The objective of the current study was to test the hypothesis that blade plate fixation would provide a stiffer and more fatigue resistant fixation than intramedullary rod fixation for tibiotalocalcaneal fusion.

Materials and Methods

Ten matched pairs of frozen cadaver lower limbs transected at the mid-tibia and transverse tarsal joint were stripped of soft tissues. The bone mineral density of the posterior calcaneus of each specimen was determined by dual energy x-ray absorptiometry (DEXA) using a QDW-1000/W scanner (Hologic, Bedford, MA). These data were used to correlate stiffness and final deformation with bone density.

In one limb from each pair, the tibia, talus, and calcaneus were rigidly fixed with an intramedullary rod (Ace/DePuy, Warsaw, IN). The articular surface was left intact and the specimen instrumented as if an in-situ fusion was being performed. In all cases a 12-millimeter x 15-centimeter rod was used. The tunnel for the rod was sequentially reamed in 0.5 millimeter increments to a width of 12.5 millimeters. Proximally, two interlock screws were placed in the tibia, while distally one screw was placed in the talus and another in the calcaneus.

Fixation in the contralateral limb was achieved with a humeral blade plate (Synthes, Paoli, PA). A 95-degree 5-hole plate with a 30-millimeter blade was used in all cases. As in the contralateral specimen, the articular surface was left intact. Distally, a guide was used to position the blade in the dense subchondral bone of the sustentaculum tali. Proximally, two or three 6.5 millimeter cancellous screws were used to fix the plate to the tibia. Another 6.5 millimeter cancellous screw was used to fix the plate to the body of the talus.

The calcaneus from each specimen was secured in a pine box using Kirshner wires and polyester resin. The specimen was mounted on a servohydraulic load frame (MTS Systems, Eden Prairie, MN) allowing dorsiflexion loading through the ankle joint. The specimen was loaded through 250,000 cycles with a maximum force of 260 Newtons at a rate of 3 Hz, with failure being defined as 10 degrees of dorsiflexion. Load and deflection data were recorded during the initial load cycle and subsequently every 1000 cycles. After 250,000 cycles, a second load deflection curve was generated with the specimen being taken from its original position to failure. A Student’s t-test analysis was used to determine if observed differences in the initial stiffness, final stiffness and final deformation were significant. A Pearson’s correlation was used to determine if the measured parameters correlated with the bone mineral density.

Results

Blade plate fixation provided a significantly stiffer construct at initial loading, after fatigue loading for 250,000 cycles, and resulted in significantly less deformation when compared to intramedullary rod fixation (Figures 1 and 2). Pearson’s correlation analysis showed that there was a significant correlation between bone mineral density and the amount of deformation after cyclic loading (0.871 and 0.856 for the rod and plate constructs, respectively).

Discussion

Tibiotalocalcaneal arthrodesis is a technically demanding procedure. Clinical indications for this procedure include Charcot arthropathy, rheumatoid arthritis, neuromuscular disorders, failed ankle arthroplasty, and salvage procedures for posttraumatic arthritis. Several methods of fixation have been described for this procedure, including screws, external fixation, intramedullary fixation, and, most recently, a blade-plate device. Of these devices, biomechanical testing has been performed on both screws and an intramedullary rod. No study has compared the intramedullary rod and blade plate fixation methods in a cyclic loading regime. The plate construct was significantly stiffer than the rod construct at the initial load cycle and after completing 250,000 cycles. The additional stiffness and reduced final deformation after cyclic loading indicate that the plate construct maintains better fixation over time and may lead to increased fusion rates. One limitation of the study is that the healing of the bone surfaces intended for fusion cannot be modelled. However, this limitation was consistent for both methods of fixation and the limitation maintained a “worse case” scenario throughout the duration of the tests.

Conclusions

Blade plate fixation provided a significantly stiffer construct at initial loading, after fatigue loading for 250,000 cycles, and resulted in significantly less deformation when compared to intramedullary rod fixation.

References