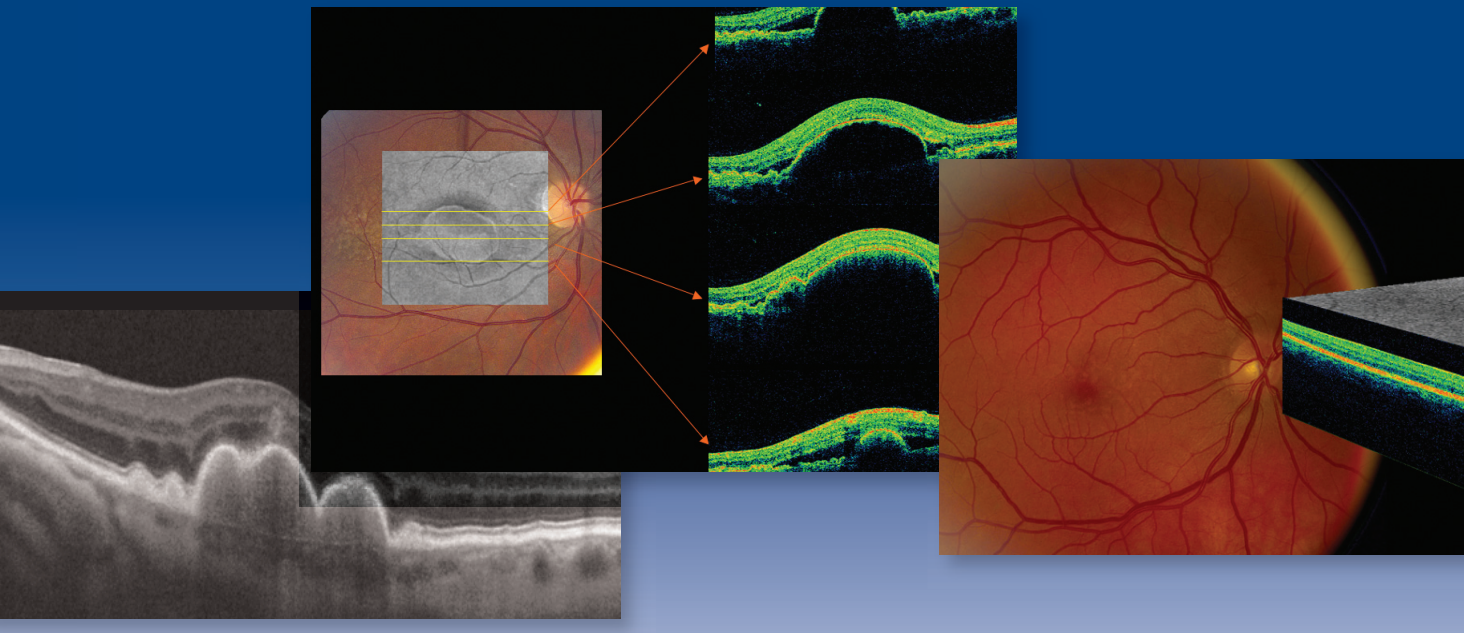
Ophthalmology MANAGEMENT
MARCH 2010

Cirrus HD-OCT

Learn how the latest tools can help guide your clinical decisions and improve outcomes.



Highlights from a special event held during the 2009 meeting of the American Academy of Ophthalmology

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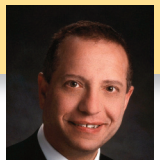
By Carmen Puliafito, MD, MBA



Cirrus HD-OCT Today and Tomorrow

Upcoming analysis capabilities complement unsurpassed image quality and ease of use.

In the past year, spectral domain optical coherence tomography (SD-OCT) has continued to evolve, further expanding its utility in the ophthalmic practice. In this article, I highlight key capabilities specific to the Cirrus HD-OCT (Carl Zeiss Meditec, Dublin, Calif.). Next, three fellow ophthalmologists describe how these capabilities enhance their glaucoma and retina practices, and they provide a preview of exciting features to come.

Ease of Use

One of the tremendous assets of Cirrus HD-OCT is its ease of use. Images can be captured readily by physicians and practice technicians. Viewing the fundus is not necessary for pre-scan focusing. Instead, focus is accomplished through a much simpler iris viewer.

The image acquisition speed of the instrument also sets it apart from other available systems. Once the patient's eye is in focus, a full scan is obtained in approximately 2 seconds. The ability to image the retina so quickly contributes to smooth and efficient patient flow.

The Cirrus HD-OCT has a small footprint and, therefore, fits easily into any practice layout, even when space is tight. The technician and patient sit 90 degrees apart, which means the technician can easily see the patient throughout testing, and the instrument can be placed in the corner of a room.

Information-Packed Reports

The speed of the Cirrus HD-OCT not only contributes to practice efficiency, it also gives the system its ability to capture a high-density cube of data. In general, I prefer reviewing OCT results in real-time via a live connection and computer monitor. Many physicians, however, prefer to work from the printout. Cirrus HD-OCT printouts (**Figure 1**) display the most clinically relevant data in images and maps.

The macular thickness printout, for example, shows the line scanning ophthalmoscope (LSO) fundus image. That image can be overlayed with either the macular thickness map or the OCT fundus image, both of which are also shown separately. The macular thickness map topographically illustrates the thickness between the internal limiting membrane (ILM) and the retinal pigment epithelium (RPE). The OCT fundus image is the surface view of the 6x6-mm cube of data. (Simultaneous capture of the OCT and the LSO fundus images ensures precise registration between the OCT scan and the fundus image.) The printout also includes the ILM and RPE layers segmented out, so their condition can be seen at a glance.

Two high-definition crosshair images on the printout provide enhanced resolution in the center of the scan, which is usually the area of interest. Central subfield thickness, total volume and overall average thickness over the entire 6x6-mm scan area are displayed in a table. A circular map provides overall average thickness values in each of nine sectors.

Enhanced HD 5-Line Raster Scan

The 5-line raster scan is the Cirrus HD-OCT's highest density scan. It consists of 4,096 A-scans in each of the five lines. The length, angle and spacing between the lines can be adjusted to acquire the best view of the area of interest.

The 5-line raster scan, which allows visualization

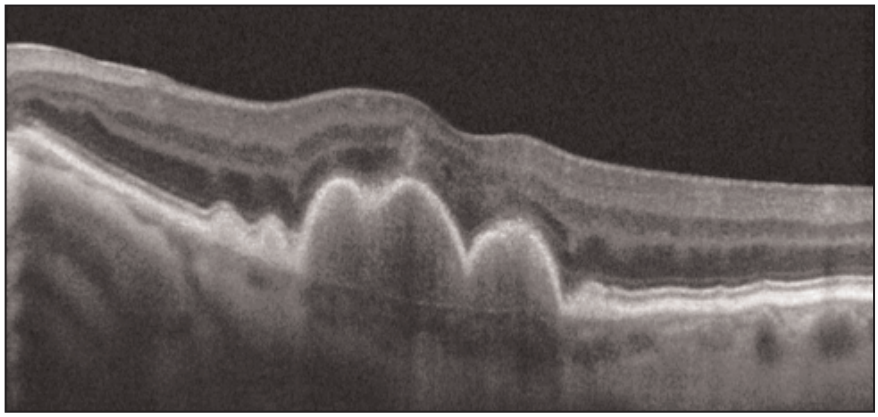
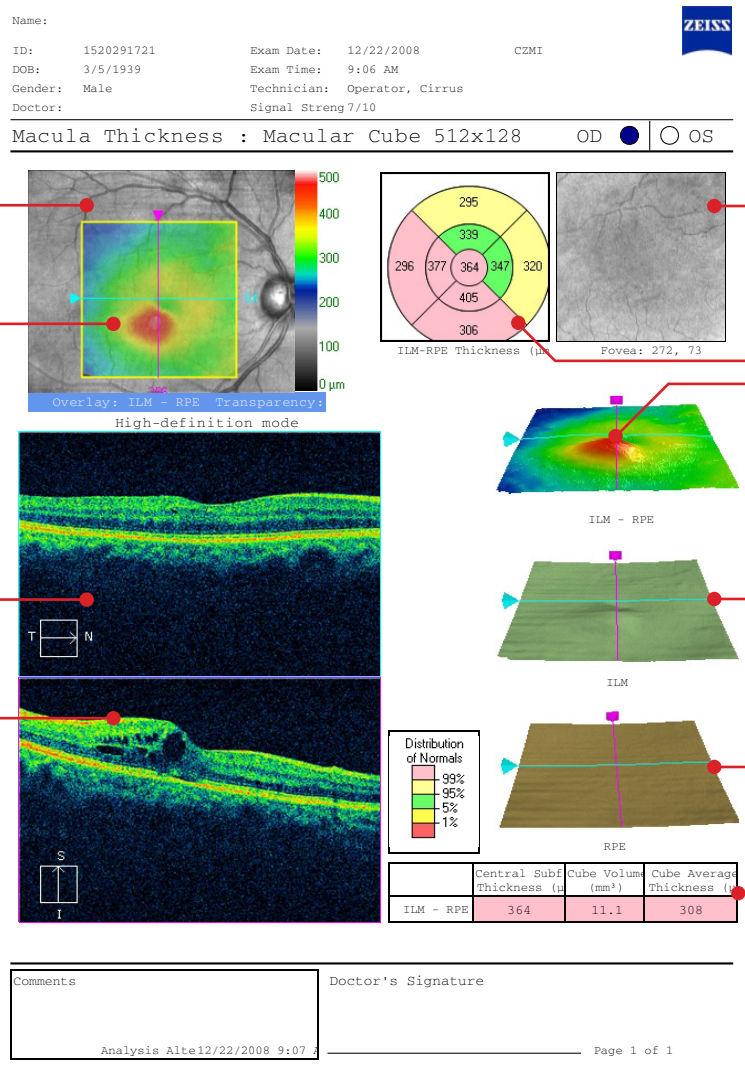


