The Role of OCT Angiography in Assessing Retinal and Choroidal Vasculature

OCT-based angiography offers several unique and novel tools for evaluating retinal diseases that may impact how we make decisions in the clinic.

BY DANIELA BACHERINI, MD, PHD

OCT has become an indispensable tool for objectively assessing retinal structure. Increasingly, it is being recognized that the microvasculature of the retina and choroid plays an important role in many ocular pathologies, implying a need to supplement OCT data with angiography. For the past few decades, clinicians have relied on a combination of angiography under fluorescein (FA) or indocyanine green (ICG) contrast dye to detect disease features. Yet, FA and ICG are associated with several well-known limitations, most prominently the requirement for intravenous contrast dye that may cause a variety of complications, including nausea, vomiting, pruritis, urticaria, and, in rare instances, anaphylaxis.[1]

The emergence of OCT angiography (OCT-A) thus offers an intriguing potential to expand the role of evaluating the microvasculature in entities such as age-related macular degeneration, diabetic retinopathy, retinal vein occlusion, and others.[2] Fundamentally, OCT-A differs from contrast-based angiography in how the images are captured. Whereas FA or ICG angiography tracks movement of intravenously injected dye through various filters, thereby acting as a surrogate marker of blood flow, OCT-A images are 3D reconstructions of numerous A-scans over the same tissue area. Laser light reflects off the surface of moving red blood cells, and analysis by the accompanying software depicts movement of the red blood cells as a function of their differing positions between serial scans.

The above is a vast oversimplification of the technical nuances of OCT-A, which have now been described in several excellent publications.[3,4] With OCT-A, the need for intravenous dye is eliminated; it has an improved safety profile, and the scan can be performed faster and easier. Some OCT machines, such as the NIDEK RS-3000 Advance 2 are now equipped with onboard OCT-A capabilities, making them even more convenient for busy clinicians and their patients and further expanding their utility. These kinds of multifunctional platforms also offer some unique features that portend to impact clinical decision-making and enhance research capabilities.

SEGMENTED ANALYSIS OF RETINAL VASCULATURE

One interesting feature of the AngioScan software (NIDEK) on the RS-3000 Advance 2 is that it can provide segmented maps of the chorioretinal vasculature. By comparison, FA images are 2D in nature, and so, these layers are depicted together. With OCT-A, the resulting image can easily be segmented to evaluate the retinal flow layer by layer;[5,6] specifically the latest software on the RS-3000 Advance 2 allows for segmentation of the superficial capillary plexus (SCP), deep capillary plexus (DCP), Outer Retina (OR), OR + Choriocapillaris (ORCC), Choriocapillaris, and Choroid Layers, which cannot be separately visualized by other techniques.

This segmentation may be useful in classifying choroidal neovascularization (CNV) as type 1 (occult, below the retinal pigment epithelium), type 2 (classic, in the OR), type 3 (retinal angiomatous proliferation lesions), or type 4 (mixed type 1 and type 2). In this regard, we have found that the ORCC layer is particularly useful, as this is where the majority of CNV lesions are found (Figure 1).

More recently, evidence has emerged that alterations in the DCP correlate with visual acuity outcomes in many retinal diseases. We recently demonstrated a positive correlation between the restoration of the DCP and improved vision after surgery to repair macular hole (Paper submitted). At a minimum, this recent research suggests that it may be useful to evaluate the DCP before and after surgery as an additional metric for assessing the outcome.[7]

CONNECTING STRUCTURE AND FUNCTION

Because the OCT-A function is integrated into the existing platform of the RS-3000 Advance 2, it is possible to perform angiography and traditional OCT imaging at the same time. Furthermore, the RS-3000 Advance 2 is equipped with a scanning laser ophthalmoscopy eye tracer, thereby allowing compensation for eye movements resulting in a more accurate scan and higher image quality. This functionality also increases the reproducibility of the scanning location during follow-up.

There is an additional possibility to connect the RS-3000 Advance 2 with other diagnostic modalities, such as the MP-3 Microperimeter (NIDEK). The multimodal integrated evaluation permits assessment of both structure and retinal function during the same examination (Figure 2). In our clinic, we have found that, in some surgical cases, despite anatomic success in repairing retinal tissue, visual acuity gains may not be apparent. In these cases, multimodal evaluation, including retinal sensitivity assessment, helps us to understand exactly what is going on from a functional perspective and to connect that with vascular and structural details.

FAZ ASSESSMENT

The foveal avascular zone (FAZ), as the name would imply, is the area in the central part of the fovea where vessels are absent, and it is surrounded by the perifoveal capillary plexus. The AngioScan software on the RS-3000 Advance 2 automatically detects the FAZ, providing quantitative metrics, including its area, perimeter, and circularity. There is already literature supporting the notion that FAZ size may be a biomarker for visual changes in diabetic retinopathy, branch retinal vein occlusion, and other retinal diseases.

