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Retinal Thickness Analysis by Race, Gender, and Age Using Stratus OCT™

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Abstract

PURPOSE—To detect differences in retinal thickness among patients of different race, gender and age using Stratus OCT™.

DESIGN—Cross-sectional study.

METHODS—In a multicenter, university-based study, 126 patients with no history of ocular disease were enrolled (78 diabetics without retinopathy and 48 nondiabetics). Optical coherence tomography measurements were performed using Stratus OCT™. Statistical comparisons of centerpoint foveal thickness and mean foveal thickness were made using generalized estimating equations adjusting for diabetic status, race, age, and gender.

RESULTS—The study population consisted of 36% males, 39% Caucasians, 33% African Americans, and 28% Hispanics. Mean foveal thickness was 191.6±2.7μm and 194.5±2.7μm for diabetics and nondiabetics, respectively (P=0.49). Mean foveal thickness in males was significantly larger than in females (201.8±2.7μm and 186.9±2.6μm, respectively; P<0.001). Mean foveal thickness was 200.2±2.7μm for Caucasians, 181.0±3.7μm for African Americans, and 194.7±3.9μm for Hispanics. Mean foveal thickness was significantly less for African Americans than Caucasians (P <0.0001) or Hispanics (P=0.005). Centerpoint foveal thickness and mean foveal thickness showed a significant increase with age.

CONCLUSIONS—There are statistically significant differences in retinal thickness between subjects of different race, gender, and age. When compared to Caucasians and Hispanics, African-American race is a predictor of decreased mean foveal thickness; and male sex (regardless of race) is a significant predictor of increased mean foveal thickness. Mean foveal thickness is similar among diabetics and nondiabetics when data are controlled for age, race, and sex. These results suggest that

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studies comparing OCT measurements should carefully control for age, race, and gender-based variations in retinal thickness.

Keywords

optical coherence tomography; Stratus OCT™; foveal thickness; age; race; sex

The Stratus OCT™ normative database reported by Fraser-Bell and colleagues (Fraser-Bell S, *et al*. IOVS 2005;46:ARVO E-Abstract 1542) suggests differences in retinal thickness based on age, gender, ethnicity, and refractive error; however, very few published studies have systematically attempted to establish a normative range of optical coherence tomography (OCT) measurements in healthy patients. Such a database is important for identifying and characterizing pathologic changes. Asrani and colleagues[1] used a retinal thickness analyzer to measure retinal thickness in a small sample (n=29) of normal patients. Their results suggested that race and gender have a small effect (< 35 microns) on retinal thickness, but the authors found no correlation between retinal thickness and age. Wong and colleagues2 reported that a larger body mass index, higher axial length and male gender were significantly correlated with increasing central retinal thickness as measured by Stratus OCT™. A number of other small studies have suggested significant differences in retinal thickness between genders and among races.[3,4–6] Recently, Kelty and colleagues[7] showed that mean foveal thickness was greater in Caucasians than African-Americans and greater in healthy males than in females.

One example of the impact of race and gender on OCT measurements may be in studies of retinal thickness measurements in diabetic patients with minimal or no diabetic retinopathy. Studies evaluating the retinal thickness in diabetic and nondiabetic patients have reported variable findings for unclear reasons.[3, 8–11] Using first-generation OCT, Hee and colleagues[3] found no significant difference in mean foveal thickness between diabetics without retinopathy and nondiabetic controls. Lattanzio and colleagues[10] showed that there is as much as 40–50 μm difference between diabetics without retinopathy and nondiabetic controls. Bressler and colleagues[4] recently reported no difference in central subfield thickness on Stratus OCT™ among diabetics without retinopathy and nondiabetic patients without any ocular pathology. The variability in these findings suggests that factors such as race, gender, and age may affect retinal thickness in these study populations.

Currently, there are no reports of OCT- based retinal thickness measurements controlling for age, race, and sex simultaneously in a multiethnic population of Caucasians, African Americans, and Hispanics. In the present study, we report Stratus OCT™ measurements of retinal thickness in a population of diabetics and healthy patients stratified by race, gender and age, and we analyze correlations based on these demographic data.

