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Non-Contact Ultrasound Imaging Applied to Cortical Bone Phantoms for Determination of Bone Mineral Density, Speed of Sound, and Ultrasound Attenuation

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A non-contact ultrasound imaging (NCU) system including transmitting and receiving transducers coupled to the air was applied to custom designed cortical bone phantoms to determine bone mineral density, speed of sound, integrated acoustical response and attenuation for possible medical applications in quantitative ultrasound imaging. Air gaps of greater than a centimeter for two non-contact transducers specially designed for thin cortical bones such as those in the distal radius, two transmission as well as two reflection paths, and a digital signal processor were used to collect data on cortical bone phantoms of nominal density that varied from 1.17 g/cm^3 to 2.25 g/ cm^3, with nominal bone mineral density (BMD) from 0 g/ cm^3 to 1.7 g/cm^3. Good correlation between nominal density and measured speed of sound, integrated acoustical response, and attenuation was obtained for all of our phantoms and techniques for limiting various sources of systematic errors were studied. In particular, reproducibility, agreement with contact ultrasound, and stability for speed of sound and other parameters versus phantom BMD was found to be at a level of a few (about 1-3) percent over a period of several months when the NCU system was carefully and routinely optimized and calibrated. The results of these investigations suggest that non-contact ultrasound might find applications in quantitative bone assessment and in medical imaging in the near future.