Title:
Fluid–structure interaction (FSI) modeling of bone marrow through trabecular bone structure under compression

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Abstract:
The present study has sought to investigate the fluid characteristic and mechanical properties of trabecular bone using fluid–structure interaction (FSI) approach under different trabecular bone orientations. This method imposed on trabecular bone structure at both longitudinal and transverse orientations to identify effects on shear stress, permeability, stiffness and stress regarded to the trabeculae. Sixteen FSI models were performed on different range trabecular cubes of 27 mm3 with eight models developed for each longitudinal and transverse direction. Results show that there was a moderate correlation between permeability and porosity, and surface area in the longitudinal and transverse orientations. For the longitudinal orientation, the permeability values varied between 3.66 × 10–8 and 1.9 × 10–7 and the sheer stress values varied between 0.05 and 1.8 Pa, whilst for the transverse orientation, the permeability values varied between 5.95 × 10–10 and 1.78 × 10–8 and the shear stress values varied between 0.04 and 3.1 Pa. Here, transverse orientation limits the fluid flow from passing through the trabeculae due to high shear stress disturbance generated within the trabecular bone region. Compared to physiological loading direction (longitudinal orientation), permeability is higher within the range known to trigger a response in bone cells. Additionally, shear stresses also increase with bone surface area. This study suggests the shear stress within bone marrow in real trabecular architecture could provide the mechanical signal to marrow cells that leads to bone anabolism and can depend on trabecular orientation.