High Rate Internal Pressurization of the Human Eye to Determine Dynamic Material Properties

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ABSTRACT

Over 1.9 million people suffer from eye injuries in the United States, occurring from automobile accidents, sports related impacts, and military combat. As a result of trauma, approximately 30,000 people become blind in one eye every year in the United States. A common injury prediction tool used for eye injuries is computational modeling, which requires accurate material properties to produce reliable results. The purpose of this study is to create a high rate pressurization system to analyze the rupture pressure of human eyes and to determine the dynamic material properties of human eyes. A high rate pressurization system was used to create a dynamic pressure event to the point of rupture in 20 human eyes. The internal pressure was dynamically induced into the eye with a drop tower while the rupture pressure was measured with a small pressure sensor inserted into the optic nerve. Measurements were also obtained for the diameter of the globe, the thickness, and the changing coordinates of the optical markers. A relationship between stress and Green-Lagrangian strain was determined for each test specimen in the x and y direction to show directional effects. It was found that the average rupture stress was 13.10 MPa, the average maximum Green-Lagrangian strain in the x-direction was 0.060, and the average maximum Green-Lagrangian strain in the y-direction was 0.087. It was also found that the average high rate rupture pressure of human eyes was 0.972 ± 0.29 MPa. In comparing these data with previous studies, it is concluded that the loading rate directly affects the rupture pressure and that the human eye is both anisotropic and viscoelastic.