Retinal Measurements:

Comparison Between Cirrus HD-OCT and Stratus OCT

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INTRODUCTION

Carl Zeiss Meditec Inc. (CZMI) manufactures and distributes the Stratus OCT, an optical coherence tomography (OCT) instrument that uses a beam of light to rapidly scan the eye and provides a very detailed cross-sectional image of various retinal structures of the eye. It is currently the standard of care for aiding in the diagnosis and monitoring of a variety of ophthalmic diseases.[1-6]

CZMI has also developed a spectral domain optical coherence tomography (SD-OCT) instrument that incorporates aspects of the Stratus OCT. Named the Cirrus HD-OCT, it has a scanning beam very similar to the Stratus OCT but with better axial resolution and a higher scanning speed (50x faster) allowing for scanning of a much greater area of the retina.

The Cirrus HD-OCT system was recently released with Macular Thickness Analysis package (software version 2.0). Both the Stratus and Cirrus systems image retinal anatomy and identify the retinal layers by using segmentation algorithms to mark the internal limiting membrane (ILM), the inner segment/outer segment junction (IS/OS) for Stratus and the retinal pigment epithelium (RPE) in Cirrus. From these layer positions the instruments calculate retinal thickness and summarize the thickness results according to the Age Related Eye Disease Study (AREDS) subfields, as shown in Figure 1.[7]

Because both systems report values in the same manner, it is essential to understand any differences between the actual values measured. In order to understand these differences, we reviewed study records of subjects scanned with both Cirrus and Stratus instruments. We now report our preliminary findings on eleven subjects without retinal abnormalities and five subjects with known retinal abnormalities. We hope this will pave the way for us to understand the sources of the differences. Future studies will provide the means to enable quantitative conversions that will allow measurements to be easily interpreted between the two systems.

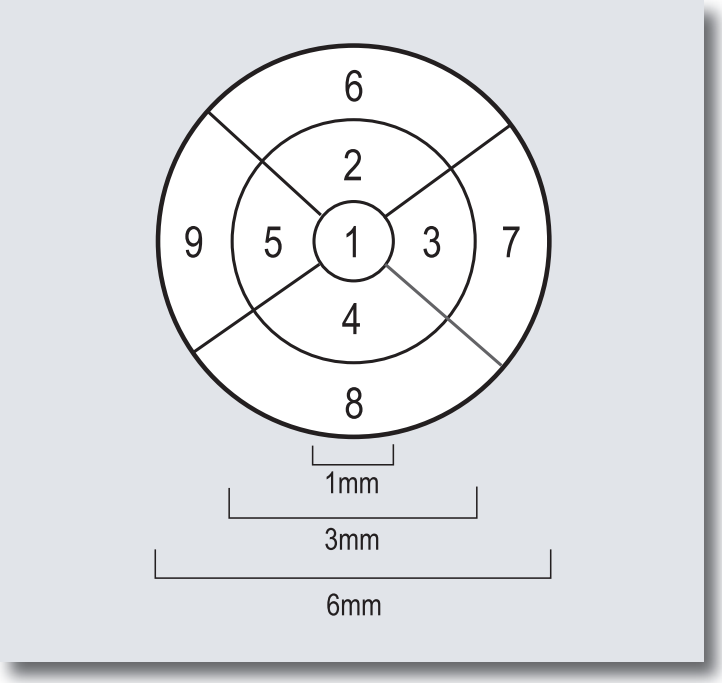


Fig. 1 *AREDS grid used for reporting retinal thickness in both Cirrus and Stratus OCT systems.*

METHODS

We reviewed the scans of subjects with no known retinal abnormalities imaged in a single session with both the Stratus and the Cirrus during an in-house CZMI study. The Bascom Palmer Eye Institute provided retrospective Stratus and Cirrus data from several subjects with known retinal abnormalities enrolled in a separate study.

All images obtained were reviewed for quality. Those with signal strength of 5 and below were excluded. Also excluded were cases where the segmentation algorithm could not identify the layers thus preventing a meaningful thickness map from being generated.

Stratus data was processed using the Beta release of software version 5.0. Cirrus data was processed using the 2.0 release of the Macular Thickness Analysis package. Average thickness in nine retinal subfields were calculated and compared for both Stratus and Cirrus. Data were compared qualitatively and quantitatively. By reviewing the segmented layers with the OCT image outputs, we attempted to evaluate the primary and secondary reason for any differences in measured average retinal thickness.

RESULTS

Subjects without retinal abnormalities

The mean retinal thickness values for each instrument and the mean difference and standard deviation for paired data are shown in table 1.

