3-15-2014

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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Recommended Citation
Christina Salas, Justin Brantley, James Clark, Evan Baldwin, Mahmoud Reda Taha, Deana Mercer. Patterns of failure in the distal radius following treatment for extra-articular fractures (AO 23-A3.2) using two-column volar plates. Poster presented at: ORS 2014 Annual Meeting; Mar 15-18 2014; New Orleans, LA

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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)

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.

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

- 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 ($E_{\text{eff}}$) from hysteresis data (Fig. 3B)
  $D = 1 - \frac{E_{\text{final}}}{E_{\text{initial}}}$ where $E_{\text{initial}}$ is calculated at cycle 5; $E_{\text{final}}$ 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)

- Group II specimens experienced significantly more damage under cyclic loading than Group I specimens. (0.78±0.11 and 0.66±0.10, respectively; p=0.02) (Fig. 4A, Fig. 4B)
- One specimen in Group II experienced coronal fracture of the dorsal pole of the lunate during cyclic loading and was excluded from load to failure testing.
- Group I specimens were significantly stiffer than Group II specimens. (481.47±161.37 N/mm and 337.90±112.04 N/mm, respectively; p=0.04) (Fig. 4C)
- Ultimate force at failure in Group I (1268.50±307.69 N) and Group II (1025.63±496.45 N) specimens was not significantly different (p=0.11) (Fig. 4D)