A Novel Bone Remodeling Mechano-Biological Model Combined With Advanced Discretization Meshless Techniques

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ABSTRACT

The bone tissue, as a living tissue, is capable to respond to an external stimuli, by changing its external shape and its internal trabecular architecture. In this work, a new mechano-biological model is presented. The model is capable to predict the adaptation of the trabecular bone to the mechanical environment, by taking into consideration a mechanical stimulus and the consequent biological response. The novel mechano-biological model here presented combines the mechanologic model proposed by Belinha [1] and the biological model proposed by Komarova [2]. Thus, first a mechanical analysis is performed, seeking the minimization of the strain energy density (SED) field. Then, the cell density of osteoclasts and osteoblasts is calculated using the differential equations proposed by Komarova and correlated with the bone's apparent density.

In this work, the variable field required by the model (the SED) is obtained with three distinct numerical methods: the Finite Element Method (FEM), the Radial Point Interpolation Method (RPIM) and the Natural Neighbour Radial Point Interpolation Method (NNRPIM). A benchmark trabecular patch example is used to validate the numerical approach here proposed [3]. The results show that bone apparent density distributions obtained with the suggested technique are in good agreement with the expected structural bone's architecture.

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