Investigative Ophthalmology & Visual Science

Invest Ophthalmol Vis Sci 2008;49: E-Abstract 2839.

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Modeling the Mechanism of Compensation of Aberrations for Accommodation and Age

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Commercial Relationships: J. Tabernero, None; **P. Artal**, None.

Support: MEC_FIS2004-2153 (Spain)

Abstract

Purpose: To investigate the potential changes in the amount of compensation of aberrations as a result of the changes in lens shape factor (curvature) and asphericity of the crystalline lens as a function of accommodation and age.

Methods: We measured corneal and ocular aberrations, lens alignment, and axial length of the eye in a group of 18 young subjects. These data were used to develop individualized models for the unaccommodated eye [Tabernero et al., JOSAA, 2007]. The curvature and asphericity of the crystalline lenses were selected to match the refraction and spherical aberration of each eye. This correctly predicted the compensation of coma. To evaluate the effect of the geometrical changes of the lens due to accommodation and age on the compensation of aberrations, we used the average geometrical data available in the literature [Dubbelman et al., Vis. Res, 2005; Dubbelman & Van der Heijde, Vis.Res., 2001]. These changes were incorporated in each individual eye model. The eye's aberrations were calculated, using exact ray-tracing, every 0.25 D of accommodation (from 0 to 7 D.) and every 5 years of change in lens parameters (from 20 to 75 years old).

Results: The change in the crystalline lens curvatures (shape factor) occurring during accommodation predicts well the change in ocular spherical aberration (SA) with a sign reversing from positive to negative. The changes in lens asphericity with accommodation have a smaller effect in the evolution of SA. During accommodation coma changed less than SA. This made the balance of aberrations between cornea and lens rather stable. This result could also be explained by Seidel aberration theory. The change in power of the lens would increase coma, but on the other hand, the change in shape factor towards a

more equibiconvex lens counteracts in part this effect. The scenario is slightly different when age is considered. In order to explain the increase in ocular SA and coma with age [Artal et al., JOSA A, 2002], the increase in asphericity of the lens surfaces need to be incorporated in the modeling. The change in lens curvature alone cannot be responsible for this effect, since it would only generate a similar situation as lens accommodation: a decrease in SA; which is against the experimental results.

Conclusions: The mechanism of compensation of aberration between the cornea and lens is some how disrupted both during accommodation and aging. We used customized modeling to evaluate the effect of the change sin lens curvatures and asphericity in this mechanism. The curvatures in the case of accommodation and asphericity in the case of aging is the main responsible for the changes in aberrations

Keywords: aberrations • aging • accomodation