SWEPT SOURCE OCT ANGIOGRAPHY

Charles Reisman, Zhenguo Wang, Jonathan Liu, Qi Yang, Ying Dong, and Kinpui Chan,
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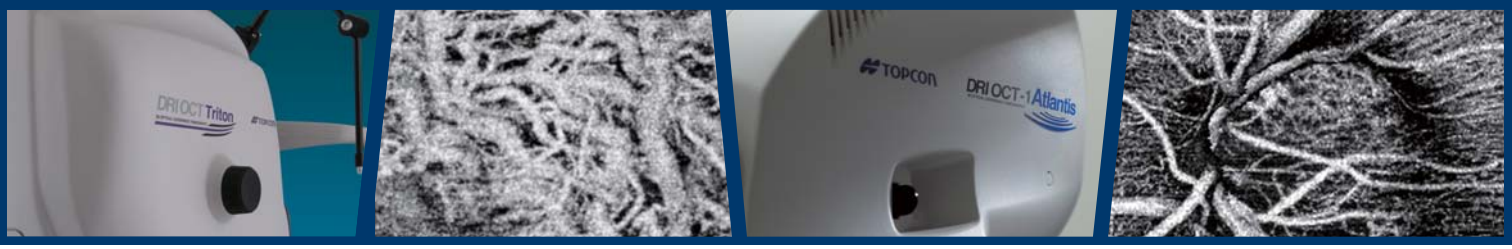

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Poster # PP2219

1. Purpose

To demonstrate an innovative OCT angiography method with improved detection sensitivity of low blood flow and reduced motion artifacts without compromising axial resolution using commercially available swept source OCT (SS-OCT).

2. Methods

We performed SS-OCT imaging at 100,000 A-scans per second (DRI OCT-1, Topcon, Tokyo, Japan) in both healthy and diseased eyes. Volumetric OCT scans of 256 (A-scans) x 225 (B-scan positions) were performed. Each B-scan position was repeatedly scanned 4 times. All scans were acquired over a 3mm x 3mm field of view in about 3 seconds of total OCT scan time. For OCT angiography processing, B-scan repetitions at each scan location were registered. OCT angiography images were generated by a formula representing a relative measurement of OCT signal amplitude change which enhances the minimum detectable signal compared to other techniques based on variance and decorrelation calculations. Our method preserves the integrity of the entire spectrum and therefore does not suffer from compromised axial resolution, an inherent disadvantage of split-spectrum OCT angiography techniques. Motion artifacts were suppressed by selectively averaging over multiple B-scan combinations in our OCT angiography method. High quality OCT structural images were generated by averaging registered B-scans. Automated segmentation of retinal layer boundaries was performed on OCT structural images. Enface projections allow visualization of vascular details within segmented retinal layer boundaries.

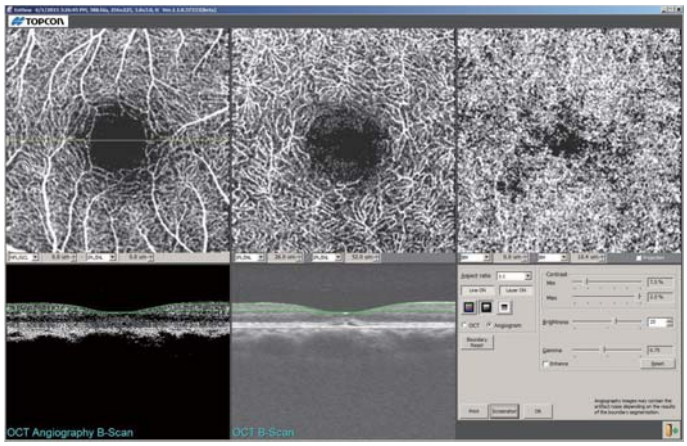

Figure 1. Enface DRI OCT-1 angiography of the macula using Topcon EnView software showing superficial (top left) and deep (top center) capillary plexus as well as choriocapillaris (top right).

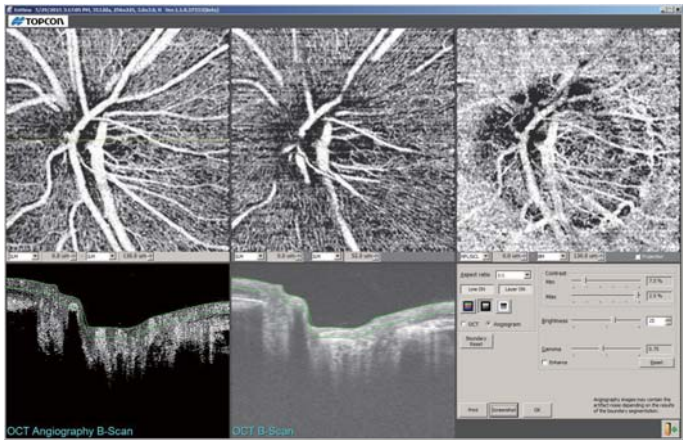

Figure 2. Enface DRI OCT-1 angiography of the optic nerve head using Topcon EnView software showing superficial vascular layers (top left), superficial vascular layers emphasizing the radial peripapillary network (top center), and deep vascular layers (top right).

