CIRRUS HD-OCT: Practical Application and Interpretation for Glaucoma And Retinal Disease

Current and future capabilities of Cirrus HD-OCT and their impact on retina and glaucoma patient care.

Highlights from a panel discussion held at the annual meeting of the American Academy of Ophthalmology in November 2008 in Atlanta.

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ZEISS
Using Cirrus HD-OCT for the Management of Age-related Macular Degeneration

Learn about current applications and future capabilities.

In 2001, the images obtained using the Stratus OCT 3 (Carl Zeiss Meditec, Dublin, Calif.) revolutionized the way physicians managed patients with macular diseases. Using the OCT 3 with breakthrough 3,072 A-scans within six diagonal B-scans centered on the fovea, we’ve been able to image most macular pathologies. However, this type of scanning pattern limited our ability to easily sample pathology outside the central 1 mm, therefore requiring multiple scans positioned outside the central macula. Moreover, the algorithm that measured retinal thickness was unreliable and prone to artifacts. Despite these limitations at the time, the technology was sufficient for most of our needs. Since then, our needs have changed, and our expectations have increased due to new spectral domain optical coherence tomography (SD-OCT) technology.

Now we have Cirrus HD-OCT (Carl Zeiss Meditec) with scanning patterns totaling 27,000 A-scans per second. The question heard most often involves the clinical use of the different scanning patterns: “What’s the purpose of the scanning patterns, and when should we use them?”

I think of this the way I think of currency. As your salary increases, you find good use for the additional income. We’ve gotten an enormous raise in A-scans. Now I’m using them in ways I never imagined, and I wonder how I ever survived with just 3,072 A-scans. Here’s some insight into the Cirrus HD-OCT scanning patterns and when and why you’ll use them.

Cirrus HD-OCT Scan Patterns

Cirrus HD-OCT uses three major scanning patterns, each of which has different benefits and practical applications. There’s the 200 A-scan x 200 B-scan macular cube with lower horizontal B-scan image quality used for volumetric and area analysis; the 512 A-scan x 128 B-scan macular cube that delivers an excellent, higher image quality B-scan representation of the macula; and the 5-line raster scan that delivers the highest B-scan image quality for a detailed analysis of the macula.

- **Macular cube 200 x 200 combo**: I use this cube scan on every patient to obtain proportionately accurate areas and volumes involving the macula. I like the 200 x 200 macular cube scanning strategy because both the A-scans and the B-scans are separated by 30 microns. As a result, I get a uniform sampling within a 6-mm x 6-mm area of the macula. If you want proportional volume and area measurements, and a retinal thickness map that’s...
identification, segmentation and quantitation. The latter feature hinges on our ability to achieve the first two. That is, the OCT retinal thickness algorithms identify the boundaries of the internal limiting membrane (ILM) and the retinal pigment epithelium (RPE). The distance between these two boundaries determines the retinal thickness, and the more accurate the boundary identification, the more accurate the thickness quantitation.

Cirrus HD-OCT retinal segmentation algorithms are highly accurate and reproducible when compared with hand-drawn ILM-RPE boundaries, which are the gold standard. Depending on the scan pattern you use to evaluate wet macular degeneration, the algorithms are 97.1% to 98.6% accurate for the ILM and 85.7% to 86.1% accurate for the RPE. The quantitation is far more reliable than the quantitation we had with the OCT 3.

Segmentation techniques make it possible for the data set to be displayed in layers, such as the ILM and RPE. These layers can be displayed individually and reconstructed into two- and three-dimensional images and thickness maps.

Cirrus HD-OCT Fundus Images

Another unique feature of Cirrus HD-OCT is the OCT fundus image. Think of it this way: A-scans make up a B-scan, B-scans make up the HD-OCT cube, and the fundus image is a projection of all of the summed reflectivity on one surface of the compiled B-scans. It’s a virtual fundus image depicted on the top surface of the cube of information.

Cirrus HD-OCT provides capabilities that no other instrument offers, including the most reliable boundary identification, segmentation and quantitation. The latter feature hinges on our ability to achieve the first two. That is, the OCT retinal thickness algorithms identify the boundaries of the internal limiting membrane (ILM) and the retinal pigment epithelium (RPE). The distance between these two boundaries determines the retinal thickness, and the more accurate the boundary identification, the more accurate the thickness quantitation.

