SUBTALAR FUSION WITH ILIAC BONE FREE FLAP AFTER A RECALCITRANT NONUNION: REPORT OF TWO CASES

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Fractures of the calcaneus are associated with secondary osteoarthritis of the subtalar joint. In a persistent nonunion, vascularized bone flaps offer superior biologic and mechanical properties as well as accelerates joint fusion and decreases morbidity. In this report, we present results of the use of vascularized iliac bone free flap for treating subtalar failed fusions in two patients. Two patients sustained calcaneal fractures due to foot trauma, which were initially or subsequently treated with subtalar arthrodesis. Case one developed septic subtalar nonunion during treatment and case two failed three attempts at subtalar arthrodeses. The iliac crest bone flap harvested measured 4 × 4 cm (case one) and 3 × 3 cm (case two). The flap was pedicled by the deep circumflex iliac artery, which was anastomosed to the anterior tibial artery at the recipient site. No flap donor or recipient site complications occurred. Fusion was confirmed on CT scan and weight bearing was initiated at 5–6 months. At latest follow up (1–2 years), no complications occurred. Our results show that subtalar nonunion treatment with a vascularized iliac bone flap may be feasible and such a reconstruction could be clinically successful. © 2015 Wiley Periodicals, Inc. Microsurgery 00:000–000, 2015.

The calcaneus is the most common tarsal bone fracture with an approximate 2% incidence[1] and the fracture involves the articular surface 70% of the time.[2] Osteoarthritis of the subtalar joint is a frequent complication after intrarticular calcaneus fractures.[3] Subtalar arthrodesis is a common treatment of this sequela but can also be fraught with complications, including nonunion. The rate of nonunion after subtalar fusion has been reported previously from 0 to 43%[4,5] depending on the investigated subpopulation and associated risk factors.[5,6] Identified risk factors for nonunion are diabetes mellitus, smoking, worker's compensation, and omitting bone grafting during surgical technique.[5,7] In studies reporting on complications, wound healing or infection occurred in 19.4%.[8]

Treatment of fusion failures can be extremely challenging, especially when involving infection. Most often, management consists of debridements, antibiotic spacers, and revision subtalar fixation. Main options for bone grafting include nonvascularized or vascularized. Vascularized bone flaps have several advantages. They can lead to a faster union,[9] generally do not undergo resorption, have good mechanical strength and bone induction while also resisting infection.[10,11] With its own intrinsic circulation, bone flaps can also be expected to deliver antibiotics locally.

The idea of utilizing iliac bone blocks as part of composite flaps from groin donor sites was first described in anatomical studies by Taylor et al in 1979.[12,13] In this article, we report two cases of failed subtalar nonunions which were treated with a vascularized free iliac crest bone flap.

SURGICAL TECHNIQUE

A lateral submalleolar approach was utilized to fully expose the talo-calcaneal articulation, which was debrided and prepared for the bone flap. Within the subtalar region, a burr was used to create space for the vascular pedicle without compression by shaping the superior edge of the defect which corresponded to the caudal aspect of the talar bone. Then, we performed an anterior approach through the extensor retinaculum for localization and dissection of anterior tibial vascular bundle.

A free iliac crest bone flap was harvested from the contralateral iliac bone measuring the desired bony defect. We used a curvilinear incision that followed the shape of the iliac crest, approximately a finger breadth superior to the inguinal ligament. The vascular pedicle compromised the deep circumflex iliac artery arising from the posterior-lateral aspect of the external iliac artery. This was found superficial to the inguinal ligament running in parallel with this inguinal ligament. An osteotome was used to create a tricortical bone cut in the iliac crest. Under fluoroscopic control, the bone portion of the flap was fixated to the calcaneus and talus with two cannulated titanium compression screws (Acutrak®), resembling a subtalar arthrodesis construct. End-to-end anastomoses were performed between the flap vessels (deep circumflex iliac

