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Canalicular fluid flow induced by bending of a long bone.

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Abstract
Interstitial fluid flow has been hypothesized to underly mechanotransduction within bone. Here, we present an analytical model of fluid flows induced at the level of osteocyte canaliculi when a long bone is subject to functionally relevant bending loads. Dynamic bending of cortical bone results in a non-uniform longitudinal normal strain environment in which strain magnitude varies both temporally (i.e., at a given location, strain varies as a function of time) and spatio-temporally (i.e., at each given point in time, strain varies between locations). To account for the complexity posed by these two aspects of the strain environment, canalicular fluid flows were decomposed into temporal and spatio-temporal components. In terms of distribution around the cortex, temporal and spatio-temporal flows in the radial direction were both maximal near sites of peak strain magnitude. Spatio-temporal flows in the circumferential direction, in contrast, were maximal near locations of minimal strain magnitude (i.e. near the neutral axis). All fluid flow components were maximal during the first load cycle and reached markedly reduced steady state levels during subsequent load cycles. The novelty of the described model is that it provides the first estimate of canalicular fluid flows induced within a complexly loaded long bone. As the model may be readily extended to provide a simplistic accounting of the fluid flow profiles induced during functional loading and other exogenous loading regimes, the approach will enhance the ability to examine fluid flow related mechanotransduction within bone.

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