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layer and subtracts it from the patient's real RPE, creating a difference map of the drusen. This correlates to the fundus image and will provide us with the ability to measure drusen areas and volumes. This feature is in development so it's not commercially available.

Keep in mind that drusen area and drusen volume aren't equivalent. The area of the drusen may be virtually the same between individuals with dry AMD, but the volume may be quite different. For future clinical trials, I'd propose placing more of an emphasis on drusen volume than drusen area.

In the past, I believed that drusen grew larger in area, then evolved into geographic atrophy, causing patients to lose vision, but we've learned that drusen volumes are quite dynamic while drusen areas may change little. Because the drusen maps are highly reproducible, you can use them to monitor drusen changes over time. For example, we measured drusen in one patient during three visits over 6 months using Cirrus HD-OCT. The volume in the patient's right eye changed at 3 months and disappeared at 6 months. In contrast, only subtle changes were evident in the patient's left eye.

Identifying Drusen

Using the Cirrus HD-OCT algorithm for boundary identification feature, you can accurately identify the ILM and the RPE, which enables you to locate the drusen. In fact, not only can you identify drusen, but you also can get point-to-point correlation in the two- and three-dimensional maps between the drusen on fundus photos and the drusen on HD-OCT maps. The maps also show how the retina has thinned over the drusen, as seen in a crater-pocked representation of the retinal thickness map (Figure 3).

In addition, Giovanni Gregori, PhD, developed an algorithm that takes an interpolation of the normal RPE layer and subtracts it from the patient's real RPE, creating a difference map of the drusen. This correlates to the fundus image and will provide us with the ability to measure drusen areas and volumes. This feature is in development so it's not commercially available.KEEP IN MIND THAT DRUSEN AREA AND DRUSEN VOLUME aren't equivalent. The area of the drusen may be virtually the same between individuals with dry AMD, but the volume may be quite different. For future clinical trials, I'd propose placing more of an emphasis on drusen volume than drusen area.

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Measuring PED

Using the same modality of analysis we used for drusen, we can use Cirrus HD-OCT to measure pigment epithelial detachments (PED), which is particularly useful after anti-VEGF therapy.

When we observe a PED image, we can superimpose the HD-OCT fundus image on a fundus photo, obtain registration of the OCT B-scan and visualize the PED on the B-scan with fluid along its edges and under the retina, as depicted in the three-dimensional map (Figure 4).
After treatment with bevacizumab (Avastin, Genentech), we saw changes in the area of the PED as we would with fluorescein angiography but, more importantly, we can follow changes in the volume of the PED. These B-scans and the volumetric analysis make it easier to follow and treat patients with VEGF inhibitors.

As a practical matter, it’s important to emphasize the power of the Cirrus HD-OCT map. I’ve learned to look at the maps immediately when I receive the printout. For example, if I have a patient with a hemorrhagic PED, I can collect the baseline HD-OCT image, as well as the fluorescein and indocyanine green angiograms. The multislice printout shows the B-scans and the superimposed thickness map, so I can see the PED. As the patient receives bevacizumab treatments, the map will show the fluid resolution and guide future treatment decisions.

Superimposed OCT Fundus Image And 3-D Maps Show PED

Figure 4. The retinal thickness map (upper right) shows fluid on the edges of a pigment epithelial detachment (PED). The ILM and RPE segmentation maps display the PED in 3-D.

Macular Change Analysis

A new Cirrus HD-OCT feature that soon will become available is called macular change analysis, and it’s going to make our lives even easier. Cirrus HD-OCT has excellent boundary identification, segmentation and quantitation. The macular change analysis software takes two HD-OCT fundus images and aligns them. This enables you to take the thickness map from one visit and subtract the thickness map from another visit, which results in a perfectly registered difference map.

The printout shows you the thickness maps from the two visits, along with the difference in thickness. As you 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. Over time, as the patient receives treatment, the difference map will show fluid changes. This is a useful feature, in addition to the high-resolution scans, particularly when using anti-VEGF therapy.

