Improving Function in Transtibial Amputation: The Distal Tibiofibular Bone-Bridge with Arthrex Tightrope Fixation

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Abstract

The distal tibiofibular bone bridge for transtibial amputation is designed to allow for axial loading in a prosthesis, better proprioception of the residual limb, and less pain from tibiofibular instability. Originally described as an osteoperiosteal sleeve by Janos Ertl, Sr. in the early 20th century, it was later modified by Pinto and Harris to a fibular bone block technique.

In this article, we describe a new technique for securing the fibular bone block. Use of the Tightrope (Arthrex, Naples, Florida) suture-button fixation system minimizes the chance of symptomatic hardware, prevents diastasis, and allows physiologic micromotion. In our experience, this procedure has been highly successful.

Surgical amputation was first documented on black stone inscribed with the code of law and methods of punishments under King Hammurabi of Babylonia (1700 BC).[1] More than a millennium later, the first therapeutic amputations were performed for battle injuries in Greece, and Hippocrates wrote, "He who wishes to be a surgeon should go to war."[2] Throughout history, from the US Civil War to the current global war on terror, military surgeons have been in the forefront of performing amputations and treating combat-related amputees.[3,4]

With every advance in amputation theory and technique, each generation of surgeons has been able to shift focus from reducing mortality to restoring function. In 1920, Janos Ertl, Sr. made an important observation that would shape the future of both amputation surgery and prosthetics. Many amputees, despite stump healing, continued to have pain and difficulty with prosthetic wear. Ertl noticed that the residual limb, rather than actively participating in ambulation, was simply a passive suspension for the prosthesis.[5] The distal tibiofibular bone bridge, the hallmark of the Ertl procedure, is designed to stabilize the 2 bones and prevent discordant painful motion during ambulation. In addition, it provides a solid platform for axial loading, compared with weight transfer bypassing the stump, as in traditional amputations.

The original Ertl procedure used an osteoperiosteal bone graft elevated from the distal tibia and fibula and sutured together in a tube-like fashion to seal the medullary canal of both bones. Over time, a bony synostosis typically ossifies within this osteoperiosteal sleeve.[5] Pinto and Harris[6] modified this technique by harvesting a fibular bone block distal to the level of amputation and creating a bone bridge at the time of surgery. We have encountered complications with conventional methods for stabilizing the fibular bone block. Sutures placed through drill holes, as described by Pinto and Harris, lack adequate compression and can be transected from repetitive wear against sharp osseous edges. Often, the traditional screws used in internal fixation become painful and may have to be removed.

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The Tightrope (Arthrex, Naples, Florida) suture-button fixation system is a relatively new implant that has been used for multiple clinical situations that require stabilization without absolute rigidity, as in acromioclavicular joint instability, hallux valgus, and Lisfranc ligament rupture. The senior author (GCB) previously published the largest case series using this system for ankle syndesmotic disruptions.[7]

In this article, we describe our technique for and experience in using this system for fixation of the distal tibiofibular bone bridge in transtibial amputation.

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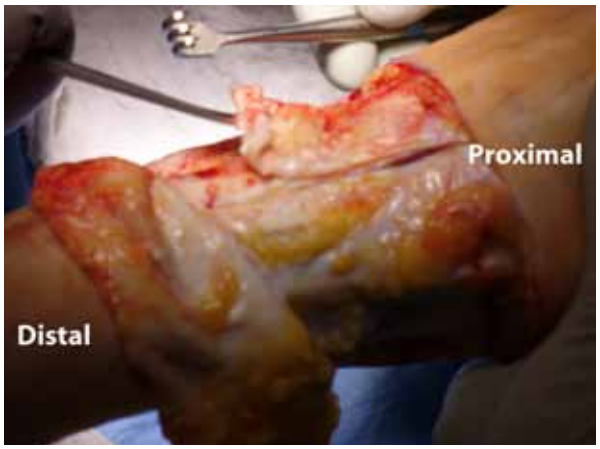

Figure 1. Elevation by osteotome of proximally based periosteal flap from medial aspect of tibia. Skin and subcutaneous tissue are peeled distally.

