Blue-light Optical Coherence Microscopy

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PURPOSE

- Optical coherence tomography (OCT) is a non-invasive imaging modality that uses low-coherent light source to get interferograms, which are processed into cross-sectional and three-dimensional images.
- Optical coherence microscopy (OCM) is an integration of OCT and confocal microscopy, and incorporates large numerical aperture objectives to get high lateral resolution.
- Currently, corneal disease is one of the fifth leading causes of visual loss globally.[1] The cornea is the outermost, transparent part of the eye that partially refracts light rays to focus them on the retina. Current corneal imaging clinical devices, such as *in vivo* confocal microscopy, offer high resolution but have some disadvantages such as limited field-of-view (imaging area), prolonged image acquisition time, and lack of volumetric imaging capability.[2]
- In this study, we present a low-cost blue-light OCM device that can visualize cellular structures with a large imaging area.

METHODS

- A super-luminescent light emitting diode (SLED) with a 450 nm wavelength was used to guide light through a fiber coupler.
- The 50:50 fiber coupler equally split light into the reference arm, which contains a mirror, and the sample arm, which holds the sample.

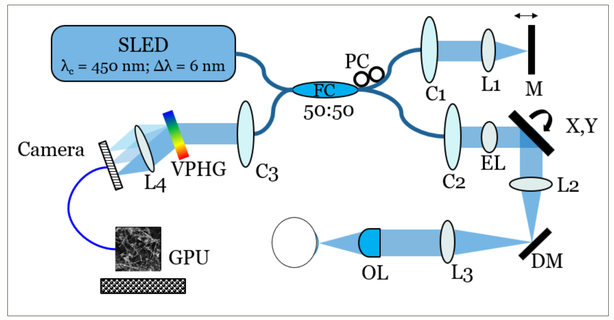

Fig. 1. Schematic diagram of the blue-light OCM system. SLED – super-luminescent light emitting diode; FC – 50:50 fiber coupler; PC – polarization controller; C1 - C3 – collimator; L1 - L4 – achromatic lenses; VFL – variable focus liquid lens; X, Y – galvanometer scanning mirrors; M – mirror; DM – dielectric mirror; VPHG – volume phase holographic grating; OL – objective lens; GPU – graphics processing unit.

- Back-scattered light from both these arms combine and interfere to form interferograms, which are detected in the detector arm. These interferograms are then processed to form cross-sectional, and three-dimensional (*en face*) images.

RESULTS

- *Ex vivo* rabbit cornea were imaged with the blue-light OCM and compared with *in vivo* corneal confocal microscopy.
- We were able to visualize enhanced contrast of corneal epithelium cells in the outermost layer, endothelial cells, which lie in the innermost region, and keratocytes, which are cells that exist in the anterior and posterior stroma.

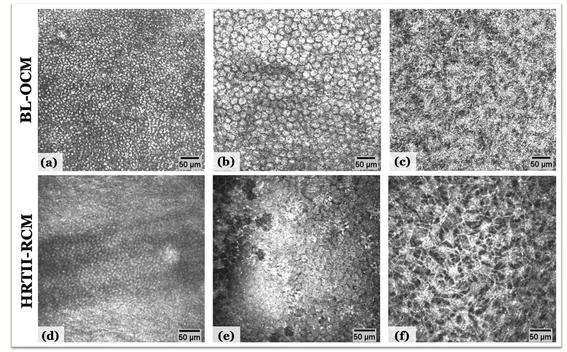

Fig. 2. Epithelium (a, d), endothelium (b, e) and keratocytes (c, f) in ex vivo rabbit cornea imaged with the blue-light OCM system (top row) and Heidelberg HRTII-RCM (bottom row).

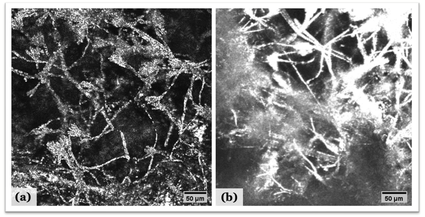

Fig. 3. Fungal filaments demonstrated on moldy bread in (a) blue-light OCM and (b) confocal microscopy (HRTII-RCM)

- Similarly, we compared filamentous fungi demonstrated on moldy bread that are known to cause certain eye diseases, such as keratitis.[3]
- The blue-light OCM achieved a lateral resolution of 1.6 µm, a field-of-view of 750 x 750 µm over a 1.2 mm imaging depth.

CONCLUSIONS

- We demonstrated a low-cost and easily reproducible blue-light OCM system. *En face* images were acquired with sufficient lateral resolution to visualize corneal epithelial cells, endothelial cells with up to 750 x 750 µm field-of-view.
- Three-dimensional images are acquired faster and thus may provide a pathway for image-based diagnosis of most common eye diseases such as keratitis.

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