METHODS

Patients were prospectively recruited from the diabetic screening clinics and private practices of individual investigators at the Wilmer Eye Institute and the Doheny Eye Institute, Los Angeles County/University of Southern California (LAC/USC) Hospital from October 1, 2005, through April 20, 2008. All patients were recruited with procedures, consents, and protocols approved by the Johns Hopkins University and University of Southern California Institutional Review Boards. Because relatively few diabetic patients without diabetic retinopathy are seen at tertiary care centers, we also recruited patients from diabetic screening examinations at both institutions. The patients seen for screening examinations at the LAC/USC and the Wilmer Eye Institute comprised referrals from physicians in the community specifically for evaluation of diabetic retinopathy. In many cases, these patients had no visual complaints and were only screened for diabetic retinopathy; they did not undergo a full ophthalmic examination. Among

this population, only patients with no visual complaints and no clinical signs of diabetic retinopathy were referred for this study. Nondiabetic patients were recruited among volunteers or patients with normal examinations from the above-mentioned clinics. Nondiabetic patients were not required to be dilated for OCT scanning. For all patients, demographic data including age, sex, and race were recorded. All patients who were enrolled were self-identified as Caucasian, African American, or Hispanic. Inclusion criteria included patients with unremarkable ocular histories or patients with diabetes but with no signs of diabetic retinopathy. Exclusion criteria include any visual complaint not corrected by refraction, self-reported history of ocular disease (other than ocular surface disease and mild refractive error), trauma, or surgery, or any findings suggestive of ocular pathology. Any patient with an abnormal fundus examination (including asymmetric cup-to-disc ratios greater than 0.2) was excluded to avoid enrollment of patients with clinically detectable glaucoma.

OCT scanning was performed using Stratus OCT™ (OCT3; Zeiss-Humphrey Systems, Dublin, CA) by experienced OCT operators. One or two scans were performed on each eye for each protocol. Only OCT scans with signal strength of “5” or greater were used for analysis. Analyses were performed employing Stratus OCT™ software for 6.0mm scan protocols. In this paradigm, retinal thickness is the distance measured between the vitreoretinal interface and the junction between the inner and outer segments of the photoreceptors. The location of these boundaries is determined by a thresholding algorithm that detects changes in reflectivity at each of these interfaces. Retinal images were generated from 6 radial scans in a spoke-like pattern using the fast macular and macular thickness automated protocols. The fast macular scan compresses the 6 radial line scans of the 2000 OCT macular thickness mapping protocol into one scan that is obtained in 1.92 seconds. Each line scan consists of 128 A-scans; therefore, retinal thickness is measured at 768 points along 6 intersecting lines. This feature decreases the total acquisition time but sacrifices resolution. Where possible, higher resolution macular thickness scans were obtained and used. Scan analysis was performed using the Stratus OCT™ hardware with the Zeiss commercial scan analysis software. We manually reviewed the retinal boundaries in 198 (26%) of the 756 line scans in the study to estimate the error rate of boundary detection by the automated software.

Centerpoint foveal thickness and mean foveal thickness were the primary OCT parameters used for analysis. Overall, 11 OCT parameters (corresponding to nine Early Trea™ent Diabetic Retinopathy Study areas, one measurement for centerpoint foveal thickness, and one measurement for total macular volume) were tabulated and analyzed as shown in Table 2. Mean foveal thickness refers to the average thickness of the retina across the entire fovea or central subfield. Centerpoint foveal thickness refers to the thinnest point measured in the fovea. Secondary analyses included inner and outer retinal parameters as defined by standard Stratus OCT™ analysis software. Both eyes of all patients were scanned for the study. Statistical models were generated with generalized estimating equations controlling for the correlation between two eyes. The SAS 9.13 programming language (SAS Inst., Cary, NC) was used for all analyses.

RESULTS

Overall, the study population consisted of 126 patients, including 78 diabetics and 48 nondiabetics. The mean age of the diabetic patients and nondiabetic patients was 54 ± 11 and 41 ± 10 (yrs ± SD), respectively. The overall study population was 36% male and 39% Caucasian. The diabetic group was 32% male, 38% Caucasian, 36% African American, and 26% Hispanic. The nondiabetic group was 42% male, 40% Caucasian, 29% African American and 31% Hispanic. Patient demographics are summarized in Table 1.

