Constitutive modeling and computational analysis of muscle tissue

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The presence of muscle activity in numerical models of human structures provides a better insight to tissue loadings during human movement. However, most studies presented in the literature for the computational analysis of human parts do not account for the particular mechanical behavior of muscle tissue. A constitutive model that describes the mechanical behavior of muscle is presented based on the consideration of muscle as a continuum. Muscle is considered as non-linear and anisotropic due to the existence of fibers in the muscle mass. Multiple muscle fiber directions can be modelled and the mechanical stress in each fiber can be written as the sum of active and passive parts. The active fiber stress is taken to be a function of activation state, muscle fiber shortening velocity and fiber strain, whereas the passive stress depends only on the strain. A methodology for the numerical integration of the resulting constitutive equations in the context of the finite element method is developed and the constitutive model is implemented in a general-purpose finite element program (ABAQUS). The model is then used for the analysis of static and dynamic problems using either the “standard-implicit” or the “explicit” versions of the code. The model is tested by simulating the extension of a squid tentacle during the strike to catch prey and is used to simulate the behaviour of the human muscle.