Retinal flow velocity measurement using optical coherence tomography angiography

Ali Fard, PhD[1]; Dmitry Rikhter, MSc[1]; Patricia Sha, OD[1]; Wei Wei, MSc[2]; Qinqin Zhang, PhD[2]; Ruikang Wang, PhD[2]

[1]Carl Zeiss Meditec Inc, Dublin, CA; [2]Department of Bioengineering, University of Washington, Seattle, WA

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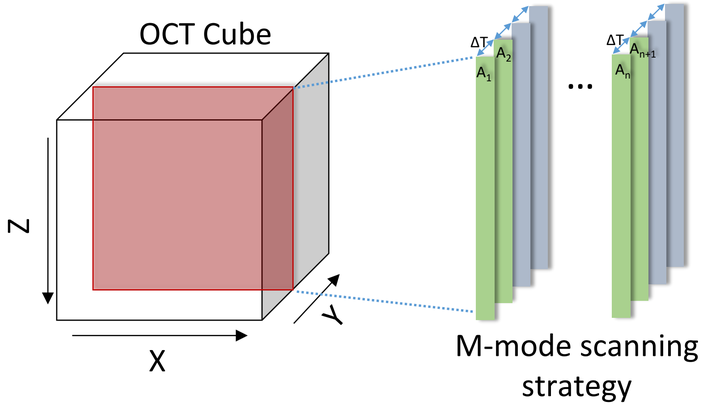
PURPOSE

Detecting abnormalities in retinal blood flow using optical coherence tomography angiography (OCTA) may provide an early biomarker for diseases such as vein occlusion. However, OCTA signal detection based on repeated raster scanning suffers from low dynamic range due to the relatively large time interval between repeated scans. Here we report on our clinical results using M-mode scanning OCTA, which reduces the time interval between repeated A-scans and increases the dynamic range.

METHODS

- Three normal subjects were scanned under an IRB-approved study using a commercial angiography 3x3mm scan and a prototype M-mode scan pattern on CIRRUS™ 5000 HD-OCT with AngioPlex® OCT Angiography
- Prototype scan specifications:
  - field of view of 2.14x1 mm
  - 175 A-scans per B-scan
  - 82 B-scans
  - Each A-scan was repeated 10x
  - 67.5 kHz A-scan rate (~15µs time interval between A-scans of the same location).
- OCT datasets were processed using Optical Micro Angiography (OMAG^c) among frames with different time intervals. Flow datasets from different time intervals were summed together to create one flow volume per scan.
- A mixture of milk and distilled water injected into a microfluidic channel at different flow rates was used to validate the method



Email: ali.fard@zeiss.com

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RESULTS

- OCTA en face images from three normal subjects are shown in Figure 1. Small capillaries and 3rd/4th branch vessels exhibit lower flow signal compared with main arteries. The red hot color scale shows the detected OMAG signal – red/yellow correspond to higher flow rates.
- Relationship between OCTA signal and flow rate was validated using a microfluidic channel. Figure 2 depicts the relationship between OCTA at the center of microfluidic channel. Flow speed was varied from 0 to 30mm/s.

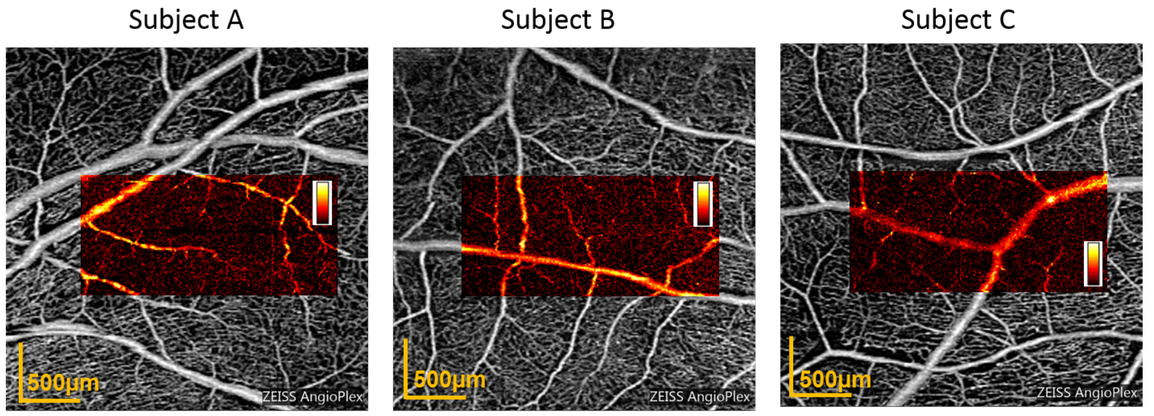

Figure 1. OCTA images from normal subjects. Gray scale: Angiography 3x3mm, Hot-color: relative flow rate acquired using M-mode scan.

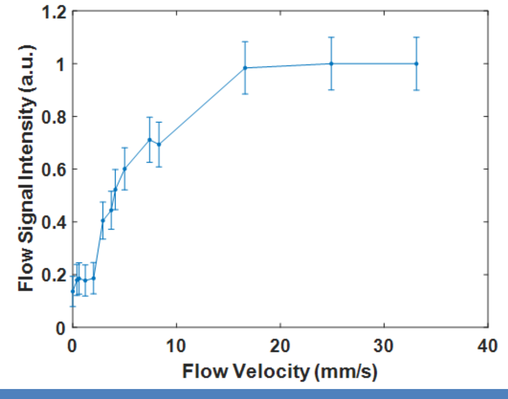

Figure 2. OCTA signal vs flow velocity in a microfluidic channel. Error bar indicates the variability between repeated measurements.

CONCLUSION

Our results suggest that M-mode OCTA can provide quantitative information about blood flow speed (from 2mm/s to 15mm/s) in the retina. Due to particle size, shape and microfluidic orientation, the validation results may not support direct comparison of phantom data and human images at this time. This method may help with detecting vein occlusions before the onset of the disease.