Table 2 summarizes the mean OCT parameters for the diabetic and nondiabetic groups. In our data set, there was no difference in Stratus OCT™ retinal thickness parameters between diabetics versus nondiabetics. The mean foveal thickness was 191.6 ± 2.7 μm in diabetics and 194.5 ± 2.7 μm in nondiabetics ($P = 0.49$). Diabetes was not significantly correlated with any change in retinal thickness or volume after controlling for age, race and gender. Only data for retinal thickness are shown since volumetric data are derived from polar approximations of line scans by the Stratus OCT™.

Our data showed that male gender was a statistically significant predictor of increased mean foveal thickness and centerpoint foveal thickness (Table 3). Centerpoint foveal thickness was 163.0 ± 3.0 μm for all males and 154.7 ± 2.5 μm for all females ($P = 0.03$). Similarly, mean foveal thickness was 201.8 ± 2.7 μm for all males and 186.9 ± 2.6 μm for all females ($P < 0.001$).

African-American race was significantly correlated with decreased mean foveal thickness and centerpoint foveal thickness (Table 4). Centerpoint foveal thickness for African Americans was 147.2 ± 3.6 μm, which was significantly less than the centerpoint foveal thickness for Caucasians (164.1 ± 2.8 μm; $p < 0.0001$) and Hispanics (161.5 ± 3.6 μm; $P = 0.002$). In addition, mean foveal thickness for African Americans was 181.0 ± 3.7 μm. This value was also significantly less than the mean foveal thickness for Caucasians (200.2 ± 2.7 μm; $P < 0.0001$) and Hispanics (194.7 ± 3.9 μm; $P = 0.005$). Across all races, males had a tendency for thicker retinal measurements. The retinal thickness data for centerpoint foveal thickness and mean foveal thickness demographic are summarized in Table 5.

The distribution of retinal thickness for patients younger than 51 years of age (median age of the entire cohort) was not significantly different from those equal to or greater than 51 years of age, regardless of diabetic status. In a multivariate model controlling for race, sex, and diabetic status, centerpoint foveal thickness and mean foveal thickness significantly increased with age. In addition, nasal outer macular thickness was significantly decreased with age. The inferior outer macula and superior outer macula showed a trend toward decreased retinal thickness. Overall, total macular volume showed a trend toward decreasing volume with age. The data are summarized in Table 6.

Some authors have shown that the Zeiss automated boundary detection algorithm erroneously detects retinal boundaries in pathologic cases, but this error rate has not been reported in normal cases.[12] Therefore, we reviewed a sample of line scans in our study to determine the error rate in boundary detection. We reviewed 198 of the total 756 line scans in the study and found a 2.5% boundary error detection rate. A boundary error was defined as misalignment of the white boundary line delimiting the internal limiting membrane and inner segment/outer segment junction on visual inspection of the OCT printout. In most cases this error occurred in one of six line scans for an individual patient. We reanalyzed the data from the 198 line scans, excluding all four patients with boundary detection errors, and found no significant change in the mean or standard error of the data.

DISCUSSION

The results of our ethnically diverse study suggest that there are no significant differences in macular thickness or volume between diabetics with no diabetic retinopathy and nondiabetic patients that can be detected by StratusOCT™. Our study demonstrates increased retinal thickness in males, regardless of race, and decreased retinal thickness in African-Americans, regardless of gender. Our study is the first to include Hispanic patients in significant numbers; and our results demonstrate a significantly greater retinal thickness in Hispanics compared to

African Americans. Our study also shows a significant increase in centerpoint foveal thickness and mean foveal thickness with age.

Using OCT1 (version A5, Zeiss Humphrey Systems, Dublin, CA, USA), other investigators have found a significant decrease in retinal nerve fiber layer (RNFL) thickness in the superior nasal quadrant and a significant increase in retinal thickness in the superior nasal quadrant.[8] Other investigators have also found significant differences in OCT measurements between diabetic patients with and without diabetic retinopathy.13 In all of the studies we reviewed,[3,8,9,13] the magnitude of difference in retinal thickness between diabetics and controls is relatively small (< 20 microns). In those cases in which the difference between controls and diabetics without retinopathy is large (>20 microns), the standard deviations are also large (>20 microns), suggesting unreliable measurements in earlier generations of OCT machines.[10] Bressler and colleagues4 show that central subfield thicknesses of diabetics without diabetic retinopathy are not significantly different from those of healthy controls in a largely Caucasian population when gender is taken into account. Our data show no difference in retinal thickness parameters between diabetics without retinopathy and nondiabetics in a multiethnic population, when age, race, and gender are taken into account. Our study further suggests that race is an important factor to consider in measuring retinal thickness and may explain some of the differences in previous study results.

