Management of Tibial Fracture Nonunion using Femoral Cortical Strut Onlay Allograft: A Case Study

Tyler McKee, DPM[1]; Joshua Wolfe, DPM[1]; Emily Keeter, DPM[1], Jesse Wolfe, DPM[1]; Lindsay Barth, DPM[2]; H. John Visser, DPM, FACFAS[3]

[1] Resident, SSM Health DePaul Hospital Foot and Ankle Surgery Residency
[2]Attending, SSM Health DePaul Hospital Foot and Ankle Surgery Residency
[3]Director, SSM Health DePaul Hospital Foot and Ankle Surgery Residency

Introduction

Management of tibial fracture non-unions is a complicated problem for the foot and ankle surgeon. Tibial fractures are among the most common fracture of long bones in the human body.[1] Typically, 26 tibial diaphyseal fractures occur per 100,000, annually.[2] Classification of non-unions has been established within the literature and utilizes radiographic callus formation as the primary indicator.[3] Non-unions are typically broken down into two categories, hypertrophic and atrophic. There are several subclassifications within each of these categories.

The treatment of non-unions with osseous deficits provide an additional layer of complexity to surgical intervention. There are a variety of treatment options ranging from autologous to allograft as well as the structural and biological composition of the implants filling the defect.[4] The structural allograft also has a variety of categories such as intercalary allograft, osteochondral allograft, segmental allograft with arthrodesis or segmental allograft with a prosthesis.[4] The use of structural allograft, particularly large frozen allografts, have a nonunion rate of 11 percent.[5]

Non-unions in the diaphyseal region of long bones requires special consideration. Deficits greater than 5 cm necessitate the use of femoral cortical strut onlay (FCSO) allograft.[6] This is due to the decreased vascularity of autogenous bone graft and has been found to have increased union failure rates.[6] Furthermore, multiple reoperations of non-unions have been correlated with increased complications and failure rates of 68%, increasing the risk of amputation.[7]

In the present case study, a variety of factors were taken into consideration. These factors, many of which have been previously mentioned, include graft size, structure, nonunion rate, resection of failed fusion, as well as multiple operations. Due to the nature of this case, it was determined that the patient had a severe limb-threatening condition which required significant perioperative consideration

Case Study

Patient is a 63 year old male with significant past medical history of smoking one half PPD for 10 year, who presents with history of a midshaft trans tibia and fibula fracture sustained from a farming accident two years ago. Patient initially underwent Intermedullary nailing of the tibia by another provider, however developed a non union to the anterior aspect of the fracture site of the tibia.

Patient then sought a second opinion where removal of IM nail and debridement of non union with application of internal fixation of plate and screws was elected. Throughout this postoperative course, the patient went back to the OR twice for hardware removal and additional debridement of continued non union with cancellous bone graft. The patient did experience soft tissue envelope wound complications and was treated with a partial thickness skin graft, concluding his history of five prior right lower extremity surgeries.

At this time, the patient presented for a third opinion due to continued right leg pain and inability to ambulate on his right leg.

Figure 1. Resection of anterior tibial nonunion through utilization of a cortical window

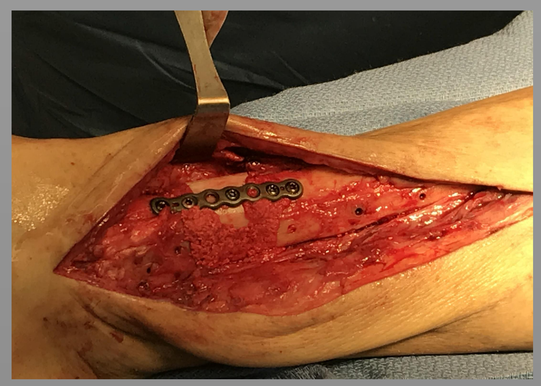

Figure 2. Application of Femoral Cortical Strut Onlay Allograft in conjunction with bone marrow aspirate, cancellous bone chips and highly-porous calcium phosphate

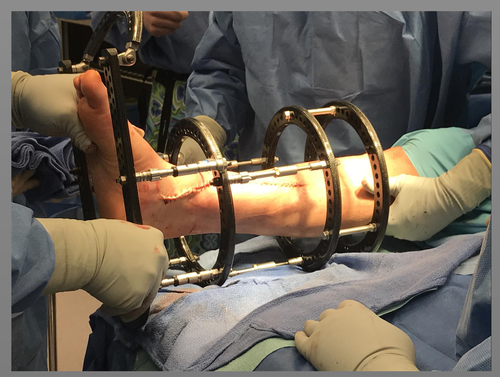

Figure 3. Application of external fixator for additional stability for FCSO graft incorporation.

