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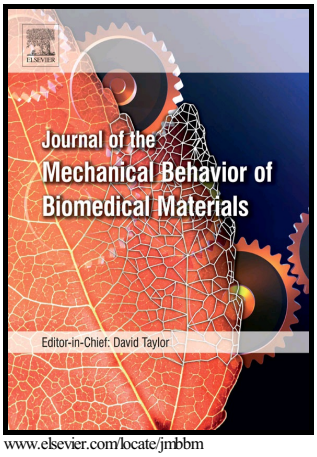

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Modeling with a meshfree approach the cornea-aqueous humor interaction during the air puff test

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Abstract

The air puff test is an in-vivo investigative procedure commonly utilized in ophthalmology to estimate the intraocular pressure. Potentially the test, quick and painless, could be combined with inverse analysis methods to characterize the patient-specific mechanical properties of the human cornea. A rapid localized air jet applied on the anterior surface induces the inward motion of the cornea, that interacts with aqueous humor –the fluid filling the narrow space between cornea and iris– with a strong influence on the dynamics of the cornea. While models of human cornea reproduce accurately patient-specific geometries and have reached a considerable level of complexity in the description of the material, yet scant attention has been paid to the aqueous humor, and no eye models accounting for the physically correct fluid-solid interaction are currently available. The present study addresses this gap by proposing a fluid-structure interaction approach based on a simplified two-dimensional axis-symmetric geometry to simulate the anterior chamber of the eye undergoing the air puff test. We regard the cornea as a membrane described through an analytical model and discretize the fluid with a mesh-free particle approach. The membrane is assumed to be nonlinear elastic and isotropic, and the fluid weakly compressible Newtonian. Numerical analyses reveal a marked influence of the fluid on the dynamics of the cornea. We perform a parametric analysis to assess the quantitative influence of geometrical and material parameters on the mechanical response of the model. Additionally, we investigate the possibility to use the dynamics of the test to estimate the intraocular pressure.

Keywords: meshfree methods, particle methods, collocation methods, fluid-solid interaction, fluid-dynamics, air puff test

1. Introduction

The identification of the in-vivo mechanical properties of the external part of the eye stands as a hot topic in the current ophthalmologic research, since the availability of patient-specific models of the anterior chamber of eye will