MODELING DEFORMATION-INDUCED FLUID FLOW IN THE CANALICULAR-LACUNAR SYSTEM OF CORTICAL BONE

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To explore the potential role that load-induced fluid flow plays as a mechano-transduction mechanism in bone adaptation, a lacunar-canalicular scale bone poroelasticity model is developed and exercised. The model uses micromechanics to homogenize the canalicular bone matrix, a system of straight circular cylinders in the bone matrix through which bone fluids can flow, as a transversely isotropic poroelastic medium. When cortical bone is loaded, microscale stress and strain concentrations occur in the vicinity of individual lacunae and give rise to microscale spatial variations in the pore fluid pressure field. Consequently, loading of cortical bone induces an exchange of fluid between canaliculi and lacunae. In this work, a simplified two-dimensional model of a periodic array of lacunae and their surrounding systems of canaliculi is first developed, exercised and studied. Then a fully three-dimensional model capturing an array of lacunae distributed about a single Haversian canal is developed and exercised. For realistic physical parameters of the bone morphology, and for a range of loading frequencies, fluid pressures and fluid-solid shear stresses in the canaliculi are computed.

One possible form of macroscopic evidence of fluid flow on the microscale in bone is mechanical energy dissipation. The energy dissipation in cortical bone due to lacunar-canalicular scale load-induced fluid flow is computed and compared to that measured in physical *in vitro* experiments.