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Local measurements of the diffusion constant in multiple scattering media: Application to human trabecular bone imaging

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Multiple scattering of ultrasound can occur in trabecular bones. A typical signature of multiple scattering is the coherent backscattering effect, and the average trajectory of a wave undergoing multiple scattering can be characterized by the diffusion constant D. In this work, we present local measurements of the diffusion constant for ultrasonic waves in human trabecular bone, based on near-field observation of the backscattered intensity. The experimental set up consists in an array of programmable transducers placed in front of a slice of bone that we want to image. By achieving Gaussian beamforming both at emission and reception, an array of virtual sources and receivers located in the near-field is constructed. The time evolution of the incoherent component of the intensity backscattered on this virtual array is shown to represent directly the growth of the diffusive halo as $(Dt)^{1/2}$. A matrix treatment is proposed to separate the incoherent intensity from the coherent backscattering peak. Once the incoherent contribution is isolated, local measurements of the diffusion constant D are achieved around 3 MHz and then a D-map of the bone is built. These measurements are shown to be strongly correlated with the bone mineral density.