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Journal
Journal of Glaucoma, 22(9)

ISSN
1057-0829

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Publication Date
2013-12-01

DOI
10.1097/ijg.0b013e318264ba68

Peer reviewed

J Glaucoma. Author manuscript; available in PMC 2014 December 01.

Published in final edited form as:
J Glaucoma. 2013 December ; 22(9): . doi:10.1097/IJG.0b013e318264ba68.

Differences in Iris Thickness Among African Americans, Caucasian Americans, Hispanic Americans, Chinese Americans, and Filipino-Americans

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Abstract

Purpose—To evaluate the capability of iris thickness parameters to explain the difference in primary angle closure glaucoma prevalence among the different racial groups.

Methods—In this prospective study, 436 patients with open- and narrow-angles that met inclusion criteria were consecutively recruited from the UCSF general ophthalmology and glaucoma clinics to receive anterior segment optical coherence tomography imaging under standardized dark conditions. Images from 11 patients were removed due to poor visibility of the scleral spurs and the remaining images were analyzed using the Zhongshan Angle Assessment Program to assess the following measurements for the nasal and temporal angle of the anterior chamber: iris thickness at 750 μm and 2000 μm from the scleral spurs and the maximum iris thickness at middle one third of the iris. Iris thickness parameters were compared among and within the following five different racial groups: African-, Caucasian-, Hispanic-, Chinese-, and Filipino-Americans.

Results—In comparing iris parameters among the open-angle racial groups, significant differences were found for nasal iris thickness at 750 and 2000 μm from the scleral spurs in which Chinese-Americans displayed the highest mean value ($p=0.01$, $p<0.0001$). Among the narrow-angle racial groups, significant difference was found for nasal iris thickness at 2000 μm from the scleral in which Chinese-Americans showed the highest mean value ($p<0.0001$). Significant difference was also found for temporal maximum iris thickness at middle one third of the iris in which African-Americans exhibited the highest mean value ($p=0.021$). Iris thickness was modeled as a function of angle status using linear mixed-effects regression, adjusting for age, gender, pupil diameter, spherical equivalent, ethnicity, and the use of both eyes in patients. The iris thickness difference between the narrow-angle and open-angle groups was significant ($p=0.0007$).

Conclusion—Racial groups that historically showed higher prevalence of primary angle closure glaucoma possess thicker irides.

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Conflict of Interest: The authors have no financial or other conflicts of interest concerning this study.

Keywords

narrow-angle; open-angle; primary angle closure glaucoma; iris thickness; anterior segment optical coherence tomography; Zhongshan Angle Assessment Program

Introduction

In 1997, the World Health Organization estimated that cataract, trachoma, and glaucoma together caused about 70% of blindness globally.[1] Of the 38 million blind individuals at the time, cataract was responsible for 16 million people, trachoma for 5.9 million people, and glaucoma for 5.2 million people.[2] A more recent study in 2006 suggested that glaucoma has already superseded trachoma to become the second leading cause of blindness worldwide and is projected to affect more than 79 million people by 2010 with 11.2 million of them resulting in bilateral blindness.[3] The increasing prevalence of glaucoma is noteworthy because glaucomatous optic nerve damage is irreversible.[4]

Primary angle-closure glaucoma (PACG) accounts for 26% of all the glaucoma worldwide.[3] The prevalence of PACG in patients over age 40 varies across ethnicities: 0.06%–0.60% in Caucasians[5–10], 0.50%–0.60% in Africans[11–13], 1.10%–3.00% in East Asians[14–18], 0.10% in Hispanics[19], and 0.90%–2.50% in Southeast Asians[20–21]. Short axial length, shallow anterior chamber, and thick lens are common anatomical characteristics found in patients who develop PACG[22–24]. Despite variation in the prevalence of PACG, studies have shown these anatomical characteristics to be uniformly represented among the different ethnicities. Moreover, the biometric measurements for these anatomical characteristics between the racial groups do not differ significantly[25–27]. This suggests that other anatomical characteristics may be responsible for the increased susceptibility of PACG in certain ethnicities.

