The Transtibial Amputation

Pre-Op Plan:

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 hands 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 there 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 exactly 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.

Skin Incisions and Flaps:

The skin incisions are drawn out based on the proposed level of the tibial bone cut. Measure the anterior to posterior diameter of the limb, at the level of the tibial bone cut. 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 length of the flap 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.

1. 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.
2. The medial and lateral extensions are made 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 one additional cm.
3. Posterior incision is drawn straight around the back of the leg, connecting the ends of the medial and lateral incisions.

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

Nerves:

There are 5 nerves to isolate in the transtibial amputation. All 5 nerves *should* be carefully identified, isolated, drawn down and divided in order to avoid having the nerve endings in the area of scar, pulsating vessels or closure. Nerve endings should also be positioned to be away from areas of pressure in a standard prosthesis.

1. Saphenous Nerve – find the vein, 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.
2. Deep Peroneal Nerve – Throughout its course, it runs with the anterior tibial vessels. Most commonly missed nerve. If ligate to the vessels, may sense the cadence of the pulse and cause throbbing local pain or throbbing phantom sensation. Separate this nerve, clamp the vessels, then drawn down the nerve and ligate. No need to suture ligate this nerve. Then Double ligation of anterior tibial vessels.
3. 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.

4. Tibial Nerve – This nerve runs throughout its course with the posterior tibial vessels. It is the largest nerve in the lower leg. Separate form 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.
5. 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 (why it is not called the sural vein I will never know). 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.

Muscles:

The muscles to be managed in a transtibial amputation are located in the four anatomic compartments of the lower limb.

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.
3. Deep Posterior Compartment
    1. Posterior Tibialis (PT), Flexor Hallucis Longus (FHL), and Flexor Digitorum Longus (FDL).
    2. These muscles are carefully isolated, and the posterior tibial vessels and peroneal vessels dissected free before transection. 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. 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.
    3. 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.
4. Superficial Posterior Compartment
    1. Soleus, Gastrocnemius
    2. These two muscles make up the muscular padding of the long posterior flap.
    3. Care is taken not to separate the skin and subcutaneous tissue away from the fascia of the superficial posterior compartment, as this may compromise vascular flow to the skin and impair healing.
    4. It is important to understand that these muscles get their vascular supply from very different sources. Soleus originates below the knee joint in the tibia, and get its vascular supply from pedicles from popliteal, peroneal, and posterior tibial arteries. The majority of the blood supply is below the trifurcation of the vessels.
    5. The gastrocnemius originates above the knee joint on the distal femur, and gets its blood supply proximally from branches off of the popliteal artery, above the trifurcation.
    6. Occasionally the soleus can have poor arterial perfusion while the gastrocnemius has excellent perfusion. In other instances, the soleus has large venous channels and is very edematous and swollen. In these types of cases, the soleus muscle can be resected up near its origin preserving the gastrocnemeus muscle. The posterior myofascialcutaneus flap can survive very well with only the gastrocnemius muscle, if its fascia is carefully preserved.

Vessels:

There are 3 major vessel groups to isolate and securely ligate in the transtibial amputation: the anterior tibial vessels, the posterior tibial vessels and the peroneal vessels. These named vessel groups are typically doubly ligated first with a stick tie through the artery so that it will not pulse off of the vessel. Proximal to this, a free tie is used to avoid the possible bleeding form the stick tie, or the possibility of a small arterial-venous fistula or pseudo aneurysm forming at the stick tie site.

1. 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.

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.
3. 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.

Bones:

There are two bones to divide and shape in the transtibial amputation, the tibia and the fibula. Occasionally, in certain cases, one should consider a modification to the standard transtibial amputation that involves bone reconstruction using one of several bone bridging techniques (provide link to bone bridging for TTA).

In the traditional amputation, as described by Burgess, the periosteum is divided at the level of bone transection, as far proximal resection or elevation of periosteum can decrease the vascular supply to the bone. Also, leaving extra periosteum distal to the bone cut can leave tissue that may calcify and develop new bone formation.

