HOW DOES THE PHASE VELOCITY PREDICT THE TRABECULAR THICKNESS OF BOVINE BONE?

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Introduction

In another work of this group, a weak scattering model proposed for the ultrasonic frequency-dependent backscatter in dense bovine cancellous bone, using two auto-correlation functions to describe the medium, was found that could predict ultrasonic backscattering and estimate the trabecular thickness [Deligianni, 1997]. The phase velocity was found to increase with increasing apparent bovine bone density with high correlation [Lee, 2011]. The aim of this work was to correlate trabecular thickness values, estimated by the above referred model, with phase velocities in order to investigate whether they reflect structural parameters of trabecular bone.

Methods

16 cancellous bone specimens, obtained from bovine femurs and tibia of different animals, were prepared as cubes, with a side length of 18-21mm, using a slow speed diamond wafering saw. Bone marrow was removed in order to determine apparent density and obtain images. Ultrasonic measurements (backscatter, phase velocity) were performed in a water bath at room temperature in all three perpendicular directions with an ultrasonic pulser receiver that could operated in a through-transmission or pulse-echo mode. The -20 db frequency bandwidths were 0.24-1.24 MHz for unfocused transducers. For backscatter determination, 25 measurements less than 50% overlap were obtained from each sample surface. Individual measurements of trabecular thickness were performed on each specimen. Successive slices, perpendicular to the ultrasonic propagation, of 1 mm thickness, were produced by a microtome in one direction. The trabecular thickness was measured from these images by an in-house code. Estimation of trabecular thickness by the model was performed as previously reported [Deligianni, 1997].

Results

The estimated correlation length, interpreted as the dominant trabecular thickness obtained from distribution graphs for each specimen, and calculated by the weak scattering model, were highly correlated with the measured scatterer sizes. Moreover, strong correlations between phase velocity and trabecular thickness were acquired in all three directions (R^2=0.61 in the Z (loading) direction, R^2=0.92 (Fig. 1) and R^2=0.76 in the X and Y directions respectively). It should be noted that the phase velocities have been calculated at those frequencies at which the correlation lengths were calculated.

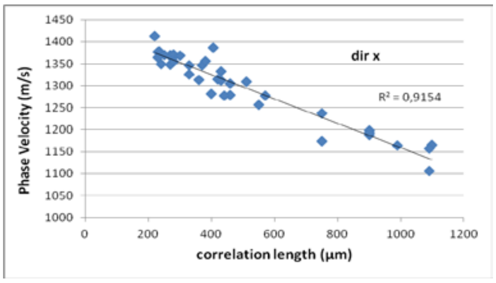

Figure 1: Correlation between phase velocity and trabecular thickness in the X direction.

Discussion

Wear [2012] suggested that attenuation, phase velocity, and backscatter are primarily determined by bone quantity, but multiple regression models based on bone quantity plus microarchitectural features achieve slightly better predictive performance than models based on bone quantity alone. From this work, it can be concluded that the phase velocity can predict the trabecular thickness, implying that it reflects bone structure.

References

Deligianni *et al*, J Acoust Soc Am, 122:1180-90, 2007.
Lee, J Acoust Soc Am, 130:EL399-404, 2011.
Wear *et al*, J Acoust Soc Am, 131:1605-12, 2012.