

# Predicting age-dependent changes in human native heart valves due to growth and remodeling

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## ABSTRACT

One of the hallmarks of living tissues is their ability to adapt in response to changes in their environment in order to maintain a mechanical homeostasis [1]. This homeostasis is maintained by tissue growth and remodeling, where the former can be defined as a net increase in tissue mass and the latter as architectural changes. In this study, a computational model, based on experimental findings, is proposed to elucidate the particular roles of growth and remodeling in the preservation of the mechanical homeostasis in human heart valves during somatic growth.

In recent studies, structural, geometrical and mechanical properties were estimated of human aortic and pulmonary heart valves of fetal to adult origin using a variety of numerical-experimental techniques [2, 3]. With increasing age, both aortic and pulmonary heart valve leaflets were found to grow isotopically in the leaflet plane and feature only minimal changes in thickness, while a stretch homeostasis was maintained.

The experimental data were used to establish a computational model to elucidate the relative roles of growth and remodeling in the preservation of the mechanical homeostasis in human heart valves during somatic growth. Environmental changes due to somatic growth were simulated between the three age groups by imposing the temporal increase in transvalvular pressure and annular radius through boundary conditions. Next, tissue growth and remodeling were applied to investigate if and how the stretch homeostasis can be restored. Tissue growth was modeled using the theory of finite growth [4], aiming to restore the stretch homeostasis. Tissue remodeling was implemented by prescribing a change in the structural and material properties in order to impose a linear transition of the stress-stretch response from one age group to the other. For the constitutive model, a discrete fiber distribution was coupled to an adapted Holzapfel model [2].

The proposed computational model based on extensive experimental findings allows us to further assess what role tissue growth and remodeling play in the preservation of the mechanical homeostasis in human heart valves. Most interestingly, this computational model allows us to distinguish between growth and remodeling, and to systematically compare what influence both processes have in maintaining the mechanical homeostasis in human native heart valves.

## REFERENCES

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