Measurement Area	Stratus 5.0 (SD) (µm)	Cirrus 2.0 (SD) (µm)	Mean Paired Difference (SD)(µm)
Central	198.10 (17.3)	258.08 (16.8)	60.0 (9.0)
Outer Temporal	221.87 (20.3)	267.92 (17.0)	47.4 (10.2)
Outer Superior	242.48 (17.3)	288.42 (16.5)	47.5 (6.8)
Outer Nasal	262.98 (25.6)	309.17 (18.9)	46.9 (14.3)
Outer Inferior	236.65 (20.5)	278.83 (19.9)	43.7 (7.9)
Inner Temporal	265.67 (22.7)	320.08 (15.2)	54.5 (16.8)
Inner Superior	279.63 (15.3)	332.33 (14.4)	53.0 (10.2)
Inner Nasal	275.93 (23.9)	335.83 (12.6)	61.1 (19.6)
Inner Inferior	279.11 (16.8)	330.67 (15.9)	52.9 (11.6)

Table 1 *Mean and standard deviation for each subfield. All units are in microns (µm).*

Differences between the Stratus and the Cirrus average retinal thickness measurements range from 43.7 to 61.1 microns, with the difference being more pronounced in the central and inner nasal subfields. A Bland Altman plot was generated for the central subfield differences, as seen in the figure 2. This shows that in all subjects, the differences were all within a 40 to 80 micron range.

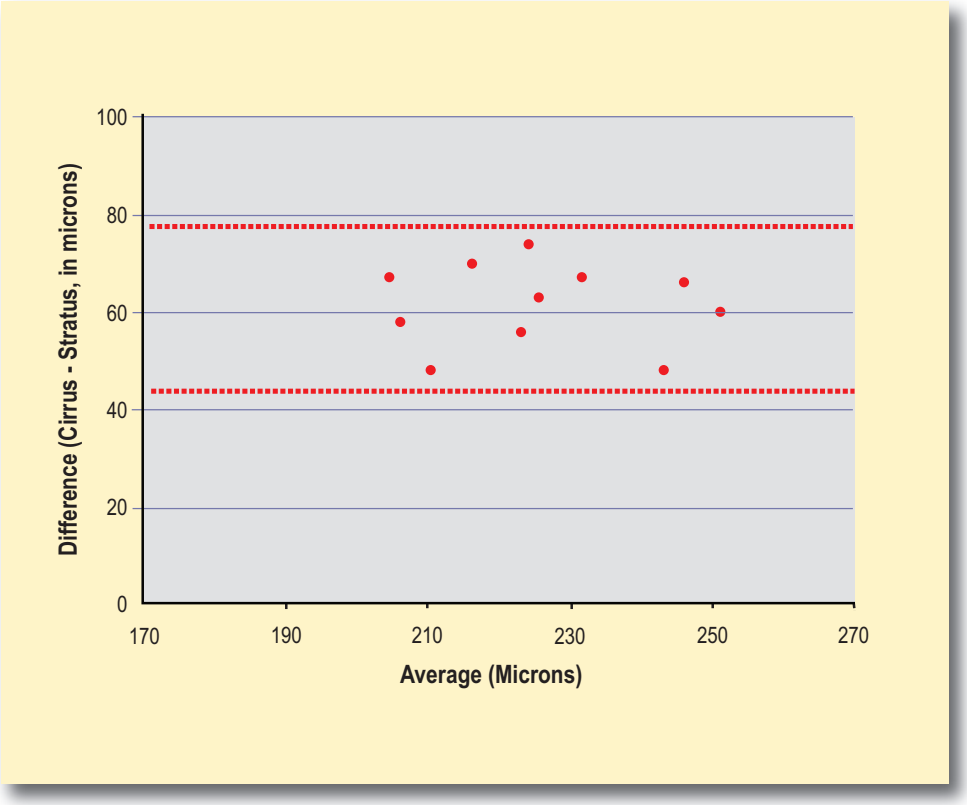


Fig. 2 *Bland Altman plot comparing Stratus central subfield thickness measurements to Cirrus 2.0*

Subjects with Retinal Abnormalities

Due to the varying anatomical configuration of subjects with retinal abnormalities, mean thickness measurements calculation across the subject population was not done. The graphical representation shown below highlights the differences from subject to subject.

