MODELLING OF EYE LENS FUNCTION: OPTICAL AND MATERIAL PROPERTIES

Barbara Pierscionek (1), Lin Ye (1), Kehao Wang (2)

1. *Faculty of Health Education Medicine and Social Care. Medical Technology Research Centre, Anglia Ruskin University Bishop Hall Ln, Chelmsford CM1 1SQ, UK*
2. *Beijing Advanced Innovation Centre for Biomedical Engineering, School of Engineering Medicine, Beihang University, Beijing, China*

Introduction: The growth of research in computational models and data that these provide has added to understanding of lens function and ageing, notably the processes of accommodation and presbyopia. However, models are dependent on the parameters used in their construction and can give different data depending on material properties and how these are distributed, lens shape and zonular insertions. The parameters that affect shape change and stress distributions have been investigated as have software packages.

Methods: Finite Element models were developed from measurements of refractive index made on in vitro lenses (Figure 1). Modelling and simulated stretching was conducted using ANSYS based on biological lenses from four different ages: 16, 35, 40, 57 years old. Further models on a 35 year old lens were also constructed using ABAQUS software to compare to ANSYS modelling. Models considered varying distributions of elastic moduli based on refractive index profiles [1] and longitudinal modulus profiles taken from mechanical analysis [2] (Figure 2). Various combinations of zonular insertions were tested and simulated [3].

Results: The internal stress distributions depend on the modelling of elastic moduli in the cortex with a more even spread of internal stresses and fewer discontinuities in models that have a gradient of modulus than those with a uniform equivalent modulus. Greatest stresses are seen in the nucleus of the lens regardless of model type. There is no difference in optical power between models with gradient or uniform elastic modulus. Inclusion of equatorial zonule appears not to have an effect on lens shape change with simulated stretching but does affect stress distributions. Comparison of different software for the same lens indicate that shape change with simulated stretching are similar but there are variations in stress distributions.

Discussion: Modelling can provide data to complement experimental measurements on lens function and can relate optical and mechanical properties of the lens. Account needs to be taken of material property distributions, zonular insertions and different software packages.

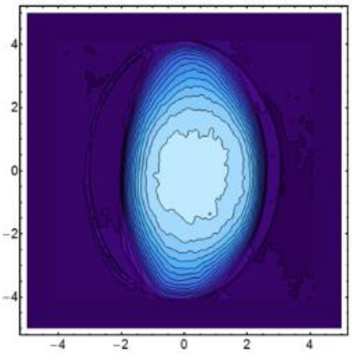

Figure 1: Refractive index contours for a 16 year old lens used in developing biomechanical models.

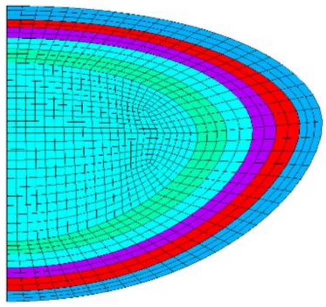

Figure 2: Contours of elastic modulus based in refractive index measurements.

References

1. B. K. Pierscionek et al., Oncotarget, vol. 6, no. 31, pp. 30532-30544 (2015).
2. S. Besner et al., Invest. Ophthalmol. Vis. Sci., vol. 57, no. 13, pp. 5093-5100 (2016).
3. K. Wang et al. IEEE TBME, vol. 67, no. 4, pp. 999-1006(2020).

Acknowledgements

Lin Ye is an early stage researcher in the doctoral training centre supported by the EU Horizon 2020 Research and Innovation programme under the Marie Skłodowska-Curie grant agreement no 956720