COMSOL Multiphysics® Used for Simulating Biological Remodeling

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Abstract

In this work, we present a mathematical model formulated to simulate the mechanical behavior of articular cartilage. Biological tissues of this kind can be modeled as fiber-reinforced porous media, filled with an interstitial fluid and exhibiting a process of remodeling [2]. With this term, we refer to a class of dissipative phenomena which occur to modify the internal structure of the tissue and, in some case, follow injuries and traumatic events [1]. In particular, we consider two type of remodeling process. The first one is related to the development of inelastic distortions in the extracellular matrix, while the second one is given in terms of the deformation-driven reorientation of the fiber pattern. Within a purely mechanical framework, a set of non-linear and fully coupled partial differential equations are obtained [1,3] and solved numerically by using the COMSOL Multiphysics® platform. Specifically, by choosing suitable boundary and initial conditions, we implement in COMSOL Multiphysics® a benchmark problem consisting in an unconfined compression test of a cylindrical sample of tissue. In order to do this, we take advantage of the tools offered by the Darcy's Law physics interface, the Structural Mechanics Module and Mathematics physics interfaces. Finally, our results allow us to investigate how the remodeling phenomena interact with the fibers and how this influences the behavior of the interstitial fluid.

References

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