Optoretinography with Time-Domain Full-Field OCT: Achieving Cellular Resolution and Wide Field-of-View Functional Imaging

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1. Abstract

Time-domain Full-Field OCT (TD-FFOCT) enables cellular-resolution retinal imaging over a wide field-of-view (FOV) using a compact system suitable for clinical application. However, inherent phase instability in TD-FFOCT has been a significant challenge, preventing optoretinography (ORG) application for functional photoreceptor imaging. Here, we successfully apply ORG in TD-FFOCT, achieving cellular resolution across a wide FOV (5° × 5°) in a clinically applicable system.

2. Methods and results

We used our TD-FFOCT with a pupil-conjugated deformable mirror at the sample arm. Wavefront sensorless approach was used to correct only for defocus and astigmatism. To enable ORG application, a spectral filter (10 nm FWHM, 810 nm central wavelength) was used to increase the coherence length up to 20 µm. Image sequences (2 s baseline, 1 s light stimulus with 16.5% photobleaching, and 2 s recovery) were acquired at 400 Hz from two subjects at 2° and 6° eccentricities for the IS/OS and COST layers. The 5° FOV included a centrally stimulated 2° area, allowing comparison with unstimulated control regions. ORG was analyzed using an intensity-based algorithm after averaging image sequences in groups of 20 frames.

Figures A and B exhibit FFOCT images at both eccentricities, highlighting the stimulated region with red dashed lines. Zoomed-in views highlight that photoreceptors are visible across the 5°x5° FOV. Photoreceptors highlighted in red indicate intensity variations associated with ORG within the stimulated zone. Figures C and D illustrate the spatial standard deviation over time for photoreceptors in the stimulated and control regions, clearly demonstrating an ORG response. Responses were observed in both IS/OS and COST layers, with those at 2° eccentricity being 2–3× stronger than at 6°.

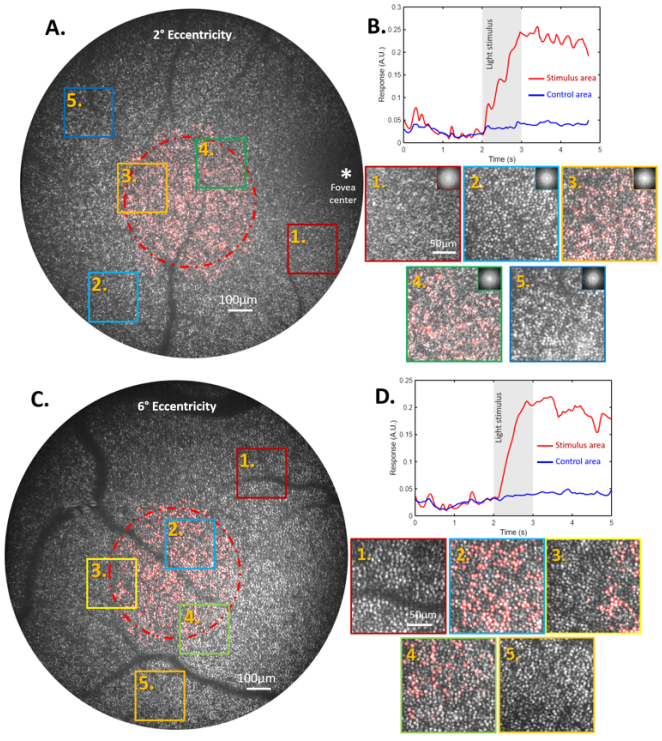

Fig. 1. ORG responses measured with TD-FFOCT at two different eccentricities

3. Conclusions

We present the first successful ORG application employing TD-FFOCT, achieving cellular resolution with minimal aberration correction (limited to defocus and astigmatism). The considerable FOV of TD-FFOCT, paired with its cellular resolution, supports ORG across expansive retinal areas, offering the potential for comprehensive evaluation of healthy, transitional, and disease.

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