ABSTRACT
NONINVASIVE ASSESSMENT OF PHOTORECEPTOR STRUCTURE AND FUNCTION IN THE HUMAN RETINA

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The human photoreceptor mosaic underlies the first steps of vision; thus, even subtle defects in the mosaic can result in severe vision loss. The retina can be examined directly using clinical tools; however these devices lack the resolution necessary to visualize the photoreceptor mosaic. The primary limiting factor of these devices is the optically aberrations of the human eye. These aberrations are surmountable with the application of adaptive optics (AO) to ophthalmoscopes, enabling imaging of the photoreceptor mosaic with cellular resolution. Despite the potential of AO imaging, much work remains before this technology can be translated to the clinic.

Metrics used in the analysis of AO images are not standardized and are rarely subjected to validation, limiting the ability to reliably track structural changes in the photoreceptor mosaic. Preceding the extraction of measurements, photoreceptors must be identified within the retinal image itself. This introduces error from both incorrectly identified cells and image distortion. We developed a novel method to extract measures of cell spacing from AO images that does not require identification of individual cells. In addition, we examined the sensitivity of various metrics in detecting changes in the mosaic and assessed the absolute accuracy of measurements made in the presence of image distortion. We also developed novel metrics for describing the mosaic, which may offer advantages over more traditional metrics of density and spacing. These studies provide a valuable basis for defining the application of AO imaging for monitoring the photoreceptor mosaic longitudinally. As part of this work, we developed a platform (Mosaic Analytics) that can be used to standardize analytical efforts across different research groups.

In addition, one of the more salient features of the appearance of individual cone photoreceptors is that they vary considerably in their reflectance. It has been proposed that this reflectance signal could be used as a surrogate measure of cone function. As a first step to understanding the cellular origin of these changes, we examined the reflectance properties of the rod photoreceptor mosaic. The observed variation in rod reflectivity over time suggests a common governing physiological process between rods and cones.