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MULTISCALE ELASTICITY OF TISSUE ENGINEERING SCAFFOLDS WITH TISSUE ENGINEERED BONE: A CONTINUUM MICROMECHANICS APPROACH

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ABSTRACT

Tissue engineering (TE) is the use of a combination of biological cells, engineering and materials methods, and of suitable biochemical and physico-chemical factors, in orders to improve or replace biological functions [1]. It has brought the advent of entirely new classes of hierarchically organized, multiporous materials, consisting of both chemically and biologically produced parts. We here aim at contributing to the unsettled question of the mechanical functioning of bone tissue engineering scaffolds with tissue-engineered bone – from a theoretical and applied mechanics viewpoint. Thereby, we build on recently developed microelasticity models [2] for vertebrate bone and hydroxyapatite biomaterials, respectively. Tissue engineering scaffolds with tissue engineered bone are micromechanically represented as tissue engineered bone-coated macropores in a matrix built up by microporous hydroxyapatite polycrystals, based on an extension towards anisotropy, of Hervé-Zaoui's n-layered inclusion problem [3]. The stiffness of macroporous hydroxyapatite-based TE scaffolds with newly ingrown bone is mainly governed by their porosities [vascular ('macro'-)porosity defined through initial scaffold design and volume fraction of ingrown bone; and intercrystalline ('micro'-)porosity between the hydroxyapatite crystals of the scaffold matrix material], while being less influenced by the type of bone growing inside the macropores. For a given degeneration kinetics of the scaffold, the microelastic models suggests apposition rates of bone needed to maintain the stiffness characteristics of the overall biomaterial-bone construct. This can be seen as a first step towards computer-aided engineering design of tissue engineering scaffolds for large bone defect regeneration.

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