A number of other considerations and limitations may account for the differences in our study results. In most studies, the absolute magnitude of difference in measurements between diabetic and control groups is about 5% to 7% of the absolute retinal thickness. This is marginally greater than the axial measurement error for StratusOCT™ (8–10 microns)[14] and OCT2 (10–15 microns).15 Measurements made with OCT1 have interscan reproducibilities of ± 5% – 6% for healthy and diabetic patients,5 whereas StratusOCT™ has interscan reproducibility of 2% –7%.15 Our study used the StratusOCT™, which enables retinal thickness measurements with an axial resolution of 8–10 microns, higher axial sampling rates, greater transverse sampling density and a faster A-scan rate than previous generations of machines.14 This may also explain some of the differences between our study and studies that used earlier generations of OCT machines. Future studies employing the latest generation of spectral domain OCTs are needed to determine whether similar findings are observed.

Several potentially confounding factors in our study deserve further attention. For example, we did not dilate all of our control patients for OCT scans. However, Paunescu and colleagues[14] report a small but insignificant increase in minimum (or centerpoint) foveal thickness after dilation. The lack of dilation may result in a small underestimate of macular thickness for our nondiabetic patients but is unlikely to change the significance of the results.

Another possible confounding factor in our study is the 13-year age difference between our diabetics and controls. Some evidence suggests that retinal thickness varies inversely with age. Our study did show a small but insignificant trend toward decreasing total macular volume. Alamouti and colleagues[16] reported a statistically significant decrease in retinal thickness and RNFL thickness with age (using OCT2), but the correlations they reported were only R^2=0.13 and R^2=0.09, respectively. Varma and colleagues[17] have shown a small (10–15 microns) but statistically significant decrease in RNFL thickness with age. Cavallotti and colleagues18 reported a decrease in mean retinal thickness in post-mortem specimens measured by scanning electron microscopy; but this measurement technique is very different from OCT measurements, suggesting that the two methods of measuring retinal thickness are not comparable. Earlier studies also suggest that time to fixation and fixation artifact contribute to retinal thickness measurements in histologic specimens.19 A number of other studies using the retinal thickness analyzer and OCT2 as well as StratusOCT™ fail to show any effect of age on retinal thickness.[1,5] Interestingly, our data shows a significant increase in the

centerpoint foveal thickness and mean foveal thickness with age. If confirmed by other reports, our study may suggest the presence of interstitial edema from foveal capillary dropout with age. It is likely that individual retinal layers (like the RNFL) are preferentially affected by age and that this is not detected in measurements of the whole retina. Future studies using more advanced retinal segmentation methods will be necessary to evaluate this possibility.

An additional limitation of our study is the lack of data pertaining to refractive errors, blood glucose control (such as hemoglobin A1C values), and visual fields. Although we did not have the resources to perform protocol refractions on our study patients, any moderate or large refractive error would have been minimized (using the manual refraction dial on the StratusOCT™) in the process of correcting for OCT image quality. In addition, a number of recent studies show that refractive errors and keratometry readings do not correlate significantly with central retinal thickness or RNFL measurements; therefore, it seems unlikely that our results would be significantly affected by these variables.[2,4,7,20] Because glaucoma affects the ganglion cell layers, which may affect retinal thickness, we excluded patients with a history of glaucoma or with disc changes that may have suggested glaucomatous damage. We did not find sufficient indications to perform visual field testing on patients who had no evidence of glaucoma.

