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Estimation of the effective bone-elasticity tensor based on μCT imaging by a stochastic model. A multi-method validation.

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Abstract

In previous work, we proposed a stochastic model to describe the elasticity of bone matrix (so-called ultrastructure, US) based on basic statistical information on the *tissue mineral density* (TMD). This information was obtained by analyzing high-resolution images of a human femoral neck realized by means of synchrotron radiation micro-computed tomography (SR − μCT). In this paper, we extend this study by focusing at the upper scale where cortical bone is described as a two-phase mixture made up of water-filled Haversian pores (HP) embedded in the surrounding solid US. The goal of this paper is to develop a stochastic model of cortical bone elasticity accounting for the effect of uncertainty affecting both phases, the US *via* the TMD and the HP.

Experimental information was assumed to be given in terms of mean values and dispersions of the average TMD (denoted $\overline{\text{TMD}}$) and HP at the millimeter scale. To this aim, SR − μCT images were used to extract several representative volume elements (RVEs) spanning the whole cortical tissue which, in turn, were analyzed to obtain the required statistical information on $\overline{\text{TMD}}$ and HP. This information has been used for constructing a stochastic multiscale model of cortical bone based on the Maximum Entropy (denoted MaxEnt) principle. This stochastic multiscale model is used in the estimation of the ef-

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