Figure 2. Enhanced HD Scan from the Cirrus HD-OCT.

Figure 1. Cirrus HD-OCT printouts display the most clinically relevant data in images and maps.



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ILM and RPE layers segmented out, so conditions can be seen at a glance.

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of the fine details of the retinal structure, has recently been improved. With what is known as Selective Pixel Profiling, the new scan protocol collects more data per scan location than the other Cirrus scans and then evaluates all of the pixel data to construct the best possible image (**Figure 2**). It leverages the scan engine's capabilities to produce images with outstanding detail without impacting the patient workflow.

New Capabilities Improve Care

The next three articles further describe how the advanced features of the Cirrus HD-OCT are helping ophthalmologists better diagnose and manage glaucoma, age-related macular degeneration (AMD) and diabetic retinopathy.

They also describe some impressive new capabilities in the areas of glaucoma progression, which are available now, and dry AMD analysis, which will be added to the system soon.

Dr. Puliafito is dean of the University of Southern California's Keck School of Medicine, where he also serves as a professor of Ophthalmology and Health Management.

Optic Nerve Analysis With Cirrus HD-OCT

Automatic disc evaluation and progression detection are breakthroughs in glaucoma care.

Compared with its time domain predecessor, spectral domain OCT can provide earlier and more precise detection of glaucoma. "The introduction into clinical practice of SD-OCT is revolutionizing the diagnosis and management of glaucoma," says Robert N. Weinreb, MD, Distinguished Professor of Ophthalmology and Director of the Hamilton Glaucoma Center at the University of California, San Diego. "The result is improved patient outcomes, specifically reduced functional impairment and blindness."

This article summarizes the capabilities of the newest version of software for the Cirrus HD-OCT. Version 5.0 gives physicians powerful new tools including optic disc analysis, quantitative assessment of progression and reports that provide structural information for diagnosing and managing glaucoma patients.

"The introduction into clinical practice of SD-OCT is revolutionizing the diagnosis and management of glaucoma. The result is improved patient outcomes, specifically reduced functional impairment and blindness."

— Robert N. Weinreb, MD

Optic Disc Analysis

Glaucoma specialists have been using new technology to assess the retinal nerve fiber layer (RNFL). However, what is unique about the new Cirrus software is that it applies the same high-resolution data cube used for RNFL analysis to the optic disc. Therefore, it is possible to assess not only the RNFL but also the optic disc, which has been the standard for glaucoma diagnosis and treatment for many years. In addition, optic disc analysis can be performed retrospectively on images obtained before the new software was created.

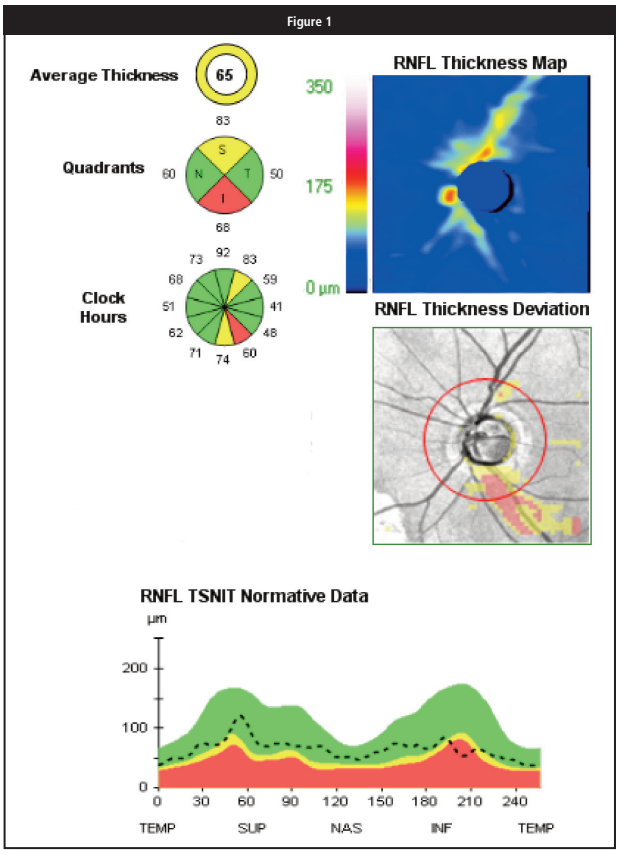
The new software allows, for the first time, automatic evaluation of several disc parameters:

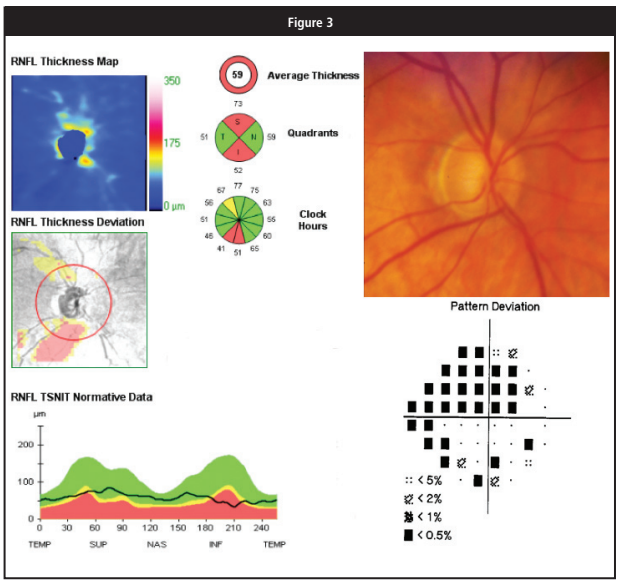
- rim area
- disc area
- average cup/disc ratio
- vertical cup/disc ratio
- cup volume.

Disc area allows the clinician to ascertain the significance of the rim area. With the new Cirrus software, the significance limits for the optic disc parameters are used to provide the standard color-coded scheme for comparison to normals. They are derived from the same normals used in the system's RNFL Normative Database. This comparison to normative data should be available for the Cirrus later this year.

One of the challenges in measuring the optic disc is determining its margins. The Cirrus HD-OCT 5.0 software accomplishes this by defining the edge of the disc as the termination of Bruch's membrane.[1] This is done at multiple points around the nerve head. The resulting optic disc outline, which is used for computing the disc parameters, is displayed for evaluation. TSNIT analyses of the RNFL are taken from a circle that is centered on the optic disc. Neuroretinal rim width around the circumference of the optic disc is then determined in the plane of the disc.[2,3]

According to Dr. Weinreb, measuring rim area in the same plane as the optic disc may be helpful for examination of tilted discs. "In cases where the nerve exit is oblique, the disc is viewed at an angle by the clinician, foreshortening the image," he says. "Therefore, areas visualized via ophthalmoscopy, photographs or other imaging modalities will be reduced. Because the measurements taken by Cirrus HD-OCT are in the same plane, it is likely that results more accurately represent the true anatomy."

