Multiscale approach for bone remodeling simulation based on finite element and neural network computation

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The aim of this paper is to develop a multiscale hierarchical hybrid model based on finite element analysis and neural network computation to link mesoscopic scale (trabecular network level) and macroscopic (whole bone level) to simulate bone remodelling process. Because whole bone simulation considering the 3D trabecular level is time consuming, the finite element calculation is performed at macroscopic level and a trained neural network are employed as numerical devices for substituting the finite element code needed for the mesoscale prediction. The bone mechanical properties are updated at macroscopic scale depending on the morphological organization at the mesoscopic computed by the trained neural network. The digital image-based modeling technique using m-CT and voxel finite element mesh is used to capture 2 mm3 Representative Volume Elements at mesoscale level in a femur head. The input data for the artificial neural network are a set of bone material parameters, boundary conditions and the applied stress. The output data is the updated bone properties and some trabecular bone factors. The presented approach, to our knowledge, is the first model incorporating both FE analysis and neural network computation to simulate the multilevel bone adaptation in rapid way.

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