Customized finite element modelling of the human cornea

Irene Simonini* and Anna Pandolfi†

* Dipartimento di Matematica (DM)
† Dipartimento di Ingegneria Civile ed Ambientale (DICA)
Politecnico di Milano (POLIMI)
Piazza Leonardo da Vinci 32, 20133 Milano, Italy
e-mail: irene.simonini@polimi.it, anna.pandolfi@polimi.it, web page: http://www.polimi.it

ABSTRACT

The present study has been carried out in order to validate the performance of an advanced numerical procedure that, starting from images of the anterior chamber of the eye, builds an accurate, patient-specific geometrical model of the human cornea [1]. The patient-specific geometry is obtained by a sophisticated interpolation procedure on the surface points provided by the Sirius (CSO, Scandicci, Italy) topographer apparatus. The innovation of the present approach is represented by a patient-specific geometry and by a more accurate estimation of the individual material properties with respect to previous contributions [2].

Recent studies [3] discuss including the description of the fibril organization in the human cornea. The current version of the finite element code uses improved models of statistically distributed fiber materials [4], applied over a particular organization of the collagen fibrils in the cornea [5].

The geometrical model is used in a static stress analysis solver that estimates, by means of a simplified identification procedure, the customized material properties of the eye according to the chosen material model [1]. The material model used in the present calculations has been proved to be sufficiently accurate, robust, and efficient in previous applications [2].

The patient-specific approach has been used to perform quasi-static analyses of the corneas of five patients, undergoing laser refractive surgery to treat myopia or astigmatism [1]. The analyses involved preoperative and the postoperative corneas, and provided a wealth of numerical results, in terms of displacements, strains and stresses. The knowledge of the preoperative and postoperative stresses is instrumental in order to prevent the possible damage induced by the refractive surgery.

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