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Numerical Investigation of Fluid Outflow through a Retinal Hole after Scleral Buckling

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Abstract : Objectives of the study are i) to perform numerical simulations that permit an analysis of the dynamics of subretinal fluid when an implant has induced scleral intussusception and ii) assess the impact of the physical parameters of the model on the flow rate. Computer simulations were created using finite element method (FEM) based on a model that takes into account the interaction of a viscous fluid (subretinal fluid) with a hyperelastic body (retina). The purpose of the calculation was to investigate the dependence of the flow rate of subretinal fluid through a hole in the retina on different factors such as viscosity of subretinal fluid, material parameters of the retina, and the offset of the implant from the retina's hole. These simulations were performed for different speeds of eye movement that reflect the behavior of the eye when reading, REM, and saccadic movements. Similar to other works in the field of subretinal fluid flow, it was assumed stationary, single sided, forced fluid flow in the considered area simulating the subretinal space. Additionally, a hyperelastic material model of the retina and parameterized geometry of the considered model was adopted. The calculations also examined the influence the direction of the force of gravity due to the position of the patient's head on the trend of outflow of fluid. The simulations revealed that fluid outflow from the retina becomes significant with eyeball movement speed of 100°/sec. This speed is greater than in the case of reading but is four times less than saccadic movement. The increase of viscosity of the fluid increased beneficial effect. Further, the simulation results suggest that moderate eye movement speed is optimal and that the conventional prescription of the avoidance of routine eye movement following retinal detachment surgery should be relaxed. Additionally, to verify numerical results, some calculations were repeated with use of meshless method (method of fundamental solutions), which is relatively fast and easy to implement. The paper has been supported by 02/21/DSPB/3477 grant.

Keywords : CFD simulations, FEM analysis, meshless method, retinal detachment
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