10:05 AM

Projection-Resolved Optical Coherence Tomography Angiography in Healthy and Diabetic Retinopathy Eyes

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- Thomas S. Hwang, MD
- David Wilson
- Yali Jia

OBJECTIVE Improve the detection of capillary dropout and vascular abnormalities by using a novel project-resolved optical coherence tomography angiography algorithm.

PURPOSE In optical coherence tomography angiography (OCTA), superficial vascular pattern are duplicated on deeper layers due to the flow projection artifact. The novel projection-resolved (PR) OCTA algorithm removes these artifacts while retaining in-situ flow signals. We hypothesize that PR-OCTA would allow more accurate detection of pathologies in the deeper retinal vascular plexuses.

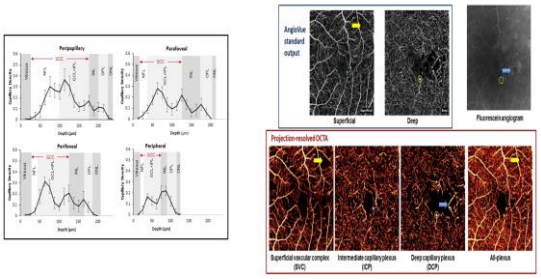
METHODS A 70-kHz spectral-domain OCTA system was used to scan healthy and diabetic retinopathy (DR) eyes. The data was exported and processed by custom PR-OCTA software. To visualize the depth of the retinal vascular plexuses, the capillary density at each depth plane was generated in healthy eyes. Using depth-resolved capillary density profiles, we defined segmentation boundaries that separated 4 retinal vascular plexuses (Fig. 1): radial peripapillary capillary plexus (RPCP), superficial vascular plexus (SVP), intermediate capillary plexus (ICP), and deep capillary plexus (DCP). Outside of the

peripapillary region, the RPCP and the SVP merge to form the superficial vascular complex (SVC).

RESULTS 29 eyes of 15 healthy individuals (age 36.2+/-13.4 [mean+/-SD] years; 11 women) and 47 eyes of 29 DR patients (age 55.5+/-11.9; 10 women) underwent imaging. One eye from each of 9 human subjects (age 30.2+/-7.4; 3 women) were processed for depth-resolved capillary density (Fig. 1) from which the boundaries of the retinal plexuses were defined. In eyes with DR, using PR-OCTA to visualize the retinal circulation as 3 separate en face slabs (SVC, ICP, DCP) disclosed incongruent areas of nonperfusion not obvious on an all-plexus OCTA (Fig. 2). Microaneurysms and dilated capillaries were better visualized in the ICP and DCP slabs of the PR-OCTA. Masked grading of 3-slab PR-OCTA detected capillary nonperfusion with 100% sensitivity in the DR eyes, and 100% specificity in the healthy eyes. The all-plexus retinal OCTA provided 78.7% sensitivity and 100% specificity. The sensitivity was significantly better (P = .002) for 3-slab PR-OCTA.

CONCLUSION We propose an improved system of nomenclature and segmentation boundaries that divides the retinal circulation into 4 plexuses based on concentrations of capillary density revealed by PR-OCTA. PR-OCTA improved the visualization of the ICP and DCP and helps distinguish DR from healthy eyes with greater accuracy compared with conventional OCTA.

TAKE HOME MESSAGE Use projection-resolved OCT angiography to optimize the noninvasive evaluation of capillary dropout and vascular abnormalities in diabetic retinopathy.



HUMAN RESEARCH This study involves human research.
IRB Approval Status: Approved by institutional review board

10:08 AM

Ultra-Wide Field OCTA For Evaluation of Diabetic Retinopathy

- Kasra Rezaei, M.D.
- Qinqin Zhang
- Zhongdi Chu, MS
- Chieh-Li Chen
- Wang Ruikang, PhD

OBJECTIVE Develop ultra-wide field OCTA (UW-OCTA) for imaging patients with diabetic retinopathy (DR).

PURPOSE Diabetic retinopathy is the leading cause of blindness in patients age 20-64. Ocular imaging has an important role in early diagnosis and treatment of diabetic retinopathy. Our goal was to develop ultra-wide field OCTA (UW-OCTA) for imaging patients with diabetic retinopathy (DR).

