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Computational analysis of interstitial fluid flow through the lacunar-canalicular system with morphological variations. SHAILESH KHADANGALE, SAMIRA HAJEBRAHIMI, MAUREEN LYNCH, DEBANJAN MUKHERJEE, University of Colorado Boulder — Osteocytes play a central role in maintenance of skeletal structure and associated mechanobiological processes. Interstitial fluid flow in the lacunar-canalicular system (LCS) is pivotal for osteocyte mechanotransduction but is challenging to model. For this we developed a CFD framework, based on Stokes-Brinkman model with variable permeability, for interstitial fluid flow in the LCS, and quantify shear at the osteocyte wall. We used our framework to quantify variations in shear due to changes in LCS morphology observed in metastatic bone cancer. A range of parametrically varied LCS morphologies were modeled based on lacunae dimensions and position data from micro-CT scan of healthy and cancerous mouse tibia. Shear on osteocytes was quantified for the various LCS morphologies considered to obtain bounds on osteocyte shear based on knowledge of lacuna shape and dimensions alone. Also, shear variations on osteocytes resulting from LCS morphology variations from neighboring sites were quantified. Our study revealed significant shear stress variations across all LCS morphological variations. Our over-arching theme is to advance this model into a computational toolkit to generate and test hypotheses on the role of shear mechanotransduction in metastatic bone cancer.

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