Clinical Case Report

Surgical Treatment of Avascular Necrosis of the Body of the Talus with a Patient Specific Additive Manufactured Implant.

Mr Mark Davies
BM FRCS (Tr & Orth)
Consultant Orthopaedic Foot and Ankle Surgeon – Sheffield, UK.
The introduction of additive manufacturing techniques into the design and production of orthopaedic implants has increased the options available to patients presenting with significant osseous defects. Customised patient specific implants can be designed for clinical situations where existing implants and techniques may not adequately accommodate these abnormalities. Moreover, the highly porous titanium structures, which additive manufacturing generates, facilitates the use of bone graft materials within the body of the defect filling device.

The case history below illustrates the use of a custom additive manufactured cage as an interpositional spacer, in combination with a hindfoot nail, to facilitate fusion of the ankle and subtalar joints.

Case History

In the spring of 2016, a 57-year old male presented with a 9-month history of unremitting pain in his left ankle. All weight-bearing activity exacerbated his pain and for four months he had interrupted sleep because of his symptoms. As a result of his pain, he had been declared unfit to work as his managerial role required him to walk over 5 miles per day.

There was no history of preceding injury to his ankle and direct questioning about his general health revealed him to be entirely fit and well with no risk factors for avascular necrosis of the talus. Examination revealed swollen hindfoot with stiffness and irritability within both the ankle and subtalar joints but good soft tissue integumen and normal neurovascular assessment. There was no significant deformity in the sagittal or coronal plane.

Plain standing radiographs revealed dense, sclerotic appearances to the body of his left talus with collapse. Both the ankle and subtalar joints were noted to be incongruent (Figures 1 & 2).

From the plain radiographs alone, it was clear that the diagnosis was avascular necrosis of the body of the talus. The patient was not keen to try further non-operative measures such as stronger analgesics and a rigid ankle-foot orthosis and was keen to discuss surgical options for treatment.
Further imaging was required to define the extent of the pathology and to guide treatment. CT and MRI imaging was requested including contralateral CT views of the unaffected hindfoot in case of planning for a 4WEB custom implant.

CT imaging revealed the true extent of collapse of the body of the talus and MRI was reassuring in determining that the head and neck of the talus were viable and vascularised (Figures 3 & 4).

The following reconstructive treatment options were then discussed:

1. Denuding the ankle and subtalar joints of articular cartilage and performing a tibio-talo-calcaneal fusion.
2. Excision of the body of the talus and tibio-calcaneal fusion with a hindfoot nail.
3. Excision of the body of the talus and tibio-calcaneal fusion and leg length restoration with an Ilizarov frame.
4. Excision of the body of the talus, femoral head bulk allograft and fusion with a hindfoot nail.
5. Excision of the body of the talus, off-the-shelf interposed metal spacer and fusion with a hindfoot nail.
6. Excision of the body of the talus, customised interposition implant and fusion with a hindfoot nail.

Of the many pros and cons with each treatment modality, in my opinion, it is difficult to achieve pain-free union in such extensive avascular necrosis using treatment option 1. Treatment option 2 has one significant disadvantage of loss of limb length. This disadvantage is addressed with option 3 but this is a lengthy treatment fraught with the issues of the patient tolerating a lengthening fine wire frame incorporating the foot. Option 4 maintains limb length but does have the risk of collapse of the allograft once re-vascularised. Option 5 means resecting the pathology to fit the shape of the metallic interpositional implant which often requires resecting healthy bone and retaining some avascular bone. After discussion with the patient, the final treatment option was agreed in order to maintain limb length, allow a complete resection of the necrotic tissue and provide a robust structure preventing late collapse.

DICOM versions of the CT images are then used by 4WEB to generate a web-based meeting between the surgeon and the designers. During this meeting, the implant is designed accounting for surgical approach, the zone of pathology and the method of fixation.

A specific 4WEB truss shape was designed to replace the avascular body of the talus (Figure 5). From a lateral view, it is wedge shaped with the tibial surface perpendicular to the mechanical axis of the tibia, the posterior wedge articulating with the posterior facet of the calcaneus and the anterior wedge articulating with the remaining talar neck. The truss design incorporates a central cannulation to allow passage of the OrthoSolutions Oxbridge nail. The nail provides two components to the final construct fixation: rotational stability with locking bolts in the tibia and calcaneus and compression with application of the proximal bolts appropriately in the oval holes within the nail. In addition, the implant allowed the viable head of the talus to be compressed by application of a 4mm lagged screw through the lateral aspect of the 4WEB truss. (Figures 6 & 7).
Mr Mark Davies

Figure 5
The definitive 4WEB PSI implant. The titanium 3D truss structure and open porosity is clearly visible.

