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Finite Element Modelling Predicts Large Accommodation Induced Optic Nerve Head Deformations

Xiaofei Wang[1, 2,*] and Yubo Fan[1, 2]

[1]Beijing Advanced Innovation Center for Biomedical Engineering, Beihang University, Beijing 100083, China.

[2]Key Laboratory for Biomechanics and Mechanobiology of Ministry of Education, School of Biological Science and Medical Engineering, Beihang University, Beijing 100083, China.

[*]Corresponding Author: Xiaofei Wang. Email: xiaofei.wang@buaa.edu.cn.

Abstract: Accommodation is the ability of the eye to adjust its lens thickness to alter the refractive power through the contraction of ciliary muscles. The loss of accommodation ability due to aging leads to presbyopia, a condition in which the eye is unable to focus on near objects. Glaucoma is a disease that vision is impaired due to damage of the retinal ganglion cell at the optic nerve head (ONH) region, which is the leading cause of irreversible blindness worldwide. The biomechanical theory of glaucoma suggests that the deformations of ONH tissues could (directly or indirectly) drive retinal ganglion cell death. Recently, it has been hypothesized that the contraction of ciliary muscle during accommodation could also deform ONH tissues [1], indicating that presbyopia may be a contributing factor for glaucoma. However, the magnitude of the accommodation induced ONH deformation is unknown. The aim of this study was to use finite element (FE) modelling to estimate ONH strains due to the pulling of ciliary muscle during accommodation. A 3D axisymmetric FE model of one eye was reconstructed to simulate ciliary muscle pulling, which incorporates retina, sclera, choroid, Bruch's membrane, lamina cribrosa, neural tissue, dura and pia sheath of the optic nerve. FE-derived ONH strains induced by ciliary muscle pulling was compared to those resulting from an intraocular pressure (IOP) elevation. Our models predicted that ciliary muscle pulling force could be transmitted to ONH region through choroid and Bruch's membrane. The mean effective strain of the lamina cribrosa in the ONH was 0.011, which is comparable to those induced by an IOP elevation to 50 mmHg (0.016). In conclusion, our models predicted high ONH strains due to ciliary muscle pulling during accommodation. Further experimental and clinical studies are needed to explore possible links between presbyopia and glaucoma.

Keywords: Glaucoma; presbyopia; accommodation; optic nerve head; biomechanics

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References

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