Vitreous shrinkage and posterior vitreous detachment

Amabile Tatone, Alessandro Testa
Department of Engineering of Structures, Water and Soil, University of L'Aquila, Italy
E-mail: amabile.tatone@univaq.it

Vitreous undergoes a progressive separation into a gel-like phase and a liquid phase with aging. This liquefaction process is very slow and results from a structural change in the network of collagen fibrils which are the main constituent of the vitreous gel [2]. The fibrils coalesce into bundles and let the liquid vitreous free to separate from them. The vitreous is bounded by a thin collagen cortex [4] which is initially bonded posteriorly to the internal limiting lamina of the retina (ILL). The fibril remodeling gives rise to tractions on the boundary which makes the cortex detach, while the liquefied vitreous flows outside the detached cortex. This process is called posterior vitreous detachment (PVD) ([3], [1]). A complete harmless detachment may be hampered by small areas of focal adhesion where a strong traction may cause retinal tears triggering retinal detachment.

In this work the vitreous gel is assumed to be made of a homogenous and isotropic solid undergoing a shrinking process described by a uniform spherical contraction at constant velocity. The cortex is kept inside the vitreous chamber by a field of repulsive forces and its adhesion to the ILL is described by a field of adhesive forces. Both force fields are constitutively defined by a surface potential on the boundary. A non uniform adhesion gives rise to different detachment patterns which look very similar to those observed in reality. The shrinkage is assumed to be slow enough that there is no interaction between the flow of the liquefied vitreous and the remaining collagen fibril network. Even the inertial and gravity forces are neglected. Numerical simulations have been performed on a two-dimensional model, although the mechanical model has been defined in a three dimensional setting. The simulations are illustrated by movies showing the evolution of the detachment and by graphs showing the evolution of the elastic energy and of the adhesion energy.

References

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