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HEMODYNAMICS-MECHANICS COUPLING IN STUDYING LARGE DEFORMATIONS OF LAMINA CRIBROSA

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The Lamina Cribrosa (LC) is a part of the Optic Nerve Head (ONH) consisting of a framework of thin collagen beams acting as a scaffold for collecting the retinal ganglion cell axons. The optic nerve carries, through the axons, the signal generated by the retina to the brain. The LC is also the region crucial for blood supply to the whole optic nerve. An increased pressure inside the vitreous chamber (IOP) can generate a deformation of the LC pinching the retinal ganglion cells and progressively leading to cell death. Furthermore, LC deformation can affect the vascular perfusion in extended regions.

In order to study the interplay between deformation and blood perfusion, we chose to model the LC as a poroelastic material where the saturated porosity stands for the vascular network, made up of the capillaries running inside the collagen beams [1, 2].

We carried out several finite element simulations, modeling the LC as a soft poroelastic tissue in the shape of a spherical cap enclosed in the peripapillary sclera, made up of a stiffer incompressible tissue. The numerical results show that an increasing IOP leads to the so-called cupping of the LC, characterized by a strong shear deformation in a region close to the boundary with the sclera, which is the origin of the blood flowing through the capillaries. The shear deformation makes the porosity sharply decrease in an annular region, thus slowing down blood flow from the boundary to the central vein. This is consistent with the conjecture that ischemia is a major cause of unrecoverable damage of the ONH, in the presence of Glaucoma. The coupling between deformation and porosity is strongly related to the permeability being dependent on the porosity. We used a modified Kozeny-Carman formula to describe this relation.

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