Stress-relaxation behaviour of the retina characterized through small punch test and computational modelling

Damiano Bertolo, Anna Pandolfi, Federica Boschetti
Politecnico di Milano, Department of Chemistry, Materials and Chemical Engineering "Giulio Natta" (LaBS)

Abstract:
Hereditary retinal diseases are one of the leading causes of blindness among working-age adults, with an incidence of 1:1380 people. The optimal treatment option is genic therapy delivered by subretinal injections. To evaluate the influence of different aspects of the surgery, such as the rate, the site, and the volume of the injection on the rupture of the retina, a material model of the retina is being developed. In the literature, the retina has been characterized mostly through uniaxial tensile testing, a method that does not reproduce the load conditions occurring during the injection, nor the in-vivo physiological state. This study employs a novel approach based on the small punch test to investigate the retinaâ€™s behaviour under a stress-relaxation test. Porcine retinas have been employed due to their similarity to human retinas and their high availability, making them the preferred animal model. The experimental protocol involves three preconditioning cycles at 0.1 mm/s up t o 1 mm, followed by three displacement ramps of 1 mm at the same strain rate, each maintained for 120 s. Preliminary results have demonstrated the efficacy of this protocol in capturing the stress-relaxation behaviour of the retina. To determine the most suitable viscoelastic material model and parameters for the stress-relaxation behaviour of the retina, an axis-symmetrical computational model has been developed in Abaqus/Standard 2022 alongside the experimental test. A response surface methodology is employed to estimate the viscoelastic parameters of the retina by comparing the stress-relaxation curves generated by the model with the experimental ones. The best-fitting parameters are obtained by minimizing the Root Mean Squared Error, selected as the loss function for the comparison.