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Mathematical modelling of applanation tonometry for intraocular pressure measurements. (39958)

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Intraocular pressure (IOP) is an important aspect in the evaluation of patients at risk from glaucoma.

Applanation tonometry estimates intraocular pressure by quantifying the force needed to generate a defined amount of deformation of the cornea (Goldmann Tonometry) or by estimating the diameter of the circular contact area of the cornea and flat tonometer of defined load (Maklakoff Tonometery). The geometrical parameters of eyes essentially vary for different people and change with age, different pathologies of vision or after refractive surgery. The corneal responses are not fully understood and predictable. It is now clear that mathematical modelling plays an important role in the analysis of the overall mechanical interactions between cornea and sclera. Proposed model can elucidate how scleral properties may play a role in determining IOP.

In the developed model, the shell of an eye is considered to consist of two segments with different mechanical properties. The two-segments shell is filled with incompressible liquid under the pressure. Nonlinear theory of shells that takes into account normal and shear stresses, and normal strain is used to analyze deformations since the deformation of the shell part, which models the cornea, is significant. The effect of the geometrical and physical properties of the shell on the results of the modelling is studied.

The model shows that tonometry readings do not always reflect true IOP values. For example, if IOP is not very high and after refractive surgery the thickness of the cornea is small the cornea may buckle and detach from the tonometer.

This model permits to estimate the effect of parameters of a sclera on the change of the IOP after injections into a vitreous body. Considering nonlinear shells model could be used to explain different results of elastotonometry.

1. Bauer S.M, Ermakov A.M. Buckling of a spherical segment under the flat base load Proceedings of the 2nd International Conference Optimization and Analysis of Structures, Editors J.Lellep, E.Puman, Tartu, Estonia, August 25-27, 2013, p. 24-27
2. Bauer S.M., Voronkova E.B., Nonclassical Shell Theories in Ocular Biomechanics, Shell and Membrane Theories in Mechanics and Biology From Macro to Nanoscale Structures, Altenbach H, Mikhasev G (eds), 2015, XI, 321 p, Springer, Hardcover, ISBN: 978-3-319-02534-6 p.81-98
3. Ermakov A.M. The buckling of the transversal-isotropic spherical segment under influence of the load with a flat base. Vestnik St. Petersburg University. Ser. 1. 2014. № 4. Pp. 589-598 (in Russian)
4. Bauer S.M., Venatovskaya L.A., Franus D.V., Redotova L.A. Estimation of changes in stress-strain state of an eye shell and intraocular pressure reading after refractive correction of hyperopia, Russian Journal of biomechanics, 2015, v.19, N 2, p.117-123