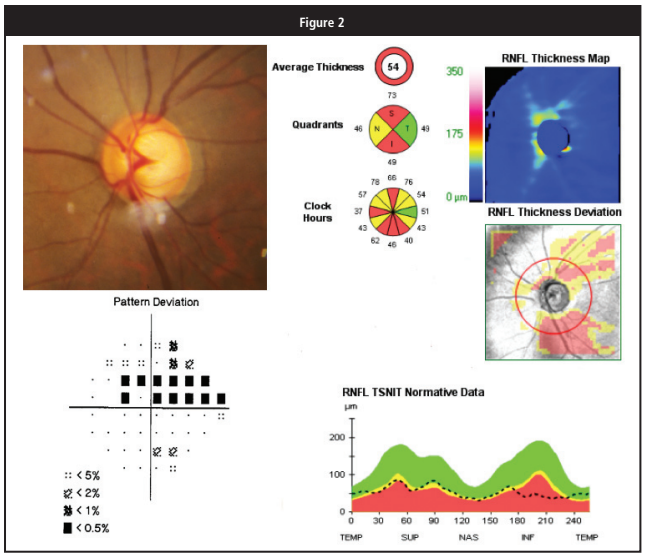




Figures 1-3. In these 3 cases, Cirrus HD-OCT optic disc and retinal nerve fiber layer analyses reveal defects that would be difficult to detect by other means.

Structure and Function Data in One Report

For decades, those with an interest in glaucoma diagnosis and assessment of progression have sought the ability to put together structural and functional information. Soon, using data from



Cirrus and HFA, the Zeiss eyecare data management system, Forum, will create a Combined Report. This convenient summary of structure and function data simplifies patient management and also can be useful for patient education.

"Structural and functional information are not interdependent," Dr. Weinreb says. "If a change in the visual field is observed, there is not necessarily a change in the optic disc." Last year, Dr. Weinreb and colleagues published a paper showing how structure can predict function in many patients.[4] "However, that is not always the case," he says. "In some patients, function can predict structure. Structural and functional testing are complementary."

SD-OCT Case Studies

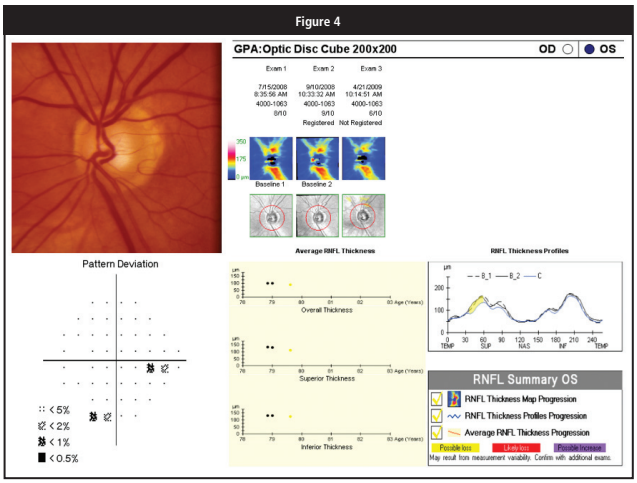
The following cases of patients with glaucoma illustrate how Cirrus HD-OCT enhances the clinician's diagnostic and monitoring capabilities.

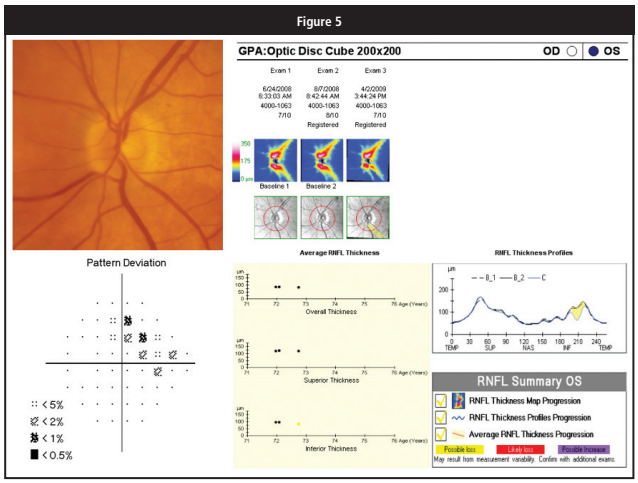
Case 1 - Figure 1

The optic disc photograph of this patient with glaucoma shows thinning of the inferior rim and an area of peripapillary atrophy. The visual field has a supranasal step. The SD-OCT analysis of RNFL thickness clearly reveals a wedge-shaped defect inferiorly. Following along the calculation circle centered on the optic disc, an infratemporal depression into the abnormal zone is visible. The depression corresponds to the RNFL defect.

Case 2 - Figure 2

The eye of this patient with glaucoma has almost no neuroretinal rim. Notable in this case is





Figures 4 and 5. Using new Cirrus HD-OCT software for detection of glaucoma progression, clinicians can quantitatively assess images and progression in the RNFL and optic disc. In these cases, changes in the RNFL and optic disc are visible before changes in other parameters.

how clearly SD-OCT shows the presence of a broad, wedge-shaped defect that corresponds to a change in the typical neuro-double-hump pattern, with loss of RNFL tissue. It would be difficult, if not impossible, to visualize the RNFL with a handheld lens using any of the methods suggested previously, including red-free or green light or high-resolution, monochromatic photographs.

Case 3 - Figure 3

This glaucoma patient has inferior thinning of the rim. Note how SD-OCT reveals the broad-shaped defect in the images as well as in the description of the RNFL.

Progression Analysis

Cirrus HD-OCT is also equipped with GPA software for detection of glaucoma progression. Clinicians can quantitatively assess images and look for disease progression in the RNFL and — in the future — in the optic disc. The following two cases show detection of disease progression that occurred in a relatively short period.

Case 4 - Figure 4

In this patient, baseline testing shows a possible small change in the neuroretinal rim superiorly and inferiorly. The visual field shows a small infranasal step. The patient was followed at 3- to 6-month intervals over less than 2 years. During that time, neither the visual field nor the results of clinical examination of the optic disc changed. However, upon analysis with the GPA software, an RNFL change became apparent superiorly, with RNFL thinning corresponding to RNFL loss in the supratemporal region.

Case 5 - Figure 5

In this patient, baseline visual field results were not changing, but Cirrus GPA software revealed repeatable RNFL changes in the infratemporal region.

Major Impact in Glaucoma Care

Dr. Weinreb predicts that the latest improvements in how SD-OCT technology can be used to diagnose and follow glaucoma will have a major impact in ophthalmology. “They will allow the individualization of therapies to a greater extent than is possible today,” he says, “which will further reduce the burden of glaucoma-related functional impairment and blindness.”

REFERENCES

1. Strouthidis NG, Yang H, Fortune B, Downs JC, Burgoyne CF. Detection of optic nerve head neural canal opening within histomorphometric and spectral domain optical coherence tomography data sets. *Invest Ophthalmol Vis Sci* 2009;50:214-223.
2. Strouthidis NG, White ET, Owen VM, Ho TA, Garway-Heath DF. Improving the repeatability of Heidelberg retina tomograph and Heidelberg retina tomograph II rim area measurements. *Br J Ophthalmol* 2005;89:1433-1437.
3. Tan JC, White E, Poinoosawmy D, Hitchings RA. Validity of rim area measurements by different reference planes. *J Glaucoma* 2004;13:245-250.
4. Medeiros FA, Alencar LM, Zangwill LM, Bowd C, Sample PA, Weinreb RN. Prediction of functional loss in glaucoma from progressive optic disc damage. *Arch Ophthalmol* 2009;127:1250-1256.

By Philip J. Rosenfeld, MD, PhD

Best Practices in AMD Management

Learn why Cirrus HD-OCT is the ideal instrument for wet — and dry — AMD.

For retinal specialists who see a high volume of AMD patients daily, the Stratus OCT (Carl Zeiss Meditec, Dublin, Calif.) is a useful instrument. For wet AMD in particular, the Stratus allows us to see everything we need to see to provide quality care. However, I have made the switch to spectral domain OCT because it is faster and easier, and it gives me greater confidence in my wet AMD diagnostic and management decisions. Furthermore, when it comes to dry AMD, SD-OCT is revolutionizing the way we manage our patients.

In this article, I explain how I use SD-OCT in practice, specifically the Cirrus HD-OCT.

