



Material Properties are Related to Stress fracture Callus and Porosity of Cortical Bone Tissue at Affected and Unaffected Sites

REF: Entwistle R, Sammons S, Bigley R. Material Properties are Related to Stress fracture Callus and Porosity of Cortical Bone Tissue at Affected and Unaffected Sites. Journal of Orthopaedic Research. 2009. 1272-1279.

▼ Key Findings

▼ Scintigraphy and MRI indicate that bone inflammation and edema are present before callus is observed. The extent of functional compromise of parent bone tissue during stress fracture development and resolution is unknown.

▼ Callus formation stages

▼ Stage I: no or minimal (<.5mm) periosteal surface elevation and red brown discoloration comparable with hemorrhage or hyperemia typical of parent cortical surface

▼ Stage II: periosteal new bone of .5-2 mm thick discoloration, and soft rough surface texture typical of woven bone.

▼ Stage III - periosteal new bone >2 mm thick, discoloration, and a firm surface typical of consolidating bone tissue

▼ Stage IV- the callus is fully formed and tolerant to training

▼ **Higher staged callus had lower modulus, yield and ultimate strength open mechanical testing.**

▼ **Porosity was greatest in stage three callus. Stage I and II had greater porosity than stage 0 (control).**

▼ **Porosity accounted for 25-65% of the variability in material properties at the affected site**

▼ Cortical bone tissue subjacent to callus at the stress fracture site was mechanically compromised, attempted to recover early with increasing callus maturity, but decompensated with the most mature callus.

▼ **Callus maturity was negatively associated with a number of material properties**

- ▼ The classification system is consistent with the natural progression of bone healing after trauma.
 - ▼ Inflammatory phase is dominated by cellular infiltration, edema, and hyperemia
 - ▼ Reparative phase is characterized by woven bone callus formation that is highly vascularized and coarse
 - ▼ Remodeling phase is characterized by replacement of woven bone with lamellar bone that is smooth and hard.
- ▼ The lack of observed differences between yield strains among bones with callus and w/o callus is consistent with the concept of strain controlled bone failure.
- ▼ Bones elastic behavior before failure is modulated by mineralization and collagen quality.
- ▼ Bone appears to be most weak when it's difficult to detect stress fracture radiographically (prior to callus formation)
 - ▼ Modify activity at the earliest stage of potential BSI
- ▼ **Cortical tissue at a site distal to the stress fracture also underwent material property changes**