

## Transtibial Amputation with Extended Flap and Bone Bridging

### Site of previous surgeries:

Amputation indication: four years status post a crush injury to his left foot. Patient experiences chronic pain and dysfunction after several reconstructive surgeries.

### Bone cut level:

One very critical decision is where exactly to cut the tibia and fibula for this particular individual. Several factors must be taken into consideration when choosing where to cut the bone.

1. Historically, many surgeons recommended a tibial bone cut that was always one hand's breadth distal to the tibial tubercle. This gives a tibial length of between 10 and 15 cm depending on the size of the surgeon's hand.
2. Recently it has been recognized that additional tibial length may have some value up to a certain level.
3. It is almost always recommended to avoid amputation in the distal 1/3 to 1/4 of the tibia, as there is very little muscular tissue for padding in the distal most portion of the lower limb.
4. Calves vary dramatically in their anterior to posterior diameter, so ideally the tibia would be divided at a point where the distal edge of the appropriate length posterior flap would occur at the junction of the soleus muscle and the Achilles tendon.
5. When the transtibial amputee is standing up, the distance between the ground and the end of the residual limb allows adequate space for the liner, socket, proximal connector, pylon, distal connector, and foot.
  1. 4 to 6 inches of space allows for the use of most standard prosthetic feet and a pin lock suspension system.
  2. 6 to 8 inches allows for the addition of a shock absorbing component to the above standard prosthetic system.
  3. 8 to 10 inches is required for the use of most integrated high-impact foot/pylon/shock absorbing systems.
6. Practically, the tibial bone cut is planned to keep one third to one half of the length of the tibia. The exact location is based most commonly on the quality of the soft tissue envelope, the shape and size of the calf muscle, the overall height of the individual, and the location of scars, ulcerations or soft tissue defects.

### Measure limb diameter:

Measure the anterior to posterior diameter of the limb, at the level of the tibial bone cut. In this case the diameter is 12 cm. The skin of the flap needs to rotate all the way from the posterior aspect of the limb up and over the distal end, to join the anterior skin in a tension free closure. This flap has an axis of rotation that is just posterior to the limb, not at the mid-limb as is still shown in some older texts. Therefore, the traditional flap length needs to be equal to the AP diameter of the limb, plus an additional cm to allow for the curvature of the tissue around the end of the limb.

In the case of the **extended** posterior soft tissue flap, an additional 5cm must be added to that measurement. Therefore, in this case the length of the flap is 18 cm. (the 12 cm diameter plus 1 cm for rotation plus 5cm of added length).

### Draw incision lines:

The skin incisions are drawn out based on the proposed level of the tibial bone cut.

1. The **medial** and **lateral** extensions are drawn straight distally, and do not drift posteriorly. The length of the extensions is equal to the AP diameter of the limb at the proposed level of the tibial bone cut, plus 6 additional cm. The extended flap is approximately 5cm longer than the traditional posterior flap.
2. **Anterior** incision – down approx half diameter of limb. Medially this extends down to an inflection at the edge of gastrocnemius muscle. Laterally, this extends down to the posterior edge of fibula. The incisions curve very slightly from distal to proximal as it moves from anterior to posterior.
3. **Posterior** incision is drawn straight around the back of the leg, connecting the ends of the medial and lateral incisions.

### Aesanguinate leg before applying the tourniquet

#### Incisions:

Incisions should be made in a decisive fashion to provide a clean and pure incision through skin, subcutaneous tissue, down to and through the fascia. One should avoid feathered or beveled edges, and avoid irregularly cut surfaces that can lead to devitalized tissue which may be a focus for non-healing or infection.

#### Saphenous vein and nerve:

Find the saphenous vein, the nerve is usually just lateral to the vein. Separate vein and nerve, drawn down nerve and cut, no need to suture ligate this nerve. Ligate the saphenous vein with absorbable suture.

## **Lateral incision**

## **Medial incision**

## **Distal incision/Achilles transection**

### **Dissect lateral edge of tibia:**

Dissect away anterior and lateral muscles from tibia, preserve periosteum.