3. Results

Comprehensive structural OCT and OCT angiography imaging of the human retina was performed. SS-OCT utilizes longer wavelength infrared light than conventional spectral domain OCT (SD-OCT) and therefore has improved penetration into tissue, can image through optical opacities, and is invisible to the subject. SS-OCT also does not suffer significant signal roll-off when compared to SD-OCT, which requires enhanced depth imaging (EDI) techniques to visualize the choroid.

An innovative OCT angiography processing method with improved detection sensitivity of microvasculature was demonstrated. In the optic nerve head region, the radial peripapillary capillary network and microcirculation in the disk was better visualized compared to conventional speckle variance and split-spectrum OCT angiography methods. In the foveal region, retinal vasculature and the foveal avascular zone were clearly visualized. In addition, the inner vascular plexus in the ganglion cell layer and outer layers of capillaries in the inner nuclear layer were readily distinguishable. Furthermore, choroidal perfusion information in large choroidal vessels and choriocapillaris was detected.

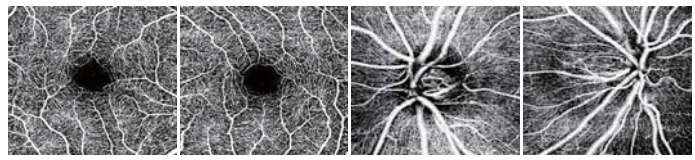

Figure 3. Example DRI OCT-1 angiography images of healthy eyes.

Topcon OCT angiography **SSADA algorithm**

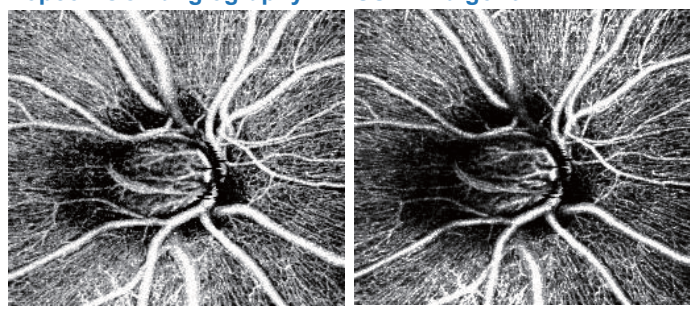

Figure 4. Comparison with split-spectrum amplitude-decorrelation angiography (SSADA) [1] based result. Topcon's OCT angiography implementation utilizes an intensity-based technique with full-spectrum processing, thereby allowing the axial resolution of angiographic images to match that of the underlying OCT images for a better visualization of the vascular network. Significant portions of the Topcon OCT angiography image are displayed with higher relative intensity with better visualization of hard-to-detect capillary flow.

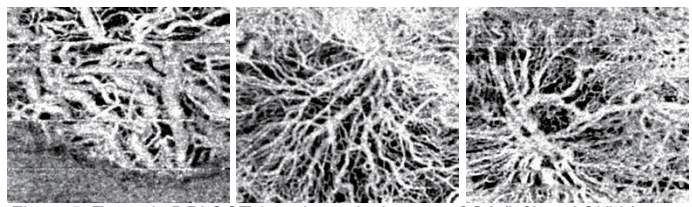

Figure 5. Example DRI OCT-1 angiography images of GA (left) and CNV (center, right) cases displaying angiographic signal integrations below the Bruch's Membrane.
Data courtesy of Dr. Laura Kuehlewein and Dr. SriniVas R. Sadda, Doheny Eye Institute. [2]

4. Conclusions

Standard OCT structural imaging reveals micron-scale morphological changes in the retina while OCT angiography detects functional impairment in retinal and choroidal vasculature at the capillary level. Our OCT angiography method notably is not based on amplitude decorrelation, but rather an innovative scheme with significantly improved detection sensitivity of microvasculature signal. Furthermore, our processing method does not require splitting the spectrum and therefore preserves axial resolution. All in all, our high sensitivity, high axial resolution OCT angiography can facilitate better visualization and detailed evaluation of individual capillary layers as well as choroidal vasculature.

References: 1. Jia et al., Opt. Express. 2012;20(4):4710-4725.
2. Kuehlewein et al., Retina Today. 2015;10(4):73-75.

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