Model for guided waves in an orthotropic bone plate coupled with soft tissue and marrow

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Ultrasound has been used in recent years to the assessment of bone characteristics since the nature of ultrasonic mechanical vibration is able to provide desired information on the elastic properties of bone structures. Wave propagation in bones, however, remains a challenging research due to the nature of multi-layer, anisotropic, and viscoelastic behaviors. Thus, our understanding of wave interaction with bone structures is still far from complete and the resulting wave modes have not been fully explained. In the current work, we aim to study a model for propagation of ultrasonic guided waves in an orthotropic bone plate coupled with a soft tissue and a marrow layer. The characteristic equation for the trilayered structure is derived that results the dispersion curves of Lamb type waves. The amplitudes of guided wave modes in the trilayered plate subjected to a time-harmonic load are theoretically computed by the use of reciprocity theorems. A semi-analytical finite element (SAFE) scheme is also developed to simulate the propagation of guided waves in the bone plate coupled with the soft tissue and the marrow. The analytical predictions are compared with numerical results for several case studies. Comparisons of results obtained by the two approaches are graphically displayed and shown reasonable agreement.