# MODELING AND SIMULATION OF AN OSTEOCYTE CELLULAR PROCESS INTERACTING WITH FLUID FLOW IN A CANALICULUS

**Jared Barber (1), Maxim Mukhin (2), Vanessa Maybruck (3), Luoding Zhu (4)**

*1. Indiana University – Purdue University Indianapolis, USA; 2. Vanderbilt University, USA; 3. University of Colorado Boulder, USA; 4. Indiana University – Purdue University Indianapolis, USA.*

## Introduction

An osteocyte is a bone cell situated inside hard bone matrix in an interstice (lacuna). It has many dendritic structures called processes that radiate outward in the bone matrix through cylindrical openings (canaliculi). Osteocytes can sense stress applied by the interstitial fluid flow and respond by releasing biochemical signals that regulate bone remodelling. Experiments have suggested that the stress and strain typically experienced at the macroscale tissue level have to be amplified 10X in order for osteocytes to have a significant response in vivo. The stress/strain amplification mechanism is not yet well understood [1-2]. Studies indicate that the process is the primary site for mechanosensation due to the tethering elements that attach the process membrane to the canalicular wall [3-5]. However, there are other potential factors which may also contribute to stress amplification such as canalicular wall geometry and osteocyte-associated proteins in the interstitial space called pericellular matrix (PCM) [6-7]. In this work, we perform computational studies on possible effects of canalicular wall roughness in stress/strain amplification.

## Methods

The cellular process is modelled by a gradually tapered porous cylinder made from two families (longitudinal and circumferential) of orthogonal deformable fibers and a centered elastic spring connected to the cylinder surface by flexible fibers on cross sections. Canalicular wall roughness is modelled by randomly generated protrusions on the wall. The interstitial liquid is modelled by a viscous incompressible Newtonian fluid. The flow is modelled by the lattice Boltzmann equations (D3Q19 model). The fluid-structure-interaction is handled by the immersed boundary framework [8].

## Results

Our preliminary results (Fig. 1) show a significant increase in deformation and shear stress on the cellular process when the canalicular wall is rough, compared to the smooth case. This suggests roughness may play a significant role in stress/strain amplification.

## Discussion

Understanding the potential synergistic interplay between canalicular wall roughness and factors such as tethering elements and PCM may prove essential for better understanding of the stress amplification process.

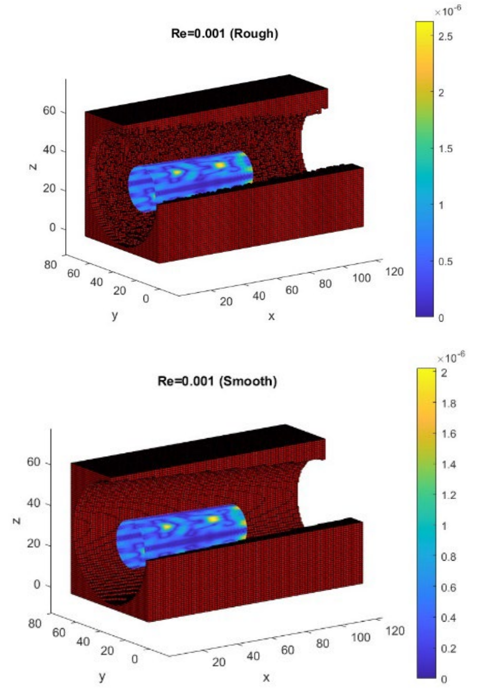


*Fig.1. Fluid shear stress by color on the process surface (the color cylinder) in a canaliculus (the space bounded by the wall of the red solid (bone matrix) for the smooth case (upper) and rough case (lower). Re=0.001. One can see that the stress and streching of the process is greater in the rough case.*

## References

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## Acknowledgements

This work was supported by grants DMS-1951531 and DMS-1852146 from NSF USA and SoS Near-Miss Grant from IUPUI.