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Figure 1. Left: Lateral foot radiograph showing example of the Vira® system, a minimally invasive primary subtalar arthrodesis implant used in treatment of calcaneus fractures. ***Right****: AP and lateral radiograph showed subtalar nonunion present after primary arthrodesis treatment with the Vira® system (cannulated screws removed due to pain).*

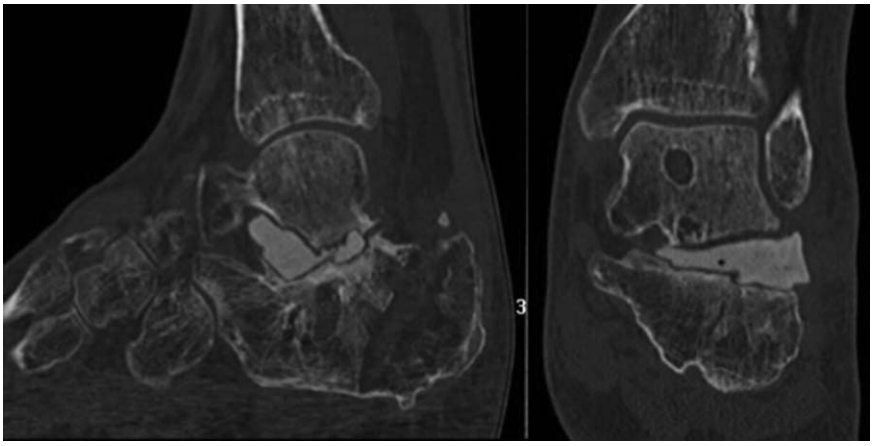

Figure 2. CT scan sagittal ***(left)*** *and coronal* ***(right)*** *images showed antiobiotic-impregnated PMMA bone cement placed within the subtalar space after debridement for infection.*

artery) and the anterior tibial artery as well as one venous anastomosis to the venae concomitant of the artery.

The flap was monitored with a Doppler probe placed over the pedicle hourly for the first 24 hours, every 2 hours for the subsequent two days and then every 8 hours until discharge.

Case 1

Thirty-four year old male with subtalar septic nonunion, following primary arthrodesis of an acute intra-articular calcaneus fracture obtained after fall from height.

The patient was referred to our service, two years postoperatively, with persistently elevated complement-reactive protein levels and productive fistula. At another medical facility, his fracture initially was stabilized with the Vira® system,[14] and was partially removed after one year for pain thought to be secondary to hardware irritation (Fig. 1). His pain continued due to subtalar nonunion and was treated with revision of subtalar arthrodesis using staples and autologous nonvascularized iliac crest bone graft. This construct subsequently became infected and was treated with hardware removal and multiple debridements prior to referral to our service.

Our two-stage operative treatment included a thorough debridement and implantation of antibiotic-impregnated polymethylmethacrylate (PMMA) bone cement to fill the defect (Fig. 2) in addition to long term antibiotics. After six months, there were no clinical or laboratory signs of infection and we performed the second reconstruction stage with an iliac bone free flap which measured 4x4 cm (Fig. 3). During our procedure, after cement removal, cultures were taken that had detected no further organisms.

No anastomosis or donor site complications occurred. The patient was maintained in a posterior below-knee splint with neutral ankle position for 5 weeks. After five weeks, the patient was allowed progressive passive and active movement of the ankle. He began partial weight-bearing with crutches ten weeks postoperatively and progressed to full weightbearing at six months.

At the latest two year follow up, the patient had shown increasing features of radiographic bony union

and no recurrence of infection or wound healing problem. Imaging showed successful subtalar arthrodesis on radiograph and computed tomography (CT) scan (Fig. 4). The patient was pain free without limp or limitation of daily activities. Ankle range of ankle motion measured 20 degrees dorsiflexion and 30° plantar flexion.

Case 2

Fifty-year-old man with failure of three subtalar arthrodesis procedures, following conservative management of an intra-articular calcaneal fracture after foot trauma.