In 2010, Nongpiur et al found eyes with primary angle closure (PAC) and PACG to have larger lens vault (LV) compared to eyes with open-angle.[28] They explained that increased LV likely leads to a more pronounced iris curvature. Mechanistically, forward displacement of the iris is usually the final common denominator in the various mechanisms that cause angle closure.[29] If the dynamics of the iris can contribute to angle closure and subsequent development of primary angle-closure glaucoma, will variation in the iris structure, specifically its thickness, be capable of anatomically predisposing the iris to more bowing and crowding of the anterior chamber angle? The purpose of this study is to evaluate the capability of iris thickness parameters to explain the difference in PACG prevalence among the different ethnic groups by comparing narrow- and open-angle eyes between African-American, Caucasian-American, Chinese-American, Filipino-American, and Hispanic-American populations.

Methods

Study population

This is a prospective single-center multiethnic clinic-based study in which 259 patients with open-angles and 177 patients with narrow-angles from five different ethnicities were consecutively recruited from the University of California, San Francisco general ophthalmology and glaucoma clinics between March 2008 and September 2010. Institutional review board approval was obtained from the University of California, San Francisco, Committee on Human Research, and written consents were obtained from all participants. Ethnicities were self-designated by the patients. Inclusion criteria for both narrow-angle and open-angle groups include: 1) ≥ 18 years of age, 2) absence of corneal abnormalities that may obscure the view of anterior segment structures, 3) lack of prior laser or incisional surgery, and 4) absence of previous ocular trauma. Both the narrow-angle and open-angle groups included non-glaucomatous and glaucomatous subjects.

All enrollees received an ophthalmic examination that included intraocular pressure measurement by applanation tonometry, refraction, and gonioscopy. A single trained ophthalmologist (SL) performed gonioscopy using a Zeiss four-mirror gonioprism at x16 magnification with slit-lamp microscopy in a darkroom setting. Evaluation of the anterior chamber angle was based on the Shaffer gonioscopic grading classification in all four quadrants: angular opening between 35° and 45° was classified as grade 4, between 20° and 35° was classified as grade 3, between 10° to 20° was classified as grade 2, and less than 10° was classified as grade 1. Grade 0 was assigned if no angle structures could be observed.[30] For this study, eyes with an average Shaffer grade of ≤ 2 among superior, inferior, nasal and temporal quadrants were defined as narrow, while eyes with an average Shaffer grade of > 2 among superior, inferior, nasal and temporal quadrants were defined as open.

In the open-angle group, there are 56 Chinese (including 7 primary open angle glaucoma [POAG]), 29 Filipino (including 4 POAG), 45 African (including 13 POAG), 27 Hispanic (including 7 POAG), and 102 Caucasian (including 20 POAG). In the narrow-angle group, there are 32 Chinese (including 1 PAC, 1 PACG, and 1 plateau iris), 22 Filipino (including 1 PAC and 1 PACG), 26 African (including 1 PAC, 2 PACG, and 1 plateau iris), 24 Hispanic (including 1 PAC and 1 PACG), and 73 Caucasian (including 2 PAC, 1 PACG, and 3 plateau iris). If qualified, both eyes from the study patients were selected for anterior segment optical coherence tomography imaging.

Anterior segment optical coherence tomography (ASOCT) imaging and measurements

The ASOCT (Visante OCT, Carl Zeiss Meditec, Inc., Dublin, CA) is a non-contact optical coherence tomographic system using 1310-nm wavelength light to capture high-resolution cross-sectional images of the anterior segment of the eye.[31] For this study, imaging was performed in a darkroom setting to capture the temporal and nasal quadrants of the anterior segment. Three to five images were acquired for each selected eye and the image with highest visual quality was used for analysis. High-quality images were defined as those with good visibility of the scleral spurs with no discontinuity in anterior segment structure.

Selected images were then transported into the Zhongshan Angle Assessment Program (ZAAP) software, which contains algorithms that will automatically define the borders and curvatures of anterior chamber structures and measure anterior chamber parameters after the scleral spurs are manually located. Another trained ophthalmologist (GH), masked to the patient’s ethnicity, manually located the scleral spurs for all selected images. Due to the subjective nature of manually locating the scleral spurs, twenty-seven images were randomly selected for reassessment by the same ophthalmologist to test the reproducibility of the anterior segment measurements.

