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Large Deformation Dynamic Three-Dimensional Coupled Finite Element Analysis of Soft Biological Tissues Treated as Biphasic Porous Media

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Abstract: The paper presents three-dimensional, large deformation, coupled finite element analysis (FEA) of dynamic loading on soft biological tissues treated as biphasic (solid-fluid) porous media. An overview is presented of the biphasic solid-fluid mixture theory at finite strain, including inertia terms. The solid skeleton is modeled as an isotropic, compressible, hyperelastic material. FEA simulations include: (1) compressive uniaxial strain loading on a column of lung parenchyma with either pore air or water fluid, (2) out-of-plane pressure loading on a thin slab of lung parenchyma with either pore air or water fluid, and (3) pressure loading on a 1/8th symmetry vertebral disc (nucleus and annulus) with pore water. For the simulations, mixed formulation Q27P8 and stabilized Q8P8 finite elements are compared ("Q" indicates the number of solid skeleton displacement nodes, and "P" the number of pore fluid pressure nodes). The FEA results demonstrate the interplay of dynamics (wave propagation through solid skeleton and pore fluid), large deformations, effective stress and pore fluid pressure coupling, compressibility and viscosity of pore fluid, and three-dimensional effects for soft biological tissues treated as biphasic porous media.

Keywords: soft biological tissues; biphasic mixture theory; dynamics; large deformations; coupled three-dimensional finite element analysis

1 Introduction

It is well-known that soft biological tissues are multiphase (oftentimes treated as a biphasic mixture of solid and fluid phases (Holmes, 1986; Suh, Spilker, and

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