

Application of fractional calculus to the ultrasonic characterization of human bone tissue.

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ABSTRACT

Transient ultrasonic propagation in human bone tissue is considered according to Biot's theory. The bone is modeled as a porous medium with an elastic structure. The viscous fluid/structure interactions are described by fractional calculus in the time domain. The slow and fast compressional waves, as well as the rotational shear wave predicted by Biot's theory obey fractional propagation equations. The fractional equation system is solved analytically in the time domain, thus obtaining the expressions of the reflection and transmission scattering operators. Inverse identification of the intrinsic microstructure of the pores and of the mechanical properties of the bone is performed in the time domain (waveforms) and frequency domain (attenuation and phase velocities), by adopting a statistical Bayesian inference technique using ultrasonic transmitted and reflected signals, which allows to find the identified parameters and their associated uncertainty.