Faster Scanning Produces More Data

The raster scanning pattern utilized by Cirrus HD-OCT has changed the way we generate images. In less than 2 seconds, 40,000 A-scans (200 A-scans x 200 B-scans) are obtained. In less than 3 seconds, 65,536 A-scans (512 A-scans x 128 B-scans) are obtained. The result is an astounding set of information covering a 6-mm x 6-mm cube.

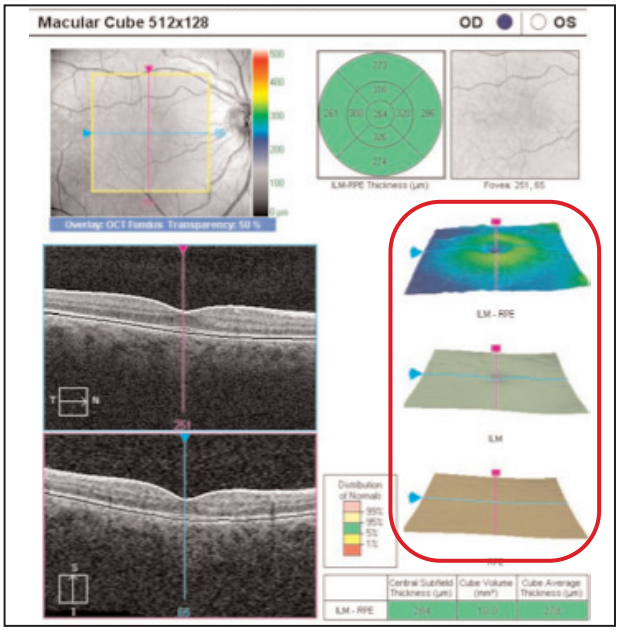


Figure 1. Segmentation techniques make it possible to view retinal layers individually, such as the internal limiting membrane and retinal pigment epithelium.

The information, of course, is represented for us on a printout. The printout for the dense macular cube scan (512 x 128), for example, includes the horizontal and vertical B-scans. It also includes 3-D segmentation maps of the ILM and the RPE (**Figure 1**). The segmentation techniques also make it possible to reconstruct 2-D and 3-D thickness maps (**Figure 2**).

Macular Change Analysis in Clinical Practice

The following cases from my practice demonstrate how the newest Cirrus HD-OCT image-capture and analysis algorithms improve clinical decision-making.

Case 1

In the first case, the patient presented with a hemorrhagic pigment epithelial detachment (PED) and visual acuity of 20/30^{+2}. The diagnosis was relatively straightforward. Fluorescein angiography showed a well-defined PED and blockage from the blood. Indocyanine green angiography showed neovascular tissue creeping up the side of the PED.

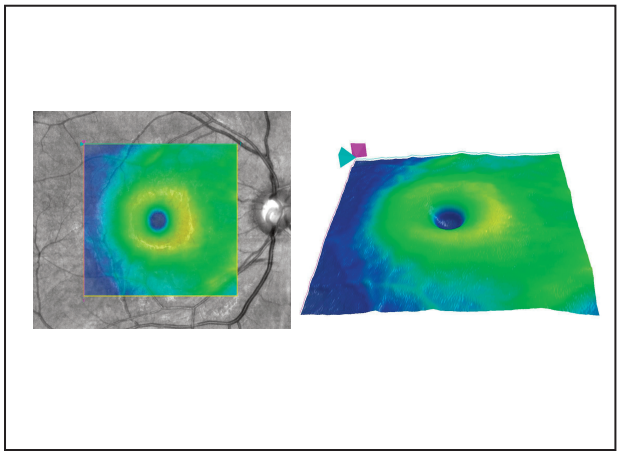


Figure 2. From the large amount of data obtained, the Cirrus HD-OCT reconstructs 2-D and 3-D thickness maps.

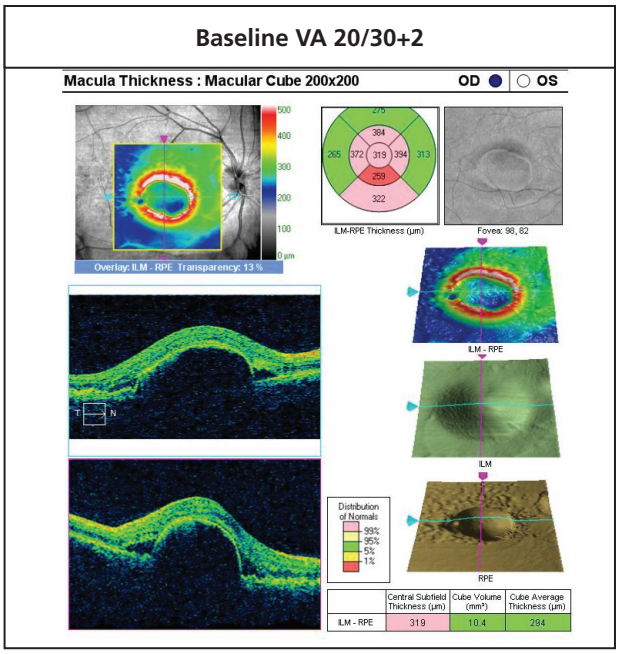


Figure 3. Two- and three-dimensional thickness maps reveal a ring of fluid in this eye with a hemorrhagic pigment epithelial detachment (PED). The PED is clearly visible on the RPE segment map.

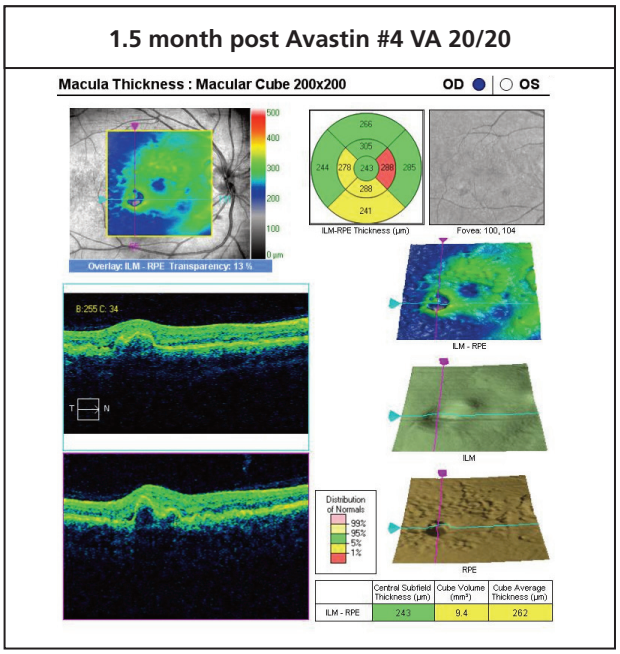


Figure 5. While the amount of subretinal fluid in the patient's eye was nearly gone 1.5 months after a fourth injection of bevacizumab (Avastin, Genentech), the high-definition crosshair image indicated the possibility of a small amount remaining. The PED was still present. Based on this information, it was decided the patient would be observed rather than treated again.

When we scanned the patient with Cirrus HD-OCT, the 2-D and 3-D thickness maps revealed a ring of fluid, and the segmented view of the RPE revealed

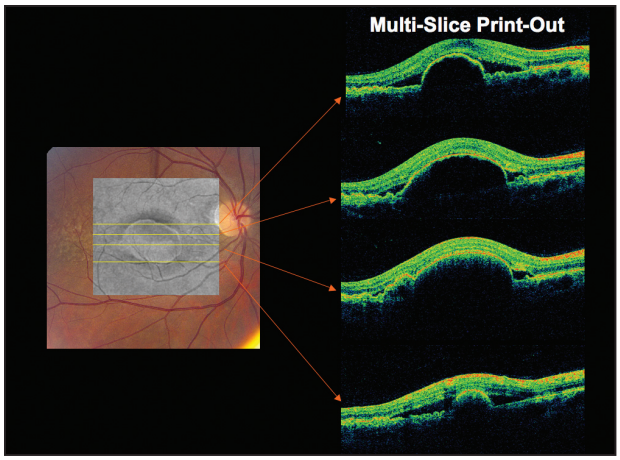


Figure 4. Confirmation of subretinal fluid using the Cirrus HD-OCT Multi-Slice Report.

