Title of dissertation: *In-vivo* assessment of age-related changes in the human crystalline lens using optical imaging systems

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Abstract

The human crystalline lens is a biconvex adjustable refractive element of the eye and consists of concentric layers of fibre cells that form the lens nucleus and cortex. The lens is subject to several ageing processes that alter structural, optical and biomechanical lens properties, leading to a gradual deterioration in vision. The ever-growing fibre cells cause continuous remodelling of lens morphology by increasing the lens size and weight. Human crystalline lens transparency is achieved by specific structural lens organisation, and age-related molecular changes in the lens lead to increased intraocular light scattering.

The main goal of the study was to demonstrate and quantify characteristic age-related alterations in the crystalline lens by the measurement of forward- and back-scattering in healthy subjects and to associate those changes with vision degradation. Specifically, the thesis concentrated on: (1) lens shape remodelling with age, (2) gradual loss of lens transparency and reduction of visual performance, and (3) optical inhomogeneities within the lens associated with the micro-structural lens organization. Two modern imaging instruments, anterior segment swept-source optical coherence tomography (OCT) and double-pass imaging of retinal point spread function, were used to assess both the lens morphology and intraocular scattering. Firstly, I demonstrated that crystalline lens morphology (thickness and radii of surface curvature) changes with age. I also evaluated that the optical quality of the lens degrades with age as the back-scattered optical signal increases. Secondly, I performed a detailed analysis of the age-related changes in the optical signal discontinuity zones of the lens (nucleus and cortical C1α, C1β, C2, C3, and C4 zones) based on high-definition OCT images and Oxford system nomenclature. The bright zone, C3, was primarily responsible for the overall growth of the crystalline lens and also highly correlates with the increase in the back-scattered signal. Finally, I was able to visualize lenticular suture architecture from volumetric OCT data.

The results help towards an improved understanding of the structure/function relationship of the crystalline lens, and can contribute to a better insight into the development of age-related eye diseases such as cataract and presbyopia.

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