Main Outcome Variables and Statistical Analysis

The following iris parameters for the temporal and nasal quadrants were compared between patients from the five racial groups: iris thickness at 750 μm from the scleral spur (IT750), iris thickness at 2000 μm from the scleral spur (IT2000), and maximum iris thickness at the middle one-third of the iris (ITCM). Mean and standard deviation were calculated for all iris thickness parameters measured by the ASOCT. The following comparisons were performed: narrow-angle vs open-angle within each ethnic group, narrow-angle vs narrow-angle between the ethnic groups, open-angle vs open-angle between the ethnic groups. The statistical test used for analysis was linear mixed-effects regression, which controlled for the use of both eyes in patients and adjusted for age, gender, pupil diameter, and spherical equivalent. The conservative Bonferroni correction was utilized to correct the problem of multiple comparisons, which yielded a new critical value threshold of 0.05/12 (approximately 0.0042).

The spherical equivalent was derived from the refraction using the following formula: sphere plus half of the cylinder. Mean, standard deviation, and 95% confidence intervals were calculated for all spherical equivalent and Shaffer gonioscopic grading of the four quadrants. To determine the associations among myopia, iris thickness, and angle closure, linear mixed-effects regression, controlling for age, gender, ethnicity, and the use of both eyes in patients, was performed between the six iris thickness parameters and spherical equivalent and then between angle status and spherical equivalent.

All statistical analyses were conducted at the 0.05 significance level and with R v2.13.0 software for Macintosh.

Results

A total of 436 patients were recruited into the study. Among them, 11 patients were excluded due to poor visibility of the scleral spurs on all the ASOCT images. Therefore, 425 patients were available in which 684 eyes were used for statistical analysis. Table 1 and 2 summarize the demographics and clinical characteristics of the study subjects. Table 3 and 4 show the refraction (spherical equivalent) and the Shaffer gonioscopic angle grade for the study subjects by ethnicity and angle status.

Table 5 displays the patients' iris characteristics among those with narrow-angles. Caucasian-Americans had the lowest mean values while Chinese-Americans had the highest mean values for nasal IT2000 ($p<0.0001$). Nasal IT2000 remains statistically significant after the Bonferroni correction for multiple comparisons. For temporal ITCM, Caucasian-Americans had the lowest measurement, while African-American had the highest measurement ($p=0.021$). Temporal ITCM does not survive the Bonferroni correction for multiple comparisons, however the p value without the multiple measures correction suggests that significant difference might exist. Caucasians-Americans had the lowest measurements for all iris thickness parameters, while African-Americans had the highest measurements for nearly all iris thickness parameters, except for nasal IT2000 in which Chinese-Americans exhibited the highest measurement.

Table 6 shows the patients' iris characteristics by presence of open-angles. Among the open-angle populations, Caucasian-Americans had the lowest measurements for nasal IT750 and IT2000 ($p=0.01$ and $p<0.0001$). Chinese-Americans had the highest measurements for nasal IT750 and IT2000 ($p=0.01$ and $p<0.0001$). Nasal IT2000 remains statistically significant after the Bonferroni correction for multiple comparisons. Nasal IT750 does not survive the Bonferroni correction for multiple comparisons, however the p value without the multiple measures correction suggests that significant difference might exist. Similar to their narrow-angle counterparts, Caucasians-Americans nearly had the lowest measurements for all iris thickness parameters, except for temporal IT750 and ITCM. Chinese-Americans had the highest measurements for all iris thickness parameters.

Iris thickness was modeled as a function of angle status using linear mixed-effects regression, adjusting for age, gender, pupil diameter, spherical equivalent, ethnicity, and the use of both eyes in patients. The iris thickness difference between the narrow-angle and open-angle groups was significant ($p=0.0007$).

Table 7 shows the association between the six iris thickness parameters and spherical equivalent after controlling for age, gender, ethnicity, and the use of both eyes in patients. These linear mixed-effects regression analyses did not show any statistical significance (p>0.05) for an association between refractive status and iris thickness. However, statistical significance was found in the linear regression analysis of the relationship between spherical equivalent and angle status, indicating that greater spherical equivalent was associated with more narrow angles after controlling for age, gender, ethnicity, and the use of both eyes in patients (p=0.0051).