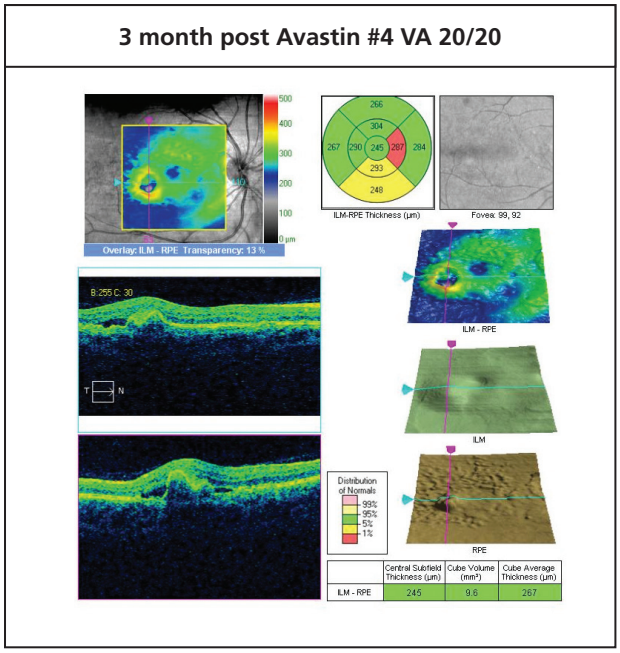


Figure 6. When the patient returned to the office 3 months after the fourth treatment with bevacizumab, it was immediately clear from the thickness map derived from the 200 x 200 Macular Cube Scan that macular fluid had returned.

the PED (**Figure 3**). The Stratus OCT would have shown us the same features, just not in such elegant, three-dimensional detail. Using the Cirrus HD-OCT Multi-Slice Report, which displays a sampling of B-scans (**Figure 4**), we confirmed the presence of subretinal fluid. We treated the patient with an intravitreal injection of an anti-VEGF agent, bevacizumab (Avastin, Genentech).

One month later, when the patient returned for scheduled follow-up, the thickness maps indicated

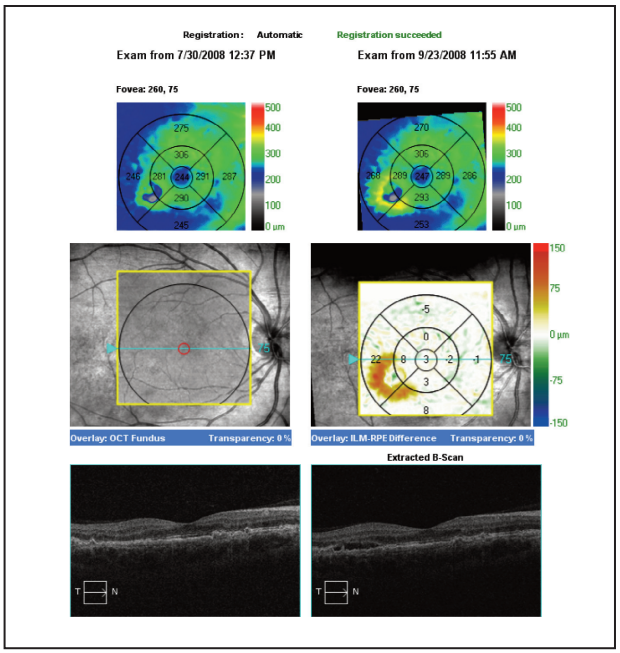


Figure 7. The Macular Change Analysis printout shows the thickness maps from two visits along with the difference in thickness.

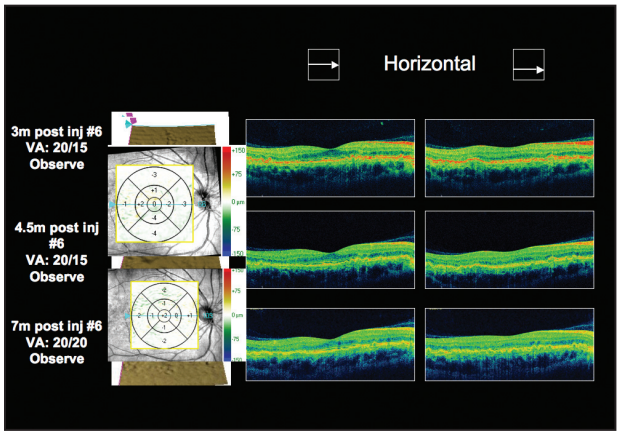


Figure 8. As the patient was followed over time, Cirrus HD-OCT high-resolution scans and Macular Change Analysis showed resolution of subretinal fluid and the PED.

the amount of macular fluid had decreased. The elevation was less and the horizontal and vertical B-scans showed the PED was smaller. However, some fluid was still present. From this point, we treated the patient with three additional injections of bevacizumab at scheduled intervals.

At the next follow-up visit, 1.5 months after the fourth injection (**Figure 5**), little to no fluid was visible on the thickness map. However, on the high-definition crosshair image, which provides enhanced resolution at the center of the scan, there appeared to be a very small amount of fluid. Also the PED was still present. Based on what we were seeing, combined with the patient's desire to delay treatment, we decided to observe rather than treat the patient.

When the patient returned to the office 3 months after the fourth treatment with bevacizumab, it was immediately clear from the thickness map derived from the 200x200 Macular Cube Scan that more subretinal fluid had returned (**Figure 6**). Not only were we able to see the fluid on the map, but we were also able to confirm the status of the retina using the Cirrus HD-OCT's Macular Change Analysis feature.

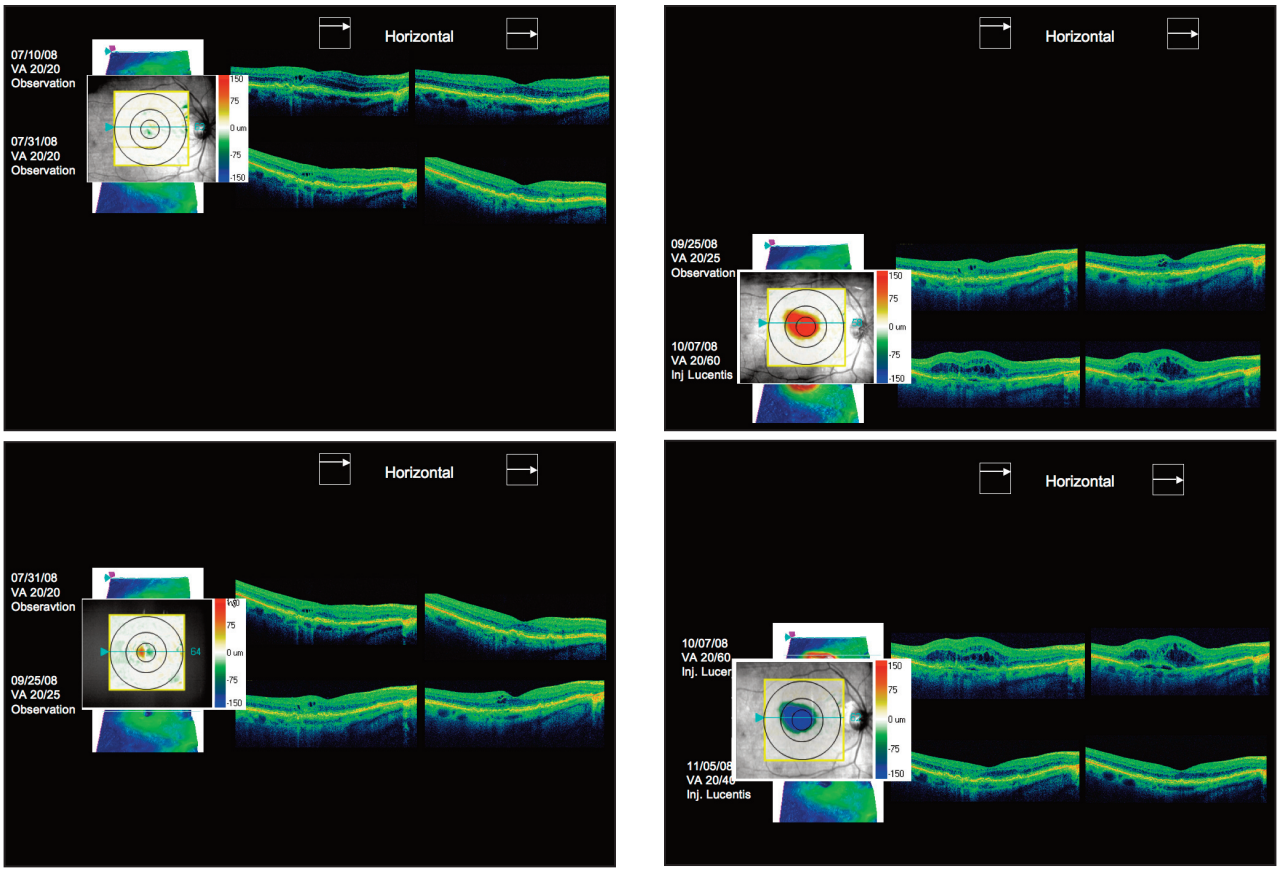
The Macular Change Analysis algorithm allows us to automatically compare results from one patient visit to the next. It takes two HD-OCT fundus images and aligns them. The thickness map from one visit is subtracted from the thickness map from another visit, which results in a perfectly registered difference map. As we move the horizontal B-scan on the first image, the B-scan moves accordingly on the second image. This permits the correlation of registered B-scans from one visit to the next. The printout shows the thickness maps from the two visits, along with the difference in thickness.

