Investigative Ophthalmology & Visual Science

Invest Ophthalmol Vis Sci 2008;49: E-Abstract 1796.

1796—D661

Simulated Eye Model Experiments for Selecting a Depth-of-Focus Metric

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Commercial Relationships: M. Bird, AMO, E; **J. Tabernero**, AMO, C; **P. Artal**, AMO, C; **H.A. Weeber**, AMO, E; **P.A. Piers**, AMO, E.

Support: None.

Abstract

Purpose: An intraocular lens (IOL) that extends depth of focus (DOF) will result in greater spectacle independence because of gains in pseudo-accommodation. To determine DOF, a standard metric is needed to gauge the accuracy between subjective and objective DOF measurements. This study reports on four different DOF metrics: two through-focus modulation transfer function (MTF) responses at 6c/deg and at 15c/deg; through-focus Strehl ratios (SR), and one that considers through-focus ensquared energy (EE) on the image plane.

Methods: Corneal topography measurements of 24 real eyes were integrated into the ZEMAX^{TM} optical design program to create individual eye models (Tabernero *et al.*). Two types of IOL were added: a lens designed to correct corneal spherical aberration and a lens with positive spherical aberration. All eye models were astigmatism corrected for a 4 mm entrance pupil in the spectacle plane with a standard Zernike phase plate. In the same Zernike phase plate, -2D to +2D of defocus, in steps of 0.25D, were added to step through the eye's range of focus. At each step a white-light radial MTF response was calculated at the image plane. At the same time, the SR and EE (40µm by 40µm) on the image plane were recorded at each step. Through-focus plots were generated from the radial MTFs for spatial frequencies of 6c/deg and 15c/deg. The results from all eye models were averaged, and the full width at half maximum for each of the through-focus plots was determined.

Results: The metrics provided varying DOF for the same lens type. The EE metric provided the largest

DOF (±2D), followed by the MTF-based metrics (≤±1.5D), and finally the SR metric (±0.875D). Comparing the results from these simulations to those of Piers *et al.*, which showed DOFs of ±1D and lower, the 15c/deg MTF metric produces the DOF that is most consistent with subjective measurements.

Conclusions: Based on these simulations, the 15c/deg metric appears to be the most suitable for predicting DOF. More subjective data will allow a deeper analysis into which metric best represents individual DOF.

Keywords: intraocular lens