Effects of Non-Uniform Osteocyte Distribution and Anisotropic Spongy Bone Property on Bone Remodeling Process

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Spongy bone is continuously remodeled through a coupled process of bone resorption and bone formation. In 2000, a semi-mechanistic bone remodeling theory was proposed in which strain energy density (SED) was used as mechanical stimulus for bone remodeling and osteocytes were assumed to act as mechnosensors, which can sense the SED and then recruit osteoblasts to form new bone. Recently, by incorporating the effects of micro-damage and disuse, the former theory was reformulated by our group. In this research, we hypothesized that osteocyte distribution can be considered as a crucial factor that can alter the bone apparent density and microstructure. The main objectives of this research are to simulate the spongy bone remodeling using a semi-mechanistic bone remodeling theory, and also to investigate the effects of osteocyte distribution on the spongy bone remodeling. We developed a two dimensional finite element model of spongy bone using MATLAB. Bone was considered as an isotropic and linearly elastic material in this study. In our computer simulations, we changed the loading magnitude, loading direction, and the osteocyte distribution. The simulation results showed that the final structures of the model were correlated to the magnitude of external loads and also the trabeculae are lined up with the external load direction. The models with the non-uniform osteocyte distribution, however, resulted in different configurations from the results of the model with uniformly distributed osteocytes. Thickness of the trabeculae diminished with the decrease of the osteocyte density. Moreover, the final structure of the model with non-uniform osteocyte distribution was not as regular as the final configuration of the spongy bone with uniform distribution. In order to investigate the relationship between the spongy bone remodeling and osteocyte distribution more accurately, a three dimensional computer model is in progress now and some preliminary results are gained.