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VIRTUAL ELEMENT MODELING OF CAPILLARY DISTRIBUTION IN THE OPTIC NERVE HEAD

Daniele Prada[1]

[1] Istituto di Matematica Applicata e Tecnologie Informatiche "Enrico Magenes", Via Ferrata 1, Pavia, Italy, daniele.prada@imati.cnr.it

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In this study, we numerically investigate blood perfusion of the lamina cribrosa, a collagen structure located in the optic nerve head that plays a critical role in ocular pathologies, especially glaucomatous optic neuropathy [1].

The lamina is modeled as a porous material where capillaries are viewed as isotropically distributed pores in a solid matrix comprising collagen, elastin, extracellular matrix and neural tissue [2]. The permeability tensor of the lamina is isotropic and homogeneous with a scalar value that is estimated via the volume averaging method [3]. We test this method on two morphologically-based micro structural models of the lamina using the Virtual Element Method (VEM) [4] for the solution of the averaging closure problems. After estimating the permeability, the three dimensional model for the lamina is coupled with a simplified zero dimensional model for the blood circulation in the arteries nourishing it, in order to account for systemic factors that influence the local perfusion [5]. Finally, the coupled system is solved with VEM.

Simulated distributions of blood pressure and perfusion velocity within the lamina are quantitatively close to realistic data. These results, together with the high flexibility that VEM allows in the treatment of complex geometries, suggest that VEM is a promising candidate for modeling ocular biomechanics.

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