A DYNAMIC POROVISCOELASTIC FINITE ELEMENT FORMULATION FOR BIOLOGICAL SOFT TISSUES: POTENTIAL APLLICATIONS TO HIGH-SPEED IMPACT BIOMECHANICS

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Hydrated soft tissues are composed of a porous viscoelastic solid matrix and an interstitial fluid. The apparent viscoelastic behaviors of soft tissues are due to the intrinsic viscoelasticity of the solid matrix as well as the diffusive interaction between the solid and fluid. The linear biphasic poroviscoelastic (BPVE) theory has been developed and successfully implemented to account for such viscoelastic mechanisms in simulating some simple viscoelastic behaviors of soft tissues. The objective of the present study was to extend the previous BPVE model in order to investigate the wide range of dynamic behaviors of soft tissues including high-speed impact injuries. Such analysis will help us to understand the injury mechanism of soft tissues, such as contusions or traumatic brain injuries.

In this study, to investigate the dynamic behavior of such biphasic poroviscoelastic media under impact loading, a mixed finite element formulation, in which the inertial effects of both phases are taken into account, is developed. A continuous biquadratic displacement interpolation and discontinuous linear pressure interpolation (Q2-P1) is used for two-dimensional elements to obtain second order accuracy. A segregated solution scheme is adopted to overcome numerical difficulties associated with the incompressibility assumption.

This formulation for dynamic analysis is applied to biomechanics problems of brain subjected to a high speed impact loading. The high speed impact is either in the form of a high G-acceleration or in the form of a direct contact pulse. The utility of the present dynamic mixed FE method for a biphasic poroviscoelastic material is demonstrated in this study.