For example, I followed one patient with dry AMD in a clinical study. The Cirrus HD-OCT map showed me areas of geographic atrophy and dryness. Follow-up scans at one and a half months showed some activity. At two and a half months, the patient came in complaining of decreased vision, and the maps showed a little more fluid indicative of some diffuse occult leakage. I treated the patient; she returned, and the maps improved. The macular change analysis showed me the change, and I was able to scroll up and down on the map to precisely locate the fluid. The analysis gave me an accurate picture of the patient’s condition at the beginning and end of treatment.

Power for the Future

In my view, Cirrus HD-OCT gives me one-stop shopping for dry and wet AMD. I still get fundus photographs, and I like autofluorescence, but I can see everything with Cirrus HD-OCT. I use a 200 x 200 macular cube when I want accurate volume and area measurements, which is most of the time. I use the 512 x 128 macular cube when I want a good representation of B-scans through the macula. Plus, I use the 5-line raster for high-definition images.

What I like about Cirrus HD-OCT is the quantitation and all of the different scanning strategies I can perform in a short period of time. The Cirrus lets me perform multiple scans, and it interprets the data in several ways. I’ve found that it quickly becomes indispensable.

My colleagues and I are incorporating all of these scan patterns in clinical trials as we move forward. I believe the device helps us manage our patients more successfully than ever before. OM

Dr. Rosenfeld is professor of ophthalmology at Bascom Palmer Eye Institute, University of Miami Miller School of Medicine.

References
Learn the Advantages of Spectral Domain OCT

Obtain more precise imaging and relevant data for improved diagnoses and treatment decisions in retinal disease.

Spectral domain optical coherence tomography (SD-OCT) is opening up doors for OCT technology that we never thought possible. It’s exciting to learn about its new capabilities. But this new level of OCT technology isn’t just an exciting development. It has many practical applications for today’s physician.

Gleaning More Information

Time domain OCT provides us with a large amount of data, but spectral domain affords us exponentially more data because of its dramatically decreased acquisition times. With the increased data, you can visualize the entire macula and produce crystal clear 3-D images. Moreover, SD-OCT devices deliver additional information we’re just beginning to learn how to use.

If you’re hesitant about switching from time domain OCT to SD-OCT, consider the superior results you’ll get when imaging certain areas of the retina. With time domain OCT, it’s often difficult to identify abnormalities at the vitreomacular interface, such as subtle epiretinal membranes (ERM). Often, a patient will complain of vision problems due to an ERM that time domain OCT can’t identify. However, Cirrus HD-OCT, an SD-OCT device, clearly shows the ERM (Figure 1).

SD-OCT is also superior to time domain when evaluating the photoreceptor layer. While you can sometimes see the inner segment-outer segment junction of the photoreceptor layer with time domain, you can see it consistently with SD-OCT. This is important in postoperative patients and those who have unexplained vision loss. For example, when the vision of one of my patients wasn’t what I’d hoped for 1 month after macular hole surgery, time domain OCT showed no problems. The hole had completely closed, and everything looked beautiful. However, when I used Cirrus HD-OCT, I saw a small area in

**Figure 1.** Cirrus HD-OCT clearly shows an epiretinal membrane that time domain OCT may not identify.

**Figure 2.** Spectral domain OCT consistently allows you to see the inner segment Outer segment junction of the photoreceptor layer.
the fovea where the inner segment-outer segment junction was still abnormal, and there was a small amount of retinal tissue that needed to coalesce (Figure 2).

Therefore, I was able to tell this patient with confidence that his vision likely would continue to improve as this area healed. Without using Cirrus HD-OCT, I wouldn’t have known this, and I would’ve had to tell the patient, “I really don’t think we’re going to get additional visual improvement.”

I’ve also found Cirrus HD-OCT to be very useful after retinal detachment repair. When one of my patients complained of poor vision, I needed to know if it would improve. HD-OCT showed a little puddle of fluid that remained in the fovea. Again, I was able to tell the patient, “The fluid is going to resolve, and you’ll have better vision. We just have to wait.”

