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NEAR INFRARED OCULAR WAVEFRONT SENSING WITH A FEMTOSECOND LASER

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Abstract

Purpose: To use a femtosecond laser to measure ocular aberrations and chromatic difference of focus in the 700–900 nm wavelength region, where optical properties of the eye have not been explored so far.

Methods: We used a compact, short–pulse (6.5 fs), mode–locked Titanium:sapphire laser, emitting a smooth spectrum of 277 nm optical bandwidth (at full width at half maximum) centered at 790 nm, to measure wave–front aberrations of the eye in the near infrared. We systematically measured aberrations with a Hartmann–Shack wave–front sensor at the following wavelengths: 700, 730, 750, 780, 800, 850, 870 and 900 nm, in four normal subjects. The wavelengths were selected by using 10 nm band–pass filters. For safety reasons, femtosecond pulses were stretched by passing the beam through a 100 meters fiber before entering the eye. The accommodation was paralyzed with tropicamide (0.5 %) and the averaged exposure levels at the cornea were kept below 1 mW during the measurements. The chromatic aberration was estimated as the difference in focus between selected wavelengths.

Results: Monochromatic high order aberrations were found to be very similar across wavelengths from 700 to 900 nm in the four subjects. The change in each individual Zernike term for the tested wavelength range was smaller than the measurement errors. Chromatic difference of focus was 0.4 diopters in average from 700 to 900 nm. We found that the extension of a simple water–eye model to the near infrared region predicts the behavior of defocus as a function of wavelength in this range.

Conclusions: We demonstrated the feasibility of using broad bandwidth, femtosecond lasers, for wave–front aberration measurement in the human eye in the 700–900 nm wavelength region. High order aberrations are stable in this range and chromatic defocus follows a simple water–eye model. These results have potential applications when wave–front correction is required in imaging techniques in the near infrared range or with broad bandwidth light sources, such as for ultrahigh resolution optical coherence tomography.

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