A BIOMECHANICAL COMPARISON OF MICROMOTION AFTER ANKLE FUSION USING TWO TECHNIQUES: FIXATION WITH AN IM NAIL OR ILIZAROV EXTERNAL FIXATION

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Introduction

Complex ankle arthrodesis relies upon a solid fusion at a compromised bony interface to provide pain relief, restore joint stability, and realign lower extremity deformity. Popular methods for accomplishing ankle fusion include crossed screws, plate and screws, IM rod, and external fixation. Obtaining a solid fusion can be challenging for those patients who have undergone previous surgery. Traditional methods of internal fixation with screws or plates are less than ideal in these situations.1,2,3,4,5

An IM device is a popular choice in most of these situations both for superior stability and for its less invasive nature. However, the IM technique requires violation of the subtalar joint, the locking bolts may provide inadequate purchase in compromised bone, and IM fixation has a history of infection. The Ilizarov method relies on the use of percutaneously placed narrow wires and half pins. Problems with poor skin, confined soft tissue circulation, and poor bone quality are minimized; quality of bone loss, rigid fixation is obtained, and bone graft is added. No internal hardware is used, making this method ideal for cases of infection or poor wound healing potential. Malalignment can be corrected initially and fine-tuned throughout the course of the treatment.

Though both techniques are clinically popular, few studies exist to establish the relative fixation biomechanically. The purpose of this investigation was to compare the amount of motion at the ankle fusion site using two different methods of fixation: retrograde IM nailing and Ilizarov Taylor Spatial Frame external fixation using a motion capture system to pinpoint the motion between the calcaneal and the tibia.

Methods

Specimen preparation: Eight pairs of human cadaver lower legs (ages 50-75 years old) were thawed and dissected free of all soft tissue except ligamentous tissue. The tibiae were transected at mid-diaphysis, and the proximal portion discarded. Joint surfaces were prepared for fusion identically in all specimens. The ankle was approached laterally; the talar surface was prepared by resecting the proximal 5mm of the talar head. A wire was advanced from medial to lateral across the distal tibia 1cm proximal to the plafond. The wire was placed orthogonal to the tibial shaft, and served as a guide for cutting the tibia. The distal tibia with attached medial malleolus was cut with a power saw and removed. The talar surface was prepared by resecting the proximal 5mm of the talar body using the saw. The extremity was aligned plantargrade, in 10º of external rotation, and 3-5º of hindfoot valgus. The resected joint surfaces were compressed and provisionally fixed with two transcalcaneal k-wires. DEXA scans of the calcaneal were performed to evaluate bone density to see if bone quality would be a factor in the amount of displacement or rotation recorded.

Testing: The proximal portion of the tibia and inferior surface of the foot, including the calcaneal, were potted in epoxy and placed in a biaxial MTS load frame (Fig. 1A). Reflective markers were placed on the specimen above and below the fusion site. Three mechanical tests were performed. First, a sinusoidal cyclic axial compressive load was applied at 0.5Hz from 0-700N. The specimen was then tested in torsion to ±5.0Nm at 0.25Hz with a 700N compressive load. The final test was dorsiflexion (Fig. 1B) at 0.5 Hz between 0-50Nm. The 700N axial compressive load represented body weight. All tests were conducted to 500 cycles to represent motion immediately after surgery.

Optical data were recorded every 100 cycles using a three-camera Qualisys motion capture system for all three tests. The manufacturer’s stated error for the camera configuration used was 0.03mm. Three-dimensional displacements and rotations were calculated across the osteotomy site from the overall motions of each marker. Paired t-tests were used to compare the two fixation types.

Results

No significant difference (p=0.30) was found between the axial displacements for the IM rod group (0.15 ± 0.12mm) and the displacements found for the external fixation group (0.17 ±0.1mm). The average relative rotation for the IM rod group was 0.91º (± 0.71º) while the external fixation group was –0.31º (± 0.33º), again not a significant (p=0.07) difference (Figure 2). There was no correlation between bone mineral density and the amount of displacement or rotation recorded.

Discussion

The concern in ankle fusions is that motion at the fusion site as a result of ambulation in the early post operative period may lead to nonunion. Too much motion at the fusion site will prevent healing. How much motion is allowable or even advantageous is still unknown, but motions less than 100 – 150 microns (such as were found in this study) are thought to be within the allowable range. The two common modes of fixation did not significantly differ from one another, providing comparable stability at the level of the fusion. Thus, the choice of fixation can be made based on clinical indications without biomechanical concern.

Motion was measured directly at the fusion site between the tibial and calcaneal surfaces using an optical system. This approach provides a direct benefit over those employing global displacement measurements that include extraneous displacements occurring in the grips far away from the fracture or osteotomy site. Similarly, displacement measurements across the site provide more meaningful information than stiffness measurements of fixation, from which displacements can only be inferred.

References


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Figure 1 A. Axial and torsion testing set-up B. Dorsiflexion set-up

References