3-D Imaging

The single-scan tomogram, however, isn’t always the best way to evaluate retinal pathology. Cirrus HD-OCT scans rapidly, gathering a large amount of information we can analyze in new and useful ways. For example, HD-OCT can perform a cube scan that images the entire macula. Often, we can barely see subtle retinal pathology with time domain OCT, but by scanning with a cube scan, we can view pathology easily since we can see it in three dimensions. For example, we can visualize subtle subretinal or intraretinal fluid when treating age-related macular degeneration (AMD) patients with anti-vascular endothelial growth factor drugs. This ability gives us the power to make better treatment decisions for our patients.

If you’re looking for vitreous traction, the three-dimensional view allows you to see the relationship between the vitreous and macula, and you can rotate and view it from several angles. As a result, you can more accurately plan your surgical approach if the patient needs surgery.

These 3-D views are also very exciting to show patients. They’re the “Gee whiz!” of Cirrus HD-OCT. Single-scan tomograms might give you a 5-line raster through the fovea and a cool view of a macular hole. But if you look at the retina in 3-D and show this to your patients, you can pinpoint the traction descending onto the optic nerve and fovea, and help them understand why treatment options to relieve that traction will work. You also can show the 3-D view to patients to help illustrate macular edema with an ERM. This view is incredibly revealing. Patients get an “Ah-ha!” moment when they see 3-D scans.

Viewing the Layers

The automated segmentation of these scans gives us another opportunity to improve diagnosis and management of retinal disease. For example, we can view the segmented layers of the retina and see how an ERM affects the retinal contours. You can see the crinkling of the internal limiting membrane (ILM). In the future, this might help us decide whether or not a patient needs surgery.
More Accurate Retinal Maps

Because Cirrus HD-OCT provides so much more information than time domain OCT, we can obtain retinal maps that are considerably more accurate. Time domain OCT captures six radial line scans, and then interpolates between the scans to create a retinal thickness map. HD-OCT gives us a 6-mm cube with almost every point within that grid map measured directly — far more than the area mapped with time domain OCT.

This is very important for a reading center. With time domain OCT, you can miss small lesions that fall between the radial lines, and if there’s an error in the segmentation analysis, the software will propagate it into a large area of the resulting retinal thickness map.

In addition, time domain software assumes that all six of the radial lines intersect at one point. In real-

Evaluating Macular Change

Cirrus HD-OCT soon will have a feature called macular change analysis, which calculates changes by comparing images over time. This technology helped me manage a patient with macular edema secondary to branch retinal vein occlusion (BRVO) (Figure 1).

I gave the patient an off-label intravitreal injection of bevacizumab (Avastin, Genentech), after which she returned with essentially unchanged visual acuity. At first glance, the cube scan of Cirrus HD-OCT didn’t look all that different, so I wondered if I should perform another injection.

The retinal thickness analysis looked about the same — just a slight change in volume that didn’t convince me there was significant improvement. Next, I used the macular change analysis function on the patient’s scans. This analysis showed me there had been a dramatic decrease in thickness we didn’t appreciate without the change analysis feature. The system registered the images, did a comparison and displayed the change analysis. We decided to treat again based on this analysis.

Another patient had choroidal neovascularization due to age-related macular degeneration. I treated the patient with ranibizumab (Lucentis, Genentech), but there was no change in vision. Looking at the B-scans, I’d argue that the OCT images didn’t change. So, was the treatment effective for this patient?

The retinal thickness analysis looked like the drug therapy worked, but when I performed the macular change analysis, the evidence was even more dramatic. It was easy to see the therapy had been successful.

The advanced visualization tool is exciting because we’ve used the term “optical biopsy” for years with time domain OCT — but now Cirrus HD-OCT technology makes it possible (Figure 3).

In the Cirrus HD-OCT display, I can show the ILM map, view it from the top and see any distortion on the retinal surface. Then I can guide the view farther down into the retina and look at the choroidal vessels. I can see the choroidal vessels on en-face — a view that just isn’t available with any other technology to date.

One thing I appreciate about Cirrus HD-OCT is the ability to print all of these images in a way that’s both helpful for making diagnoses and meaningful to patients. A standard printout includes everything you’d want to show your patient. New Review software allows us to remotely show these images and videos in our clinic as well.

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In addition, time domain software assumes that all six of the radial lines intersect at one point. In real-
ity, there’s eye movement between each of the scans, so they don’t intersect at one point. This is a big issue since eye movement can cause the software to artificially under- or overestimate retinal thickness. SD-OCT devices image a larger area of the retina and are much faster, so eye movement becomes less of an issue and we get a more accurate retinal map. This hopefully will translate into more accurate outcomes in clinical trials and when we follow up with patients to determine treatment response.