1. Tibia – the tibia is typically divided at the level of the anterior skin incision.
    1. The tibia is initially transected perpendicular to its long axis. Just before closure, the tibia is shaped with an anterior bevel to better accommodate prosthetic fitting.
    2. 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.
    3. 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 45º to a point approximately one cm proximal to the original cut. The edges of the tibia are then smoothed and shaped with either the saw blade, a rasp, or the rounger.
2. Fibula– the fibula is typically divided between 1 and 2 cm proximal to the level of the divided tibia. It is typically cut perpendicular to its long axis. If the fibula is long or at the same level as the tibia, it frequently feels long to the patient and prosthetists and can create a bone prominence that can cause increased pressure, pain, and skin breakdown.
    1. There are exceptions to this traditional fibular bone cut level of 1 to 2 cm shorter than the tibia.
    2. First – if bone bridging techniques are used, most surgeons recommend having the tibia and fibula at either equal levels, or with the fibula a very slight amount shorter than the tibia (appr. .5 to 1cm shorter than the tibia).
    3. Second – in the ultra short transtibial amputation, the fibula is quite frequently removed by careful dissection on the fibular side of the proximal tibia/fibula joint to preserve the capsule of the joint in the tibial side. The fibular collateral ligament and the biceps femoralis tendon (often confluent) which attach to the proximal tip of the fibula are carefully dissected off the fibula and then reattached with suture to the tibia via the tibia/fibula joint capsule.
    4. In trauma situations, the surgeon has to be aware that the zone of injury may extend proximally and the syndesmotic membrane and even the proximal tibia/fibula joint may be disrupted. If this is the case, then the joint needs to be reduced and the fibula stabilized to the tibia proximally, distally, or in both locations.
    5. The fibula also needs to be shaped to smooth the anterior corner, the outer or lateral edge. Care also needs to be taken to look for a posterior spike of bone of periosteum that can lead to development of a small bone spur
3. Bone bridging reconstruction is not performed in the traditional reconstructive posterior flap transtibial amputation as described by Burgess.

Closure:

1. Muscular Closure:
    1. 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 the 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 (link to it), the fascia is advanced several cm proximal to the cut edge of the tibia.

2. To accurately secure this myodesis, typically three or four sutures are carefully placed under direct vision in the periosteum and in the deep and superficial layers of the fascia. The sutures do not grab muscle tissue. They may secure the edge of the Achilles tendon in the longer transtibial amputation. The sutures are all placed and clamped, and only tied after placing all three or four myodesis sutures. If the first suture is tied, it is more difficult to accurately see the layers and accurately place the subsequent myodesis sutures.
3. The myodesis is typically performed with an absorbable suture of moderate strength such as number 1 or O suture material.

2. Fascial Closure: The fascial closure needs to be secure.
    1. A deep suction drain is placed prior to the fascial closure. The drain should not exit near the subcutaneous surface of the tibia, as the small scar left from the drain exit site can be a source of pain in a prosthesis. Instead, the drain should be placed so as to exit in the soft tissue of the anterior compartment.
    2. The fascial closure is typically performed with an absorbable suture of moderate strength such as O suture material.
3. 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.
    2. The subcutaneous closure is typically performed with an absorbable suture of light strength such as 2-O suture material.
4. Skin Closure:
    1. As mentioned, 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-O 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.
    2. The skin closure is typically re-enforced with skin tapes to help take tension off of the sutures.

Bandages and Casting:

- The incision is initially covered with non-stick gauze.
- Then 4x4 gauze is opened up and carefully layered over the amputation site so as not to not form a large single mass of bandages that could potentially shift in position and cause a pressure point inside the cast.
- Fluff gauze is laid over this to even out the padding.
- A amputation sock is gently rolled over the gauze to help shape the limb and minimize the post-operative edema.
- Cotton cast padding is applied over the amputation sock to further pad the amputation site
- A reticulated distal foam end-pad is placed over the end of the amputation
- Tibial crest pads are then placed over the anterior-medial and anterior-lateral tibial flare regions. These are two regions loaded in a traditional transtibial prosthetic socket, and help protect both the tibial crest and push the tibia back away form the cast to protect the skin over the distal end of the tibia.
- A patellar pad is placed over the patella to identify the location for the patellar-cut as the last step in the final casting procedure.
- Two rolled of plaster with elastic gauze is 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 take to not wrap circumpherentially as to avoid constricting the limb.
- 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 addition rolls of regular cast material with standard non-elastic gauze is used to complete the cast.
- The casted limb is laid onto a pillow to allow 3 to 5 degrees of knee flexion, avoiding hyperextension of the knee; and to facilitate molding of the cast.
- 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.
- The patellar area of cast is cut out to provide a landmark to assure the nurses, therapist, and physicians that the cast is indeed located properly and has not rotated or moved distally.