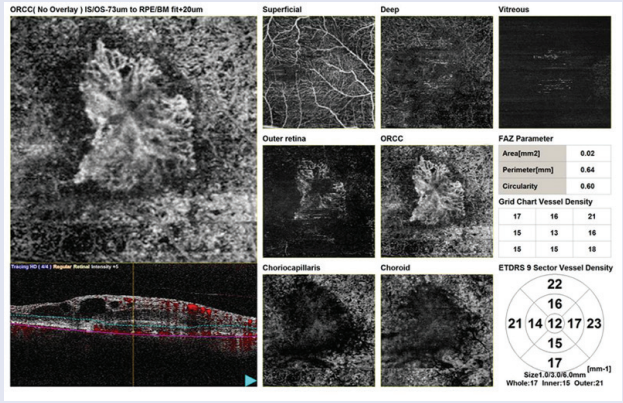

Figure 1. OCT-A in a case of neovascular age-related macular degeneration. A large CNV is evident in the ORCC layer.

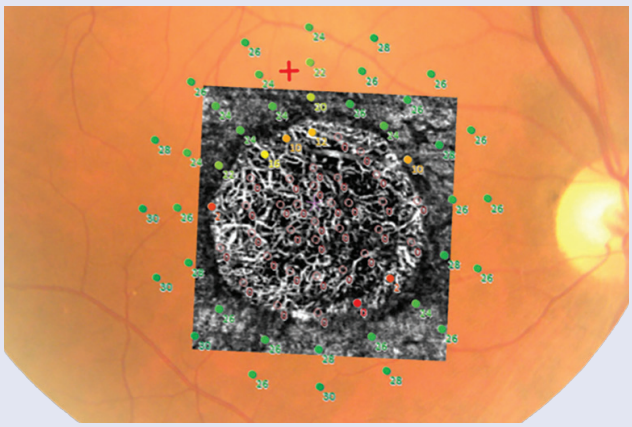

Figure 2. Overlay of the microperimetry onto the choroidal slab on OCT-A in Stargardt disease.

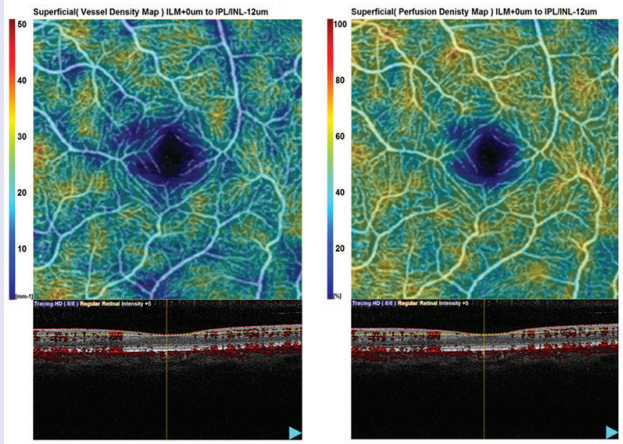

Figure 3. Vessel density map (left) and perfusion density map (right).

VESSEL DENSITY AND PERFUSION DENSITY MAPS

With the AngioScan software, the angiography image can be converted into two color-coded types of vascular density maps, which differ in how they are calculated. The vessel density map provides a display of total linear millimeter of vessels per square millimeter regardless of the vessels' original thickness. The perfusion density map takes into account the original thickness of the vessel when calculating density to display the percentage of tissue that is perfused by blood flow (Figure 3).

Each of these may be important, as one or the other might show alterations depending on the particular pathology and/or the evolutionary stage of the disease.

CONCLUSIONS

Based on what we currently know about OCT-A, this new tool for assessing the retinal and choroidal vasculature does not yet supplant the role of FA or ICG angiography. Indeed, it is likely that there will be a role for each of the three, at least for the foreseeable future. For instance, dye leakage on FA is a diagnostic sign in retinal vasculitis, and this is not visible on OCT-A due to the working principle of the imaging. Furthermore, the role of OCT-A for peripheral retina is as of yet undefined, and this, too, is better visualized with contrast-based angiography.

At the same time, OCT-A offers novel mechanisms for assessing chorioretinal vasculature in a noninvasive way that is not possible with other modalities. OCT-A also has intriguing potential for adding to clinical decision-making. I have found the device to be easy to use and understand; the interface is very user-friendly, thus making it suitable for a wide range of clinical applications. In addition, the connectivity and multimodal capabilities of this platform technology make it an exciting addition to the research setting. ■

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