Taking Retinal Imaging To the Cellular Level

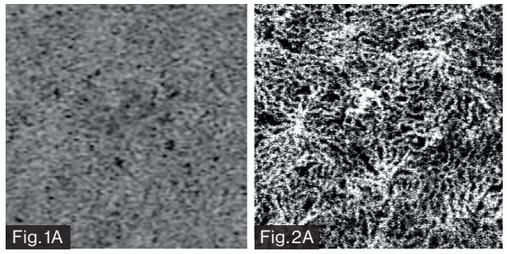
Fig. 1A

Fig. 2A

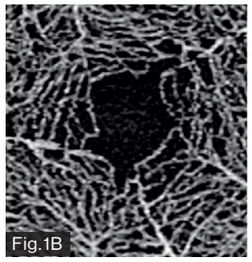
Fig. 1B

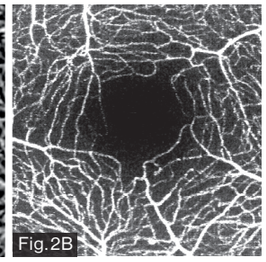
Fig. 2B

Justin Migacz, PhD, in the David E. Marrus Adaptive Optics Imaging Laboratory at NYEE

Fig. 1 and 2. A comparison of choriocapillaris (Fig. 1) and retinal (Fig. 2) images from the same subject on two different OCTA systems. Images from the commercially-available system (1A and 1B) pale in comparison to those taken with the research-grade, ultrahigh-speed OCTA system images shown on the right (2A and 2B).

Breakthroughs in treating elusive diseases like macular degeneration and glaucoma will be facilitated by modalities for imaging their unique vascular and blood flow characteristics. Scientists are now closer than ever to achieving this, thanks to impressive advances in optical coherence tomography angiography (OCTA), and no institution is working harder to bring that science into the mainstream than New York Eye and Ear Infirmary of Mount Sinai (NYEE).

In the field of ocular imaging, speed is paramount in order to capture the movement of blood cells across the intricate network of veins and arteries of the eye. Researchers at the David E. Marrus Adaptive Optics Imaging Laboratory at NYEE have developed a super-fast, 1.64 MHz OCTA system that is now able to take retinal imaging to the cellular level. "Within the retina are at least 10 layers of cells that house many of the changes that trigger disease," explains Richard Rosen, MD, Deputy Chair for Clinical Affairs and Director of Ophthalmic Research at NYEE. "Having this high-speed OCTA capability will allow us to study many individual cell types that we couldn't visualize before, and that will put us in the forefront of imaging research into glaucoma, macular degeneration, and other intra-retinal diseases."

Leading the development of this technology is Justin Migacz, PhD, a biomedical engineer and postdoctoral imaging fellow in Dr. Rosen's lab, who began the project during his PhD work at the University of California-Davis Medical Center in Sacramento. In an article in *Biomedical Optics Express* (December 2018), Dr. Migacz describes how OCTA, with its rapid frame rate, enables visualization of high-speed blood flow within the choroid and choriocapillaris, at a level never seen before. The choroidal vessels form a complex vascular network, and it is believed that defects of the choroid—particularly the choriocapillaris layer—may play a significant role in the early stages of age-related macular degeneration.

"With OCTA we can distinguish much more clearly than before the motion of the choriocapillaris from other distracting features in the image," says Dr. Migacz. "It essentially allows you to see the outline of the blood vessels in fine detail and with a high level of confidence." In turn, this high-resolution visualization provides a window on how blood vessels are structurally changing—becoming more brittle, or thinning out—and how this decay affects progression of the disease. Because OCTA exposes each individual branch of the blood vessels in minute detail, Dr. Migacz is hopeful this magnification will also reveal how and when the disease starts, enabling treatment to begin at the earliest possible stage.

In addition to OCTA, adaptive optics scanning laser ophthalmology (AOSLO) provides NYEE clinicians unprecedented cellular-level views of retinal microvascular structure and blood flow. Researchers in the Marrus Adaptive Optics Imaging Laboratory are now working on marrying the high-resolution strength of AOSLO with the high-speed advantages of OCTA to reveal a piece of the glaucoma puzzle that has evaded researchers for years: the role of ganglion cells, the neurons that relay information from the retina to the brain. "This would take us to another level in terms of looking at the actual histological structures within the retina," points out Yuen Ping Toco Chui, PhD, Director of the Marrus Adaptive Optics Imaging Laboratory and Associate Professor of Ophthalmology at the Icahn School of Medicine at Mount Sinai. Collaborating with NYEE on this imaging project are researchers from Stanford and UC-Davis's Department of Ophthalmology.

Undergirding the cutting-edge work of Drs. Migacz and Rosen in the adaptive optics lab is the goal of transferring their findings to the clinic so they can benefit patients. This will first require working with and convincing device manufacturers and system developers of the enormous potential that vasculature imaging—exemplified by what NYEE has achieved in the lab—holds both commercially and clinically. "We want to make this technology user-friendly so it can be readily adopted in the clinic," emphasizes Dr. Migacz. "My personal hope is that our work will open the door to developing treatments for patients sooner, and monitoring them to ensure they are effective."