Abstract

In the research conducted as part of this doctoral dissertation, the dynamic biomechanical behavior of the crystalline lens was analyzed, with particular focus on the oscillation (wobbling) phenomenon taking place immediately after the sudden cessation of the eyeball's rotational movement. Inspired by existing experimental observations, a computational model was developed using the Finite Element Method (FEM) combined with a fluid-structure interaction (FSI) approach to simulate the dynamic phenomena occurring within the eyeball under these conditions. The accuracy of the model was verified by comparing the results of mechanical simulations with experimental data (both *ex vivo* and *in vivo*) obtained from a system for recording Purkinje images and their sequences. This comparison was made possible by using optical simulation software in the computational cycle, which generated Purkinje images analogous to those obtained in experiments. This required a detailed analysis of mechanical parameters. Sensitivity analysis of the biomechanical parameters of individual model structures highlighted the importance of factors such as the Young's modulus of the zonules, on which the lens is suspended, in developing a reliable biomechanical model. Furthermore, the presented research showed that the pressure conditions prevailing in the direct vicinity of the crystalline lens may play a certain role in the dynamics of the lens wobble phenomenon. The results suggest that lens oscillations may in the future serve as a biomarker for non-invasive estimation of intraocular pressure, offering a promising direction for the development of ophthalmic diagnostics. The comprehensive biomechanical approach presented in this work provides a source of new information on the behavior of the lens during rotational eye movements, and the presented results may have implications for both clinical research and the development of diagnostic tools.

Keywords: Crystalline lens, Ocular biomechanics, Fluid-Structure Interaction (FSI), Sensitivity Analysis, Intraocular pressure (IOP)