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Patterns of Failure in the Distal Radius Following Treatment for Extra-Articular Fractures (AO 23-A3.2) Using Two-Column Volar Plates

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INTRODUCTION

- The distal radius is the most common fracture site in the upper extremity.
- Dorsally displaced, unstable fractures are commonly treated with locked plate fixation using a volar approach.
- Damage analysis of matched paired specimens with simulated AO 23-A3.2 fracture treated with volar plating may provide information on whether implant geometry may affect fracture stability. (Fig. 1)

PURPOSE

- The purpose of our study was to characterize the damage accumulated in a model of extra-articular distal radius fracture with dorsal comminution treated using two-column volar distal radius plates during a simulated post-operative healing period. Patterns of failure of the bone and implant are reported from cyclic testing and ramped load to failure experiments.

METHODS

- Ten matched pairs of fresh-frozen, cadaveric distal radii were used in this study:
  - One radius from each donor was randomized to Group I; the contralateral limb from the same donor assigned to Group II
  - Group I: Prepared with Geminus® volar distal radius plating system by Skeletal Dynamics. (n=10) This implant uses a dual head design for independent two-tier scaffolding. (Fig. 2A)
  - Group II: Prepared with Acu-Loc® 2 Proximal Volar Distal Radius Plate by Acumed. (n=10) This implant uses a single head design for enhanced ulnar buttressing. (Fig. 2B)
- A custom fixture was designed to apply a 60/40 ratio through scaphoid and lunate facets. (Fig. 3A)
- Specimens were subject to cyclic axial loading; sinusoidally compressed from 75-250N at a rate of 1 Hz for 5,000 cycles

RESULTS

- Specimens failed by distal fragment collapse leading to plate bending (Group I n=5/10; Group II n=2/9) and fracture of the lunate facet (Group I n=5/10; Group II n=7/9)

Figure 2: A. Group I radius plated with Geminus® volar distal radius plate from Skeletal Dynamics. B. Group II radius plated with Acu-Loc® 2 proximal volar distal radius plate from Acumed.

- Damage (D), which defines the period between a state of material perfection and the onset of crack initiation, was calculated using the effective Modulus of Elasticity (E) from hysterisis data (Fig. 3B)
  - D = 1 - (E_final / E_initial)
  - where E_initial is calculated at cycle 5;
  - E_final is calculated at every 500th cycle
- Constructs not failed during cyclic loading were subject to a ramped load to failure at 1mm/s
- A matched-paired t-test was used to determine statistical significance (p<0.05)

CONCLUSIONS

- Structural damage, though greater in Group II specimens during low cycle loading, did not significantly affect the ultimate failure force of the bone/implant constructs.
- In order to determine the cause of the low-cycle structural damage to Group I and Group II specimens, a patient-specific computational analysis is underway, developed using pre-study calibrated quantitative computed tomography scans of the bones and solid models of the implants

CLINICAL RELEVANCE

- If a patient is subject to high impact loading of the distal radius (fall on outstretched hand) prior to the end of their post-operative healing period, both implants may provide equivalent resistance to fracture
- Should the post-operative healing period be delayed, it is likely that increasing damage may lead to fracture with Group II implants; high frequency fatigue testing is necessary to confirm

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