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Fluid Flow During Descemet Membrane Detachment

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Abstract

Descemet membrane detachment (DMD) happen when the aqueous humour (AH) in the aqueous chamber flow into the descrement membrance (DM) space through a break and separate the membrane from the stroma. This often happen after the cataract surgery. The fluid is driven by the buoyancy force that generated by to the existing of temperature different between the cornea and the pupil. COMSOL Multiphysics with using the interface of Laminar Flow and Heat Transfer in Fluids, is applied to study the mechanisms of the fluid flow in DMD. From Figure 1, the temperature at the pupil/iris is fixed at Tp which is 37 Celsius (the human body temperature), and the temperature at the cornea is assumed to be Tc, around 35 Celsius as a result of the cornea is cooled by the surrounding air which is estimated to be 24 Celsius. The gravity, g is acted along the positive x-axis because the patient is assumed to be in an upright position. A set of typical values for human eye is used: h0 = 2.75[mm] and a = 5.5[mm] (Ref. 1, Ref. 2 and Ref. 3). The AH have the properties similar to water (Ref. 1, Ref. 2 and Ref. 3), therefore, the AH is assumed to be Newtonian, viscous and incompressible. The DMD is assumed to be a thin and small flap attached onto the anterior surface of the cornea (Ref. 1).The boundary conditions for velocities, u and w, are all non-slip condition. No information on the pressure within the model is given, so the model will estimate the pressure change instead of the pressure field. In order to confirm the problem converge, pressure at a point is arbitrary fixed in the model using the point settings. The boundary conditions for the temperature for the temperature are fixed as mentioned above.Figure 2(a) illustrates the fluid flow in the AC driven by the buoyancy convection without the DMD and it is concur to the results computed by Ismail and associates (see Figure 3 in Ref. 1) and Canning (see Figure 4 in Ref. 3). Besides that, the maximum flow speed that we obtained in this study is 3.760E-4[m/s] which exist at position (0, 5.516E-4) and Ismail and associates (Ref. 1), determined analytically that the maximum flow speed exist at (0, 5.811E-4) with the value 3.962E-4[m/s]. The great agreement between the present results with the previous obtained solutions have enhanced our confidence to the results determined in this research. Figure 2(b) shows the velocity profile when the DMD exist. The existing of DMD do affect the behaviour of the fluid flow in AC, it will reduce the magnitude of the velocity in AC.The behaviour of the AH flow driven by the buoyancy force through the DMD have been studied. COMSOL Multiphysics can effectively be used to simulate the fluid flow in DMD. This is validated when the computed solutions have a great agreement with the theoretical solutions for the case without DMD.

Reference

1. Ismail., Z., Fitt., A. D., and Please., C. P., “A fluid mechanical explanation of the spontaneous reattachment of a previously detached Desecement membrance.,” Mathematical Medicine and Biology, vol. 30, pp. 339-355 (2013).

2. Fitt., A. D., and Gonzalez.,G., “Fluid Mechanics of the Human Eye: Aqueous Humour Flow in The Anterior Chamber,” Bulletin of Mathematical Biology, vol. 68, no. 1, pp. 53-71(2006).

3. Canning., C. R., Greaney., M. J., and et.al “Fluid flow in the anterior chamber of a human eye,” IMA Journal of Mathematics Applied in Medicine and Biology., vol. 19, pp. 31-60, (2002).

Figures used in the abstract

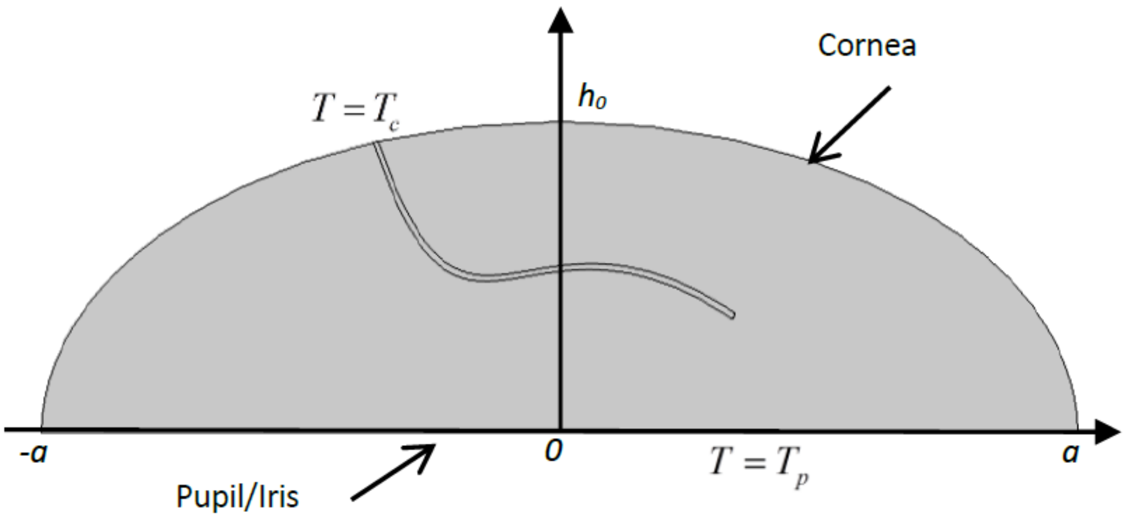

Figure 1: Schematic diagram of the DMD in the AC.