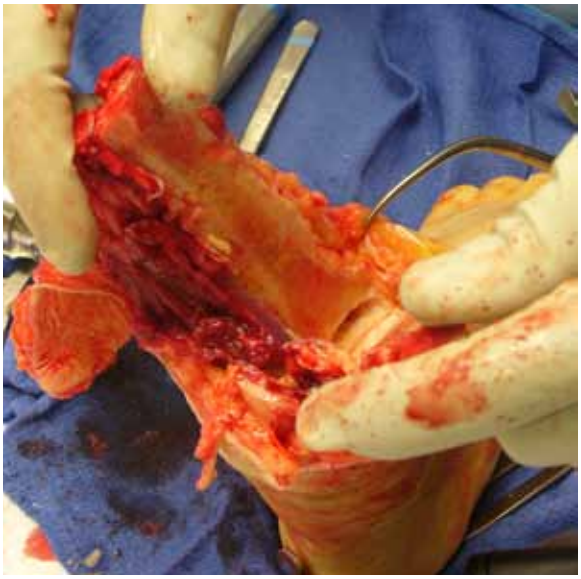

Figure 2. Amputated tibia is split longitudinally to allow harvest of metaphyseal bone marrow.

Surgical Technique

The indications for and fundamentals of performing traditional below-knee amputation, as well as earlier versions of the Ertl procedure, have been described elsewhere.[5,6,8,9] Our experience with the Tightrope suture-button fixation system for the distal tibiofibular bone bridge has led us to make the following technical modifications.

After a long posterior flap incision is made, the skin and subcutaneous fat are peeled off the anterior aspect of the leg to expose the distal tibia. An osteotome is used carefully to elevate a proximally based flap of the periosteum from the medial aspect of the tibia starting about 7.5 cm distal to the eventual tibia transection (Figure 1). The anterior and lateral compartment musculature is dissected free to fully expose the tibia and fibula. An oscillating saw is used to make osteotomies through both bones at the same level. The distal limb is removed by carefully dissecting the posterior flap off its osseous attachments.

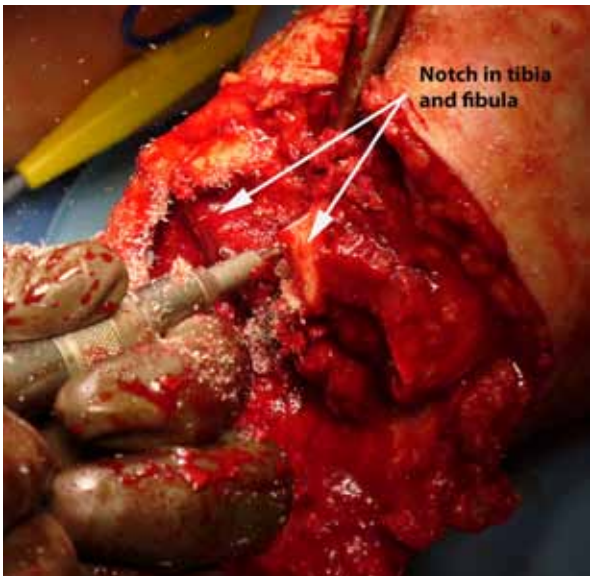

Figure 3. Power burr is used to create notch in tibia and fibula to allow seating of fibular segment bone bridge.

