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Assessment of cortical bone density and anisotropy in human femur using ultrasound and X-ray

Dorian Cretin[a], Ryouichi Suetoshi[a], Atsushi Uodome[a], Shinji Ogawa[a], Sakaya Miyabe[b] and Takayoshi Nakano[b]

[a]Furuno Electric Co., Ltd, 9-52 Ashihara-cho, 662-8580 Nishinomiya, Japan

[b]Graduate School of Engineering, Osaka Univ., Division of Materials and Manufacturing Science, 2-1 Yamadaoka, Suita, 565-0871 Osaka, Japan

The purpose of this research is to investigate the contribution of the intrinsic properties of human bone to the ultrasound velocities in the axial, radial and tangential directions.
Samples of cortical bone were cut from 19 human medial femurs and polished to a rectangular parallelepiped shape. The orientation of apatite crystallites was assessed by microbeam X-ray diffraction, the density with a densitometer using the Archimedes' principle. Bone Mineral Density (BMD) was also measured with Peripheral Quantitative Computed Tomography (pQCT) and Dual-X-ray Absorptiometry (DXA).
The Speed Of Sound (SOS) for each 3 directions was measured with 3MHz ultrasonic broadband transducers.
Results: Radial and Tangential SOS demonstrated a strong correlation with density ($R=0.83, p<0.0001$ and $R=0.85, p<0.0001$ respectively). In the axial direction, the correlation between density and SOS was moderate ($R=0.59$). However, a significant correlation was found by using density and apatite orientation of c-axis in a multiple regression analysis ($R=0.85, p<0.001$).
Axial SOS can be explained by contributions of both density and crystal orientation.