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CHARACTERIZATION AND MODELLING OF RUPTURE IN OF ARTERIAL MEDIAL TISSUE UNDER TENSION FROM IN SITU EXPERIMENTS WITH X-RAY TOMOGRAPHY

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Summary: Aortic dissection (a sudden delamination of the aortic wall) is a life-threatening event associated with a very poor outcome, and requires rapid diagnosis and decision-making. Current knowledge and clinical criteria to predict its occurrence and evolution would greatly benefit from advanced mechanical analyses of the underlying mechanisms. Indeed, many studies have investigated global wall properties but only a few of them have been focusing on micro-scale damage initiation, and little is known about what triggers dissection and rupture. In an attempt to alleviate the scarcity of data at this scale, uni-axial tests were performed on porcine medial arterial tissue under x-ray micro-tomography in a previous study. The analysis presented in the present study consists of a numerical model that reproduces the experimental uni-axial tests, and that was developed based on an analytical model, first, and a finite element (FE) model, then. The analytical model is composed of several layers representing the media of the arterial wall (the layer in which dissection happens), each having their own elastic and damage (longitudinal type 1 rupture) properties. The elastic properties are modelled with a hyperelastic constitutive law (Gasser-Holzapfel-Ogden) and the damage properties with a bi-linear cohesive law. The cohesive properties were assumed to represent the physiological defects present in each layer. Hyperelastic parameters and critical fracture energy were assumed to be the same for all the layers. Two FE models were created to validate the analytical model using user-set parameters (comparing the stress-strain responses). Then, an inverse analysis was performed to fit the damage model parameters on experimental curves from the described experiments. A limitation of this analytical model is that shear delamination between layers is not taken into account. Consequently, a FE model that additionally includes shear delamination was developed and used to investigate the influence of the delamination on the tensile stress-strain response. In conclusion, this simple model was able to reproduce the successive delamination of the media sheets as observed in the experiments and showed promising insight towards a better understanding of the underlying rupture mechanisms.