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ABSTRACT

Modeling Bone Remodeling: Continuum Mechanics with Evolving Substructure

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Bone remodeling is a complex biological and mechanical process where bone tissue adapts its microstructure in response to mechanical stimuli, ensuring optimal functionality and strength. This presentation explores a novel continuum mechanics framework incorporating evolving substructure to model the remodeling process. Building on the foundational principles of Wolff's law and mechanostat theory, we introduce an orthotropic continuum model that captures the interplay between mechanical deformation, material orientation, and substructural evolution [1].
Key features include a variational formulation for remodeling, second-gradient mechanical energy considerations for low-density regions, and nonlocal stimuli models to address interactions between healthy, necrotic, and bioresorbable bone. Numerical simulations, such as cantilever bending and three-point flexure tests, demonstrate the model ability to predict changes in bone material parameters and structural orientation under mechanical loads.

This work provides insights into the mechanobiological processes driving bone adaptation and highlights the potential for advanced modeling techniques in designing biomaterials and improving clinical treatments.

[1] I. Giorgio, F. dell'Isola, U. Andreaus and A. Misra, Biomech Model Mechanobiol, 22, 2135–2152 (2023).