What’s more, the segmentation algorithms of Cirrus HD-OCT have improved its ability to identify the retinal boundaries in patients with AMD and choroidal neovascularization. Retinal thickness measurements in patients with AMD can be inaccurate with time domain OCT. In contrast, HD-OCT mapping is extremely precise. Moreover, if the lines don’t accurately reflect the location of the inner and outer retina, we can move the lines to correct the issue. This isn’t possible with time domain devices.

Finally, Cirrus HD-OCT offers dramatically improved registration between visits. We can register a patient’s retinal maps to ensure we’re imaging the same place every time we perform our scans. We can compare certain locations on the retina over time. Therefore, we’ll know if the patient’s vision has changed as a result of disease progression or clinical treatment. Registration accuracy at this level simply isn’t possible with time domain OCT.

**Dramatic Shift**

Cirrus HD-OCT has dramatically changed the way I practice, and I think it will change the way we conduct clinical trials. The accuracy of the boundary detection has improved significantly, giving us more precise and more relevant measurements for both clinical practice and clinical trials. Scanning speed has become so amazingly fast that we can attain highly detailed cubes of data for 3-D analysis, and we can examine a large area of the macula. Hopefully, this will improve our diagnosis and treatment decisions in the future. **OM**

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Dr. Kaiser is director of the Digital OCT Reading Center of Cole Eye Institute at the Cleveland Clinic Foundation. He’s study chairman of the DENALI trial, and principal investigator in multiple national, multicenter clinical trials.
Understanding the Utility of Spectral Domain OCT in Glaucoma

Here’s how top physicians use Cirrus HD-OCT to diagnose and treat patients.

Spectral domain optical coherence tomography (SD-OCT) has proven to be a very useful tool for the detection and management of glaucoma. Its 3-D imaging enhances reproducibility and registration and offers the objective quantitative data that supports global standardization of care at an expert level. SD-OCT helps physicians establish and pinpoint correlations in ocular structure and function, matching areas of abnormal tissue with attendant vision problems. The technology also may enhance sensitivity and specificity in disease detection and reduce uncertainty in glaucoma suspects. Software is under development to help detect disease progression.

SD-OCT is part of the standard approach of many physicians to managing glaucoma.

Reproducibility Study

Kim and colleagues studied the reproducibility of time domain OCT and Cirrus HD-OCT. It’s been well documented that HD-OCT produces high-definition digital photos. Physicians can see cross-sectional images and 3-D cubes and can detect fluid or topographic distortion, making it easy to see the presence of pathology. High precision digital imaging has become an excellent advantage of OCT that ophthalmologists have relied on for years.

However, one of the great features of OCT is its objective quantitative data, which is what will drive this technology in the global standardization of care, according to Joel S. Schuman, MD, FACS, professor and chairman of ophthalmology at the Eye and Ear Foundation, University of Pittsburgh School of Medicine, and director of the University of Pittsburgh Medical Center (UPMC) Eye Center. Physicians can expect the same good quantitative, reproducible data in Omaha, Beijing and Madrid.

To ensure that reproducibility is excellent, Kim and colleagues studied the reproducibility of time domain OCT versus Cirrus HD-OCT.

Hypotheses. Researchers approached the study with two hypotheses: First, they believed Cirrus HD-OCT would have better reproducibility than time domain OCT. Second, they knew that when they took retinal nerve fiber layer (RNFL) measurements, they should measure a 3.4-mm scanning circle, centered on the optic nerve head. They believed the placement of that circle would influence the value and, therefore, the reproducibility. In other words, the way they placed the circle would be relevant. And there are two ways to place the circle. Physicians can center a new circle every time they have a data cube or do what some of the confocal scanning laser ophthalmoscopes do and register the images. Then they can import the circle they placed the first time.

Methods. The researchers enrolled 14 healthy subjects and studied 27 eyes. Using time domain OCT (Stratus OCT software version 5.0) and HD-OCT (Cirrus HD-OCT software version 3.0), they performed three repeated scans per eye on the same day. With time domain OCT, they performed a fast RNFL scan with a signal strength ≥ 6. They performed an optic disc cube scan with Cirrus HD-OCT at a signal strength ≥ 8.

