Elastic moduli of untreated, demineralized and deproteinized cortical bone: Validation of a theoretical model of bone as an interpenetrating composite material

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A theoretical experimentally based multi-scale model of the elastic response of cortical bone is presented. It describes the hierarchical structure of bone as a composite with interpenetrating biopolymers (collagen and non-collagenous proteins) and minerals (hydroxyapatite), together with void spaces (porosity). The model involves a bottom-up approach and employs micromechanics and classical lamination theories of composite materials. Experiments on cortical bone samples from bovine femur include completely demineralized and deproteinized bones as well as untreated bone samples. Porosity and microstructure are characterized using optical and scanning electron microscopy, and micro-computed tomography. Compression testing is used to measure longitudinal and transverse elastic moduli of all three bone types. The characterization of structure and properties of these three bone states provides a deeper understanding of the contributions of the individual components of bone to its elastic response and allows fine tuning of modeling assumptions. Very good agreement is found between theoretical modeling and compression testing results, confirming the validity of the interpretation of bone as an interpenetrating composite material.

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