

Calibrating corneal material model parameters using only inflation data: An ill-posed problem

S. Kok^{1,*}, N. Botha^{1,2} and H. M. Inglis¹

¹*Department of Mechanical and Aeronautical Engineering, University of Pretoria, Pretoria, 0002, South Africa*

²*Advanced Mathematical Modelling, CSIR Modelling and Digital Science, PO Box 395, Pretoria, 0001, South Africa*

Abstract

Goldmann applanation tonometry (GAT) is a method used to estimate the intraocular pressure by measuring the indentation resistance of the cornea. A popular approach to investigate the sensitivity of GAT results to material and geometry variations is to perform numerical modelling using the finite element method, for which a calibrated material model is required. These material models are typically calibrated using experimental inflation data by solving an inverse problem. In the inverse problem, the underlying material constitutive behaviour is inferred from the measured macroscopic response (chamber pressure versus apical displacement). In this study, a biomechanically motivated elastic fibre-reinforced corneal material model is chosen. The inverse problem of calibrating the corneal material model parameters using only experimental inflation data is demonstrated to be ill-posed, with small variations in the experimental data leading to large differences in the calibrated model parameters. This can result in different groups of researchers, calibrating their material model with the same inflation test data, drawing vastly different conclusions about the effect of material parameters on GAT results. It is further demonstrated that multiple loading scenarios, such as inflation as well as bending, would be required to reliably calibrate such a corneal material model.