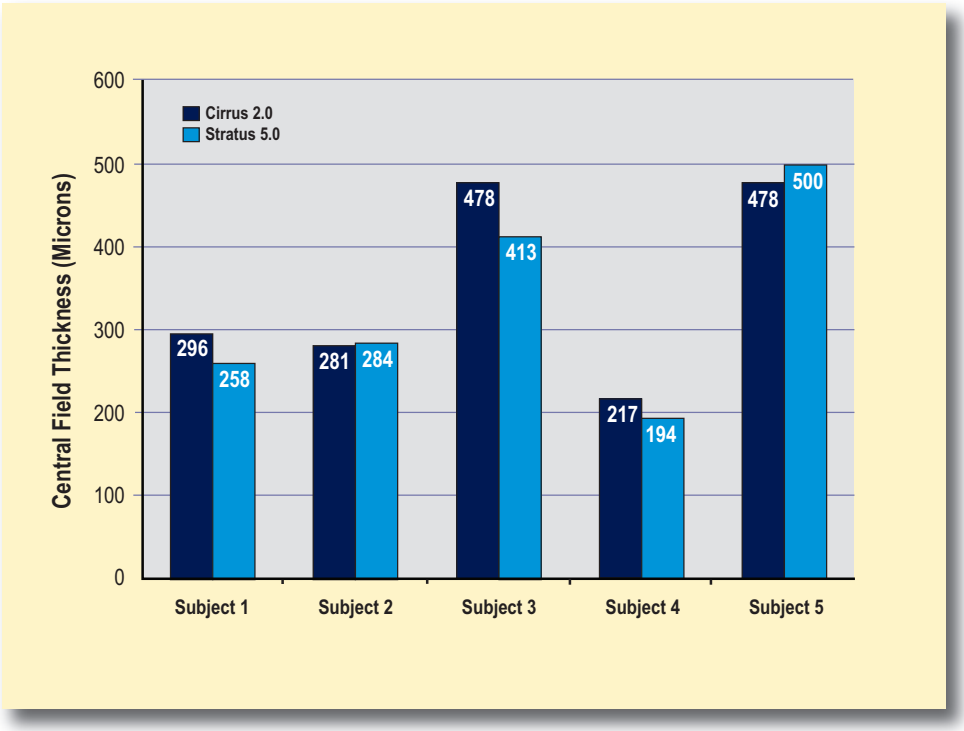


Fig. 3 *Average retinal thickness in the central subfield for all abnormal subjects*

The differences between Cirrus and Stratus measurements in all subfields were calculated for each individual subject and shown in Table 2. The differences range from 3 to 131 microns.

Subject	Difference between Cirrus and Stratus measurements (µm)								
	Central	Inner Temp	Inner Sup	Inner Nasal	Inner Inf	Outer Temp	Outer Sup	Outer Nasal	Outer Inf
1	38	69	39	48	56	131	57	-31	43
2	-3	37	54	49	21	46	56	41	31
3	65	35	46	68	66	32	52	60	51
4	23	53	43	66	55	49	46	39	44
5	-22	17	17	17	67	32	31	27	29

Table 2 *Differences between Cirrus and Stratus measurements in all subfields for each subject (all units in microns)*

DISCUSSION

Our results show that the difference between a typical Stratus and Cirrus measurement of the central subfield on subjects without abnormalities is approximately 60 ± 9 µm. For the other subfields, the difference ranges from between 43 µm and 61 µm, with standard deviations that range from less than 10 µm to almost 20 µm.

There are several known key differences between Stratus and Cirrus that will lead to different measured values, as follows:

Segmentation -The most important difference is that the Cirrus segmentation identifies the thickness of the retina from the RPE to the ILM, while the Stratus segmentation identifies the thickness of the retina from the IS/OS to the ILM, thus Cirrus will be inherently thicker by the distance between the IS/OS and the RPE, which is approximately ~45 µm. An example of scans from a subject without retinal pathology is shown in Figure 4. The images clearly show the segmentation lines as they are generated for Stratus and Cirrus. The quantitative difference between the two images is mainly determined by the anatomical distance between the inner boundary of the IS/OS and the inner boundary of the RPE.

Stratus acquires data for thickness calculations by collecting 256 A-scans along six linear B-scans that pass through the center of the fovea. Cirrus acquires the same data by collecting 200 A-scans from 200 linear B-scans that are evenly distributed in a 6 mm square centered on the fovea. Cirrus samples significantly more points, and the distribution of the sampled points is even over each subfield. Stratus samples more heavily towards the center of the scan. Stratus corrects for this effect, but cannot correct for regions of anatomy that are missed by the scanning, thus Stratus values are affected by which region is actually sampled and the quantitative differences between systems may depend on the anatomy being studied.

