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Ultrasonic velocity dispersion in bovine cortical bone

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The evaluation of cortical bone quality has become possible in clinical practice, but the interaction between a broadband ultrasonic pulse and this complex multiscale medium remains poorly understood. Specifically, the frequency dependence of phase velocity has been sparsely investigated. This study aims at evaluating the determinants of the frequency dependence of phase velocity in bovine femoral cortical bone samples using an in vitro ultrasonic transmission device. Phase velocity is shown to vary quasi linearly in a 1 MHz restricted bandwidth around 4 MHz, which enables dispersion evaluation. Axial dispersion is significantly higher than radial and tangential dispersions. Significant differences in dispersion are obtained according to the anatomical location. The microstructure of each sample is determined using an optical microscope, which allows assessing the dependence of dispersion on the type of bone microstructure. Mostly positive, but also negative values of dispersion are measured. Negative dispersion is obtained mostly in samples constituted of mixed microstructure, which may be explained by phase cancellation effects due to the presence of different microstructures within the same sample. Dispersion is shown to be related to broadband ultrasonic attenuation values, especially in the radial direction. This dependence is compared with results derived from the local Kramers-Krönig relationships.