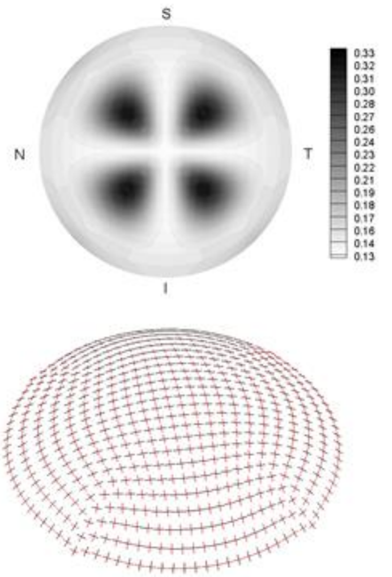
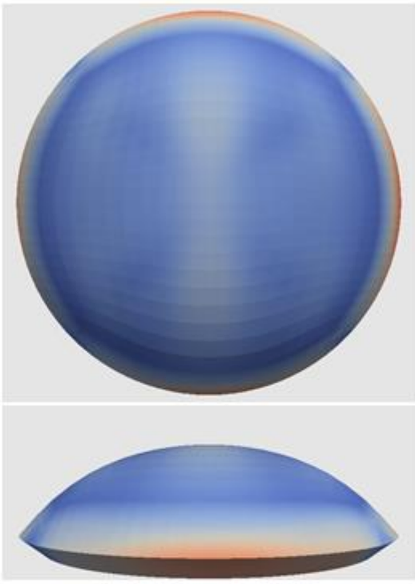
Anna Pandolfi "Understanding and modeling the biomechanics of the human cornea"

KTH SOLID MECHANICS SEMINAR; Wednesday, September 17th, 10.15; KTH Solid Mechanics Seminar room

The cornea is a thin concave-convex lens which provides 70% of the total refractive power of the eye. The anterior and posterior surfaces of the cornea are similar to spherical segments, and the cornea reaches its maximum refractive power (43 diopters) in the equilibrium configuration under the action of the physiological intraocular pressure (15-18 mmHg). Refractive errors resulting in myopic, hyperopic or astigmatic vision can be partially or totally corrected with laser refractive surgery (PKR, LASIK, LASEK). On the basis of the geometry of the original cornea and of the desired power correction, refractive surgery removes a thin layer of the cornea, modifies the external curvature, and changes the refractive power. In the past years, we developed an accurate three-dimensional finite element model of the human cornea. The discretized patient specific geometry is created by an automatic procedure, based on a few geometrical data available from standard clinical measurements or starting from the geometrical coordinates of set of points located on the anterior and posterior surface of the cornea. The material is modeled as a distributed two-fiber reinforced hyperelastic medium, describing the well organized collagen structure embedded in isotropic matrix of the cornea. In order to simulate the surgical correction of myopic, hyperopic and astigmatic eyes, the code is equipped with a reshaping procedure based on standard and personalized ablation profiles. Besides the postoperative shape of the cornea and the final effective refractive power, numerical results provide the pre-postoperative stress distribution, of primary importance in refractive surgery planning. We used the numerical model to carry on a quantitative study on the influence of the cornea geometry on the mechanical response, by direct comparison with laboratory tests on pig corneas; and to estimate the increase on the local stress induced by the PRK reshaping by using accurate patient specific corneal geometries. We observed that the use of simple mathematical models based on the linearized thin shell theory applied to short-term postoperative measurements can be useful in identifying corneal tissues prone to develop post-operative ectasia.





Anna Pandolfi is an Associate Professor of Structural Mechanics at the Politecnico (Technical University) of Milano, Italy. She received a M.S. degree in Civil Engineering from the Politecnico di Milano and a PhD in Mechanics from the University of Metz, France. From 1988 to 1994 Anna Pandolfi has been working as entrepreneur in a scientific software company, and in 1995 she joined the faculty of the Politecnico di Milano. Since 1996 she has been holding a Visiting Associate position at the California Institute of Technology, Pasadena CA. Anna Pandolfi authored/coauthored about 100 scientifical papers, 45 in international journals; she has one USA patent application. She serves as reviewer for more than 60 international journals. Her interests in research span from fracture and contact mechanics, discretization methods, constitutive modelling, biomechanics of soft tissues, complex and metamaterials.