Lastly, a growing body of evidence suggests that automated StratusOCT™ measurements are prone to errors. Since we did not manually confirm the StratusOCT™ automated measurements (using calipers) of our patients, there may have been some errors in retinal boundary detection, as described by Sadda and colleagues.[12] However, we do not think that our overall measurements are significantly affected by automated errors for a few reasons. First, most automated errors of retinal boundary detection and thickness measurements occur in scans of patients with subretinal or retinal pathology. Our scans were exclusively of normal patients with normal scans. Second, systematic random errors in automated boundary detection or thickness measurements would have most likely negated the differences we have described among races and between sexes. Therefore, our results would likely be an underestimate of the real differences, if indeed there were many errors in automated boundary detection in our study. Finally, manual review of the location of the boundaries on 198 (26%) of the 756 OCT line scans in our study showed a 2.5% false boundary detection rate (affecting a total of four patients). Exclusion of these four patients from the 33 patients in that subset did not significantly alter the means or standard deviations of that subgroup; therefore, we do not feel that our results were significantly affected by these errors.

Based on our data, which comes from a relatively large, ethnically well-represented study, a significant amount of the variability in retinal thickness data in normal patients and diabetics without diabetic retinopathy may be due to differences in race and gender. It is not possible to retrospectively analyze most studies because racial and gender data are not consistently reported in all studies. Additionally, these studies have other systematic differences in methodology, including the type of OCT device that was available at the time of each study. The observation that retinal thickness varies with race and gender is an important one since many clinical studies enroll patients of different ethnic backgrounds, with variable male-to-female ratios. Our study reports the variation in normative retinal thickness values among Caucasians, African Americans, and Hispanics of both genders and a wide age range. Such normative data suggests it is critical to control for variation in OCT parameters based on race, age, and gender when conducting analyses of OCT measurements. The data may also help explain the occurrence of race- and gender-based disease predilections. For example, the significant preponderance of women in the macular hole population may be related to their relatively thin retinas. It will also be important to pursue similar studies in the future, using spectral domain OCT to determine whether the differences we found to be associated with age,

race and gender can be verified and perhaps better characterized using volumetric measurements that are not confounded by polar approximations.

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C. Study design (QDN, SMS, AHK). Patient recruitment (AHK, IZG, JAH, DVD, QDN, DE). Collection, analysis and preparation of data tables, figures and graphs (AHK, LD). Preparation and editing of manuscript (AHK, QDN, DVD, DE, JAH).

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Biography

Amir H. Kashani attended Johns Hopkins School of Medicine where he received his M.D./Ph.D. degrees in the Medical Scientist Training Program from 1998–2006. He completed medical internship on the Osler Medicine Service at Johns Hopkins Hospital in 2007 and is now a senior resident at the Doheny Eye Institute at the University of Southern California. Dr. Kashani is applying for a fellowship in vitreoretinal surgery and plans on a career in academic medicine.

Table 1

Retinal Thickness Analysis by Age, Race and Gender: Population Demographics of Patients Enrolled in the Study

	Total	Diabetic	Nondiabetic
All races	126	78 (62%)	48 (38%)
Male	45/126 (36%)	25/78 (32%)	20/48 (42%)
Female	81/126	53/78	28/48
Caucasian	49 (39%)	30 (38%)	19 (40%)
Male	17/49 (35%)	8/30 (27%)	9/19 (47%)
Female	32/49	22/30	10/19
African American	42 (33%)	28 (36%)	14 (29%)
Male	14/42 (33%)	9/28 (32%)	5/14 (36%)
Female	28/42	19/28	9/14
Hispanic	35 (28%)	20 (26%)	15 (31%)
Male	14/35 (40%)	8/20 (40%)	6/15 (40%)
Female	21/35	12/20	9/15
Mean Age (years)	49 ± 2	54 ± 11	41 ± 10

Percentages are given in parenthesis. Where appropriate, ratios are provided adjacent to percentages to clarify the total reference population used to calculate the percentages.