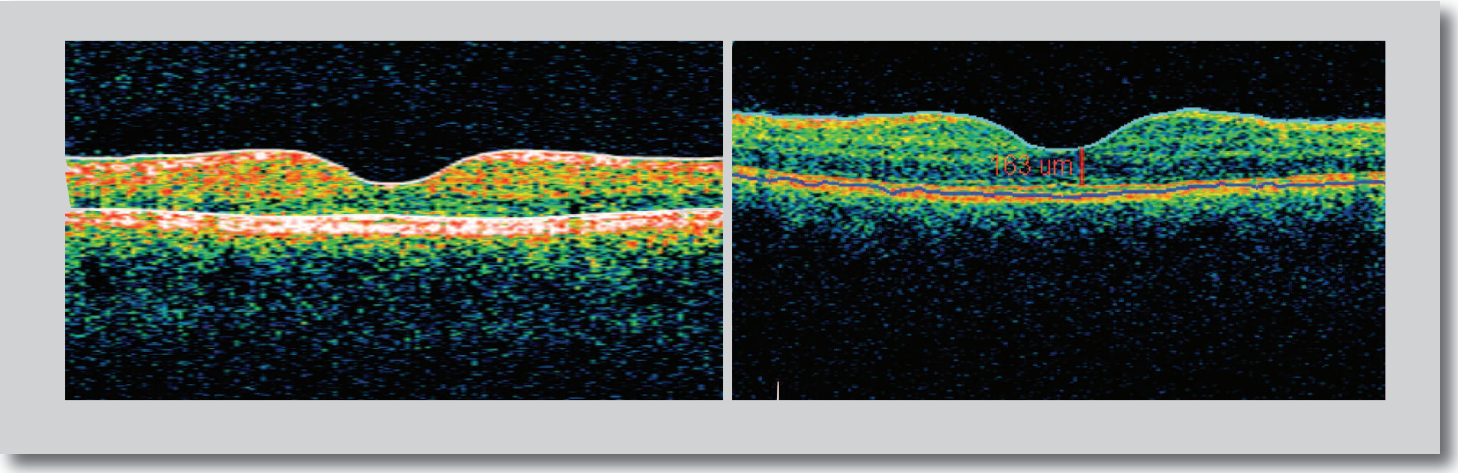
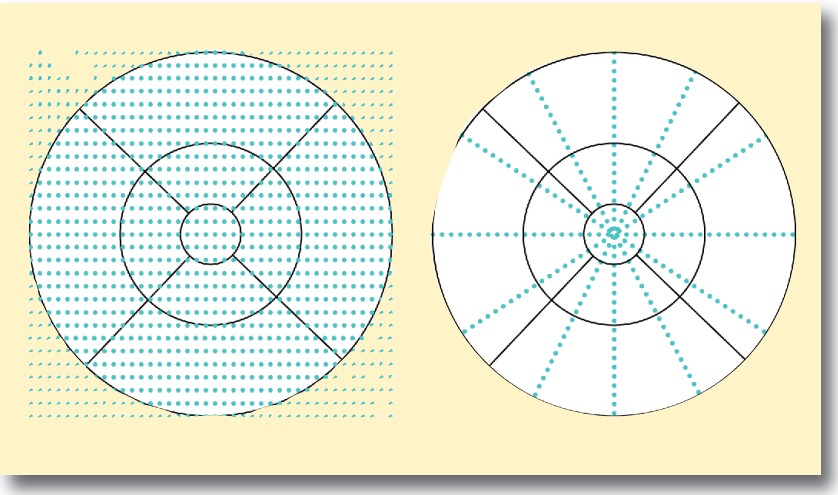


Fig. 4 *Horizontal B-scan through the fovea for a subject with no retinal pathology imaged on the same day on Stratus (left) and Cirrus (right).*



Subfield Averaging - Another important difference between the Cirrus and Stratus reported values arises because the two systems of necessity sample the retina in two different ways, which are illustrated in Figure 5.

Fig. 5 *Illustration of how Cirrus and Stratus samples the retina differently. Cirrus sampling is on the left, and Stratus is on the right.*

Axial Resolution and Calibration – The effect of these differences are expected to be negligible. Cirrus has improved axial resolution over Stratus. However, this is not expected to affect the measured thickness values. Calibration in the axial and lateral directions between the two systems are expected to be the same to within 1%, so we do not expect calibration differences to contribute to differences between Cirrus and Stratus in excess of the expected differences between one Stratus and another.

The comparison between Stratus and Cirrus measurements of the central subfield on subject with abnormalities is not as straightforward as for subjects without abnormalities. In some subjects, the difference is entirely the same as for normals. When the IS/OS is not visible due to pathology, both systems may find a similar boundary, and the difference is reduced (Fig. 10). Also, in subjects with drusen (Fig. 9), the thickness may be dominated by the pathology, and the difference in thickness found by the two segmentation strategies will be reduced. The figures 6-10 show the scans and maps of the subjects with retinal abnormalities.