Twenty-seven ASOCT images were randomly selected to test for intraobserver reproducibility. The intraclass correlation coefficients for the reproducibility of the iris measurements are listed on Table 8.

Discussions

The purpose of this study was to assess the variability in iris thickness parameters to potentially explain the differences in prevalence of PACG among African-, Caucasian-, Hispanic-, Chinese-, and Filipino-Americans. In the open-angle population, we found Chinese-Americans to have the highest mean value for all measured iris thickness parameters, tying with Filipino-Americans for the highest mean value in nasal IT750. Of these six measured iris thickness parameters, nasal IT2000 was significantly different (p<0.0001). Nasal IT750 does not survive the Bonferroni correction for multiple comparisons, however the p value without the multiple measures correction suggests that significant difference might exist (p=0.01). Linear regression analysis of the relationship between spherical equivalent and angle status showed significant association between hyperopia and narrow angles (p=0.0051). In our analyses between iris thickness parameters and ethnicity, we have controlled for this potential confounder by adjusting for spherical equivalent.

It is interesting to note that in two out of the six measured iris thickness parameters, Filipino-Americans had mean values very close to those of Chinese-Americans. These two iris thickness parameters were nasal and temporal IT750. For nasal IT750, Chinese-Americans had a mean value of 0.46, while Filipino-Americans also had a mean value of 0.46. For temporal IT750, Chinese-Americans had a mean value of 0.45, while Filipino-Americans had a mean value of 0.44. Previously, Wang et al confirmed an association between increased iris thickness and angle closure by studying Singaporean subjects.[32] They explained that thicker irides might lead to angle closure because the iris would be in closer proximity to the angle. This explanation suggests that the portion of the iris closer to the scleral spur likely contributes more to angle crowding. The iris position closest to the scleral spurs that can be measured by the Zhongshan Angle Assessment Program is IT750. Despite scoring relatively high measurements in only the nasal and temporal IT750 parameters, the effect of these two parameters on angle narrowing may be more substantial since these portions of the iris make up part of the angle.

Our analysis of the open-angle population suggests that Chinese-Americans inherently have thicker irides than the other racial groups. Past studies have shown that increased iris thickness is associated with angle closure and subsequent glaucoma development,[29,32,33] so it is plausible that the inherently thicker irides in Chinese-Americans may predispose them to angle narrowing, thereby contributing to the their higher prevalence of PACG (1.10%–3.00% in East Asians[14–18]). This idea is also evident in Filipino-Americans, who have relatively high mean values for nasal and temporal IT750. Literature reports prevalence of PACG to be as high as 0.90%–2.50% in Southeast Asians[20–21].

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This relationship of iris thickness to prevalence of PACG continues in the other three racial groups. Caucasians-Americans had the lowest mean value for nasal IT750, while African-Americans and Hispanic-Americans tied for the lowest mean value for temporal IT750. Historically, the prevalence of PACG is relatively low in these ethnic groups: 0.06%–0.60% in Caucasians[5–10], 0.50%–0.60% in Africans[11–13], and 0.10% in Hispanics[19].

In the narrow-angle population, African-Americans exhibited the highest mean value for nearly all iris thickness parameters (5 out of 6), while Chinese-Americans only had the highest mean value for nasal IT2000. There are at least two potential interpretations for these results. The first interpretation is that even though African-Americans tend to have thinner irides, those with unusually thick irides develop angle narrowing. The second interpretation is that Chinese-Americans with open-angles inherently possess thick irides that predispose them to angle narrowing, thus iris thickness would be similar between Chinese-Americans with narrow- and open-angles.

When iris thickness was modeled as a function of angle status using linear mixed-effects regression, adjusting for age, gender, pupil diameter, spherical equivalent, ethnicity, and the use of both eyes in patients, significant difference was observed between the narrow-angle and open-angle groups (p=0.0007). This result suggests that an association exists between iris thickness and angle closure when controlling for ethnicity, specifically those with thicker irides tend to experience angle narrowing. This inference, together with our previous observation that Chinese-Americans have the highest measurements in the more pertinent iris parameters among the different racial groups in the open-angle population, supports the notion that thicker irides are associated with angle narrowing and racial groups that historically showed higher prevalence of primary angle closure glaucoma possess thicker irides.

