Titanium Induced Foreign Body Giant Cell Reaction Following a Pantalar Arthrodesis and Lateral Calcaneal Sliding Osteotomy

Garrett B. Nguyen1, Ryan J. Lerch2, Stephen L. Smith1, Reisha R. Banzon1
1PMS-II, Midwestern University, Arizona School of Podiatric Medicine

Statement and Purpose
Abnormal immune responses to metallic implant surfaces, such as cobalt, chromium, and nickel, can lead to detrimental health outcomes for patients. Metallic hypersensitivities have directed surgeons to choose more inert materials, such as titanium. Although the incidence of hypersensitivity reactions to titanium and its associated complications seem to be frequently associated with hip arthroplasty, recent reports demonstrate a potentially self-limiting FBR to titanium implants used in ankle arthrodesis.

Literature Review
Composed of macrophages, a FBR is an abnormal immune response during inflammation, and involves the biologic implantation of all biological materials, including titanium. In the presence of arthrodesis, may cause injury to the surrounding cancellous tissue. Associated complications with the use of titanium include inflammation, osteolysis, and metal and nonmetal ions. Metal cell degeneration releases histamine, interleukin (IL)-4, and interleukin (IL)-10, which further promote phagocyte recruitment to the implant. Planes and thickness present around the implant also participate in macrophage recruitment by releasing various chemokine signals, including pro-inflammatory chemokines IL-6 and IL-12.

Case Study
Patient history: A 67-year-old male presented with a chronic ulcer on the right 5th toe for the past 2 years. Past medical history indicates previous bilateral bilateral tibiotalar, tarsal, and calcaneo navicular joint fusions approximately 10 years ago. The patient has a history of Charcot-Marie-Tooth Disease which caused his right foot to shift to a fixed cavo varus position with slight rightward in the subtalar joint. The patient was treated conservatively with a custom brace for 2 years. Partial pressure measurements were obtained at 80 mmHg, below the ankle, and 120 mmHg, above the ankle. Pressure outside the ankle and foot would remain within the normal range. This resulted in an ulcer that failed to heal for 4 years. Surgical intervention was attempted for his chronic instability in conjunction with the various rammifications and ankle joint arthropathy.

Procedure: On 4/13/2015, the patient underwent reconstructive surgery. Significant hypertrophic bone to the dorsal fibula and lateral wall of the calcaneus was removed. Varus correction was achieved through reduction of the arthritic surface from the talus dome, calcaneal plafond, and medial malleolus. The malleoli were fenestrated bilaterally with a 2.5 mm drill bit and microfractured with a 1.4 mm osteotome. The foot was reduced out of varus and placed into a 90° degree surgical position and adequate reduction was confirmed via fluoroscopy. However, the calcaneal side was deemed necessary due to considerable varus remaining at the level of the calcaneal tuberosity. After osteotomy the posterior tuberosity of the calcaneus was transected laterally approximately 1 cm and fitted with a titanium 5-hole revision compression (MC II) screw; left-lateral fluoroscopy confirmed adequate lateral takedown. A tibial plate was inserted interosseal across the ankle joint and fixed with 5 proximal 4.9 and 2.7 locking-hex locking titanium screws. Proximal to the tibia, a screw (21 mm 4.7) CMC screw was angled from the medial tubia, across the ankle joint, and extending centrally and anteromedially into the navicular bone. Adequate compression was achieved by fluoroscopy. (Figures 3 and 7) All graft bone paty, consisting of debrided matrix with crushed cancellous particles, was injected in the gap to achieve proper bone apposition. The Achilles tendon was lengthened approximately 1 cm using a posterior incision. Bone was added to the lateral aspect of the calcaneal and dorsal fibula to create 27° hypertrophic osteosynthesis. Deep closure was obtained using 2-0 Vicryl, subcutaneous using 3-0 Vicryl, and skin closure using 4-0 nylon. A dry sterile dressing and posterior splint were applied.

