Research paper

Stiffening by fiber reinforcement in soft materials: A hyperelastic theory at large strains and its application

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1. Introduction

Several biomechanical studies have been carried out concerning the mathematical representation of the anisotropic behavior of soft materials undergoing finite strains. Numerous formulations have been recently proposed for the modeling of fiber-reinforced tissues such as skin (Xu et al., 2008), arteries (Holzapfel and Ogden, 2010), esophagus (Natali et al., 2009) and abdominal organs (Ciarletta et al., 2009).

Classical constitutive equations in soft tissue biomechanics are based on a phenomenological approach, which is concerned mainly with fitting the constitutive equations to experimental data (Fung et al., 1979; Chuong and Fung, 1983). As discussed by Holzapfel et al. (2002), these models predict qualitatively reasonable responses for restricted geometry and loadings, but the physical meaning of the proposed mechanical parameters is difficult to interpret, while restrictions on their values are needed to ensure convexity and, consequently, to avoid material instabilities. Even if a lack