Feasibility of fast measurement of macular pigment optical density using a slit-scanning ophthalmoscope

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PURPOSE

Objective, non-invasive measurement of the optical density (OD) of human macular pigment (MP) can be performed *in vivo* using fundus autofluorescence (FAF) imaging [1]. To be suitable for use in a screening setting, it is crucial that such a measurement can be performed rapidly. Depending on the protocol used, however, the exam duration may be prolonged by the need for pupil dilation, repeat image acquisitions, and/or separate calibration for crystalline lens fluorescence. In this study, we investigate the feasibility of quantifying macular pigment optical density (MPOD) using a slit-scanning ophthalmoscope with a fast, single-flash measurement protocol.

METHODS

A slit-scanning ophthalmoscope (CLARUS™ 500, ZEISS, Dublin, CA) with prototype software was used to perform non-mydriatic measurements of MPOD, derived from pairs of FAF images obtained with blue (λ_{peak} = 459 nm, well-absorbed by MP) and green (λ_{peak} = 520 nm, much less absorbed) excitation sources. The illumination rapidly alternates between the sources during a single scan, which is completed in less than 0.2 seconds. The image sensor records separately the partial images of stripes of illuminated retina, from which a 2D MPOD profile can be derived [1].

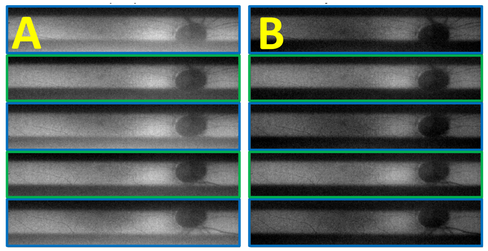

Figure 1. (A) Raw (stripe) FAF images of a human eye, with alternating blue and green excitation. The captured region-of-interest exceeds the illuminated stripe portion, vertically; (B) Straylight-corrected images, obtained by estimating and subtracting the unwanted anterior segment autofluorescence component.

Retinal autofluorescence appears only within the illuminated stripe, but unwanted crystalline lens fluorescence appears nearly uniformly across the partial image (Figure 1A), allowing it to be estimated and subtracted in image post-processing (Figure 1B).

REFERENCES

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[3] Bernstein, Paul S., et al. "The value of measurement of macular carotenoid pigment optical densities and distributions in age-related macular degeneration and other retinal disorders." Vision research 50.7 (2010): 716-728.

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RESULTS

A fluorescent phantom, incorporating a yellow-colored filter of known OD, was used to test the implementation [2]. MPOD measurements were then performed on 5 human subjects. The 2-D MPOD profile for the test phantom is shown in Figure 2D.

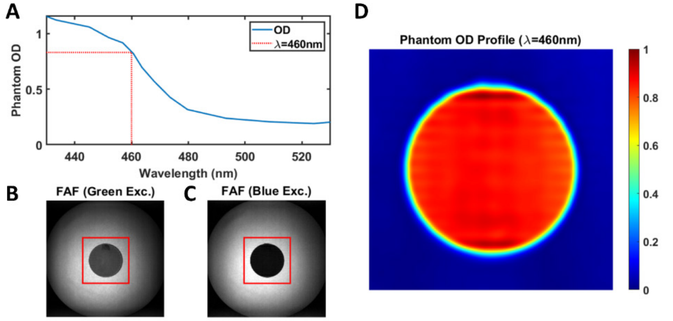
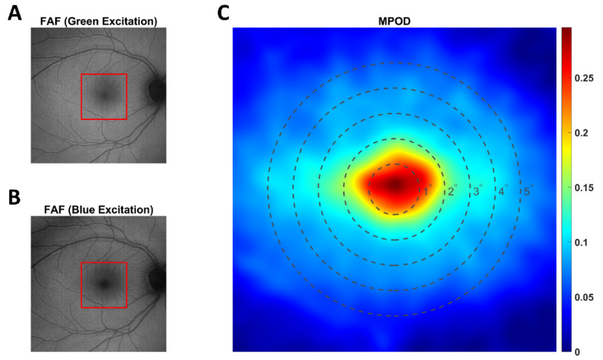


Figure 2. (A) OD of test phantom filter, per manufacturer; (B) FAF images of test phantom with green excitation and (C) blue excitation; (D) Derived OD profile at 460 nm.

The mean MPOD was within 2.5% of the value quoted by the filter manufacturer. FAF images and the derived MPOD profile for a human subject are shown in Figure 3.

Figure 3. FAF images of a human subject using (A) green excitation and (B) blue excitation; (C) Image processing methods are used to derive the MPOD spatial distribution around the foveal region at 460nm [1].



CONCLUSIONS

A slit-scanning ophthalmoscope can perform objective FAF measurements of MPOD in a single perceived flash, through non-dilated pupils. This gives encouragement that such a method potentially could be implemented in a practical manner for screening, e.g., risk of age-related macular degeneration [3]. Validation of such an approach for *in vivo* use will require careful consideration of confounding effects, such as secondary fluorophores and photobleaching.