# Phase-field Modeling of Rupture in Soft Biological Tissues

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**ABSTRACT**

The prediction of rupture in soft biological tissues has emerged as one of the central tasks in medical monitoring and risk assessment of diseases such as atherosclerosis, aortic dissection, aneurysms, and tears in ligaments and tendons. However, the structural composition of tissues and the tangled series of coupled biomechanical processes thereof pose a number of challenges in our understanding of the rupture phenomena.

In an attempt to address the challenges we have established a computational framework within the context of crack phase-field modeling and proposed a novel energy-based failure criterion based on the distinction of the isotropic and anisotropic constitutive behavior [1, 2]. To date several contributions on the anisotropic failure criteria have been reported, see [3, 4] to mention just a few. However, a numerical investigation of their capability to describe an admissible failure surface and a crack propagation is not present, the main objective of this study. Other numerical aspects render the incorporation of *Q1P0*-element formulation into the phase-field model, and a rate-dependent setting of the crack phase-field formulation which not only enhances the algorithmic stability upon macro-cracking, but also becomes physically justifiable as the aortic dissection is observed to be rate-dependent.

A canonical rate-dependent setting of the crack phase-field model is formulated, i.e. a rate-type saddle point principle based on power balance yields the strong forms of the multi-field problem which is solved in a weak form by a standard Galerkin procedure featuring a one-pass operator-splitting algorithm on the temporal side. The extant anisotropic failure criteria are numerically tested according to their performance on reflecting an admissible initiation and the propagation of the crack via simple yet representative geometrical and loading conditions. Results favor the energy-based criterion over stress-based criteria as a better candidate to reflect a stable and physically relevant crack propagation, particularly in complex three-dimensional geometries with a highly anisotropic texture at finite strains.

# References

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