Results: No infection was noted following post-surgical follow up and incisions showed minimal swelling and/or scabbing. The closure site on the right lateral malleolus displayed no edema, erythema, or purpura from the wound. Following range of motion examination showing no signs of eczema, instability, or deformity, the patient was placed back into a posterior plaster and shoe brace. Tendon testing was performed approximately 1 week post-op. At approximately 2 weeks post-op, increased edema to the foot and ankle resulted in dorsal distal paresthesia. Radiographic evaluation at 5 weeks post-op confirmed proper anatomic surgical alignment to the fusion osteotomy sites, and the hardware was not displaced with a weight-bearing gait. At 6 weeks post-op, the patient was placed in a full weight-bearing, non-weight-bearing range of motion exercises. Physical examination demonstrated puressure ulceration on the ankle and the ankle itself was stable. However, the ankle was slightly tender to palpation, but no signs of infection were noted. Imaging was obtained 1 day post-op and no evidence of infection was demonstrated. The ulcer continued to be monitored and was noted to improve over the ensuing weeks.

Clinical photographs
Figure 3. Conical CT: ventral hypertrophic osteosynthesis with percutaneous screw.
Figure 4. Sagittal CT: fixed interosseal osteotomy with 5 proximal 4.9 and 2.7 locking-hex locking titanium screws.
Figure 5. Medial calcaneus, 1 cm incision for the ankle joint arthrodesis.
Figure 6. Patellar tendon and extensor mechanism.
Figure 7. Arthroscopy showing intact cartilage.

Operative slides
Figure 8. Incision.
Figure 9. Medial incision used to perform ankle joint arthrodesis.
Figure 10. Bone graft, Vicryl, sutures, edema.
Figure 11. Incision.

Figure 12. Incision.
Figure 13. Incision.

Discussion
Research shows that titanium ions are capable of binding to native protein forming several different antigenic epitopes, which can then elicit anti metal and metalloprotein reactions, as well as to establish the Type IV hypersensitivity reaction. This Type IV hypersensitivity reaction has been shown in macular irritation from a few days to years after contact with alloys.1 One case study discussed a FBR to titanium implants following hip arthroplasty, with additional granulomatous reactions in the liver, spleen and local lymph nodes.29 Parhetsymetrical evaluation of metal allergies using skin patch testing, however, reliability is controversial as positive results are infrequent and the test is only 70% sensitive.30 (Figure 1) Serum lymphoblastic transformation can be used as an alternative to skin patch testing because lymphoblastic transformation test are more sensitive than patch tests, and may have less specificity.31 Despite persistently negative skin patch testing, the postoperative lymphoblastic transformation test demonstrated marked proliferation in response to titanium.

Analysis and Discussion
Although approximately 10-mg fragments of the patient’s skin patch test was negative for nickel, chromium, potassium, copper, molybdenum, manganese, and titanium, however, the test did not include other Ti-based compounds, aluminum (Al), molybdenum (Mo), and tantalum (Ta), which are unaccounted for. Mostard, et al studied the molecular composition of surgical TiAlV implants.48 For the commercial implants, they reported a greater surface aluminum content compared to bulk material.49 Although the implant is within guidelines for bulk percent composition, 12% surface concentration is greater than 10% as defined by the ASTM standard.

Complications regarding debridement and cancellous bone matrix particles should also be considered. Although contraindicated, some circumstances support the use of a multidisciplinary giant cell reaction towards demonstrated bone matrix used in a non-inflammation model.50 This study noted that cortical bone, instead of cancellous, was integrated in the bone matrix. Differences in the bone graft composition between their study and our case report therefore limits the ability to correlate the bone graft or a non-inflammatory agent.51 CT imaging at both 3 and 6 months post-surgery excelled in detecting bone alteration and altered biomechanics as possible cause of impaired healing. Before surgery, a non-weight-bearing bone scan confirmed arthritis in the shoulder, hip, elbow, and knee, which was subsequently confirmed with post-operative imaging. Treatment of this case report is currently determined to be limited, as the patient is not able to receive both arthroplasty and a distal femoral revision.

References