Statement of Purpose

Ankle arthrodesis is a standard treatment for end-stage arthritis and deformity of the ankle joint. It restores function, provides a stable, well-aligned, pain-free joint(1,2).

Methods and Hypothesis

Recent developments in plating technology have presented new options for fixation; however, studies comparing the various forms of locking plate fixation are few. Furthermore, no studies are available that compare the use of locking plates with and without interfragmentary screws.

Methodology and Hypothesis

Testing was performed on full-scale anatomic models consisting of fourth-generation composite tibia and talus. This was an experimental design with each of the specimens prepared for ankle fusion and treated with the following conditions: 1. Tripod construct 2. Anterior plate 3. Anterior plate with compression screw 4. Lateral plate 5. Lateral plate with compression screw [See Figure 1]. Each construct had 5 specimens.

Literature Review

Friedman et al(10) evaluated the biomechanical comparison between 2 crossed screws and 2 parallel screws for ankle arthrodesis on cadaveric specimens. They found that the two parallel screws were more rigid in resisting plantarflexion and inversion and that the two crossed screws were more rigid in resisting dorsiflexion and eversion.

Schuurbiers et al(11) described the techniques for fixation using the tripod configuration.

Jang et al(12) evaluated the effect of order of screw insertion within a tripod construct. They found no significant difference in contact area or compression between for initial insertion of medial, lateral, or posterior screw.

Nasson et al(13) evaluated the biomechanical comparison between 2 crossed screws and a blade plate on older generation saw-bone models. Their study found that crossed screws had greater stiffness during dorsiflexion and valgus loading. This was significant because neutral to slight valgus fusion position is desired and dorsiflexion is the main stress during gait.

Procedures

All 25 specimens were tested with a standardized protocol using an Instron 4505 Universal Testing System/Instron, Norwood MA. Tibia were affixed to the load cell, and pulled tendons were bolted to a rod steel carverbeam. This beam was allowed to freely pivot on a fulcrum mounted to the crosshead of the testing machine 12cm from the center of the ankle joint. Two beams were rotated in placing the fulcrum anterior, medial, posterior, and lateral to the arthrodesis site for respective bending in modes of dorsiflexion, inversion, plantarflexion, and eversion (Figure 2). Two trials of each bending mode were performed for each specimen, with the second trial being recorded. Force-displacement data were captured and recorded every 10ms and curves plotted using Bluehill software (Instron, Norwood, MA).

The slope of each curve was used as representation of bending stiffness (Nm/mm). Groups were compared using one-way ANOVA with Tukey post-hoc tests.

Results

Overall testing showed that a plate with a compression screw had significantly greater stiffness than a plate alone, or three compression screws (Graph 1). There was no significant difference between the anterior plate with compression screw or the lateral plate with compression screw (p < 0.05). There was no significant difference between the anterior plate, lateral plate, or three compression screws (p > 0.05).

The greatest dorsiflexion bending stiffness observed was the anterior plate with compression screw. This was 71% greater than the anterior plate alone (Table 1). The greatest plantarflexion bending stiffness observed was anterior plate. This was not significantly different from the anterior plate with compression screw. The greatest inversion bending stiffness observed was lateral plate with compression screw. This was not significantly different from the lateral plate alone. The greatest eversion bending stiffness observed was anterior plate with compression screw. This was not significantly different from the anterior plate with compression screw, but was 76% greater than the lateral plate alone (Table 1).

Analysis and Discussion

Our data shows that the lateral plate with compression screw resisted inversion and eversion the best, the anterior plate with compression screw resisted dorsiflexion and plantarflexion the best, and had the greatest bending stiffness overall. In conclusion, anterior plate with compression screw and lateral plate with compression screw were shown to have the most overall bending stiffness. Plate fixation was shown to have the greatest resistance to bending when placed on the tension side, and bending resistance was significantly improved with the use of a compression screw.

References