Oral Presentation
Track 1: Bone Mechanics - Joint ESB Track
1.1. Advanced Detection of Bone Quality

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Prediction of the apparent elastic modulus and strength of vertebral cancellous bone based on patient-specific apparent morphology

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In the context of osteoporotic fractures, the strength and stiffness of cancellous bone are key determinants of the fracture risk. However, standard imaging (DEXA, QCT) cannot measure these mechanical properties directly, and so, an estimation of the risk for fracture is made by correlating the relative density or mineral density at a skeletal site with statistics of fracture occurrence. This method provides limited and partial indications on the fracture risk because of the indirect assessment. Fortunately, this problem can be resolved by means of patient-specific finite element (FE) modeling of cancellous bone, which is expected to support clinical assessment of the fracture risk in the near future (Diamant et al., 2005). We developed an FE parametric model of lattice cancellous bone structures to determine its apparent elastic modulus and strength based on clinically measured morphological/physical parameters: trabecular thickness, trabecular separation and bone mineral density. We further conducted uniaxial compression tests on canine vertebral cancellous bone specimens in order to validate the model predictions of specimen-specific strength and stiffness. Our model predictions of strength and stiffness matched the experimental results from canine bone within errors of 17.7% and 12.8%, respectively. We then applied our model to predict human cancellous bone properties from individual specimens and obtained apparent elastic modulus of 190±50 MPa and strength of 1.7±0.4 MPa for L1 and L5 vertebrae. Overall, the model was shown to be useful for predicting the mechanical properties of individual specimens, which supports its clinical applicability as well as its utility as a research tool to reduce the large number of experiments usually needed for characterizing the mechanical properties of osteoporotic cancellous bone.

Reference: Diamant I., Shahar R., Gefen A. (2005). Med Biol Eng Comput 43: 465-472.