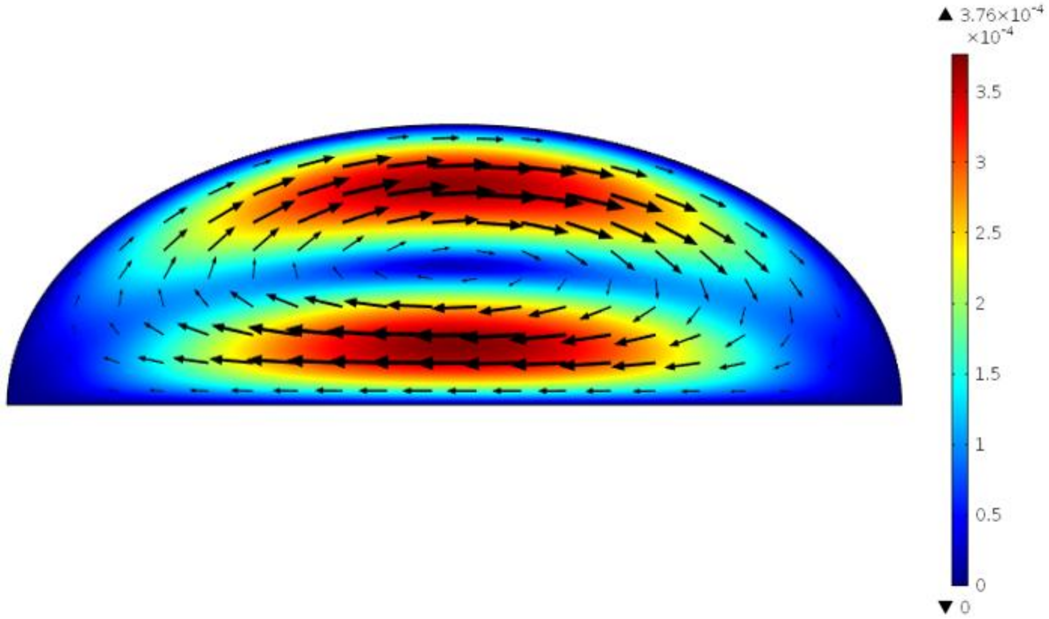

Figure 2: Velocity profile and arrow surface of without DMD by using the kinematic viscosity = 0.9E-6[m2s-1], the density ρ = 1000[kgm-3], the specific heat k = 0.57 [Wm-1K-1], the thermal conductivity Cp = 4200 [J kg-1K-1], the gravity g = 9.8[ms-2] and the coefficient of linear thermal expansion of the fluid α = 3E-4[K-1]. (Ref. 3).

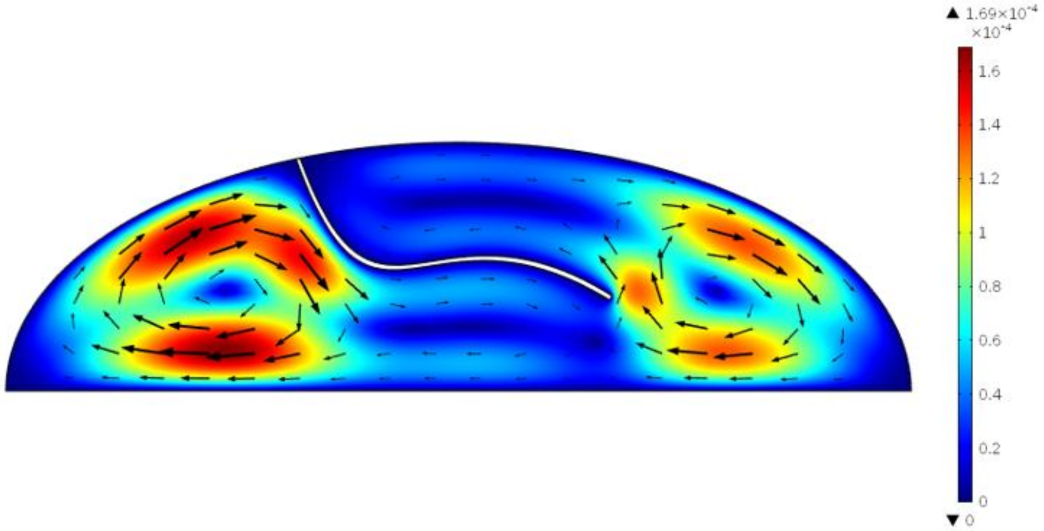

Figure 3: Velocity profile and arrow surface of with DMD, by using the kinematic viscosity = 0.9E-6[m2s-1], the density ρ = 1000[kgm-3], the specific heat k = 0.57 [Wm-1K-1], the thermal conductivity Cp = 4200 [J kg-1K-1], the gravity g = 9.8[ms-2] and the coefficient of linear thermal expansion of the fluid α = 3E-4[K-1]. (Ref. 3).