Figure 4. Radiograph demonstrating FCSO graft incorporation at 12 weeks postoperatively.

Case Study (Cont'd)

Physical exam showed a notable antalgic gait with, induration of the soft tissue envelope corresponding to previous surgical incisions. Discussion surgical treatment option with patient including obtaining a CT for surgical planning, removal of hardware, cortical-windowing and resection of the tibial nonunion with placement of a cryopreserved femoral cortical strut allograft, internal fixation, and external fixation. **[Fig 1-4]** Patient agreed and elected to proceed with surgery.

Patient presented at initial follow one week later with minimal discomfort at pin sites. No acute signs of infection noted to pin sites or incisions. Postoperative follow up was regimented every 2 weeks with radiographs taken every other visit. At the 4th week follow up, skin staples were removed with no acute wound dehiscence's or signs of infection present. Patient continued to experience an unremarkable postoperative course until week 10 where he suffered a fall.

Case Study (Cont'd)

Radiographs were obtained demonstrating FCSO graft incorporation without deformity of the tibia. The external fixator was subsequently remove and remained non weight bearing to the right lower extremity with application of posterior splint. At 14 weeks, the patient was placed into a CAM boot and physical therapy was then initiated three times a week for 6 weeks with progressive weight bearing. At six month follow up, patient was able to bear full weight and return to daily activities. Patient continued with physical therapy monthly for improvements in proprioception and musculoskeletal strength. At one year follow up, radiographic studies demonstrating complete graft incorporation with resolution of the tibial nonunion and patient was ambulating without complication.

Discussion

Cortical strut allografting has been described throughout the orthopedic literature, particularly in the presence of periprosthetic femoral fractures.[8] Cortical strut allografts is indicated when segmental cortical bone loss greater than 5 cm is present in the diaphyseal region of long bones. When utilized as an onlay graft, the cortical strut allograft secondarily acts as a biological plate while providing osteoinductive and osteoconductive properties.[8-9]

In the presence of tibial non-unions of the tibia secondary to traumatic injuries, a two staged procedure is usually indicated. The first stage includes radical debridement of the devitalized bone with implantation of a polymethylmethacrylate (PMMA) spacer.[6] At 6-8 weeks, the second stage includes morselized autografting in conjunction with the FCSO allograft. This two stage technique, described by Masquelet & Buegge (2010), found utilization of the PMMA spacer allows for the formation of a foreign-induced membrane allowing for decreased reabsorption of the cancellous bone, increase vascularity, and increased presence of VEGF, TGF-β, and BMP-2 growth factors, and increased formation of mesenchymal stem cells to osteoblasts, thus leading to more favorable outcomes.[6]

The present study demonstrates the use of a FCSO in the management of traumatic tibial aseptic nonunion revision was performed. In the presence of a revision, foreign implantable material has typically been utilized where formation of membrane has been achieved. Further study to evaluate the effectiveness of the foreign-body induced membrane secondary to prior implants in revisional surgery should be performed. The authors present a case study demonstrating utilization of a FCSO allograft technique as a single-staged procedure.

Conclusion

FCSO grafting is often utilized when significant osseous defects are present with previous publications describing techniques in the femur secondary to failed arthroplasty or malignancies. The authors present a case study with surgical technique for performing a revision of a tibial nonunion utilizing a FCSO technique.

References

1 Tzioupis C, Giannoudis PV. Prevalence of long-bone non-unions. Injury 38 Suppl 2:S3-9, 2007
2 Court-Brown CM, Caesar B. Epidemiology of adult fractures: A review. Injury 37:691-697, 2006
3 Megas P. Classification of non-union. Injury 36 Suppl 4:S30-7, 2005
4 Delloye C, Cornu O, Druez V, Barbier O. Bone allografts: What they can offer and what they cannot. J Bone Joint Surg Br 89:574-579, 2007
5 Vander Griend RA. The effect of internal fixation on the healing of large allografts. J Bone Joint Surg Am 76:657-663, 1994
6 Masquelet AC, Begue T. The concept of induced membrane for reconstruction of long bone defects. Orthop Clin North Am 41:27-37; table of contents, 2010
7 Egol KA, Bechtel C, Spitzer AB, Rybak L, Walsh M, Davidovitch R. Treatment of long bone nonunions: factors affecting healing. Bull NYU Hosp Jt Dis 70:224-231, 2012
8 Judas F, Saavedra MJ, Mendes AF, Dias R. Cortical strut allografting in reconstructive orthopaedic surgery. Acta Reumatol Port 36:24-28, 2011
9 Mauffrey C, Hake ME, Chadayammuri V, Masquelet AC. Reconstruction of Long Bone Infections Using the Induced Membrane Technique: Tips and Tricks. J Orthop Trauma 30:e188-93, 2016