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WESTERN ORTHOPAEDIC ASSOCIATION

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INFLUENCE OF STRAIN MAGNITUDES ON THE STRUCTURAL/MATERIAL ORGANIZATION OF BONE - IMPLICATIONS FOR OSTEOPOROSIS RESEARCH

In order to prevent age-related loss of bone mass in osteoporosis, it is necessary to determine how specific mechanical stimuli enable cells to maintain a normal skeletal phenotype. It has been hypothesized that specific strain-related features such as strain magnitude or mode (tension vs. compression) are important in the attainment and maintenance of normal bone architecture (1). Rubin and co-workers have shown that the mid-shaft of the equine metacarpus receives greater magnitudes of longitudinal (normal) strain and strain energy density (SED) in the posterior and medial cortices (2). The objective of the present study is to determine if the non-uniform strain environment in the equine metacarpus is reflected in the structural/material organization of bone. Metacarpi from 19 skeletally mature horses were each cut into a 0.5 cm section at mid-shaft. Cortical thickness was measured at the anterior (A), posterior (P), medial (M) and lateral (L) aspects. Bone fragments spanning the entire cortex were obtained from A, P, M and L regions, and ashed at 550C to determine mineral content. Using selected 100 micron sections, qualitative observations of collagen orientation were made under circularly polarized light. Results showed that there were no significant differences in the cortical thickness between A, M and L regions, but the posterior cortex was significantly narrower ($p < 0.001$) than the other three regions. Mineral content of the posterior cortex (66.5 +/- 1.0) was significantly lower ($p < 0.001$) than each of the other regions (A: 68.3 +/- 0.9; M: 68.6 +/- 1.1; L: 67.9 +/- 1.1). Examination of the thin sections showed that collagen orientation was uniform throughout except for a narrow (< 1 mm) band along the endosteal margin of the some sections. These data show that the medial and lateral cortices have similar structural/material organization despite the nearly 40 fold difference in stress magnitude shown in vivo between these regions (2). This suggests that in this model, large strain or stress magnitudes do not engender structural/material adaptations in bone. Understanding how various strain features enable cells to maintain normal skeletal mass will ultimately improve our ability to successfully prevent and treat osteoporosis. [1) Martin and Burr 1989, Functional Adaptation of Compact Bone, Raven Press, NY; 2) Gross et al. 1992, J. Biomech. 25:1081-1087]

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