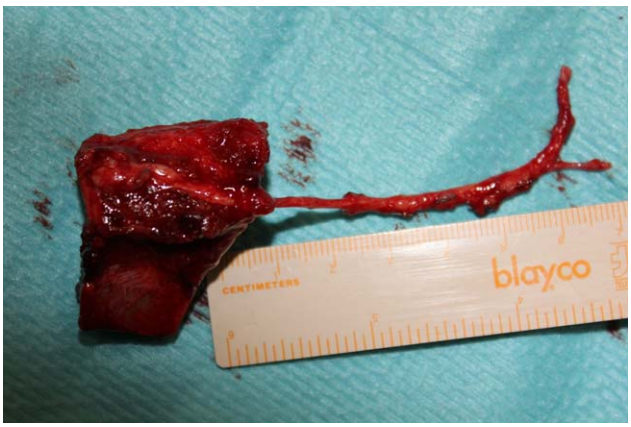

Figure 3. Photograph of the harvested iliac corticoperiosteal flap with pedicle that measured ~6 cm. The vascular pedicle compromised the deep circumflex iliac artery arising from the posterior-lateral aspect of the external iliac artery.

Initially, to treat his post traumatic arthritis he underwent subtalar arthrodesis with a Vira® System. A CT scan revealed partial talo-calcaneal arthrodesis with bridging bone <20% (Fig. 5). The patient then underwent removal of hardware, posterior ankle arthroscopy with debridement and tibio-talar-subtalar arthrodesis with two Acutrak® screws. A new CT scan demonstrated full tibio-talar union and incomplete union of the posterior subtalar joint. The patient was treated with debridement, removal of hardware and subtalar fusion using nonvascularized iliac crest bone graft with screw fixation. CT scan after his third procedure continued to reveal nonunion of posterior subtalar joint. At this time in treatment, we performed a subtalar arthrodesis with free iliac crest bone flap that measured 3 × 3 cm.

No anastomosis or donor site complications occurred. The patient was maintained in a posterior below-knee splint with neutral ankle position for 4 weeks. After 4 weeks, the patient began progressive passive and active movement of the ankle. Partial weight bearing was initiated two months after surgery and full weight bearing at five months.

At the latest one year follow up, the patient had obtained successful subtalar arthrodesis with prior tibiotalar arthrodesis. The patient was pain free without limp or limitation of daily activities. Radiographic evidence of solid fusion was noted five months postoperatively and

*Figure 4. AP **(far left)** and lateral **(left)** ankle radiographs six months postoperative from iliac bone flap showed bony integration of the bone flap. Two cannulated titanium compression screws (Acutrak®) were used for fixation. CT scan images of coronal **(top right)**, axial **(far right),** and sagittal **(bottom right)** views 8 months after free iliac crest bone flap for subtalar nonunion showing fusion.*

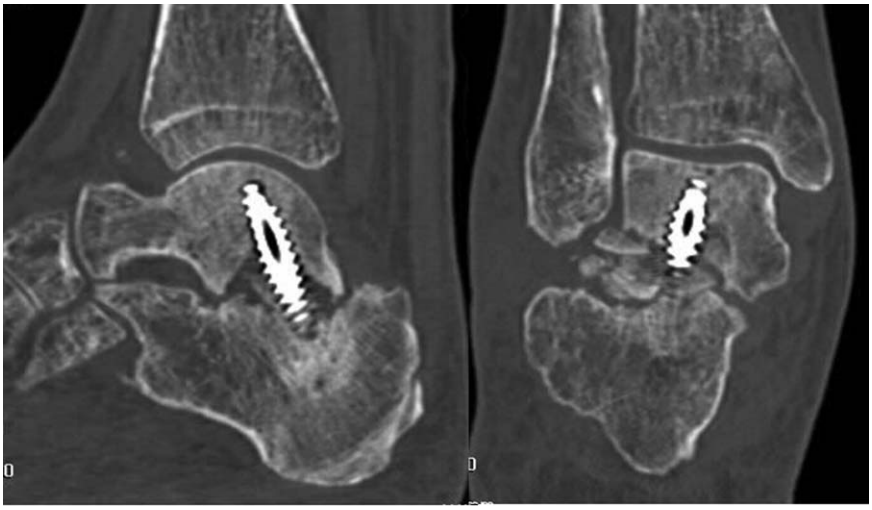

*Figure 5. CT scan images of sagittal **(left)** and coronal **(right)** views showed subtalar nonunion after subtalar arthrodesis for treatment of post-traumatic arthritis after intrarticular calcaneal fracture.*

