Prediction of Apparent Young's Moduli of Trabecular Bone by Stochastic Image-based Multi-scale Method Based on First Order Perturbation

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A stochastic image-based multi-scale method based on first-order perturbation was developed in the present study in order to predict the reliable apparent Young's moduli of vertebral trabecular bone. Considering the inconsistencies due to bone characteristics, experimental works and image processing procedures in evaluating the apparent trabecular stiffness, a systematic uncertainty model was derived. Assuming the fluctuations of uncertainty sources were in Gaussian normal distribution, the Gaussian mixture model was then applied to estimate the effective apparent Young's moduli. A new uncertain parameter β was introduced to characterize the fluctuation of the estimation due to miscellaneous errors, inter-individual differences and unknown factors. β was calibrated by validating the calculated Young's moduli to others' published experimental results. Our results indicate the importance of predicting the apparent mechanical bone properties in stochastic treatment due to many uncertainty factors that should be considered in order to obtain the reliable results.

Keywords: Uncertainties, Multi-scale theory, Image-based modeling, Apparent Young's moduli, Trabecular bone.