Table 2

Retinal Thickness Analysis by Diabetic Status: Summary Data of Stratus OCT™ Parameters for Diabetic and Nondiabetic Patients

OCT Parameter	Diabetic	Nondiabetic	*P*-Value[a]
Centerpoint Foveal Thickness	157.8 ± 3.2 μm	156.9 ± 3.2 μm	0.86
Mean Foveal Thickness	191.6 ± 2.7 μm	194.5 ± 2.7 μm	0.49
Temporal Inner Macular	255.6 ± 1.9 μm	259.7 ± 2.4 μm	0.16
Superior Inner Macula	272.2 ± 2.1 μm	274.9 ± 2.1 μm	0.39
Nasal Inner Macula	269.3 ± 2.0 μm	273.3 ± 2.0 μm	0.18
Inferior Inner Macula	266.8 ± 2.0 μm	270.5 ± 2.5 μm	0.22
Temporal Outer Macula	221.0 ± 1.8 μm	222.7 ± 1.8 μm	0.54
Superior Outer Macula	240.7 ± 2.1 μm	242.3 ± 2.8 μm	0.64
Nasal Outer Macula	257.6 ± 2.2 μm	257.0 ± 2.2 μm	0.85
Inferior Outer Macula	230.3 ± 1.9 μm	229.3 ± 2.6 μm	0.75
Total Macular Volume	6.91 ± 0.06 mm^3	6.81 ± 0.11 mm^3	0.50

[a] Generalized estimating equation (GEE), which adjusts for the correlation between eyes, was employed in the analyses. The Wald Chi-Square *P*-value is reported and means are given as least square mean ± se. All models are adjusted for race, gender, and age group (categorized by decades: 20's, 30's, 40's,50's, and 60+).

Table 3

Retinal Thickness Analysis by Gender: Summary Data of Stratus OCT™ Parameters for Males and Females

OCT Parameter	Males (mean)	Females (mean)	*P*-Value[a]
Centerpoint Foveal Thickness	163.0 ± 3.0 μm	154.7 ± 2.5 μm	0.03
Mean Foveal Thickness	201.8 ± 2.7 μm	186.9 ± 2.6 μm	<0.001
Temporal Inner Macular	263.1 ± 1.9 μm	250.9 ± 1.8 μm	<0.001
Superior Inner Macula	278.5 ± 1.8 μm	265.8 ± 2.1 μm	<0.001
Nasal Inner Macula	278.4 ± 1.9 μm	263.0 ± 2.1 μm	<0.001
Inferior Inner Macula	274.2 ± 2.1 μm	261.2 ± 2.0 μm	<0.001
Temporal Outer Macula	226.5 ± 1.8 μm	215.4 ± 1.7 μm	<0.001
Superior Outer Macula	244.5 ± 2.0 μm	236.1 ± 2.0 μm	0.003
Nasal Outer Macula	261.5 ± 2.2 μm	251.2 ± 1.9 μm	<0.001
Inferior Outer Macula	232.7 ± 2.0 μm	223.7 ± 2.3 μm	0.003

[a]Generalized estimating equation, which adjusts for the correlation between eyes, diabetic status, race, age, and gender, was used in the analyses. Errors are given as least square mean ± se.

Table 4

Retinal Thickness Analysis by Race: Summary Data of Stratus OCT™ Parameters by Race

OCT Parameter	African American (mean)	Caucasian (mean)	Hispanic (mean)
Centerpoint Foveal Thickness	147.2 ± 3.6 μm	164.1 ± 2.8 μm[a]	161.5 ± 3.6 μm[a]
Mean Foveal Thickness	181.0 ± 3.7 μm	200.2 ± 2.7 μm[a]	194.7 ± 3.9 μm[a]
Temporal Inner Macular	251.5 ± 2.5 μm	257.1 ± 2.4 μm	257.5 ± 2.6 μm
Superior Inner Macula	264.6 ± 2.8 μm	272.3 ± 2.6 μm	274.8 ± 2.9 μm
Nasal Inner Macula	262.7 ± 2.8 μm	271.9 ± 2.8 μm	270.8 ± 3.0 μm
Inferior Inner Macula	261.7 ± 2.8 μm	268.8 ± 2.7 μm	266.7 ± 2.6 μm
Temporal Outer Macula	217.8 ± 2.7 μm	218.6 ± 2.1 μm	222.5 ± 2.4 μm
Superior Outer Macula	236.5 ± 3.0 μm	238.7 ± 2.4 μm	243.0 ± 2.9 μm
Nasal Outer Macula	251.9 ± 2.8 μm	256.3 ± 2.6 μm	256.8 ± 2.6 μm
Inferior Outer Macula	225.5 ± 2.8 μm	230.0 ± 2.5 μm	224.7 ± 3.8 μm

[a]Generalized estimating equation, which adjusts for the correlation between eyes, diabetic status, race, age, and gender, was used in the analyses. Please see text for *P*-values. Errors are given as least square mean ± se.