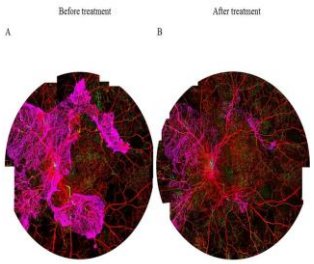
METHODS UW-OCTA was developed based on a 1060 nm swept source OCTA engine (Plex Elite, Carl Zeiss Meditec. Inc) running at 100 kHz A-line rate with motion tracking mechanism. A montage scanning protocol was designed to enable the UW-OCTA imaging, covering a field of view (FOV) of ~100 degrees. Complex OMAG algorithm was used to extract blood flow information. To visualize retinal vasculature, three layers were segmented including vitreous retinal layer (VRL) covering a slab 100 microns above the ILM, superficial retinal layer and deep retinal layer.Longitudinal scans of DR patients were collected before and after treatment to show the usefulness of the UW-OCTA in the clinical imaging of DR.

RESULTS 3 patients with proliferative diabetic retinopathy underwent UW-OCTA images before and after laser/anti-VEGF treatment. In comparison with FA, UW-OCTA images

provide distinct and detailed visualization of vascular networks over ~100-degree FOV . The neovasculatures located in the peripheral VRL were precisely detected and these neovessels were regressed dramatically after anti-VEGF treatment. The UW-OCTA images showed the macular ischemia and non-perfusion regions in far peripheral region at one scope, which makes it possible to quantify vascular features within all 7 defined EDTRS fields. UW-OCTA images also provided detail information of other vascular features, including microaneurysms and intra-retinal microvascular abnormalities (IRMA), and their locations.

CONCLUSION The wide angle OCTA is a non invasive imaging modality capable of imaging peripheral retina, comparable with wide-angle fundus image. We have successfully demonstrated the UW-OCTA of DR patients that extends to more than 100-degree view angle, and provides unprecedented vascular details in the peripheral regions. Further studies will be done to quantify OCTA defined by standard EDTRS and find the role in treatment of different macular diseases.

TAKE HOME MESSAGE The wide field OCTA is a non invasive imaging modality capable of imaging peripheral retina and can be used for early evaluation and follow up of patients with diabetic retinopathy.



HUMAN RESEARCH This study involves human research.
IRB Approval Status: Approved by institutional review board

10:11 AM

Normalized OCT Angiography Perfusion Mapping of Diabetic Retinopathy for Evaluation of Extent and Significance of Nonperfusion

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- Brian D. Krawitz
- Richard D Bavier, BA
- Shelley X Mo
- Joseph Carroll, PhD
- Toco Y. Chui, PhD
- Rishard Weitz

OBJECTIVE To evaluate *normalized* OCTA perfusion mapping as a tool for quantifying extent and significance of nonperfusion at various locations within the macula of diabetic eyes.

PURPOSE To test a novel normative-based OCTA method of mapping and quantifying extent of macular nonperfusion in different stages of diabetic retinopathy (DR) as a means measuring severity of disease.

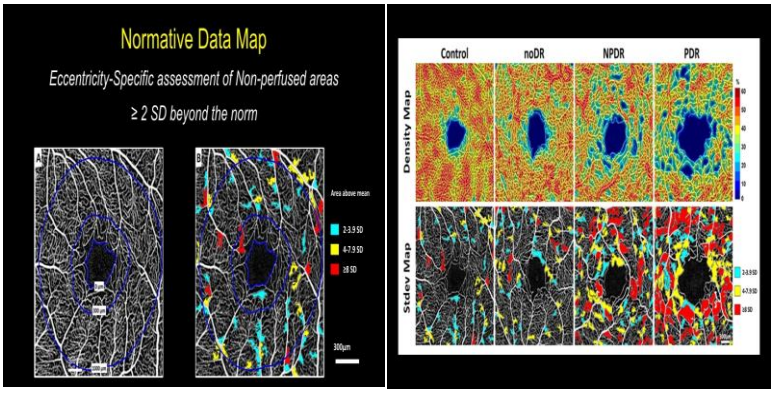
METHODS 45 diabetic eyes and 19 controls were imaged using a commercial SDOCT(Avanti RTVue-XR; Optovue). 10 sequential 3x3 mm foveal OCTA scans were registered and averaged using Image J. Nonperfused perifoveal areas were automatically delineated using custom software. An eccentricity-specific normative database was used to classify nonperfused areas according to size: 2-3.9, 4-7.9, or ≥8 SDs greater than the mean of the control group. Percentage of nonperfused perifoveal area was computed as the percentage of nonperfused area (≥ 2 SD > the mean) divided

by the 300μm region of interest surrounding the FAZ margin. Groups were compared using Kruskal-Wallis and post hoc Mann-Whitney U tests.

