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Peripheral Refraction and Aberrations for Different Wavelengths: Off-Axis Chromatic Aberration

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Abstract

Purpose: The interest in the peripheral optical quality of the eye is increasing, mainly because animal studies have shown that the off-axis refractive errors may influence the progression of myopia. Off-axis image quality is often assessed monochromatically using infrared light. To validate the data obtained with this procedure, it is important to compare off-axis refraction and aberrations for different wavelengths. This may reveal possible systematic measurement errors and potential wavelength dependence of retinal reflections in the periphery.

Methods: We developed a new wavelength tunable Hartmann-Shack (HS) wavefront sensor to measure refraction and high-order aberrations over a large field of view. The sensor incorporated four different wavelengths; infrared (780nm) from a diode laser and three visible (671nm, 532nm and 473nm) from a RGB laser. A high sensitivity electron multiplying CCD camera was used to record the HS images. Irradiance and camera exposure time were adjusted to maintain good quality images over the spectrum. The horizontal meridian of the right eye of five normal young subjects was measured from -40º to +40º in steps of 10º. The chromatic variation of defocus (i.e. longitudinal chromatic aberration), astigmatism, and high-order aberrations were computed for each eccentricity.

Results: Foveal defocus was about 1 D more positive for near infrared (780 nm) than for the middle of the visible spectrum. This shift was found to be relatively constant over the visual field. However, in some subjects a slightly larger chromatic shift (around 1.5 D) was measured at the largest eccentricities (± 40º).

No change in the oblique astigmatism as a function of wavelength was found. The recorded HS images revealed larger scattering in the near infrared wavelength compared to green light for all eccentricities. High-order aberrations were stable with wavelength and only spherical aberration was found to differ somewhat; being more positive for longer wavelengths.

Conclusions: Refraction and aberrations were successfully measured in the periphery for different wavelengths. Longitudinal chromatic aberration seems to be rather constant as a function of eccentricity. This suggests that peripheral optical measurements performed in near infrared are an accurate representation of the visible image quality as long as the shift in defocus is taken into consideration.

Keywords: aberrations • optical properties • myopia