Results. The study validated the researchers’ first hypothesis. With statistical significance, Cirrus HD-OCT showed better RNFL thickness measurement reproducibility than time domain OCT.

They invalidated the second hypothesis. Resampling circle location variation on Cirrus HD-OCT was relatively small from scan to scan, and there was no statistically significant difference between the “center each time” and “center once” methods. No matter which
method the researchers used, the device found the center of the optic nerve, recognized a 3.4-mm circle centered on that point and measured the RNFL thickness along the circle. The data showed the reproducibility was very high for both time domain and HD-OCT. When they looked at the interclass correlation coefficient, the standard deviation for the overall thickness was about 2.5 microns with time domain and about 1 micron for HD-OCT.

Glaucoma-specific Benefits of SD-OCT
In addition to its high reproducibility, SD-OCT technology can have a high utility for glaucoma suspects by helping physicians achieve these key goals:

- Identify areas of abnormality
- Reduce uncertainty in patients they’d normally classify as glaucoma suspects
- Get all the benefits of 3-D imaging. This means achieving more reproducible measurements, exact correspondence with the fundus image and the promise of greater sensitivity to abnormality and change over time.
- Use statistical software for the measurement of progression. This software is still in development, although it should be available soon.
- Correlate structure and function to diagnose glaucoma and track its progression. Physicians need detailed information about the structure-function relationship between SD-OCT, RNFL thickness and function shown through perimetry testing. Using SD-OCT technology, ophthalmologists can see a strong relationship between structure and function, and that’s very important for gauging the status of a glaucoma patient, Dr. Schuman says.

Clinically, some physicians frequently use SD-OCT to achieve these goals. The following cases are examples of how they use the technology.

Case 1: The Normal Patient
In a normal patient, physicians clearly can identify the differences between time domain and SD-OCT (Figure 1), Dr. Schuman says. Both devices provide tomograms and RNFL profiles. In this patient, you can see that the same nasal spot at one clock hour is borderline thin.

When you look at Cirrus HD-OCT, an SD-OCT device, you can see a normal-looking RNFL thickness distribution, despite a few areas nasally outside the normal range.

Figure 1. Time domain OCT and spectral domain OCT both provide tomograms and RNFL profiles. Here, the additional information provided by the 6-mm x 6-mm cube of data from Cirrus HD-OCT (upper right) shows a normal-looking RNFL distribution, despite a few areas nasally outside the normal range.
Case 2: Structure and Function

Structure and Function
- Good structural and functional correlation in normal and glaucomatous eyes evaluated with OCT
- Significant difference in RNFL thickness between healthy and glaucomatous eyes
- Differences between the patient and the healthy population are highlighted on clinical OCT assessment as deviation from the normative database.

Figure 2. Visual field and pattern deviation analysis show this patient has an inferior arcuate scotoma in each eye and a slightly deeper nasal step in the right eye. This correlates well with Cirrus RNFL analysis.

a series of scans and calculations of mean thickness to help detect changes in RNFL thickness over time.

Case 2: Structure and Function

SD-OCT demonstrates good structural and functional correlation in both normal and glaucomatous eyes, Dr. Schuman says. Often, physicians find a significant difference in RNFL thickness between healthy and glaucomatous eyes — a difference established by the software’s comparison of patient data against a normative database.

An OCT assessment of a patient’s RNFL thickness is particularly helpful in glaucoma suspects, Dr. Schuman says. If patients have a suspicious-looking optic nerve head, a family history of glaucoma, normal visual fields, and an IOP in the normal or borderline range, OCT RNFL measurements can offer an independent predictor of the glaucomatous change.1

For the most accurate results, ophthalmologists look at not only mean deviation on the visual field, but also a newer parameter called the visual field index that better compensates for nonglaucomatous visual field loss, Dr. Schuman says.

When a physician examined the visual field and pattern deviation of the patient in this example, he found an inferior arcuate scotoma in each eye and a slightly deeper nasal step in the right eye (Figure 2). Instead of doing a circular scan centered on the nerve, he acquired a 200 x 200 data cube. The software extracts the circular scan, or circumpapillary information, from that data cube, giving physicians high reproducibility and good registration from scan to scan, Dr. Schuman says.