RESULTS The percentages (mean±SD) of nonperfused areas were **4±4%** for **controls**, **5±4%** for **diabetics without clinical retinopathy(NoDR)**, **20±10%** for **NPDR patients** , and **31±11%** for **PDR patients**. While the control and NoDR groups did not differ significantly , percentage of nonperfused area between all other groups in terms of nonperfused areas of each different size (2-3.9, 4-7.9, and ≥8 SDs) was significantly different, within the 300 μm region surrounding FAZ margin ($p<0.05$).

CONCLUSION Using this novel technique of automated OCTA standard deviation mapping, it is possible to quantify the degree of location-specific nonperfusion in patients with DR. This technique is sensitive to both focal and global defects and can help evaluate the significance of areas of nonperfusion, which may prove useful for earlier diabetic retinopathy identification and severity grading.

TAKE HOME MESSAGE Normalized perfusion mapping can help the clinician determine the significance of areas of nonperfusion seen on OCTA, by grading severity and potential risk of progression in early disease.



HUMAN RESEARCH This study involves human research.
IRB Approval Status: Approved by institutional review board

10:14 AM

Impact of Multiple Enface Image Averaging on Quantitative Assessment From Optical Coherence Tomography Angiography Images

- Srinivas Reddy Sadda, MD
- Akihito Uji, MD, PhD

OBJECTIVE To investigate the impact of multiple enface image averaging on quantitative measurements of the retinal microvasculature using optical coherence tomography angiography (OCTA).

PURPOSE OCT angiography has become a common tool in retinal practice. Quantitative parameters, such as capillary vessel density, can now be computed automatically and are being used to characterize and monitor ischemia in retinal vascular diseases. Averaging multiple OCTA images has the potential to dramatically improve OCTA image quality, but the effect on quantitative parameters needs to be defined.

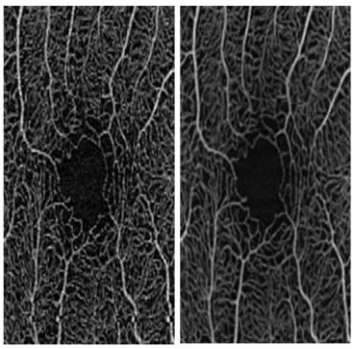
METHODS Twenty one healthy subjects with normal eyes were recruited for this prospective IRB-approved study. Macular OCTA images were acquired from all subjects using the ZEISS Cirrus 5000. Nine 3x3 and nine 6x6 OCTA cube scans per eye were obtained and 9 superficial retinal layer (SRL) and deep retinal layer (DRL) en face OCTA image slabs were individually averaged after elastic registration. Quantitative

parameters from the retinal microvasculature, including vessel density (VD), vessel length density (VLD), vessel diameter index (VDI), and fractal dimension (FD), were measured on binarized and skeletonized OCTA images and compared with single OCTA images without averaging.

RESULTS Cases with artifact or poor image quality were excluded, leaving 18 eyes for the main analysis. After averaging, qualitatively, there was apparent reduction in background noise; and fragmented vessels in the images before averaging became continuous with smoother walls and sharper contrast in both the SRL and DRL. Binarized and skeletonized derivates of these averaged images also showed fewer line fragments and dots in non-vascular area and more continuous vessel images than those of images without averaging. In both SRL and DRL, VD ($P = 0.0010$ for SRL and $P = 0.0003$ for DRL), VLD ($P < 0.0001$, for both), and FD ($P < 0.0001$, for both) significantly decreased and VDI significantly increased after averaging ($P < 0.0001$, for both).

CONCLUSION Averaging of multiple enface OCTA images improves image quality and also significantly impacts quantitative measurements. Reducing noise which could be misinterpreted as flow, and annealing discontinuous vessel segments appear to be major mechanisms by which averaging may be of benefit.

TAKE HOME MESSAGE Averaging OCT-A images, much like averaging structural OCT images, dramatically improves image quality, but does impact quantitative parameters which must be taken into consideration.



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