

ACOUSTICS2008/1255

A Finite element model of the lamellar osteonal structure based on ultrahigh frequency acoustic impedance data

Kay Raum^a, Quentin Grimal^b and Alf Gerisch^c

^aMartin Luther University of Halle-Wittenberg, Dept. of Orthopedics, Q-BAM Group, Magdeburger Str. 22, 06097 Halle, Germany

^bUniversité Paris 6, Laboratoire d'Imagerie Paramétrique, 15, rue de l'Ecole de Médecine, 75006 Paris, France

^cMartin Luther University of Halle-Wittenberg, Institut für Mathematik, 06099 Halle, Germany

Materials: A finite element (FE) model was developed, in which the osteon is considered to consist of a central Haversian canal filled with an incompressible fluid and surrounding sets of lamellar units. Each lamellar unit was further subdivided in five sublayers, whereas the orientation of the symmetry axis between adjacent sublayers was shifted clockwise. A sublayer consists of one to ten layers of parallel oriented mineralized collagen fibrils (thickness: $0.2 \mu\text{m}$, constant transverse isotropic stiffness tensor). **Results:** A variation of the sublayer thicknesses results in either isotropic or anisotropic tissue compound properties. By changing the individual layer thicknesses various degrees of anisotropy could be produced. A good agreement with the lamellar pattern obtained in 1.2-GHz SAM images as well as with the anisotropic elastic coefficients measured at the tissue level (50-MHz ultrasound) was obtained by choosing an asymmetric lamellar unit. **Conclusions:** With the proposed combination of experimentally derived microelastic and microstructural data by 1.2 GHz SAM and a micromechanical FE the homogenized elastic stiffness tensor of lamellar bone tissue was derived. The tissue anisotropy was explained by the asymmetric twisted plywood structure.