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# Ocular Off-Axis Aberrations and Refraction: A Population Study

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## Abstract

**Purpose:** This study explores the average peripheral optical quality of the human eye in a relatively large population. The purpose is to get a better understanding of the role of peripheral optics in myopia progression as well as to give more complete data to designs of eye models.

**Methods:** Fifty normal subjects participated in the study; 16 emmetropes (in between  $\pm 0.5$  D), 23 myopes (mean  $-4.2$  D), and 11 hyperopes (mean  $1.2$  D), with age ranging from 19 to 66 years (mean 31). Two custom-built Hartmann-Shack sensors were used to measure the aberrations at the fovea ( $0^\circ$ ) and in the nasal visual field at  $20^\circ$  and  $30^\circ$  off-axis with relaxed accommodation. In 10 of the subjects, a more complete set of measurements were obtained over a larger field of view and for two levels of accommodation.

**Results:** The mean spherical equivalent (field curvature, M) showed large individual variability. However, on average the emmetropes were slightly myopic towards the periphery (relative M (in D) =  $-0.0003 \cdot \theta^2$ , with  $\theta$  in degrees), the myopes tended to be relatively more hyperopic, and the hyperopes were similar to the emmetropes. Astigmatism increased quadratically with eccentric angle; the cross-cylinder in D over

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the horizontal field approximately followed the relation:  $J180 = -0.001 * \theta^2 + 0.01 * \theta$  - value on-axis. The high-order aberrations increased with eccentricity and at 30° off-axis the Strehl-ratio with refractive correction had on average dropped to half of the foveal value. With accommodation, the field curvature got more myopic for the emmetropes, but only showed small changes between far- and near-vision for the myopes.

**Conclusions:** On average, we found changes in peripheral optical quality as previously reported, except for the small accommodative shift in field curvature for myopes. This means that the difference between emmetropes and myopes is even larger during near-work. This finding might be important for the present understanding of myopia progression, since it cannot be explained by a difference in retinal shape.

**Keywords:** aberrations • myopia • refraction



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