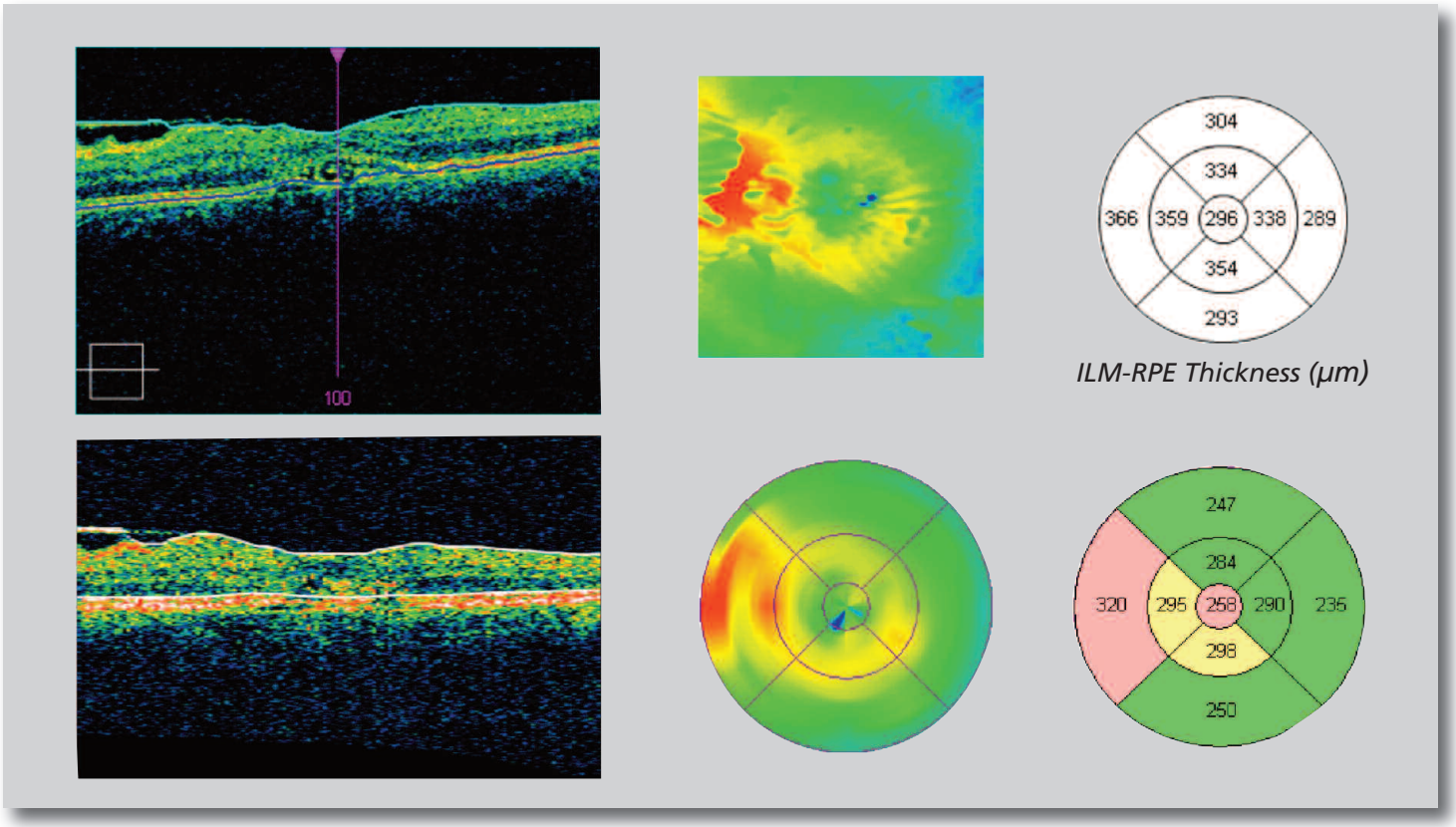


Fig. 6 *Cirrus (top row) and Stratus (bottom row) scans and maps of a subject with non-neovascular Age related Macular Degeneration (AMD) with epiretinal membrane.*

