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A Fluid-Structure Interaction algorithm for the corneal air puff test

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The air puff test is a clinical practice adopted in ophthalmology to estimate the physiological intraocular pressure (IOP) exerted on the internal surface of the cornea by the fluid filling the anterior chamber of the eye. The test consists in applying on the anterior surface a rapid air jet causing a localized transient change in the curvature of the cornea. When the cornea is locally flattened, the level of external pressure is supposed to be correlated to the IOP.

In biomechanics, the air puff test has been regarded as a possible tool for estimating the material characteristics of the corneal material. In this context, the numerical modelling of the air puff test has attracted growing interest. The calibration and the assessment of a corneal material model can be tackled through the comparison of numerical simulations and images provided by optical instruments. The comparison allows for the definition of patient-specific models, a sought support for the design of personalized refractive surgery.

Mechanically the air puff test involves a Fluid-Structure Interaction (FSI) problem. The deflection of the cornea induces local changes in the distribution of the fluid pressure acting on the internal surface of the cornea.

In this study, the FSI problem of the corneal air puff test is approached through a staggered algorithm, consisting in the use of two different solvers for the solid and for the fluid problems. The two individual solutions are exchanged in terms of modified velocities and pressure loads respectively, cf. [3] for the axis-symmetric case. The dynamic equilibrium of the cornea, in a patient specific configuration, is achieved through finite elements; the fluid problem is solved using the Modified Finite Particle Method [2], a meshfree method suitable for the Lagrangian description of the Navier-Stokes equations.

The results confirm the computational efficiency of the method to treat FSI in ocular applications. The method can be useful in the determination of the mechanical properties of the corneal tissue.

REFERENCES

[1] Pandolfi, A., and Manganiello, F. "A model for the human cornea: constitutive formulation and numerical analysis", BMMB, 5:237-246, 2006.
[2] Asprone, D., et al. "A Modified Finite Particle Method: Multi-dimensional elasto-statics and dynamics", IJNME, 99:1-25, 2014.
[3] Montanino, A., et al., "Modelling with a meshfree approach the cornea-aqueous humor interaction during the air puff test", JMBBM, 77:205-216, 2018.