Growth and remodeling of arterial tissue

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Introduction
Living tissues continuously undergo growth, i.e. a change in mass, and remodeling, i.e. a change in structure. Here, we present a model combining remodeling, through the natural concept of collagen generations [1,3], and general 3D growth.

Material and Methods

Tissue composition and remodeling The arterial wall is composed of collagen fibers embedded in an isotropic elastin dominated matrix. Collagen is continuously formed and degraded. Newly formed collagen is inserted such that it experiences a preferred homeostatic stretch under physiological load. Collagen orientation depends on tissue stretch [2].

Tissue deformation and growth Collagen stretch upon pressurisation is determined from balance of momentum. Desired volume change of a local tissue element depends on the difference between average and preferred homeostatic collagen stretch. Due to interaction with neighbouring tissue elements, actual volume change deviates from desired volume change. Assuming growth stress to fade in time, the grown configuration is used as the new unloaded one.

Results
Starting from an arbitrary non-homeostatic state the arterial wall grows and remolds until, at zero growth stimulus, homeostatic equilibrium is reached. Vessel compliance increases upon remodeling. Both collagen volume fraction and recruitment stretch are higher at the inner than at the outer surface.

Discussion
Microstructural remodeling is successfully combined with 3D growth. Application to a healthy artery yields stable results. As an extension, the effect of both smooth muscle cells and blood shear rate might be incorporated. Subsequently, pathologic vessel growth, e.g. aneurysm formation, will be studied.

Literature