The Cirrus HD-OCT printout also enables ophthalmologists to see an RNFL thickness map, a deviation plot, the RNFL thickness profile and have the profile overlaid on normative data.

Printouts include the mean thickness in quadrants and clock hours. Physicians clearly can see that the RNFL is thinner on the top half than on the bottom half, Dr. Schuman says. The numbers showed an RNFL thickness that was statistically significantly reduced compared to a healthy eye of a person in the patient’s age group, and the RNFL thickness profile illustrated where the thickness dropped down into the abnormal range.

Case 3: Following Glaucoma Suspects

Physicians are always looking for signs in patients who are glaucoma suspects, Dr. Schuman says. Does the patient need treatment, or can a doctor follow him without treatment?

A 40-year-old African American man presented with an IOP of 23 mmHg, a central corneal thickness of 555 microns and a normal visual field (Figure 3). A physician determined he had a large cup because he had a large disc. OCT put his RNFL thickness well within the normal range, so the physician decided to monitor him.

Ophthalmologists can follow RNFL thickness for
change over time to track glaucoma progression, but validated, robust software for this purpose is still in development. When it’s introduced, physicians may have the ability to detect progression more accurately using the SD-OCT RNFL thickness measurement rather than using the visual field and perimetry, Dr. Schuman says. OCT detection of a thin RNFL is an independent predictor of future glaucomatous change.2

Case 4: Patient with Glaucoma

Of course, the most important goals for glaucoma patients are obtaining a specific diagnosis to guide treatment, following the effects of treatment and detecting any disease progression, Dr. Schuman says. In this case, the patient has an RNFL defect inferotemporally in the left eye (Figure 4).

Macular segmentation with Cirrus HD-OCT shows even more information about the area of damage. Using this function, physicians can see the patient’s focal defect extending into the macula, layer by layer, Dr. Schuman says.

What’s more, although Cirrus HD-OCT was able to detect an abnormality in this patient, it wasn’t perceptible with time domain OCT. The RNFL doesn’t fall outside the normal range until it gets beyond the area of that 3.4 mm diameter circle.

Advantages of OCT

OCT helps physicians establish the presence or absence of glaucoma. They can use OCT in the correlation of structure and function, identify abnormalities and achieve truly sensitive screening for the disease. Today, ophthalmologists are realizing the power of HD-OCT. They’re developing strategies to use the vast amounts of data it collects to improve patient care. And they’re constantly extending the possibilities as new software emerges. OM

References

Catching the First Signs

Spectral domain OCT delivers precision RNFL analysis.

A variety of imaging devices for glaucoma have debuted in the last 15 years. Optic disc topographical analysis, for example, provided by the Heidelberg Retinal Tomograph (HRT, Heidelberg Engineering Inc.), has longevity, low variability, good repeatability and mature progression software, although it has limited screening value. Optical coherence Tomography (OCT), GDx and possibly HRT offer retinal nerve fiber layer (RNFL) imaging, representing a more useful screening strategy. However, earlier generation OCT devices give us a number of false positives and some variability, plus early progression software remains immature.

Glaucoma specialists look at these options in the context of their most pressing goal: to preserve vision by detecting and treating the earliest signs of the disease.

There’s some debate about whether these signs occur first in the RNFL or in the optic disc, particularly in preperimetric glaucoma. One key study showed that the RNFL might be a better place to look for early glaucomatous structural changes. Researchers showed the GDxVCC had a 0.83 correlation with preperimetric glaucoma, with documented optic disc progression on clinical exam, compared to a 0.70 correlation for the HRT II.

Clearly, because RNFL changes likely may be the first signs of glaucoma, there’s a clinical advantage to getting the best RNFL imagery possible. Today, you can obtain these images with spectral domain optical coherence tomography (SD-OCT).

**Advantages of SD-OCT**

What are the advantages of SD-OCT for glaucoma?

- Improved resolution and precision, compared to time domain OCT
- A large area of not only axial resolution, but also excellent transverse resolution, allowing you to obtain optic disc, RNFL and macular assessments
- Better repeatability than time domain OCT, which means lower variability
- Vastly improved serial overlay to scan repeatedly and ensure we’re measuring the same points over time
- Improved ease of use and speed.