### **Transect anterior and lateral compartment muscles:**

Dissect down lateral edge of tibia and along the syndesmotic membrane over to the fibula. Pass the clamp under the anterior and lateral compartment muscles. Transect the muscles.

#### **1. Anterior compartment**

1. Anterior Tibialis (AT), Extensor Hallucis Longus (EHL), and Extensor Digitorum Longus (EDL)
2. The anterior compartment muscles are transected at the level of the tibial bone cut early in the operation. The anterior tibial vessels and the deep peroneal nerve are located at the depth of the anterior compartment, just anterior to the syndesmotic membrane.

#### **2. Lateral Compartment**

1. Peroneus Longus (PL) and Peroneal Brevis (PB).
2. These muscles are transected at the same level as the anterior compartment muscles, at the level of the tibial bone cut.

### **Anterior tibial vessels and the deep peroneal nerve:**

Identify and separate the vessels and the nerve. Pull deep peroneal nerve distal and divide. Dissect the anterior tibial vessels, clamp them, and double ligate first with a stick tie, then with a free tie (proximal to first tie).

The anterior tibial vessels are located within the anterior muscle compartment, at the deepest or most posterior surface, just anterior to the syndesmotic membrane. They are most easily visualized after transecting the anterior muscles and finding the transected vessels at the posterior aspect of the anterior compartment.

### **Create tibial osteoperiosteal flap:**

A longitudinal incision is made to enable dissection of the skin and subcutaneous tissue off of the periosteum. The tibial periosteum is preserved to help build a reconstructive bone bridge across the distal tib-fib. The periosteum is divided on the anterior and posterior edges of the tibia, and transected distally.

A sharp osteotome is used to elevate an osteoperiosteal flap. The flap should be a full thickness periosteal flap with small pieces of cortical bone adherent to the flap.

The periosteum is transected proximally up past the area where the tibia will be transected. The flap is left attached proximally to maintain blood supply.

### **Dissect lateral & posterior tibial periosteum:**

Soft tissue is cleared off of the lateral and posterior portion of the tibia with a Cobb elevator.

### **Divide the tibia:**

Tibia – the tibia is typically divided at the level of the anterior skin incision. The tibia is initially transected with an oscillating saw perpendicular to its long axis. Take care to preserve the attachment of the osteoperiosteal flap. Just before closure, the tibia is shaped with an anterior bevel to better accommodate prosthetic fitting.

### **Expose the fibula:**

Dissect the soft tissue away from the fibula, but take care to preserve the periosteum. An osteoperiosteal flap will be elevated for use in the reconstruction. Place retractors to protect the soft tissue.

### **Divide the fibula:**

1. Fibula– the fibula is traditionally divided between 1 and 2 cm **proximal** to the level of the divided tibia. However, in the bone bridge procedure it is cut approximately 3cm **distal** to the cut of the tibia in order to have extra fibular bone available for the bone bridge. The fibula is cut perpendicular to its long axis.

### **Place bone hook in fibula and dissect along back of bones**

### **Incise distal end of flap**

### **Expose and ligate superficial peroneal nerve:**

In the lateral compartment, the course of the superficial peroneal nerve changes dramatically from proximal to distal. Proximally, it is found between the peroneus longus and peroneus brevis muscle. Distally, it can pierce the fascia and change from the lateral to the anterior compartment. Find the nerve, drawn down and ligate. No need to suture ligate this nerve.

### **Lift deep posterior compartment off soleus, preserve soleus fascia:**

Deep Posterior Compartment: Posterior Tibialis (PT), Flexor Hallucis Longus (FHL), and Flexor Digitorum Longus (FDL).

After dissecting down the back of the tibia and fibula to remove the foot, the deep posterior compartment is carefully lifted off of the soleus. Care is taken to keep the muscular investing fascia with the soleus to maintain the blood supply to the deep posterior compartment.

### **Clamp perforating vessels to tie:**

Care is also taken to find and clamp the small perforating vessels that go from the posterior tibial and peroneal vessels down into the soleus, so that these perforating vessels do not retract down below the fascia and cause bleeding that may be difficult to control.