In this patient, the brown color on the difference map indicated for us how the status of the retina had changed — fluid had returned since the last visit (**Figure 7**). The patient was treated subsequently with two more injections of bevacizumab. Over time, all of the fluid resolved and the PED slowly disappeared (**Figure 8**).

Case 2

This second case (**Figures 9-12**) also illustrates how the Macular Change Analysis feature improves our ability to monitor pathology and helps us more easily determine when treatment is necessary.

The patient is an 82-year-old woman with AMD. At one particular visit, a small cyst was visible on the Cirrus HD-OCT scan. To determine if fluid had accumulated since her previous visit, we checked the Macular Change Analysis. It showed no change, so we decided to observe. When the patient returned 8 weeks later, Macular Change Analysis detected a slight increase in the amount of macular fluid. Again, we elected not to treat but to have the patient come back in approximately 2 weeks. During the subsequent visit, the macular change difference map



Figures 9-12. Cirrus HD-OCT images from a patient with AMD over a 4-month period. The Macular Change Analysis function allowed precise monitoring of a gradual increase in subretinal fluid that eventually required anti-VEGF treatment. One month after treatment, the map comparing the current and previous visits showed a decrease in fluid, which indicated the therapy was effective.

clearly identified a large area of increased fluid. We treated with an intravitreal injection of ranibizumab (Lucentis, Genentech). When the patient returned a month later for follow-up, the difference map indicated the fluid had diminished.

SD-OCT Fundus Image and Dry AMD

In the previous section, I mentioned the OCT fundus image produced by the Cirrus HD-OCT instrument and its role in the Macular Change Analysis function. The OCT fundus image, which was not available with Stratus OCT, is also particularly useful for following patients with dry AMD.

To understand why, remember that the A-scans captured with Cirrus HD-OCT make up B-scans, and the B-scans make up the 3-D dataset, or SD-OCT cube. The OCT fundus image is a projection of all of the summed reflectivity of the compiled B-scans projected as a virtual 2-D fundus image. This virtual fundus image is depicted on the top surface of the cube. It provides a great representation of the macula and it can be aligned with any other fundus image to achieve point-to-point correlation (**Figure 13**).

The OCT fundus image provides excellent visualization of geographic atrophy (GA) because the 840nm light from the HD-OCT does not penetrate well into the choroid where the RPE is intact. In areas where the RPE is absent, the light has greater penetration into the choroid. Therefore, wherever the RPE is intact, there is less reflectivity, a darker image. Wherever the RPE is not intact, as in GA, there is more reflectivity, a brighter image.

We have published a study in a small number of patients showing that SD-OCT can identify and quantitate areas of GA, and the size and shape of these areas correlate well to the areas of GA seen using fundus autofluorescence (FAF).[1] We also showed that manual identification of GA using the SD-OCT fundus image is reproducible and could be used as a practical method to quantify the presence and progression of GA in a clinical trial. To measure

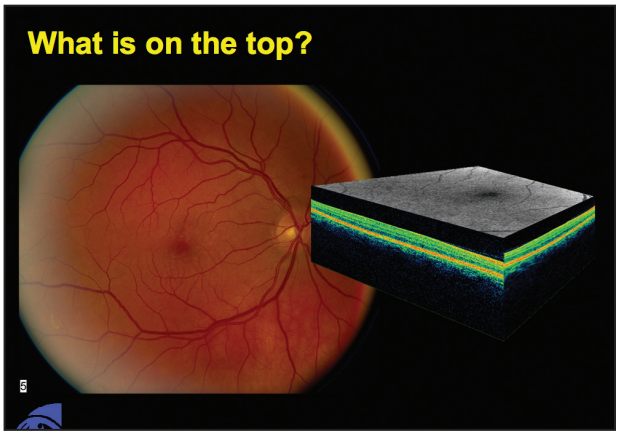


Figure 13. The SD-OCT fundus image is a projection of all the summed reflectivity and visualized on the top surface of the 6-mm x 6-mm data cube. Because it provides a great representation of the macula and can be aligned point-by-point with any other fundus image, its usefulness extends to following dry AMD.

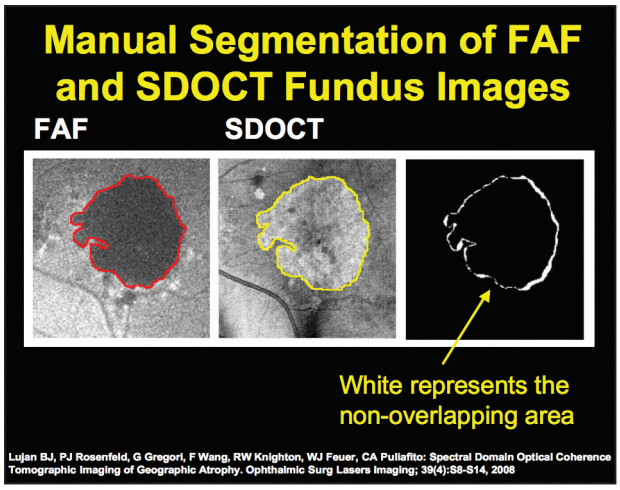


Figure 14

GA growth, we superimpose the color fundus photograph, the FAF image and the SD-OCT fundus image. By hand-drawing the outline of the GA at different follow-up time points, we can calculate the enlargement area and rate (**Figures 14-16**). Going forward, this is how we will evaluate potential new therapies for dry AMD — by testing whether treatments slow or stop the enlargement rate of GA.

A new algorithm is under development for the Cirrus HD-OCT that will allow automatic, rather than manual, quantification of GA. This will be an exciting advance for reading centers, and it will also allow those of us in clinical practice to follow our patients much more closely and better explain why they are losing vision.

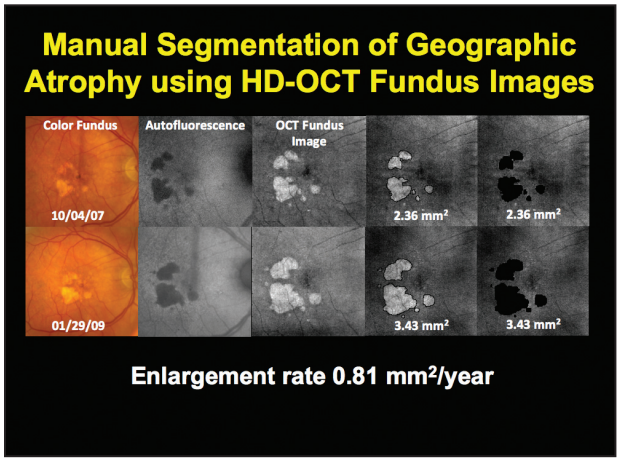


Figure 15

Because the Cirrus HD-OCT can register fundus images and segement the ILM and RPE, we can take advantage of the direct correlation of drusen and retinal thinning.

Measuring Drusen Area and Volume

Also by the end of this year, we will be able to use the Cirrus HD-OCT to measure drusen reliably. Because the instrument can register fundus images and segment the ILM and RPE, we can take advantage of the direct correlation of drusen and retinal thinning.

