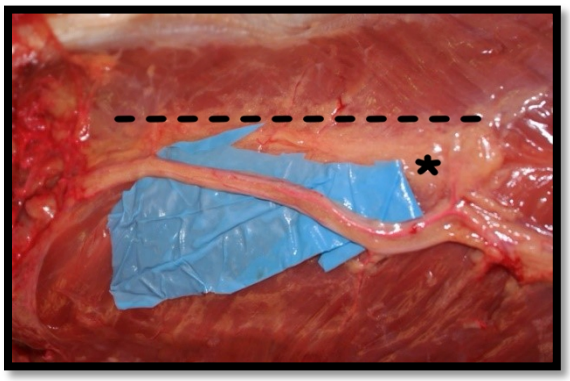
-High harvest point



- *Vein is in the superficial fascia*
- *Nerve and artery are located in the deep fascia, covered by a mesentery and are intimate with the central raphe of the gastrocnemius muscles*

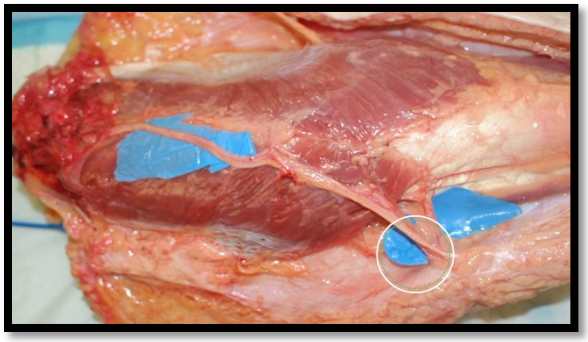
-High harvest: vein is included however the nerve and artery are left behind

-The mesentery (black star)

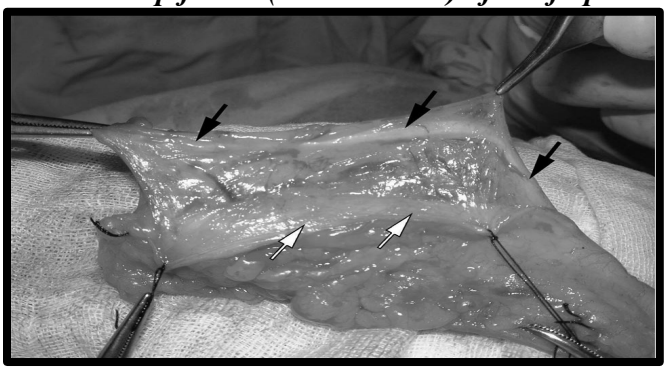


- Must preserve the mesentery for adequate circulation to high harvest flap
- Obtaining a small cuff of muscle to preserve it is often necessary (black dotted line**)**

-Low harvest point before nerve pierces the superficial fascia (Vein, artery and nerve at the same level)



-Intraoperative picture of the mesentery connecting the sural nerve (black arrows) to the deep fascia (white arrows) of the flap



- Even when the nerve is deeply embedded in the muscle, the mesentery can still readily be dissected (Usually contains significant perforators such as those shown in the above image.)

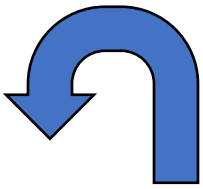
Preparation of the fascial pedicle

- Undermine the skin overlying the fascial pedicle down to the level of the pivot point.
- Minimum width of the pedicle should be as wide as the width of the widest portion of the skin island down to the pivot point.
- The fascial pedicle is developed to the pivot point.

- Once the fascial pedicle has been elevated along with the vessels and nerve, it can be inset into the recipient defect site.

- Be sure to maintain the skin on the fascial pedicle skin bridge. (can vary in width)

- Determine your arc of rotation based on the involved deficit.



- Typically, a gentle turn of 180 degrees with caution to avoid possible kinking the vessels

- The skin is then closed primarily to the extent possible

- Remaining donor-site defects are closed with a split thickness skin graft

- If a larger fascial cuff than the skin island is obtained, it allows for an easier inset and avoid tension to skin

Supercharging

- Supercharging is the anastomosis of the saphenous vein to a local vein to decrease venous congestion

Alternative to supercharging: Catheter draining

- Insert catheter angiography in vein
- Periodic drainage of the flap for the initial 24-48 hours

Surgical modifications:

- **Sural Flap Delay**
  - The goal is to redirect blood flow in a longitudinal direction
  - Flap is elevated without incising the proximal edge of the skin island completely
  - Placement of a powder-free glove between the elevated fascia and the gastrocnemius muscle, and the skin is closed
  - Two weeks later, flap is completely elevated and transferred into the defect site

- **Delayed Sural Flap**
  - The goal is to allow for the flap to become viable on its distal vascular pedicle before causing the additional trauma by transferring it, which may compromise that pedicle
  - Flap is raised entirely and sutured back into its donor site
  - As a second procedure, the flap is then transferred into its recipient site

Sural Flap Delay

Delayed Sural Flap

Other modifications:

Z-incision to harvest the fascial pedicle instead of a linear line

POST-OPERATIVE CARE

- Patient is followed very closely post-operatively, with visits at post-operative day numbers 7, 14, 28 and as needed after the third post-operative visit.
- JP drains are typically pulled 24-48 hours post-operatively. However, this could vary depending on the amount of fluid collection present. Drains are removed once <10ml is collected within a 24-hour period. This will decrease the risks for hematoma formation and post-operative compartment syndrome from developing.
- The first dressing change is scheduled at 7 days post operatively to allow for the INTEGRA® Bi-Layer Matrix or STSG to settle beneath the wound vacuum.
- The KCI® wound vacuum is changed every 5-7 days, with the settings always remaining at 75 mmHg of continuous negative pressure.

- The incisional wound vacuum, placed on the harvest site, is discontinued 7-10 days post-operatively.
- Staples and vessel loops are removed 3-4 weeks post-operatively to ensure prevention of wound dehiscence.
- At the third post-operative visit, a decision regarding the viability of the muscle is made.
- With adequate incorporation, the external fixation device is removed between weeks 4-6 post-operatively. Primary or secondary STSGs are scheduled now as well.
- After removal of the external fixation device, the patient is placed in a CAM boot and should be slowly transitioned into a weight bearing status based on the surgeon's preference, the location of the wound and the patient's compliance.
- The patient is seen every 2-4 weeks after being placed in the CAM boot until the wound is completely closed.

52 year old male who suffered from post-operative infection status post total knee replacement: A total Gastrocnemius muscle flap was implemented to correct the defect. Post-operative protocol included the use of a drain and wound vac. The above image shows the patients healing process at 4weeks, 6weeks and 12 weeks post-operatively. Note the well healed incision site and resolved infection.

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