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Quantitative 3d-Imaging of the in vivo Crystalline Lens During Accommodation

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Footnotes

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Abstract

Purpose: : To quantify the morphological changes in the crystalline lens during accommodation. To measure the fluctuations of the crystalline lens during steady accommodation.

Methods: : A high resolution, high speed custom-built spectral-OCT was used to image the anterior segment of the eye. An accommodating channel allowed stimulus vergences from 0 D to 6 D in 1-D steps by means of a Badal system. The stimulus was an eight-arm Maltese cross. One set of 3D images of the cornea (1668 A-scans in 15 mm x 60 B-scans in 9 mm) and 5 sets of 3D images of the crystalline lens (2502 A-scans in 15 mm x 40 B-scans in 6 mm) were acquired for every accommodative demand. A piezoelectric module placed in the reference mirror allows unfolding the sOCT images to obtain crystalline lens images with 14 mm axial range. Each 3D measurement lasted for 2 seconds. In addition, cross-sectional images of the crystalline lens (horizontal meridian, 1668 A-scans in 15 mm) were acquired continuously during at 14 Hz to study fluctuations of lens (standard deviation of its position) at different levels of steady accommodation.Corneal and crystalline lens images were merged by registration of the limbal region. Images were corrected from fan and optical distortion using custom-built 3D ray tracing algorithms. Corrected anterior and posterior surfaces of cornea and lens were fitted to retrieve their radii of curvature, following denoising and segmentation. Fluctuations of the lens surface postion and lens thickness were estimated from the standard deviation of the mean for each steady state.Accommodative response of the subject was separately measured with a custom-developed Hartmann-Shack system. One subject participated in this study.

Results: : Accommodative response varied from 0.39±0.12 D to 5.06±0.38 D (for 0-6 D stimuli). The anterior and posterior lens surface radii of curvature changed by 3.54 mm and 1.37 mm respectively in this range. Fluctuations of the anterior and posterior surfaces ranged from 15.3 μm to 19.6 μm and did not change significantly with accommodation ($p>0.05$). Lens thickness fluctuations ranged from 3.52 μm (0 D) to 4.02 μm (6 D), suggesting lens surfaces fluctuations are mainly due to displacement of the entire lens.

Conclusions: : High-speed, high resolution, extended axial range sOCT, provided with distortion correction algorithms allows quantitative imaging of the crystalline lens during accommodation. Accurate 3D imaging of the lens and of its dynamic processes in vivo are crucial to better understand the accommodative mechanism.

Keywords: accommodation • imaging methods (CT, FA, ICG, MRI, OCT, RTA, SLO, ultrasound)