Figures 6
DICOM model of anatomy showing suggested resection levels of diseased bone and implant shape.

Figure 7
DICOM model showing implant design incorporating central cannulation for a hindfoot nail and a cannulation for the use of a 4mm lag screw laterally.

Surgical Approach

The implant was designed to be implanted through a lateral approach, utilising a distal fibula osteotomy and retaining the superficial component of the fibula as a vascularised strut. This is a similar technique to the RAF ankle fusion and permits a full view of the diseased talus, allowing straightforward resection of the necrotic talus and the superficial portion of the distal fibula encase the lateral aspect of the 4WEB truss. In the first step, using the intra-operative plastic model as a guide, the talar body was resected by performing an osteotomy across the neck of the talus (Figure 8). K-wires and fluoroscopy were used to determine the optimal position of this osteotomy. The body of the talus was then resected piecemeal much like performing a trapeziectomy! Once this has been achieved, the next step was to create the bone cuts in the tibial plafond. Again, the model, K-wires and fluoroscopy are useful in making these cuts accurately. Finally, the articular surface was denuded from the posterior facet of the calcaneus.

Figure 8
The 3D model provided with the 4WEB truss to guide the osteotomies.

At this stage, the plastic trials can be used to make sure the bone cuts are satisfactory and that the implant is seated well in the defect (Figure 9). It is very important to make sure that the foot is plantigrade and that no equinus has been inadvertently dialled into the foot position by the bone cuts. Once this had been achieved, preparations for implantation were undertaken. This involved the usual, logical steps for insertion of a hindfoot nail: establishing the nail entry point in the calcaneus, passing a guide wire and preparing the calcaneus and shaft of the tibia with reamers. These steps were undertaken using the selected plastic trial in situ as this stabilised the foot and ankle.
Clinical Case Report

Figure 9
Intra-operative picture showing the plastic trial in situ, and preparations underway for insertion of the Oxbridge nail. Note that the foot is in a plantigrade position.

Figure 10
Cage filled with autograft.

Figure 11
The 4WEB truss in situ prior to the vascularised fibula being reduced

Prior to implantation, the interstices of the truss were filled with autograft that had been finely milled in a bone mill (Figure 10). The autograft was sourced from the reamings and the ipsilateral iliac crest. In some instances, the deep portion of the fibula provides sufficient volume to fill the voids in the truss. The implant was then reduced into position and the intramedullary guide wire passed across the implant and into the tibia (Figure 11). The nail was inserted and locked dynamically in the tibia and statically in the calcaneus.

Post Operative Follow Up

Post-operatively, the leg was rested in a cast for 6 weeks without permitting any weight-bearing. Appropriate thromboprophylaxis was administered during this time. The wounds were checked at 2 weeks and at 6 weeks the patient was allowed to commence bearing weight in a walking boot. The patient was seen in clinic with regular clinical and radiographic assessments. At 30 months of follow-up, he is free from pain and back at work doing his original job and enjoys walking up to 12 miles at a time through the terrain of the Lake District. Other than using CT, radiographically there was no way of assessing for implant incorporation, but this was deemed unnecessary given the clinical success of the case. However, final radiographs simply shown that the hindfoot remains well aligned with no evidence of collapse (Figures 12, 13 & 14).
Figures 12, 13 & 14
Standing AP and lateral radiographs of the ankle and a DP radiograph of the foot at 18 months after surgery. The construct has clearly dynamised as evidenced by the broken calcaneal screw but all other features suggest that the implant has incorporated. Note the screw lagging the head of the talus to the truss and the lagged screws engaging the superficial fibula against the lateral wall of the truss.
The results outlined in this case study are for a custom implant and are specific to the individual patient only. Individual results and activity levels after surgery vary and depend on many factors including age, weight, and prior activity level.

OrthoSolutions is the exclusive distributor for the 4WEB Custom Cage in the UK & Ireland