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Simulation of ultrasound wave propagation through trabecular bone samples with and without bone marrow

Liesbet Goossens[a], Jef Vanderoost[b], Siegfried Jaecques[c], Steven Boonen[d], Jan D'Hooge[e], Walter Lauriks[f] and Georges Van Der Perre[a]

[a]Afdeling Biomechanica en Grafisch Ontwerpen, Departement Werktuigkunde, Katholieke Universiteit Leuven, Afd. Biomechanica en Grafisch Ontwerpen, Celestijnenlaan 300, 3000 Leuven, Belgium

[b]K.U.Leuven, Celestijnenlaan 300c, bus 2419, 3001 Heverlee, Belgium

[c]Department of Dentistry, Oral Pathology and Maxillo-Facial Surgery, BIOMAT Research Cluster, Katholieke Universiteit Leuven, Kapucijnenvoer 7 - bus 7001, 3000 Leuven, Belgium

[d]Afdeling Geriatrie, UZ Herestraat, 3000 Leuven, Belgium

[e]Division of Cardiovascular Imaging and Dynamics, Katholieke Universiteit Leuven, UZ Herestraat 49 - bus 7003, 3000 Leuven, Belgium

[f]Lab. ATF, Katholieke Universiteit Leuven, Celestijnenlaan 200D, B-3001 Leuven, Belgium

For the clinical assessment of osteoporosis, ultrasound has been proposed as an alternative or supplement to the Dual-Energy X-ray Absorptiometry technique. However the interaction of ultrasound waves with (trabecular) bone remains relatively poorly understood. The aim of the present study was to improve the understanding of this interaction by simulating ultrasound wave propagation in fifteen trabecular bone samples from the human lumbar spine, using μCT based Finite Elements Modelling. The model included only the solid bone, without the bone marrow. Two structural parameters were calculated: the bone volume fraction (BV/TV) and the structural (apparent) elastic modulus (E_s), and the ultrasound parameter Speed Of Sound (SOS). At 1 MHz, correlations between SOS and the parameters BV/TV and E_s were rather weak but the results can be explained from the specific features of the trabecular structure and the intrinsic material elastic modulus E_i. The correlation found between the simulated SOS values and those calculated from the simple bar equation was poor when the three directions are considered separately. However at lower frequencies (50-300 kHz), this correlation significantly improved. Currently we investigate the correlations between SOS and the structural parameters when the bone marrow is included in the FE model.