Peeling Through the Layers: SD OCT

The technology is useful for imaging a variety of retinal diseases.

BY ZOSIA MICHALEWSKA, MD; JANUSZ MICHALEWSKI, MD; AND JERZY NAWROCKI, MD, PHD

From its first description in the early 1990s, optical coherence tomography (OCT)[1] has evolved to be an integral tool for examination of the macula. Many structural changes, however, remain below the ~10 µm axial resolution capability of standard OCT. Spectral-domain (SD) OCT is an innovative technology that enables exact presentation of all retinal layers with axial resolution of up to ~3 µm. With SD OCT, retinal images are acquired 10- to 100-times faster than with time-domain (TD) OCT, thus enabling 3-D presentation of the retina and production of maps of particular retinal layers.

Spectral OCT (SOCT) Copernicus HR (Optopol, Zawiercie, Poland; distributed in the United States by Reichert) has been used in our clinic for more than 2 years. In this article, we discuss the features of the SOCT Copernicus and describe how we have used it clinically in our practice.

FEATURES

The SOCT Copernicus system visualizes particular retinal layers with an axial resolution of 3 µm. It allows the user to choose the exact number of A-scans, B-scans, and scanning area required for each individual patient, making it possible to obtain good quality images in patients with minimal fixation loss in a short period of time. It is also possible to produce high-quality 3-D images of the macula and the optic nerve at the same time. This system produces 3-D thickness maps of an area from 3 to 10 mm.

The system also enables the user to produce C-scans and particular retinal maps such as a retinal thickness map, a nerve-fiber-layer (NFL) map, an inner segment/outer segment (IS/OS) map, and a retinal pigment epithelium (RPE) map. This information can be particularly useful in evaluation of patients after anti-VEGF treatment. Moreover, it enables performing multiple scans of the same area through time, which enables the presentation of pulse of retinal vessels.

Because many features are determined manually (eg, number of A and B scans), the learning curve can be a disadvantage of this device. The most important advantage of this device is the high resolution of a single B-scan and of single scans in the 3-D mode.

A cornea module can be attached to the device. The experimental version allows the presentation of 3-D cornea maps, measuring the corneal thickness and identifying structures of the angle.

MACULAR HOLE

The SOCT Copernicus can present the entire area of a macular hole, not only a cross sectional scan, as with standard resolution OCT. Moreover, it is possible to notice whether the photoreceptor layer is intact at the borders of the macular hole. These advances can influence treatment decisions. After surgery, various defects observed in SOCT, such as photoreceptor layer defect, nerve fiber layer defect, elevation of the photoreceptor layer and intraretinal cysts, can explain the lack of full visual recovery in some cases of macular hole surgery.[2,3] C- scans of the macular holes, presented for the first time by Hangai et al, are a rather new examination type. A "crown" or "rosette" can be seen on C-scans around the macular hole (Figure 1).[4,5]

MACULAR PUCKER

Enhanced resolution of SOCT has enabled us to observe that epiretinal membranes often coexist with lamellar macular hole. Similar to macular hole studies, defects in photoreceptor layer have been detected in cases of epiretinal membranes. Patients without any changes in photoreceptor layer had significantly better visual acuity than patients with structural changes in photoreceptors. This observation, together with correlation of visual acuity with central retinal thickness, gave additional explanation of decreased retinal function.[6]

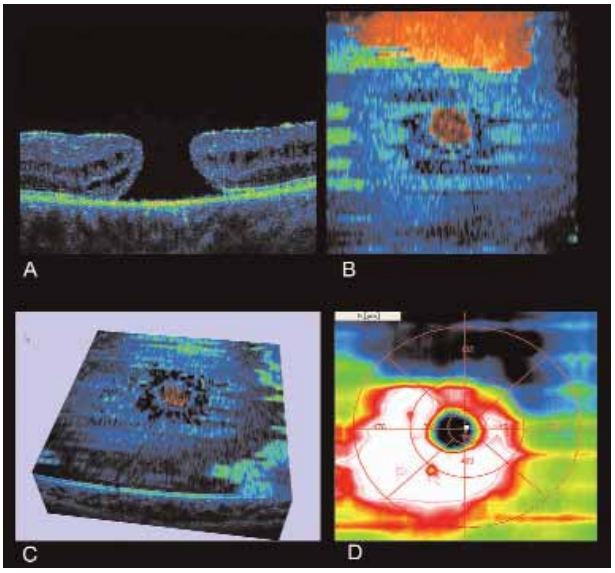

Figure 1. (A) SOCT Copernicus image of full thickness macular hole. (B) C-scan of full thickness macular hole at the level of nerve fiber layer. (C) C-scan of full thickness macular hole at the level of outer plexiform layer. (D) Retinal thickness map.