With Cirrus HD-OCT, an SD-OCT device, the automated registration and ease of use go hand in hand. In the classic scan, which is similar to macular scanning, the device gives us a 6-mm cube, 200 A-scans x 200 B-scans. But unlike other instruments, technicians don’t have to place the circle exactly where they want it to be around the disc, creating another source of error.

Technicians use the exquisite fundus image of the line scanning ophthalmoscope to visualize the optic nerve head during scan acquisition. Then Cirrus HD-OCT automatically identifies the center of the disc and performs an RNFL analysis with a 3.4-mm diameter. Then, the software compares the TSNIT graph to a normative database of about 300 patients.

Cirrus HD-OCT also gives us a beautiful display and printout of the RNFL thickness analysis so we can make efficient use of the data. The printout displays peripapillary RNFL thickness and a comparison with the normative data in graphic format. Also, the RNFL thickness map for the full 6-mm x 6-mm area shows the patterns and thickness of the RNFL, and it aids in the detection of pattern defects while the RNFL deviation map is overlaid on the OCT fundus image to illustrate precisely where RNFL thickness deviates from a normal range.

**Case Study: Closer Look at the RNFL**

A 54-year-old African American man presented with IOPs of 23 mmHg and 22 mmHg and central corneal...
and perhaps some inferotemporal changes that were beyond the disc margin and the peripapillary RNFL.

Assessing Progression
The ability to assess progression has been lacking in devices that provide RNFL analysis. And this is why we’re excited about Cirrus HD-OCT because it has an excellent ability to register serial images. Because progression can occur in several ways, this software, which is under development, analyzes:

- RNFL thickness map progression, which detects focal defects
- The RNFL thickness profile, which pinpoints more shallow or broad defects
- Average RNFL thickness progression, which identifies more diffuse changes.

The software also provides an overall assessment of possible RNFL loss in terms of these three calculations.

This software will be the next natural and essential step in HD-OCT technology. We’ve improved resolution and axial measurements. One scan can quickly capture the disc and the peripapillary RNFL and reduce the subjectivity of placing the circle around the disc. The singular report is enhanced, giving you not only an RNFL profile around the peripapillary region, but also around the entire optic nerve. And, most importantly, the registration reproducibility gives you the power to move forward in looking at RNFL progression analysis. The addition of progression analysis software will help pull all of these capabilities together. OM

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Case Study: Disc Asymmetry and RNFL Thickness Deviation

Figure 2. This patient has some asymmetry, as well as inferior thinning and superior thinning in the right eye. There also appears to be some superior loss and possible early inferotemporal RNFL bundle thinning in the left eye. Mapping and data charts spell out the patient’s RNFL thickness deviation and its comparison to normative data.

thicknesses of 540 microns and 545 microns. His right eye showed some early nasal changes in the visual field, and the left eye was essentially normal.

When you look at his optic discs, you can see some asymmetry between the right eye and left eye. The right eye showed some inferior thinning and possibly some superior thinning (Figure 2).

The RNFL thickness analysis of Cirrus HD-OCT offered additional data:

- In glaucoma, we expect to see strong thickness superiorly and inferiorly, and this patient’s map clearly shows RNFL loss in the right eye superiorly more than inferiorly, with perhaps some superior loss in the left eye.
- The global, quadrant and sector analyses are like looking at a mean deviation on a visual field. The average thickness is indicative of the overall health of the peripapillary RNFL, while the quadrant and clock hour analyses reveal more specific areas and symmetry data. In this case, we saw significant changes superiorly and inferiorly in the right eye. In the left eye, there were some changes superiorly. A subtle inferotemporal area that’s beyond the circle around the optic nerve may have had some early changes.
- The TSNIT plot is similar to what we’ve seen with GDx and time domain OCT. We saw a depressed superior pole with some inferior thinning in the right eye, and the left eye showed some subtle superior loss with perhaps some inferotemporal changes.
- The deviation map showed these changes more clearly. Overall, the results for this patient’s right eye were consistent, although the results for the left eye possibly were deceiving. The left eye had some superior changes,

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Reference