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A gradient-enhanced continuum damage model for healing in soft tissue with growth and remodeling

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Abstract

Healing of soft biological tissue is the process of self-recovering or self-repairing the injured or damaged extracellular matrix (ECM). Healing is assumed be stress-driven, with the objective of returning to a homeostatic stress metrics in the tissue after replacing the damaged ECM with new undamaged one. However, based on the existence of intrinsic length-scales in soft tissues, it is thought that computational models of healing should be non-local. In the present study, we introduce for the first time two gradient-enhanced constitutive healing models for soft tissues including non-local variables according to previous work from Dimitrijevic and Hackl [1] and Waffenschmidt et al. [2]. The first model combines a continuum damage model with a temporally homogenized growth model, where the growth direction are determined according to local principal stress directions. The second one is based on the healing model proposed by Cormellas et al [3] which is turned into a gradient-enhanced version. Both models are implemented in the finite-element package Abaqus by means of a user subroutine UEL. Three situations simulating the healing process of soft tissues are modelled numerically with both models, showing their wide potential to approach applied problems.

References

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