

Effects of Zernike wavefront aberrations on visual acuity measured using electromagnetic adaptive optics technology

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PURPOSE: The objective of this study was to measure the changes in visual acuity induced by various amounts of pure Zernike aberrations, including relatively large wavefront errors.

METHOD: We used a crx1 adaptive-optics visual simulator (Imagine Eyes, France) based on a Shack-Hartmann sensor and a 52-actuator magnetic deformable mirror to manipulate the wavefront aberrations in three subject eyes under cycloplegia. After an initial measurement of the ocular aberrations, we programmed the device to compensate for the wavefront error and successively apply pure Zernike aberrations in predefined amounts. These aberrations were generated through a 5 mm artificial pupil and included astigmatism, coma, trefoil and spherical aberration ranging between 0 and 1 μm . We assessed visual acuity for each aberration using 8-direction Landolt C optotypes presented at the internal microdisplay of the visual simulator. The wavefront shape was controlled throughout the experiment using a closed-loop feedback algorithm.

RESULTS: Every induced Zernike aberration resulted in lower visual acuity compared to the fully corrected state. Small amounts of aberrations of typically 0.1 μm induced a loss of approximately one line (or +0.1 LogMAR), without a clear dependence on the Zernike mode number. Larger amounts of aberrations, up to 1 μm , resulted in higher losses that were more pronounced with spherical aberration (up to +0.8 LogMAR) and astigmatism (up to +0.6 LogMAR). The decrease in visual acuity associated with the generated range of coma and trefoil was limited to 0.3 LogMAR.

CONCLUSION: The electromagnetic adaptive optics technology was able to generate relatively large amounts of second to fourth order aberrations. Our results confirm that the effect of pure Zernike wavefront aberrations on visual acuity depends on the Zernike mode number. The modes of lower azimuthal order seem to be more detrimental to visual performance.