*Figure 6. Lateral radiograph **(left)** and sagittal CT scan **(right)** image showed bony union 5 months postoperatively after subtalar arthrodesis with free iliac crest bone flap and screw fixation.*

CT scan evaluation showed subtalar arthrodesis union [mt]60% (Fig. 6).

DISCUSSION

It is common to use nonvascularized bone graft during treatment of subtalar nonunion. However, success has been reported in the literature for treatment of failed arthrodeses with vascularized corticoperiosteal medial femoral condyle free flaps.[15–19] In recent microsurgical literature, the vascularized fibula free flap has been used for treatment of calcaneal defects due to infection after fracture.[20,21] The fibula flap is useful for larger defect areas, but consequently can result in increased donor site morbidity including peroneal neuralgia, motor deficits of the great toe, persistent pain, and ankle instability.[22] No studies have compared the mechanical properties of vascularized bone flaps; however, one can assume an advantage of multicortical structure in providing increased strength. An iliac crest bone flap has an added advantage of abundant cancellous bone to allow optimum healing for bony fusions.

Various studies have demonstrated that vascularized bone grafts in orthopaedic and foot reconstructive surgery offer superior biologic and mechanical properties over non-vascular bone grafts as well as accelerating joint fusion and decreasing morbidity.[23–30] With a vascular supply, cell viability is maintained and less creeping substitution occurs into necrotic areas during the healing process. The bone flap provides osteoinductive, osteoconductive, and osteoprogenitor elements. This environment promotes primary bone healing instead of graft remodelling via revascularization, osteoclast resorption, and production of reactive bone.[26] Using the osteogenic and vasculogenic properties of a periosteal graft, Soldado et al. was able to promote bone vascularization of talar

dome avascular necrosis.[27] Structural integrity is also maintained with diminished bone remodelling. Vascularized grafts also sustain near normal cortical osteocyte viability[31] and increased bone mass with diminished osteopenia after transfer, compared with nonvascular counterparts.[32] In previously infected recipient sites, they also supply important host defense mechanisms and antibiotic delivery.

Successful vascularized bone grafts may be harvested from a variety of locations. In 1979, Taylor et al described transferring iliac bone blocks from donor groin sites within a composite flap.[12,13] The iliac crest provides a generous amount of cortical and cancellous bone and has been frequently utilized for conventional bone grafts as well as vascularized bone flaps. The deep circumflex iliac vessels comprise the vascular pedicle of the iliac crest flap and generally demonstrate consistent anatomy, practical length, and appropriate vessel diameter for microsurgical application. The average length of the pedicle is 5–6 cm, with diameter averaging 2.0 mm.[33] Recent literature measuring the harvestable amount of iliac crest for vascularized bone flaps determined the overall length of the crest as the distance from the anterior to posterior superior iliac spine averaged 24.75 cm with a range from 21.95 to 27.36 cm.[34] However, they cautioned surgeons on an extremely thin region, termed the oval region, in the posterior medial region of the iliac crest, which would be unsuitable for bony defects necessitating mechanical support.

In our opinion, the iliac crest is the best choice because of low morbidity rate at the donor site. More importantly, it enables the surgeon to adequately shape the graft to fit the subtalar space while also using the crest as the weight bearing surface. The iliac crest flap supplies a robust bone stock and, if necessary, an osteofasciocutaneous flap can also be harvested from this anatomical site, making it possible to reconstruct skin and soft tissue defects.[12–14,33] In our patients, a fasciocutaneous portion was not harvested as no skin soft tissue defect was present.

Our results show that the subtalar nonunion treatment with a vascularized iliac bone flap may be feasible and such a reconstruction could be clinically successful.

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