Optical coherence tomography (OCT) has become an important tool for the clinical evaluation of the optic nerve and retina. Although OCT dates to the early 1990s, the introduction of the Stratus OCT (Carl Zeiss Meditec) in 2001—the original time-domain technology—marks when OCT became widely accessible. The Stratus OCT measured retinal nerve fiber layer (RNFL) thickness via a 3.5-mm-diameter circle centered on the optic disc and used radial scans to provide measurements of the optic nerve head (ONH) such as disc, cup, and rim area. Spectral-domain OCT, first introduced in the United States in 2006 by Optovue with the RTVue OCT, offered improvements over time-domain OCT. The spectral-domain Cirrus OCT (Carl Zeiss Meditec), released in 2007, initially only measured RNFL thickness. Software modifications released soon thereafter made evaluating the ONH possible by creating a cube of data that could be used for different measurements. Heidelberg Engineering recently released the Glaucoma Module Premium Edition (GMPE) in Europe for Spectralis (available since 2008) that allows for the evaluation of ONH parameters. (GMPE is not yet approved for use in the United States.) The Spectralis has measured the RNFL since its introduction.

Alternatively, as OCT devices have evolved, a few innovations stand out. The devices’ resolution has improved, resulting in better segmentation of the retinal layers and better test-retest repeatability. These advances allow the identification and segmentation of individual layers, such as the ganglion cell layer in the macula region, and the recognition of anatomical landmarks such as Bruch membrane opening (BMO), through which the optic nerve passes. The identification of the BMO provides a more consistent measurement of the optic disc’s size and rim area.

ONH PARAMETERS AS A DIAGNOSTIC TOOL

Initially, there were concerns about using ONH parameters to detect early glaucomatous damage, because early changes in the disease process can be subtle and wide overlap exists in the ONH measurements of healthy and glaucomatous eyes. Yet, OCT scans have been shown to differentiate between healthy and glaucomatous eyes using RNFL measurements and, more recently, with ONH parameters. One important change that improved the use of ONH parameters as a diagnostic tool, instituted with both the Cirrus and Spectralis OCT devices, is the use of the BMO to define the border of the optic disc margin, which then serves as a reference structure for other measurements (Figures 1 and 2). The BMO is clinically invisible but can be identified accurately and repeatedly with OCT as compared to the clinician’s observation of where the disc margins lie.

The internal limiting membrane is the anterior boundary for neuroretinal tissue and a structure that OCT is also capable of consistently identifying. Rather than horizontal rim width, which may overestimate the extent of rim tissue, the rim tissue orientation at the point of measurement is taken into account. The orientation of rim tissue varies at different locations around the ONH. The minimum distance from the BMO to the internal limiting membrane is used to define the amount of rim tissue around the circumference of the nerve. Thus, the BMO minimal rim width (MRW) is a geometrically and anatomically accurate depiction of neuroretinal rim width at each point on the nerve.

For both the Cirrus and Spectralis OCT devices, MRW is used and compared to a reference set of healthy individuals (Figures 1 and 2). The Spectralis uses 24 radial scans, giving 48 equidistant data points. The Spectralis will further align the sector orientation based upon the
fovea-to-BMO center angle. For the Cirrus OCT, the MRW is estimated over a continuum as data points are pulled from the data cube. The Cirrus OCT fits a plane to the BMO surface and uses that plane to characterize and correct for how the optic nerve is tilted relative to the retinal surface. Also, the Cirrus corrects for disc size when comparing ONH measurements to normative limits.

Both devices present their results using a temporal-superior-nasal-inferior-temporal scale, which is color-coded based upon normative limits (green, yellow, red; Figures 1 and 2). For the Spectralis OCT’s sector map, the results are provided in a Garway-Heath layout, with the superior and inferior region sectors 40° in size, temporal 90°, and nasal 110°. The raw scores are displayed alongside a number indicating where the measurement falls in the normative data distribution. The Cirrus OCT also allows the clinician to learn where a measurement falls within the normative distribution but requires the clinician to click on a triangle in the parameters section of the screen to retrieve this information (Figure 3).

With the introduction of the GMPE software for Spectralis, RNFL analysis is provided using three different circle diameters centered on the optic disc (3.5, 4.1, and 4.7 mm in diameter). The RNFL measurements also show where the measurement falls within the normative data range. The significance of the larger circles’ diameters has not been evaluated for diagnostic significance (Figure 2).

**COMBINING STRUCTURAL PARAMETERS**

When Mwanza et al evaluated the ability of Cirrus ONH parameters to discriminate healthy eyes from glaucomatous eyes, they found that the best parameters were vertical rim thickness, rim area, RNFL thickness at 7 o’clock, RNFL thickness in the inferior quadrant, vertical cup-to-disc ratio, and average RNFL thickness. The area under the curve for these parameters varied from 0.963 to 0.890. The best ONH parameters performed similarly to RNFL with regard to differentiating glaucomatous eyes from healthy eyes. Chauhan et al examined the ability of the BMO-MRW with the Spectralis OCT to differentiate healthy eyes from...
glaucomatous eyes and reported that the global BMO-MRW provided the best diagnostic performance. At 95% specificity, the sensitivity of the RNFL was 70%; BMO horizontal rim width was 51%; and BMO-MRW was 81%.

CONCLUSION
OCT is an evolving technology that provides measurements of the RNFL, the macula, and now, the ONH. The last add important information to facilitate practitioners’ recognition of glaucoma. Based on my clinical experience, it is best to use ONH measurements in combination with other OCT structural parameters such as RNFL thickness and ganglion cell complex. Mwanza et al demonstrated that using all OCT structural parameters in combination with one another was more effective at detecting early glaucomatous damage compared with analyses done with individual parameters.
The Optic Nerve Analysis software for Optovue’s spectral-domain optical coherence tomography (SD-OCT) devices provides clinicians with three sets of data for glaucoma evaluation. The optic nerve head (ONH) analysis measures the disc area, the rim area, and the cup-to-disc ratio. The peripapillary retinal nerve fiber layer (RNFL) analysis measures the average RNFL thickness, the hemifield RNFL thickness, and the quadrant RNFL thickness. The macular region ganglion cell complex (GCC) analysis measures the average GCC thickness, the hemifield GCC thickness, the focal loss volume, and the global loss volume. The ONH and RNFL parameters are derived from the ONH scan, and the GCC parameters are derived from the GCC scan (Figure).

The measurement parameters from these three sets of analysis are automatically compared to the OCT’s normative limits, and the results are color-coded for “within normal limits” (green), “borderline” (yellow), and “outside normal limits” (red). The normative limits are always adjusted for age and, in the cases of ONH and RNFL parameters, are also adjusted for optic disc size (Figure).

The Optic Nerve Analysis with Optovue’s SD-OCT devices is repeatable and reproducible, with the coefficient of variation not exceeding 2.1% for the average RNFL thickness and not exceeding 1.7% for the average GCC thickness in healthy and glaucomatous eyes (data on file with Optovue). Trend analysis to estimate the rates of change of the RNFL and the GCC is also provided with the company’s Avanti and iVue devices for longitudinal assessment of the optic nerve.

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