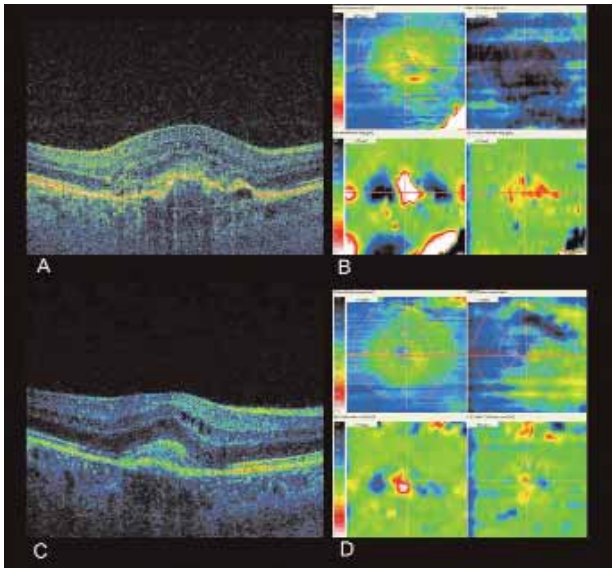

Figure 2. (A) SOCT Copernicis scan of wet AMD. (B) Retinal deformation map of wet AMD before bevacizumab injection. (C) SOCT scan 1 month after the first bevacizumab injection. (D) Retinal deformation map 1 month after the first bevacizumab injection.

AGE-RELATED MACULAR DEGENERATION

Spectral OCT can be used as a diagnostic tool that can distinguish leaking neovascularization by presentation of small amounts of subretinal fluid in the 3-D scanning mode. In combined SOCT-angiography photographs, the correlation between those findings can be noted. Retina maps also seem to be valuable not only in AMD diagnostics but also in post–anti-VEGF evaluation (Figure 2).

OTHER RETINAL DYSTROPHIES

It is not only possible to present thinning of the central retina but also to detect slight irregularities in the photoreceptor layer, which can have influence on visual outcome in heriditary diseases such as retinitis pigmentosa.

Spectral OCT enables imaging of IS/OS defects or elevation, which can explain visual deterioration in vitreomacular traction syndrome, central serous chorioretinopathy,[7] hydrochloroquine retinopathy,[8] in eyes after retinal detachment surgery[9] and other diseases.

Future advances in imaging technology will bring forth devices that will enable presentation of the retina in molecular or even nanoresolution. Until that time, SD OCT is currently the most precise examination in ophthalmology. Surely the growing availability of commercially available devices will enable not only more exact diagnostics and evaluation of our patients, but also new developments in the field of clinical science. ■

Zosia Michalewska, MD, is an ophthalmologist at Jasne Blonia Eye Clinic, Lodz, Poland.

Janusz Michalewski, MD, is an ophthalmologist at Jasne Blonia Eye Clinic.

Jerzy Nawrocki, MD, PhD, is Professor of Ophthalmology at Jasne Blonia Eye Clinic where he is a vitreoretinal specialist. The authors report no financial relationships. They can be reached at: zosia_n@yahoo.com

1. Huang D, Swanson EA, Lin CP, et al. Optical coherence tomography. *Science.* 1991;254:1178–1181.
2. Ko TH, Witkin AJ, Fujimoto JG, et al. Ultrahigh-resolution optical coherence tomography of surgically closed macular holes. *Arch Ophthalmol.* 2006;124:827–836.
3. Michalewska Z, Michalewski J, Cisiecki S, Adelman R, Nawrocki J. Correlation between foveal structure and visual outcome following macular hole surgery: a spectral optical coherence tomography study. *Graefes Arch Clin Exp Ophthalmol.* 2008;246(6):823–830. Epub 2008 Apr 2.
4. Hangai M, Ojima Y, Gotoh N, et al. Three-dimensional imaging of macular holes with high-speed optical coherence tomography. *Ophthalmology.* 2007;114(4):763–773. Epub 2006 Dec 20.
5. Brinkmann CK, Wolf S, Wolf- Schnurrbusch UEK. Multimodal imaging in macular diagnostics: combined OCT- SLO improves therapeutical monitoring *Greafes Arch Clin Exp Ophthalmol.* 2008;246:9–17.
6. Michalewski J, Michalewska Z, Cisiecki S, Nawrocki J. *Graefes Arch Clin Exp Ophthalmol.* 2007;245:1623–1631.
7. Fujimoto H, Gomi F, Wakabayashi T, Sawa M, Tsujikawa M, Tano Y. Morphologic changes in acute central serous chorioretinopathy evaluated by Fourier-domain optical coherence tomography. *Ophthalmology.* 2008; Apr 3 [Epub ahead of print]
8. Rodriguez-Padilla JA, Hedges TR 3rd, Monson B, et al. High-speed ultra-high-resolution optical coherence tomography findings in hydroxychloroquine retinopathy. *Arch Ophthalmol.* 2007;125(6):775–780.
9. Schocket LS, Witkin AJ, Fujimoto JG et al. Ultrahigh-resolution optical coherence tomography in patients with decreased visual acuity after retinal detachment repair. *Ophthalmology.* 2006;113:666–672.