The new algorithm creates a difference map that quantitates drusen by subtracting the "interpolated

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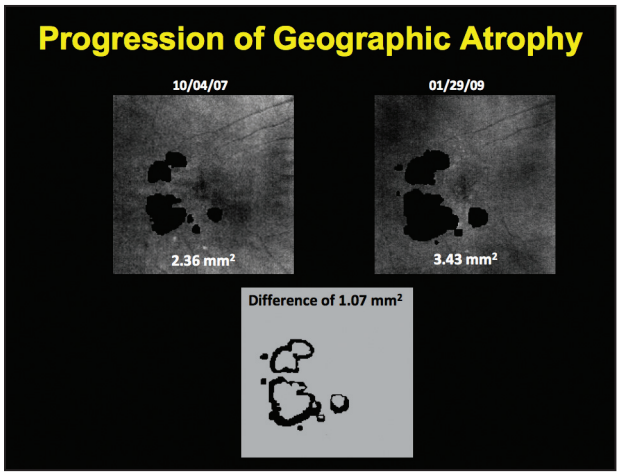


Figure 16. In Figures 14-16, Cirrus HD-OCT can be used to quantify the presence and progression of geographic atrophy

By Peter K. Kaiser, MD

Applying HD-OCT to Diabetic Retinopathy

Recognition of distinct diabetic macular edema patterns may aid in tailoring treatment strategies.

In the past, the diagnosis of diabetic macular edema (DME) was based solely on clinical examination, ie, careful binocular slit lamp biomicroscopy. The definition of clinically significant macular edema (CSME) derived from the Early Treatment Diabetic Retinopathy Study depends only on clinical exam findings, the location of hard exudates and retinal thickening in relation to the fovea. Today, however, we also use fluorescein angiography and SD-OCT to help us manage our patients with DME. In this article, I explain why the latter is an increasingly important part of my practice.

The Macular Change Analysis algorithm utilitzed by the Cirrus HD-OCT instrument allows to us to automatically evaluate changes at the same location in the retina from one patient visit to the next.

Uses and Limitations of Fluorescein Angiography

For me, fluorescein angiography serves two main purposes in the diagnosis and management of DME. I use it to confirm the diagnosis at baseline. I also use it to evaluate the amount of ischemia and to guide laser treatment. (It is not yet possible to evaluate ischemia with OCT, although that may change with future Doppler technologies.)

On the other hand, angiography has limitations when it comes to DME. First, the degree of leakage on FA does not correlate with visual acuity or clinical outcomes. Furthermore, it does not provide information about vitreoretinal abnormalities.

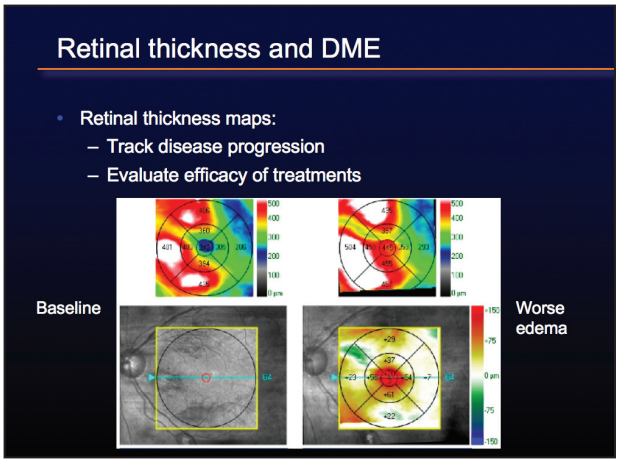


Figure 1. The Macular Change Analysis capability of the Cirrus HD-OCT is an efficient and effective way to track progression of diabetic macular edema and evaluate treatment efficacy.

Macular Thickness Mapping and Change Analysis

In contrast to FA, the macular thickness maps generated by OCT correlate very well with other key features of DME. Increased thickening on the maps corresponds to clinical leakage, fluorescein leakage and decreased vision.[1-3] As retinal thickness increases, visual acuity worsens.

The Macular Change Analysis algorithm utilized by the Cirrus HD-OCT instrument, which allows us to automatically evaluate changes at the same location in the retina from one patient visit to the next, is also advantageous in DME (**Figure 1**). It provides an efficient and effective way to track disease progression and evaluate treatment efficacy, just as it does when we are following patients with age-related macular degeneration. I like to show my patients the Macular Change Analysis difference maps, as well, to illustrate for them how they are doing.

Identifying DME Patterns for Better Treatment Choices

As useful as thickness maps and change analysis are in following patients with DME, they do not reveal structural details or information about vitreomacular interactions. In this regard, the Cirrus line scan tomograms, B-scans and 3-D views are particularly beneficial. The B-scans demonstrate several distinct patterns that can be associated with DME. It is important to recognize the various patterns

Figure 2. In the sponge-like DME pattern, fluid absorption makes the inner retinal layers appear compressed.

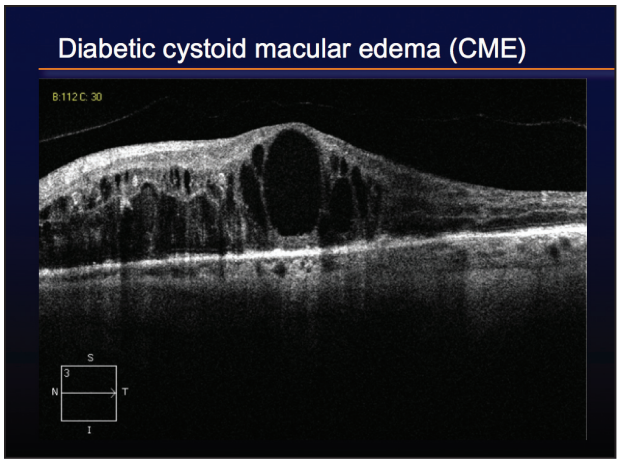


Figure 3. The diabetic cystoid macular edema pattern, shown on SD-OCT, is associated with worse visual acuity than the sponge-like pattern.

because they impact prognoses and may require different treatment strategies.

In the most common pattern of DME, termed the sponge-like pattern (**Figure 2**), we start to see an increase in retinal thickness. Usually, there are no cysts in the outer retina. Fluid absorption causes the inner layers of the retina to look compressed. This pattern may be minimal in terms of macular edema; therefore, it may not be visible clinically. In the future, we will need to decide whether to treat patients with sponge-like DME before they meet ETDRS criteria. We certainly see it first on SD-OCT.

The increased thickening involved with sponge-like DME correlates very well with visual acuity. The thicker the retina, the worse the visual acuity. Eyes exhibiting this pattern respond extremely well to laser treatment.

Diabetic cystoid macular edema (**Figure 3**) is seen in about half of patients with DME. These patients' eyes have more leakage, leading to the development of cysts. Over time, the cysts begin to coalesce. As they coalesce, the foveal depression diminishes, creating a volcano-like appearance. This pattern is associated with worse visual acuity than the sponge-like pattern. In fact, when multifocal electroretinograms are performed in the setting of diabetic CME, the response is reduced more than the sponge-like pattern.

In my experience, eyes with diabetic CME respond better to treatment with anti-vascular endothelial growth factor drugs and steroids than they do to laser.

Serous Retinal Detachment With No Posterior Hyaloid Traction

Another pattern we see in association with DME is serous retinal detachment with no posterior hyaloid traction (**Figure 4**). In these cases, the greatest subretinal fluid accumulation is usually in the fovea. In general, the fluid is not evident on ophthalmoscopy. The hallmark of this pattern is that any fluid evident on SD-OCT is due to only fluid, not traction. Fluid resorption often leads to deposition of hard exudates within the subretinal space. This pattern generally does not respond to laser treatment.

The Cirrus HD-OCT is very helpful for detecting epiretinal phenomena. If they are not visible,

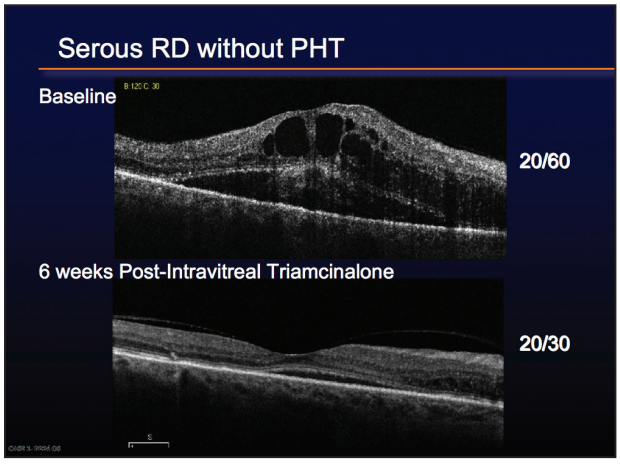


Figure 4. After a steroid was used to treat this serous retinal detachment with no posterior hyaloid traction in an eye with DME, the amount of fluid and the retinal thickness decreased. Visual acuity also improved.