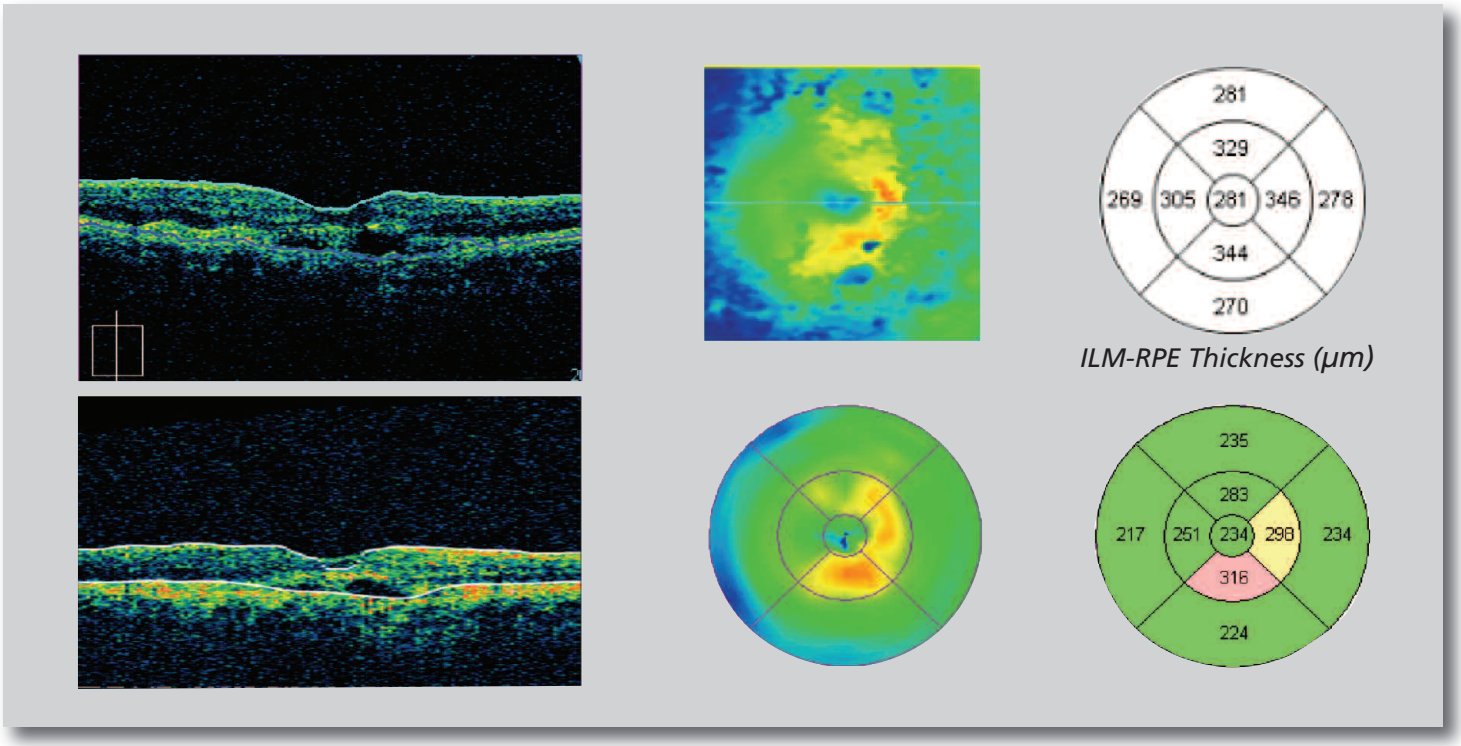


Fig. 7 *Cirrus (top row) and Stratus (bottom row) scans and maps of a subject with noeovascular AMD.*