### **Lift deep posterior compartment off of soleus:**

Blunt dissection is used to lift the deep posterior compartment off of the fascia of the soleus.

### **Dissect tibial nerve and posterior tibial vessels:**

1. The tibial nerve runs throughout its course with the posterior tibial vessels. It is the largest nerve in the lower leg. Separate from the posterior tibial vessels by opening the perineurium and physically pulling away from the vessels. Clamp the posterior tibial vessels to exclude the nerve. Draw the nerve down and divide. Ligation of this nerve to prevent bleeding from the nerve is controversial. I rarely ligate the nerve, and only do so if I visibly see small vessels that may bleed.
2. The posterior tibial vessels are located within the fascia of the deep posterior muscle compartment. They are easily visualized after gently lifting the deep posterior compartment off of the superficial compartment by manually separating the fascial plane between the soleus and deep compartment, starting on the medial edge, at the proximal portion of the flap. If the interval between the soleus and gastrocnemius is entered inadvertently, this becomes obvious when the plantaris tendon comes into view.

### **Isolate the posterior tibial vessels, clamp and cut**

#### **Isolate and clamp peroneal vessels:**

The peroneal vessels are also within the deep posterior muscle compartment, but are not as obviously identified as the posterior tibial vessels. They lie lateral to the posterior tibial vessels, and are between the FHL muscle and the PT muscle, very close to the deep edge of the fibula. The large veins are occasionally torn during the transection of the fibula, and occasionally bleeding that appears to be coming from the fibula, is actually coming from the peroneal veins. If this is the case, placing a bone hook into the fibula, and lifting the limb by the fibula allows the peroneal vessels to fall away from the bone so they can be clamped more proximally and ligated at the site of bleeding under direct visualization.

#### **Remove residual deep posterior compartment muscles:**

After separating out the posterior tibial vessels, the tibial nerve, and the peroneal vessels, the PT, FHL, and FDL are transected at or just distal to the level of the tibial bone cut.

#### **Double ligate peroneal vessels:**

- with 0-silk suture.

#### **Double ligate posterior tibial vessels:**

- with 0-silk suture.

#### **Remove remnants of the lateral compartment:**

Dissect up off of fascia, transect at bone-cut level.

#### **Ligate perforating vessels**

#### **Pull the tibial nerve distally and transect:**

Dissect soft tissue away from nerve, drawn down, transect, and allow to retract.

### **Locate sural nerve and small saphenous vein:**

**Sural nerve** – This superficial nerve runs in the posterior flap, and is located between the skin and the superficial fascia. It runs just lateral to the small saphenous vein. The vein is isolated and ligated. The sural nerve needs to be shortened dramatically so as to position the nerve ending not just away from the incision, but well up posteriorly and not in the tissue covering the distal end of the amputation.

### **Pull the sural nerve distally (10-15cm) and transect**

### **Let the tourniquet down**

### **Clamp and tie small bleeding vein**

### **Hemostasis**

## **Bone Bridging:**

### **Squeeze test:**

The fibula moves in toward the tibia. This creates the potential for tissue getting caught between the bones.

### **Measure resting distance:**

Typically 1.3cm to 1.6cm.

### **Elevate fibular osteo-periosteal flap:**

Elevate an osteo-periosteal flap from the anterior and medial surface of the fibula. Hold the distal end of the fibula with a bone clamp to stabilize the fibula and facilitate elevation of the osteo-periosteal flap with the osteotome.

### **Create segmental osteotomy:**

Use the saw to create two cuts in the fibula and remove the interval segment. The proximal cut is at the same level as the end of the tibia. The distal cut creates a 1.5cm soft tissue gap and leaves soft tissue attached to the distal piece of fibula which will be used as the bone bridge.

### **Suture bleeding peroneal vein:**

- with absorbable suture.

### **Cut graft to size:**

Mark the length of the fibular graft needed to fit the space (1.5cm). Cut the excess from the graft while keeping some soft tissue attachment.

### **Plan for tibial bevel:**

Mobilize the soft tissue to plan for anterior bevel on the tibia. Dissect anterior periosteum proximally.