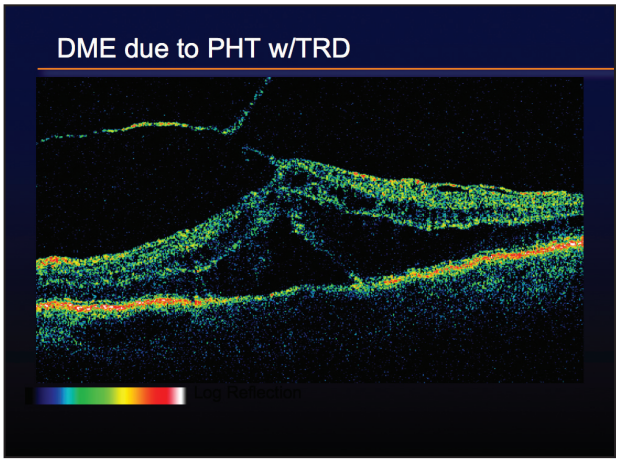


Figure 5. In cases where SD-OCT shows DME caused by posterior hyaloid traction, peeling of the traction may be the most effective strategy for improving macular edema and visual acuity.

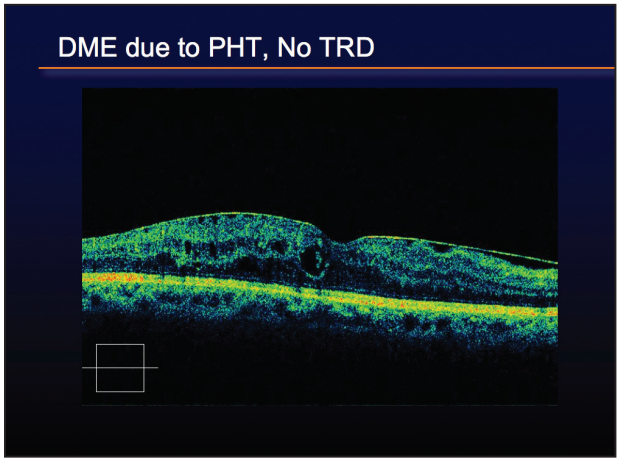


Figure 6. The appropriate treatment for DME resulting from tangential traction, rather than anterior-posterior hyaloid traction, has yet to be determined.

they are not there. That is different than with the Stratus OCT, where not seeing them did not necessarily mean they were not present.

Diabetic Macular Edema Due to Posterior Hyaloid Traction

We used to think DME due to posterior hyaloid traction occurred in approximately 16% of patients. We have since learned there are really two subgroups of posterior hyaloid traction patients. One group, first described by Hilel Lewis, is distinct in that these patients have a grayish sheen to the retina on clinical exam. They have traction that is causing their edema leading to a tent-like appearance on SD-OCT. The retina is actually being pulled up into a traction detachment. The 3-D capabilities of HD-OCT provide excellent visualization of this pattern (**Figure 5**). At this time, it appears vitrectomy and peeling of the traction may be the most effective strategy for improving macular edema and visual acuity in these cases.

Unfortunately, most cases of DME due to hyaloid traction are not in the anterior-posterior direction. They are due to tangential traction (**Figure 6**). The best way to treat these patients has yet to be determined. Should we perform surgery for tangential traction? Should we be using anti-VEGF injections? At this time, we do not know. The Diabetic Retinopathy Clinical Research Network is conducting a study to determine if removing the tangential traction would be beneficial.

SD-OCT's Role in Proliferative Disease

SD-OCT also can be useful for diagnosis and management of patients with proliferative diabetic eye disease. For example, it is helpful for evaluating vitreous traction. In addition, it can help to determine if traction is affecting the macula in cases where it is not obvious. SD-OCT clearly provides higher-quality images in these situations than Stratus OCT.

Multiple Uses in Diabetic Care

SD-OCT has become an important tool for me as I provide care for patients with diabetic eye disease, DME in particular. I use it to evaluate morphologic patterns to make more precise treatment decisions, help educate patients about the status of their conditions and monitor response to treatment.

Dr. Kaiser is professor of ophthalmology at the Cleveland Clinic Lerner College of Medicine and founding director of the Cole Eye Institute's Digital OCT Reading Center (DOCTR).

REFERENCES

1. Strom C, Sander B, Larsen N, Larsen M, Lund-Andersen H. Diabetic macular edema assessed with optical coherence tomography and stereo fundus photography. *Invest Ophthalmol Vis Sci* 2002;43:241-245.
2. Hee MR, Puliafito CA, Duker JS, et al. Topography of diabetic macular edema with optical coherence tomography. *Ophthalmology* 1998;105:360-370.
3. Browning DJ. Potential pitfalls from variable optical coherence tomograph displays in managing diabetic macular edema. *Am J Ophthalmol* 2003;136:555-557.

continued from page 11

normal RPE" from the "real RPE" segmentation map that contains the drusen. This gives us the ability to measure the area and volume of drusen.

In addition, if we think of serous PEDs simply as RPE deformation that are similar to drusen, then we can see why the same algorithm that quantitates drusen in dry AMD will also provide reliable and reproducible measurements of PEDs in wet AMD (**Figures 17-18**).

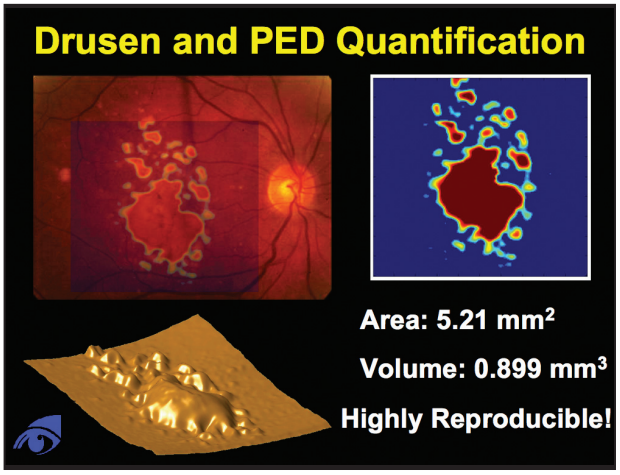
Moving Forward to Meet the Future

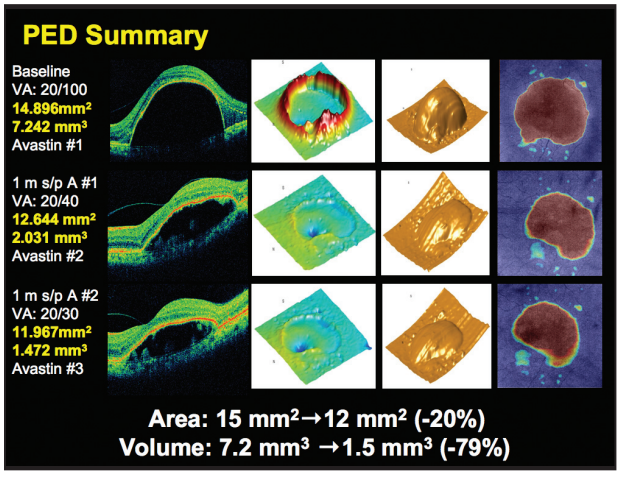
The Cirrus HD-OCT software advances discussed in this article enhance our ability to manage patients with wet AMD. At the same time, they revolutionize how we can manage our patients with dry AMD. When a successful therapy for dry AMD becomes available, we will have an ideal combination of imaging and therapy.

Dr. Rosenfeld is a Professor of Ophthalmology at the University of Miami Miller School of Medicine's Bascom Palmer Eye Institute.

REFERENCE

1. Lujan BJ, Rosenfeld PJ, Gregori G, et al. Spectral domain optical coherence tomographic imaging of geographic atrophy. *Ophthalmic Surg Lasers Imaging* 2009;40:96-101.





Figures 17-18. A soon-to-be-released algorithm for the Cirrus HD-OCT will allow automatic area and volume measurements of drusen and pigment epithelial detachments. In this case, even though the area of the PED does not appear to be changing significantly, treatment has decreased the volume of the PED by nearly 80%.

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