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Tonometric Estimation of Mechanical Properties of a Cornea and Sclera

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Abstract

Purpose: : To investigate degree of anisotropy and evaluate elastic constants of the eyeball tissues based on a shell theory.

Methods: : Simulated sclera was mechanically modeled as an orthotropic spherical shell. Scleral deformations were generated by simulated stresses in the intraocular pressure (IOP). Relations between the shape deflection mode in the shell and the ratio of tangential elasticity modules were calculated. In Maklakov's method of IOP testing, the eyeball is modelled as two spherical segments with different mechanical properties. The baseline (prior to load) two-segment shell is assumed to be filled with uncompressible liquid under pressure. Young's module of cornea is muchlower than that of sclera. Hence, cornea is more compliant than rigid sclera and doesn't resist to flexural deformations. A nonlinear shell theory was used to analyze deformations of both the cornea and the sclera.

Results: : Ratios of tangential elasticity modules of the orthotropic spherical shell in different directions appeared to have a great influence on the amplitude and shape of the deformation in the shell. Therefore, the degree of scleral anisotropy can be evaluated by ratio of anterior-posterior eye axis lengths to the equator diameter. Maklakov's method of IOP measurement, with several different loads, can be also used to investigate the elasticity of the eye tunics and to study the range of application of physically linear theories of elasticity in mechanical models of pressure-related eyeball deformation.

Conclusions: : Pressure-related eyeball deformation varies significantly dependingon the degree of anisotropy and heterogeneity of the eye tunics. Transversal shear modules have the greatest influence on the pressure-related deformation of the eyeball tunics. Physical nonlinear theories of elasticity are necessary tools to characterize details of pressure-related corneal and scleral deformations.