THE LITERATURE

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Relationship Between Optical Coherence Tomography Angiography Vessel Density and Severity of Visual Field Loss in Glaucoma

Yarmohammadi A, Zangwill LM, Diniz-Filho A, et al[1]

ABSTRACT SUMMARY

This observational, cross-sectional study evaluated the relationship between optical coherence tomography angiography (OCT-A) and the severity of visual field loss in glaucoma. Using data from the Diagnostic Innovations in Glaucoma Study (DIGS), the investigators selected eyes that had reliable visual fields, good-quality spectral domain OCT (SD-OCT) scans, and good-quality OCT-A scans. The cohort included 31 healthy individuals, 48 glaucoma suspects, 46 patients with mild glaucoma, and 28 patients with moderate to severe glaucoma. The retinal vessel density (percentage of area occupied by flowing blood vessels) was obtained by two measurements: circumpapillary vessel density (750-µm–wide elliptical annulus around the optic disc) and whole-image vessel density (entire 4.5 × 4.5-mm scan field).

The researchers found that the vessel density progressively decreased from healthy eyes to those of glaucoma suspects to eyes with mild glaucoma to those with moderate to severe disease. Lower vessel density measurements were associated with more advanced states of glaucomatous visual field loss. The association between visual field mean deviation with circumpapillary vessel density and whole-image vessel density was statistically significant and was even stronger than the association between mean deviation with retinal nerve fiber layer (RNFL) thickness and rim area. Indeed, even after controlling for the effect of structural loss on SD-OCT, the association between vessel density and visual field damage was statistically significant on multivariate regression analysis.

DISCUSSION

What blood vessels were being measured by OCT-A, and how do they relate to glaucoma pathology?

OCT-A is a relatively new, noninvasive technology that captures the dynamic motion of moving scatters (eg, red blood cells flowing through blood vessels) and provides a high-resolution 3-D image of the vasculature. In this study, the researchers used a 4.5 × 4.5-mm field of view centered on the optic disc. They measured vessel density within the RNFL from the internal limiting membrane to the RNFL posterior boundary, as determined by the OCT-A device (AngioVue; Optovue). Important for retinal ganglion cell (RGC) function, these vessels consist of the capillary network that shows a linear course along the nerve fiber layer (NFL) distribution with minimal intercapillary anastomosis. The RNFL capillaries tend to be well visualized by OCT-A because of the absence of projection artifacts from overlying vessels.

How does this study affect clinicians' understanding of glaucoma pathophysiology?

Many cross-sectional studies have found a strong association between ocular hemodynamic impairments and glaucoma, but whether changes in ocular blood flow are a cause or an effect of optic nerve damage is a long-standing question. Although this study does not address the question, the research suggests that peripapillary RNFL capillary dropout reflects functional vision loss before structural RNFL loss occurs. It is possible that dysfunctional RGCs with decreased light sensitivity have reduced blood flow and lower vessel density before they undergo atrophy. If so, vessel density may be a better reflection of RGC functioning than structural loss.

What is or will be the role of OCT-A in glaucoma management?

It is too early to tell how OCT-A will be used in managing patients. Additional studies are needed to demonstrate how well this imaging technique correlates with visual field loss, optic nerve damage, and RNFL loss. Of particular interest is how well OCT-A and visual field loss correlate by sectoral location. Is there a characteristic vessel density pattern that is associated with a nasal step or arcuate scotoma? Is there a floor effect with OCT-A, as seen with structural OCT? What effect do comorbidities such as diabetes and hypertension have on peripapillary vessel density? This study found that the correlation between vessel density and visual field mean deviation was stronger with a quadratic curve than with linear correlation. If further studies confirm the investigators' finding that vessel density better reflects visual field loss than do SD-OCT structural parameters, then OCT-A may be useful in assessing patients who cannot reliably perform visual field testing. OCT-A will very likely be readily

adopted by retina specialists, so many providers managing glaucoma patients will be gaining access to this technology. Reimbursement, of course, will be a major factor in its adoption rate for glaucoma management.

Baseline Fourier-domain Optical Coherence Tomography Structural Risk Factors for Visual Field Progression in the Advanced Imaging for Glaucoma Study

Zhang X, Dastiridou A, Francis BA, et al[2]

ABSTRACT SUMMARY

The purpose of this multicenter study funded by the National Institutes of Health was to identify baseline structural parameters on Fourier-domain OCT (FD-OCT) that predict visual field progression in patients with open-angle glaucoma. A total of 277 eyes with glaucomatous visual field loss were monitored for an average of 4 years, and 83 (30%) showed visual field progression, either event based ("likely progression" with Glaucoma Progression Analysis Software on the Humphrey Field Analyzer [Carl Zeiss Meditec]) or trend based (significant negative slope in annual rate of change in the visual field index).

FD-OCT variables examined included disc, RNFL, and macular ganglion cell complex (GCC) structural parameters. The macular GCC scan covers a 7 × 7-mm square, centered slightly temporal to the fovea, and combines the NFL ganglion cell layer and inner plexiform layer. Several baseline NFL and GCC parameters—but not optic disc parameters—were significant predictors of progression. The most accurate predictors were the GCC focal loss volume (GCC-FLV) and the NFL-FLV. Patients with an abnormal GCC-FLV at baseline were two to three times more likely to show progression than those with a normal GCC-FLV at baseline. On multivariate Cox regression analysis, GCC-FLV, age, and central corneal thickness were significant risk factors for visual field progression.

DISCUSSION

Why were macular GCC parameters better risk predictors than optic nerve head parameters and even NFL parameters?

This study suggests that macular damage is fairly common and may occur early in glaucoma. GCC-FLV and NFL-FLV were the strongest predictors of risk. Focal defects are likely more reliable indicators of damage than overall thinning, which can be due to normal variation, myopia, axial length, or aging. Macular GCC scans may better correlate with visual fields because the macular area falls within the 24-2 visual field, whereas the circumpapillary RNFL covers the entire retina, much of which falls outside the 24-2 field. Macular scans are also less prone to decentration errors, because this imaging covers a larger area than RNFL scans and the foveal center is easier to identify than the center of the optic disc.

The structure of the optic nerve head is highly variable, and current OCT devices may not accurately or consistently define the structural borders. Indeed, most clinicians probably monitor the RNFL rather than the optic disc, either with OCT or stereographic disc photography. Recent studies suggest that optic nerve head topography based on Bruch membrane opening minimum rim width improves the correlation with visual field defects,[3] so newer software may improve the utility of optic nerve head analysis with OCT.

How does this study improve glaucoma management?

The likelihood of future glaucomatous progression is often best determined by the past rate of progression, but longitudinal information is not always available for newly or recently diagnosed patients. In these cases, clinicians must rely on baseline parameters to guide initial management decisions such as target IOP and the frequency of follow-up. Factors such as age, IOP, central corneal thickness, the presence of pseudoexfoliation, and baseline visual field loss have already been shown to be important predictors of the development and progression of glaucoma. Parameters such as IOP and visual field performance can be highly variable, however, so objective baseline parameters may be more reliable initial risk predictors. This study suggests that focal loss in the macular GCC and RNFL are decent initial predictors of glaucomatous progression. Robust normative databases of GCC and macular thickness maps would improve the usefulness of macular OCT scans for glaucoma. ■

1. Yarmohammadi A, Zangwill LM, Diniz-Filho A, et al. Relationship between optical coherence tomography angiography vessel density and severity of visual field loss in glaucoma. *Ophthalmology* 2016;123(12):2498-2508.
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