### **Bevel tibia:**

1. The tibia is triangular in shape, and the anterior corner can be quite sharp and lead to a painful bone prominence at the distal and anterior aspect of the amputation site.
2. A tibial bevel is created to re-shape the tibia and remove the anterior 1/3 of the tibia. I prefer to cut from the transected surface of the bone, starting just anterior to the medullary canal and beveling up at 45° to a point approximately 1.5 - 2cm proximal to the original cut. The edges of the tibia are then smoothed and shaped with a saw blade, a rasp, or the rongeur.

### **Smooth tibia with rasp and rongeur**

### **Position the graft:**

Position the bone bridge graft between the fibula and tibia.

### **Compress with bone clamp:**

Use a large pointed bone clamp to capture the strut graft and compress it between the tibia and the fibula.

### **Drill fibula and graft:**

The fibula and graft are over drilled with a 3.5mm bit. This allows compression screw fixation to the tibia. Use irrigation to keep bit cool and minimize thermal damage.

### **Drill tibia:**

Place drill sleeve into the 3.5mm fibular hole and then drill the tibia with a 2.5mm bit. Irrigate to keep cool.

**Depth gauge:**

Measure the necessary screw length with a depth gauge. In this case, it is found that the screw path is too far posterior. The decision to reposition the graft and to re-drill is made.

**Re-drill tibia**

**Depth gauge:**

Measure the necessary screw length.

**Tap the tibia:**

Tap the drill hole with a 3.5mm tap. The tibial cortex is very hard and tapping facilitates placement of the screw and its purchase for stronger resistance to pull out.

**Place screw:**

Because of over drilling (3.5mm) the fibula and graft and tapping the tibia, the screw will compress the graft between the fibula and tibia.

**Flap positioning:**

Position the fibular osteo-periosteal flap proximal to the bone bridge. Then position the tibial osteo-periosteal flap distally over the bone bridge.

**Suture flap in place:**

Suture the tibial osteo-periosteal flap in place with absorbable suture. The periosteum forms a surface below and above the bone bridge. In essence, a tube of periosteum around the fibular graft.

- suture over the beveled area
- suture over the fibula and then to its anterior surface
- suture to the posterior surface of the fibula

**Trim excess flap:**

If not trimmed, it will form excess bone in a problematic area.

**Trim flap at bevel:**

To avoid extra or hypertrophic bone growth in the area.

**Test the extended posterior soft tissue flap position:**

For extended posterior flap technique.

**Irrigate to remove debris:**

Irrigate to clean, remove bone dust, and old blood.

**Note graft and screw placement in x-rays**

**Insert drain:**

Bring drain out laterally in the muscular area. A medial exit can cause painful scarring. Cut drain between holes.

**Close medial fascia:**

Bring the medial fascia to the soleus fascia. The fascial closure needs to be secure. It is typically performed with an absorbable suture of moderate strength such as O suture material.

**Trim flap corner for optimal alignment**

**Check flap alignment**

**Close lateral fascia:**

The fascial closure needs to be secure. It is typically performed with an absorbable suture of moderate strength such as O suture material.

**Trim flap corner for optimal alignment**

**Create flap inset and trim flap:**

The skin is marked anteriorly to define the area of inset for the extended posterior flap. The flap is positioned to trial the inset, and a scalpel is used to dissect through the epidermis and dermis. The epidermis and dermis are dissected up off of the subcutaneous tissue. The subq tissue is preserved to provide extra padding for the tibia.

### **Suture fascia to inset flap and perform the myodesis:**

Fascial sutures of the superficial fascia and the fascia of the soleus are used to inset the flap to the fascia over the tibia. The muscle itself is not sutured. Securing the posterior flap up and over the tibia and securing the fascia of the flap to the tibia is in essence a **myodesis**.