Table 5

Retinal Thickness Analysis by Sex: Retinal thickness values between males and females of all races using Stratus OCT™

	Centerpoint Foveal Thickness	Mean Foveal Thickness
Male		
Caucasian	166.4 ± 4.2 μm	207.9 ± 3.7 μm
African American	149.7 ± 4.5 μm	187.9 ± 4.7 μm
Hispanic	172.3 ± 5.7 μm	210.2 ± 4.1 μm
***P*-value**[a]		
C-A	0.008	0.001
C-H	0.41	0.67
A-H	0.002	0.0003
Female		
Caucasian	162.1 ± 3.4 μm	196.0 ± 3.4 μm
African American	144.1 ± 4.9 μm	176.6 ± 4.9 μm
Hispanic	154.4 ± 3.5 μm	184.4 ± 3.9 μm
***P*-value**[a]		
C-A	0.002	0.001
C-H	0.11	0.02
A-H	0.08	0.22

[a]Generalized estimating equation, which adjusts for the correlation between eyes, diabetic status, race, age, and gender, was used in the analyses. A = African American; C = Caucasian; H = Hispanic. Errors are given as least square mean ± se.

Table 6

Retinal Thickness Analysis by Age: Summary Data of Stratus OCT™ Parameters by Age Decile

OCT Parameter	Age 20–29 yrs	30–39 yrs	40–49 yrs	50–59 yrs	60+ yrs	*P*-Value[a]
Centerpoint Foveal Thickness	146.6 ± 5.2 μm	153.4 ± 5.0 μm	159.5 ± 3.8 μm	160.0 ± 3.2 μm	167.3 ± 6.0 μm	0.01
Mean Foveal Thickness	183.2 ± 5.4 μm	191.3 ± 4.0 μm	193.0 ± 3.9 μm	196.0 ± 3.1 μm	201.9 ± 5.4 μm	0.01
Temporal Inner Macular	257.8 ± 4.3 μm	258.8 ± 3.0 μm	255.5 ± 2.8 μm	257.5 ± 2.1 μm	258.6 ± 4.4 μm	0.93
Superior Inner Macula	278.2 ± 4.6 μm	275.5 ± 3.5 μm	272.2 ± 2.9 μm	270.4 ± 2.3 μm	271.5 ± 5.6 μm	0.19
Nasal Inner Macula	274.8 ± 4.0 μm	272.3 ± 3.6 μm	269.2 ± 3.0 μm	271.3 ± 2.4 μm	268.8 ± 5.4 μm	0.47
Inferior Inner Macula	270.9 ± 3.9 μm	272.0 ± 3.5 μm	264.7 ± 3.1 μm	267.8 ± 2.3 μm	267.7 ± 5.4 μm	0.51
Temporal Outer Macula	226.8 ± 3.3 μm	222.0 ± 3.1 μm	222.4 ± 2.5 μm	219.9 ± 2.0 μm	218.1 ± 5.1 μm	0.12
Superior Outer Macula	245.9 ± 4.3 μm	245.2 ± 3.5 μm	243.0 ± 3.2 μm	237.0 ± 2.4 μm	236.6 ± 5.7 μm	0.04
Nasal Outer Macula	263.7 ± 4.8 μm	260.9 ± 3.7 μm	258.8 ± 2.8 μm	253.4 ± 2.4 μm	249.5 ± 5.4 μm	0.01
Inferior Outer Macula	234.7 ± 3.4 μm	232.5 ± 3.7 μm	230.6 ± 2.6 μm	225.8 ± 2.4 μm	225.4 ± 5.6 μm	0.04
Total Macular Volume	7.02 ± 0.09 mm^3	6.97 ± 0.10 mm^3	6.77 ± 0.18 mm^3	6.78 ± 0.06 mm^3	6.76 ± 0.14 mm^3	0.05

[a]Generalized estimating equation (GEE), which adjusts for the correlation between eyes, was used in the analyses. The Wald Chi-Square test for trend across age decade *P*-value is reported and means are given as least square mean ± se.

All models are adjusted for race, gender, and diabetic status.