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INVERSE FEM CORNEAL TISSUE CHARACTERIZATION METHODOLOGY FOR CONTACT TONOMETRY TEST

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The eye's behaviour is considered to be determined by three different biomarkers: the intra ocular pressure (IOP) which can vary in a wide range, the corneal geometry which involves both the corneal central thickness (CCT) and the corneal curvature and, finally, the corneal tissue properties which can be affected by diseases or surgeries. The current measurement methodologies induce a non-physiological corneal load state (bending state vs. membrane stress state) and, furthermore, they are not able to discriminate the corneal tissue properties since the response is affected by different parameters. This work has a two-fold objective: firstly to establish the grounds of corneal bending response in order to gain a better knowledge and, secondly, to determine the constitutive material behaviour in order to approach to a patient specific material model by means of inverse FE method which allows estimating the mechanical constitutive behaviour (material parameters) by minimizing a cost function associated with a representative biomarker of the corneal tissue response (anisotropic hyperelastic behaviour), i.e., maximum apical displacement.

The main pipeline of our proposed methodology is to reconstruct the FE geometry by using an average geometrical of the eyeball, setting up an initial set of random materials and performing the FE analysis in order to obtain a stepwise comparison of the numerical response to a contact tonometry, where an indenter induces bending to the cornea in a displacement-controlled experiment, with the real Force-Displacement pattern obtained in a real contact tonometry. If the difference between both is less than a given tolerance the set of material parameters is said to be the patient specific corneal material. Otherwise, a new set of parameters is computed and a new FE analysis is performed.

This methodology is intended to provide a new and improved corneal biomechanical model, which may allow better understanding the corneal biomechanics.