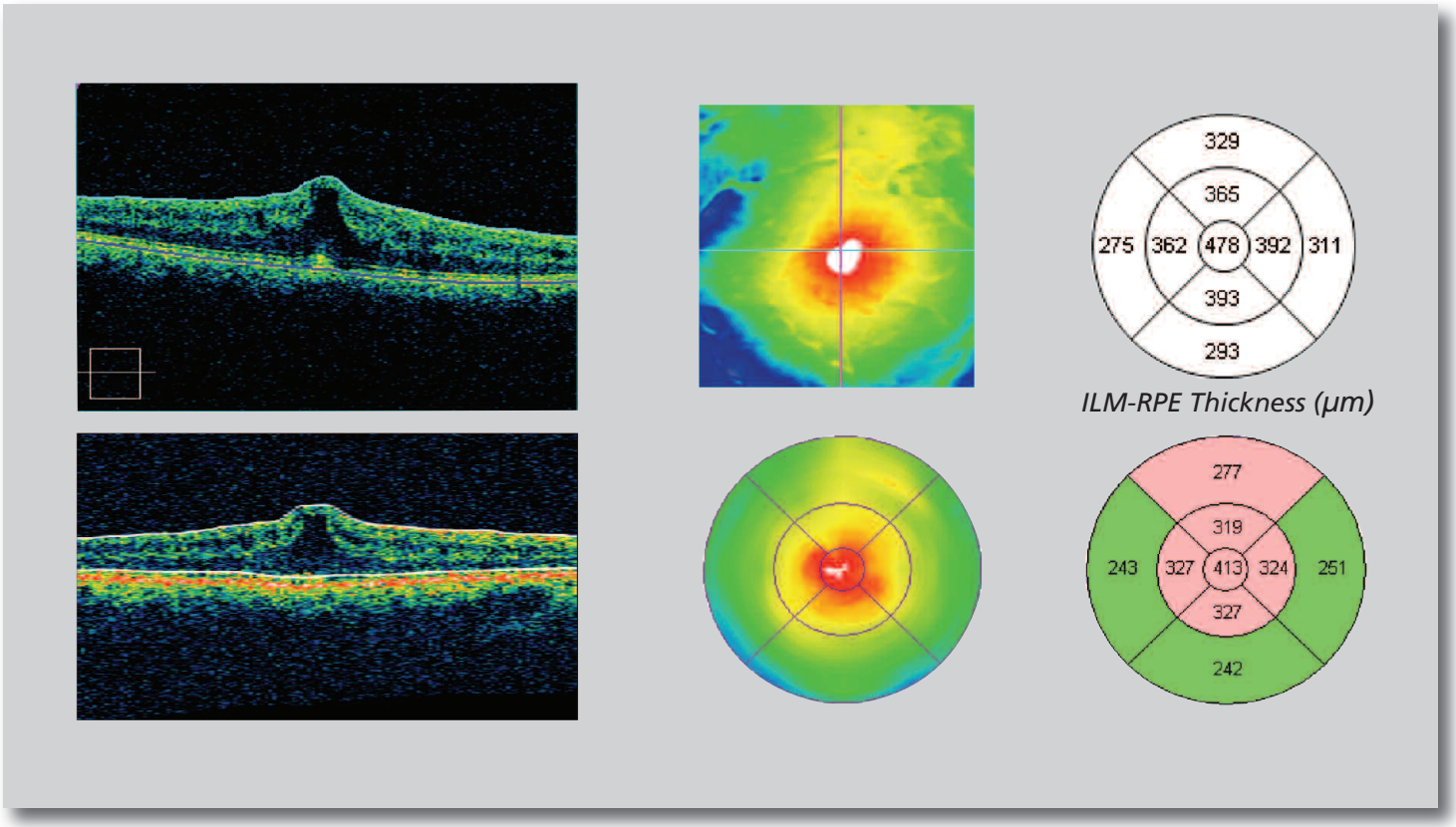


Fig. 8 *Cirrus (top row) and Stratus (bottom row) scans and maps of a subject with epiretinal membrane and macular edema.*

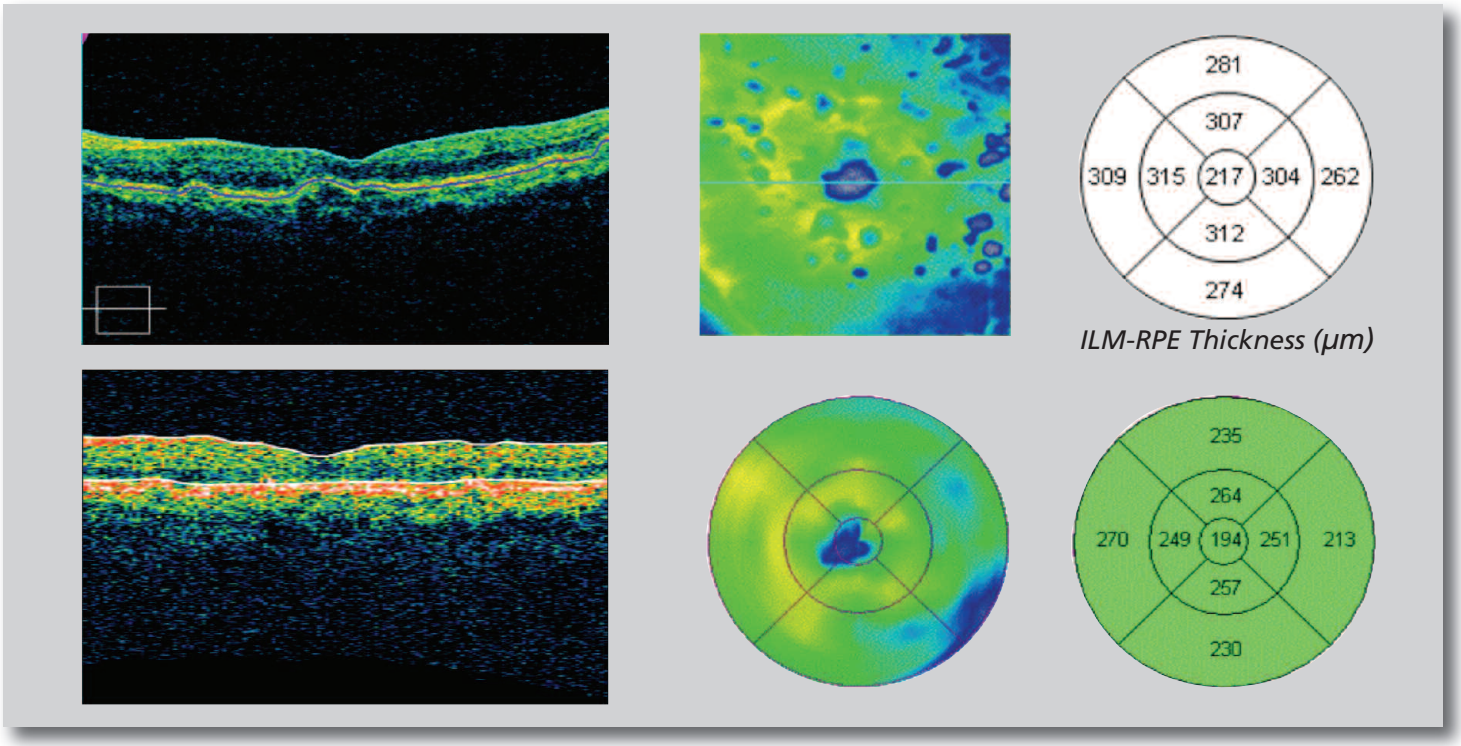


Fig. 9 *Cirrus (top row) and Stratus (bottom row) scans and maps of a subject with drusen.*