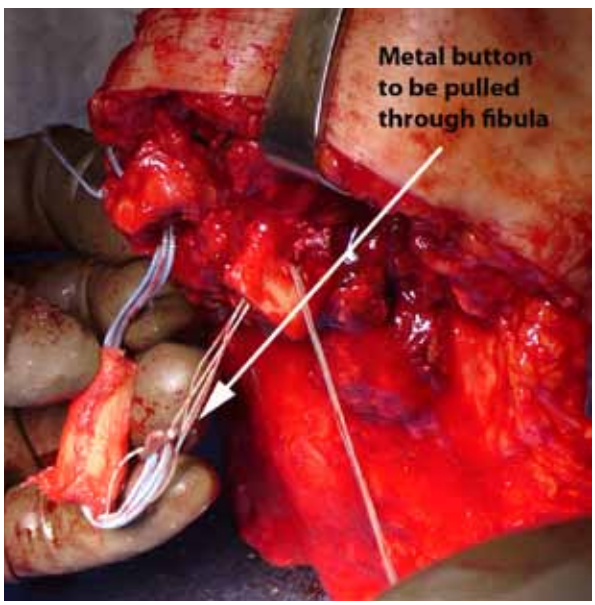

Figure 4. Suture-button fixation system (Tightrope; Arthrex, Naples, Florida) is threaded with Beath needle passed through tibia, bone bridge, and fibula.

After the residual limb is removed, the deep posterior compartment musculature is excised off the posterior flap, leaving only the soleus and gastrocnemius. On a sterile back table, a surgical assistant collects bone marrow from the distal tibial metaphysis (Figure 2). If infection or tumor precludes use of the amputated limb, iliac crest bone graft can be used. A bone segment of 3 cm to 4 cm is harvested from the removed fibula. Meanwhile, the surgeon uses a power burr to create a wide notch in the lateral tibia and medial fibula in preparation for the bone bridge (Figure 3). The fibular segment is brought to the operating table, and a power rasp is used to fashion a

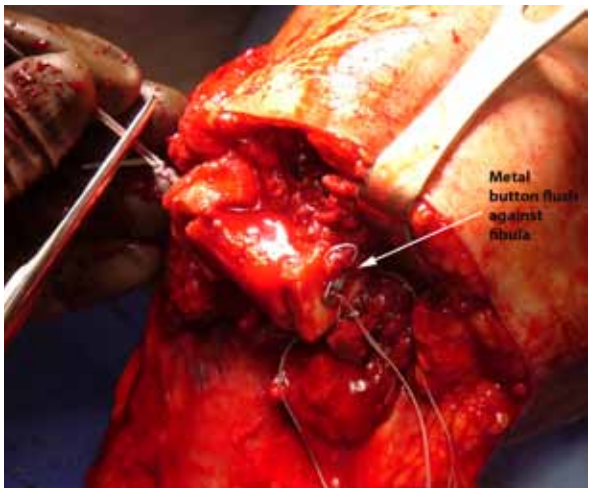

Figure 5. Bone bridge is well seated in groove and held in place with suture-button fixation system (Tightrope; Arthrex, Naples, Florida). Knots are tied on tibial side, and second metal button is secured on fibular side. Deep posterior compartment musculature has been excised from posterior flap to prevent bulbous stump.