#### **Comments on myodesis:**

Muscular Closure:

- The muscular closure should be considered as reconstruction. In the transtibial amputation the fascia of the superficial muscular compartment is advanced up and over the end of the tibia to be sewn into the periosteum of the tibia and to the fascia of the anterior compartment. Since this muscular fascia is sewn to the bone via its periosteum, this is a myodesis. Some surgeons prefer to drill holes in the edges of the tibia just medial and lateral to its crest. I personally have found that I am better able to advance the muscle proximally up and over the tibia by sewing to periosteum, and am not able to advance the muscle as well using the drill hole technique.
- In the extended posterior flap technique, the fascia is advanced several cm up and over the tibia. When the flap is inset, it is secured to the anterior tibial periosteum and creates the area of myodesis.
- The myodesis and securing the inset of the extended posterior flap are typically performed with an absorbable suture of moderate strength such as number 1 or 0 suture material.

#### **Trim the flap:**

The flap is trimmed on the medial and lateral corners.

#### **Suture fascia:**

Place medial and lateral fascial stitches to inset the medial and lateral edges of the flap.

#### **Tie the sutures:**

Bring the flap down into position.

#### **Trim the edges**

#### **Subcutaneous tissue closure:**

1. Skin healing in an amputation surgery can take longer than in other surgical procedures. A subcutaneous closure can help re-enforce the approximation of the skin edges and minimize wound dehiscence. Horizontal subq dermal sutures are placed to inset the flap.
2. The subcutaneous closure is typically performed with an absorbable suture of light strength such as 2-0 suture material.

#### **Nylon skin sutures:**

Skin healing in amputation surgery can take longer than in other surgical procedures. A suture technique that minimizes trauma to the skin edge is needed. I typically use 3-0 nylon suture and prefer it over staples as I can leave the nylon in longer with less irritation. It is not uncommon to leave sutures in 4 or 5 weeks. I have found that skin staples tend to show irritation and redness sooner than nylon suture.

#### **Appearance of the extended posterior flap:**

The initial appearance of the extended posterior soft tissue flap is quite bulbous and bulky. However, in a very short period of time the edema and the volume of the extended flap resolve, leaving a residual limb with a very well padded distal tibia and a contour that fits nicely into a prosthesis.

#### **Apply non-stick gauze**

#### **Apply open 4x4 gauze:**

Then 4x4 gauze is opened up and carefully layered over the amputation site so as not to form a large single mass of bandages that could potentially shift in position and cause a pressure point inside the cast.

#### **Apply fluff gauze**

**Roll on amputation sock:**

The sock helps to shape the limb and minimize the post-operative edema.

**Apply cast padding:**

Cotton cast padding is then applied over the amputation sock to further pad the amputation site. It is applied both above and below the drain.

**Place reticulated foam end-pad:**

Helps to control edema distally.

**Place patellar pad:**

The patellar pad is placed over the patella to identify the location for the patellar cut as the last step in the final casting procedure.

**Tibial crest pad placement:**

Tibial crest pads are placed over the anterior-medial and anterior-lateral tibial flare regions. These two regions are loaded in a traditional transtibial prosthetic socket. Padding helps to protect the tibial crest and push the tibia back away from the cast to protect the skin over the distal end of the tibia. The narrow pad goes on the lateral side to avoid pressure on the peroneal nerve.

**Two rolls of 5” elastic gauze plaster are applied:**

Two rolls of plaster with elastic gauze are used for the initial layers of the cast to both mold the amputation site and to compress the reticulated foam distal end-pad. Care must be taken to not wrap circumferentially as to avoid constricting the limb.

**Apply a 5-ply plaster splint:**

A 5 ply plaster splint is added to strengthen both the *medial* side of the knee area and the *distal* end of the cast.

**Two additional 6” regular cast material rolls applied**

**Create 3-5 degrees of flexion:**

The limb is laid onto a pillow to create 3 to 5 degrees of knee flexion, avoiding hyperextension of the knee and facilitating cast molding.

**Supra-condylar mold:**

A supra-condylar mold is applied to contour the cast above the femoral condyle to control rotation and prevent the cast from falling off the patient. The larger the patient, the larger the supra-condylar mold.

**Cut out patellar pad:**

The patellar area of the cast is cut out to provide a landmark to assure the nurses, therapists, and physicians that the cast is indeed located properly and has not rotated or moved distally. Leave the sock and padding over the patella. Feather the edges for comfort.