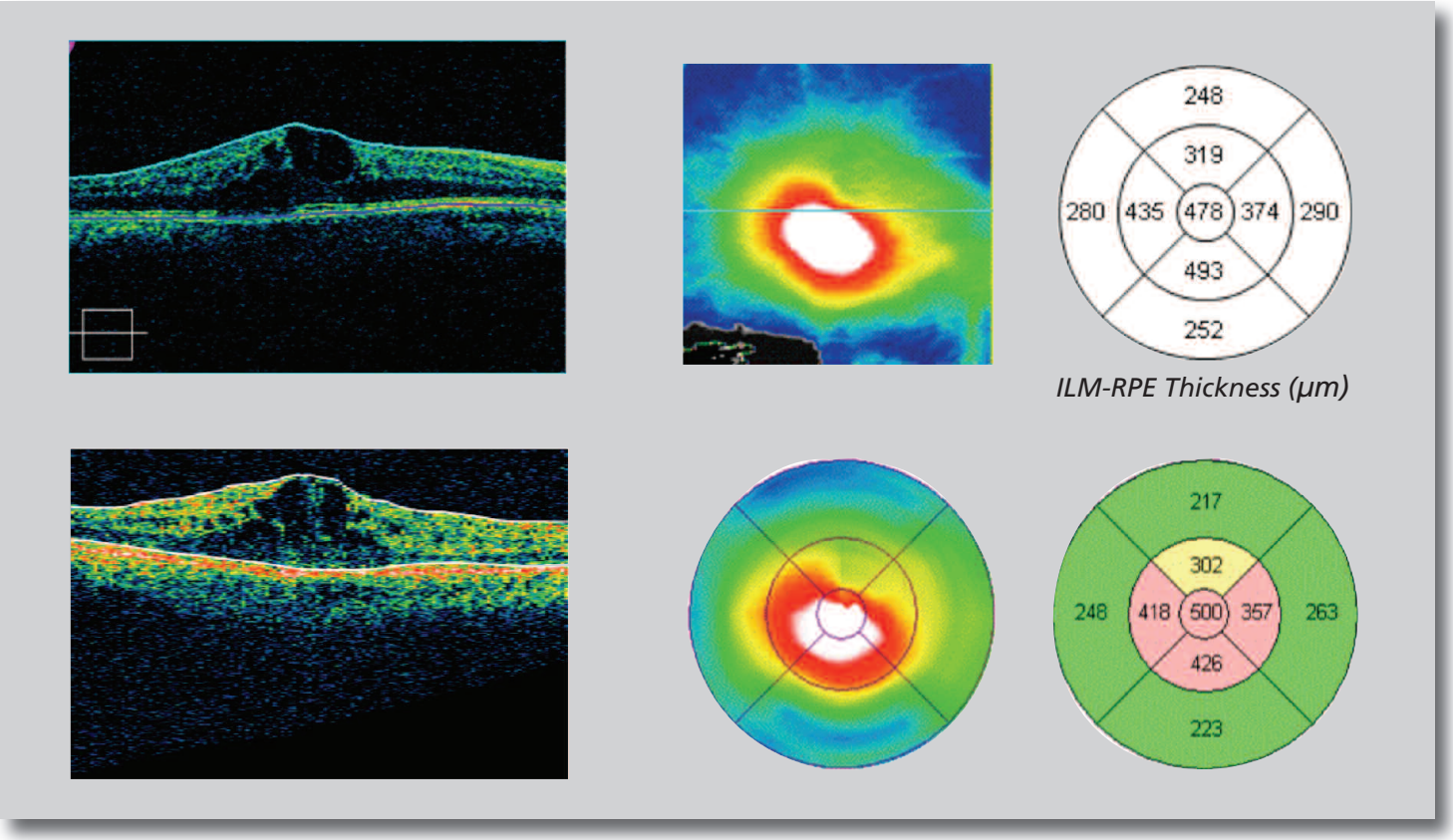


Fig. 10 *Cirrus (top row) and Stratus (bottom row) scans and maps of a subject with Central Retinal Vein Occlusion (CRVO) and macular edema.*

CONCLUSION

For subjects without retinal abnormalities, Stratus OCT data can be related to Cirrus HD-OCT data by a linear formula. For abnormal subjects, the relationship between subfields may vary according to pathology. When comparing Cirrus data to Stratus data, it is essential to examine carefully the OCT tomograms and to look at the morphology. Any reported quantitative changes should be confirmed by looking at the images.

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