Optical coherence tomography angiography of the optic nerve head, current situation and future perspective

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This article is copublished in *Yan Ke Xue Bao* and *Journal of Eye Science*.

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Received: 19 August 2016; Accepted: 19 August 2016; Published: 10 October 2016.
doi: 10.21037/jes.2016.09.03
View this article at: http://dx.doi.org/10.21037/jes.2016.09.03

The circulation of the optic nerve head is derived from two sources; the prelaminar, laminar and retrolaminar circulation are mainly arise from the posterior ciliary artery circulation, whereas the nerve fiber layer over the optic disc is fed by central retinal artery (1,2). A variety of optic neuropathies with ischemic, glaucomatous, inflammatory and hereditary etiologies may affect the optic disc circulation (1,2). Several imaging techniques have been developed for the *in vivo* measurement of ocular blood flow. Dynamic angiography using intravenous injection of a fluorescent dye has been the mainstay for the evaluation of the normal optic nerve head vasculature and for the *in vivo* diagnosis and management of the optic neuropathies for several decades (2,3). Other imaging modalities including laser Doppler velocimetry, laser Doppler flowmetry, color Doppler ultrasound imaging, and spectral-domain optical coherence tomography have been used to assess various aspects of the optic nerve head circulation (3,4). These imaging modalities suffer from limitations such as invasiveness, lack of precision, low spatial resolution, high cost and different types of artifacts.

Optical coherence tomography angiography (OCTA) is a new imaging technology that provides a non-invasive, high resolution, three dimensional depiction of the fundus microcirculation. OCTA detects variations in the intensity and/or phase properties of the OCT signals over multiple B-scans that result from movement of blood to generate the map of the vessels. OCTA has been suggested to be useful for demonstrating vascular abnormalities in many different retinal and choroidal diseases (5,6).

Recent studies using OCTA have provided useful information about the papillary and peripapillary microvasculature. Optic nerved head measurements are highly repeatable and reproducible (7). A dense microvascular network with no focal capillary dropout is observed around most healthy optic discs. Spaide *et al*. (8) showed that in healthy eyes, the radial peripapillary capillary network could not be visualized by fluorescein angiography, whereas the network was readily visualized in the OCTA images. Our group has demonstrated that in the nerve fiber layer and full thickness retinal slabs, the peripapillary capillary network was more visible immediately adjacent to the border of the disc and around the major vascular arcades, and its clarity decreased centrifugally toward the periphery (9).

Several studies have shown significant microvascular changes in the optic nerve head of eyes with glaucoma or suspicion of glaucoma compared to the healthy eyes (10-16). The microvascular abnormalities have been detected in prelaminar microvasculature, peripapillary capillaries or both. Interestingly, Jia *et al*. (11) reported that OCT angiography can detect reduced disc perfusion in a group of patients with early glaucoma with 100% sensitivity and specificity. In addition, peripapillary vessel densities have been reported to be significantly reduced at the corresponding location of the visual field defects and highly correlate with visual field pattern standard deviation (12,14). Yarmohammadi *et al*. (16) found that vessel density had similar diagnostic accuracy as nerve fiber layer thickness measurements for differentiating between healthy and

glaucoma eyes.

Few studies reported OCTA changes in eyes with other types of optic neuropathies. Wang *et al*. (17) showed that the optic disc flow index in eyes of patients with multiple sclerosis and a history of optic neuropathy was significantly lower than the values of the control group, as well as compared patients with multiple sclerosis, but without optic neuropathy. Ghasemi Falavarjani *et al*. (9) reported that the prelaminar capillary network is dilated and tortuous with an increase or decrease in the visibility of the peripapillary capillary network in disc edema, and decreased visibility of the peripapillary capillary network corresponding to the region or sector of nerve fiber layer thinning in eyes with optic atrophy.

Although OCTA is a promising technology for the assessment of the optic disc microvasculature, several limitations should be addressed before wide spread use in clinical settings. For example, the widths of the smaller capillaries fall below the resolution limit current OCTA devices. OCTA currently cannot quantify (with any level of precision) the flow velocity of the optic disc vasculature, nor can OCTA demonstrate vascular leakage. Furthermore, a variety of artifacts may affect interpretation and measurements in the OCTA images (18). The most detrimental and difficult to overcome of these is flow projection artifact from superficial blood vessels to deeper tissue levels hinders clinicians' ability to separately measure the superficial and deep disc microvasculature. In addition, the disc flow measurements combine both disc and retinal circulations, and cannot separate the PCA and retinal circulation. Most importantly, prospective longitudinal studies are required in order to best define the role of OCTA imaging in the management of patients with optic nerve head diseases.

Acknowledgements

Dr. Sadda receives research funding from Carl Zeiss Meditec, Optos, Allergan and Genentech. He also receives honoraria from Carl Zeiss Meditec, Optos and Allergan.

Footnote

Provenance: This is a Guest Editorial commissioned by Section Editor Xiaogang Wang, MD, PhD, (Department of Ophthalmology, Shanxi Eye Hospital, Taiyuan, China).
Conflicts of Interest: Dr. Sadda is a consultant for Carl Zeiss Meditec, Optos, Allergan, Genentech, Alcon, Novartis and Roche. And other author has no conflicts of interest to declare.

Comment on: Liu L, Jia Y, Takusagawa HL, *et al*. Optical Coherence Tomography Angiography of the Peripapillary Retina in Glaucoma. JAMA Ophthalmol 2015;133:1045-52.

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doi: 10.21037/jes.2016.09.03
Cite this article as: Falavarjani KG, Sadda SR. Optical coherence tomography angiography of the optic nerve head, current situation and future perspective. J Eye Sci 2016;1:38