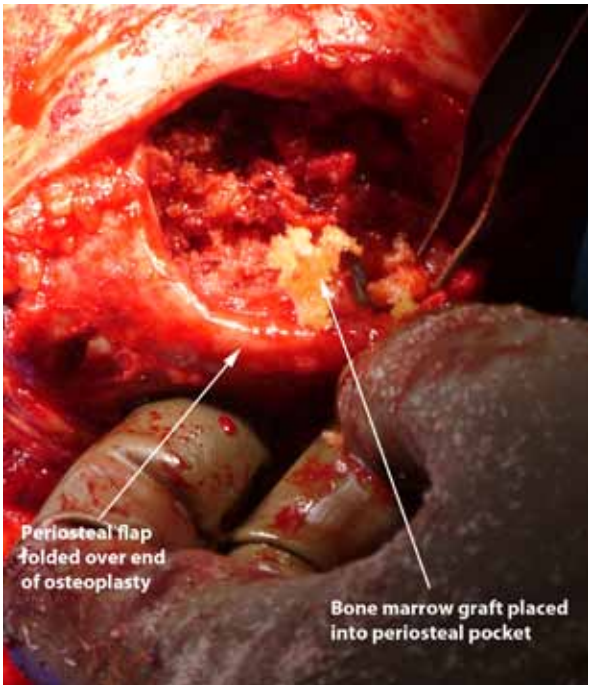

Figure 6. Periosteal flap is wrapped across end of bone bridge like a hammock and is secured with sutures. Bone marrow retrieved from amputated limb is placed around bone bridge, and periosteal flap is then fully closed.

perfect fit. The bone bridge should sit comfortably in the notch and not distract the tibiofibular space. Before final fixation of the bone bridge, the surgeon should confirm that the posterior flap is long enough to provide tension-free coverage. If significant tension is anticipated, the residual tibia and fibula should be shortened.

A 3.5-mm drill is used to make a tunnel through the canal of the fibular segment and holes through the medial and lateral cortices of the tibia and fibula, respectively.

Figure 7. Anteroposterior (A) and lateral (B) radiographs of Ertl amputation with suture-button fixation (Tightrope; Arthrex, Naples, Florida) show good healing of bone bridge.

The suture-button fixation system is passed through the tibia, the bone bridge, and finally the fibula using a Beath needle (Figure 4). After the metal button is seated flat against the cortex of the fibula, the fixation system is secured with at least 6 knots over the metal button on the medial tibial surface (Figure 5). Fluoroscopy is used to confirm adequate positioning of the osteoplasty. All sharp edges are flattened with a power rasp.

Similar to a hammock, the tibial periosteal flap is wrapped over the bone bridge and is secured on all sides with absorbable suture. The anterior aspect is temporarily left open for placement of bone marrow harvested from the distal tibial metaphysis within the periosteal suspension around the bone bridge (Figure 6). The wound is then closed tension-free with separate fascial, subcutaneous, and skin layers. A surgeon's cast is applied to help control edema and protect the stump in the early postoperative period.[9] At 6 weeks, the patient can begin bearing weight in a total-contact specific prosthesis, as would be the case with a traditional below-knee amputee. At 12 weeks, the distal tibiofibular bone bridge is mostly healed, and the patient can transition to an axially loaded prosthesis.

Results

Since December 2006, Dr. Berlet has performed this procedure on 17 limbs in 16 patients. Only the first case required revision, because of infection, to a traditional transtibial amputation. In this case, the initial modified Ertl procedure with fibular bone block secured with sutures was revised to suture-button fixation. The patient was doing well with a traditional prosthesis. None of the other patients have required revision or removal of hardware. All report being comfortable in their end-bearing prostheses. Follow-up radiographs have shown solid ossification of the distal tibiofibular bone bridge (Figure 7). There has been no evidence of loosening or

instability, even in the case of 1 patient who fell, 4 weeks after surgery, directly onto the stump with enough force to split open the skin incision.

The excellent end-bearing capability of the residual limb and the potential for high-level functioning with prostheses are demonstrated in a video, from one of our prosthetic suppliers, of a bilateral Ertl amputee.[10] The patient provided written informed consent for reference to this video.

Conclusion

Numerous variations of the Ertl procedure are performed in many different patients, ranging from multiply injured soldiers to elderly patients with diabetes. Although the superiority of the distal tibiofibular bone bridge over the traditional below-knee amputation is controversial,[11-13] we believe that it confers a significant advantage in patient comfort and level of activity. In our practice, the modified Ertl procedure is highly successful in appropriate candidates, and use of the suture-button fixation system to secure the distal tibiofibular bone bridge compares well with earlier fixation techniques.[6,14,15]

Authors' Disclosure Statement

The authors report no actual or potential conflict of interest in relation to this article.

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This paper will be judged for the Resident Writer's Award.