There are several limitations to our study. First, manual scleral spur localization is subjective in nature, however our research design tried to control for this by utilizing a single ophthalmologist to read all the images. A previous published study employed the same method of manually locating the scleral spurs with great success, reporting excellent intraclass correlation coefficients ranging from 0.88 to 0.96.[33] In our study, we also had similar success, intraclass correlation coefficients for the reproducibility of iris thickness measurements ranged from 0.96 to 0.99. Second, the ASOCT images were taken in dark condition only, so inferences cannot be made about the iris dynamics under different lighting conditions. Lastly, the study population was recruited from general ophthalmology and glaucoma clinics, so the results may not apply to the general population. Despite these limitations, we believe this study is valuable because it is the first to compare iris thickness among five different ethnic groups and is the also the first to report iris thickness in African-, Hispanic-, and Filipino-Americans.

In summary, this study found Chinese-Americans to inherently have thicker irides compared to African-, Caucasian-, Hispanic-, and Filipino-Americans. We do not know whether this is one of the underlying causes of increased PACG prevalence in Chinese-Americans, but unlike other ocular biometrics such as short axial length, shallow anterior chamber, and thick lens which are commonly found in patients who develop PACG regardless of ethnicity[22–24], iris thickness was not uniform across the five studied racial groups. Filipino-Americans also inherently have relatively thick irides at the more important nasal and temporal IT750 positions, which may help to explain their potentially higher prevalence of PACG. Future studies can help to confirm our findings by utilizing a larger sample size that's more representative of the general population. Dynamics of iris change can also be explored by capturing the images under both light and dark conditions. Lastly, our study examined multiple parameters, so our analyses are exploratory and need to be confirmed in future studies.

Acknowledgments

Financial support: This study was supported by NIH-NEI EY002162 – Core Grant for Vision Research, Research to Prevent Blindness, and That Man May See, Inc.

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Table 1

Demographics and Clinical Characteristics of Narrow-Angle Subjects

Variable	Chinese (n=50)	Caucasian (n=124)	Filipino (n=40)	Hispanic (n=43)	African (n=42)
Age	74.20 ± 10.10	66.90 ± 12.60	70.60 ± 8.24	67.10 ± 13.00	64.60 ± 9.92
Male	19	47	8	3	9
Female	31	77	32	40	33
IOP	16.45 ± 3.18	16.69 ± 3.79	16.27 ± 6.65	17.36 ± 5.28	16.94 ± 2.29
Anterior Chamber Depth	2.36 ± 0.23	2.40 ± 0.28	2.23 ± 0.27	2.35 ± 0.24	2.40 ± 0.26
Pupil Diameter	3.90 ± 0.77	4.05 ± 0.83	3.96 ± 0.59	4.04 ± 0.74	3.60 ± 0.80

* Data expressed as mean value ± standard deviation

* IOP = Intraocular pressure by applanationtonometry

Table 2

Demographics and Clinical Characteristics of Open-Angle Subjects

Variable	Chinese (n=82)	Caucasian (n=147)	Filipino (n=41)	Hispanic (n=43)	African (n=72)
Age	61.30 ± 156	65.60 ± 12.80	68.20 ± 12.40	64.70 ± 13.80	60.50 ± 13.50
Male	45	60	15	21	23
Female	37	87	26	22	49
IOP	15.70 ± 2.90	16.60 ± 3.85	16.44 ± 4.54	17.65 ± 3.77	16.56 ± 4.25
Anterior Chamber Depth	2.81 ± 0.32	2.86 ± 0.38	2.76 ± 0.28	2.79 ± 0.33	2.91 ± 0.34
Pupil Diameter	4.15 ± 0.99	4.17 ± 0.97	3.87 ± 0.826	3.84 ± 0.96	4.00 ± 0.87

* Data expressed as mean value ± standard deviation

* IOP = Intraocular pressure by applanation tonometry

Table 3

Refraction (Spherical Equivalent) By Raceand Angle Status

Ethnicity	Angle	Spherical Equivalent in Diopters
Chinese	Open	−2.522 ± 0.473 (−3.451, −1.594)
	Narrow	−0.073 ± 0.608 (−1.265, 1.119)
Caucasian	Open	−0.902 ± 0.285 (−1.462, −0.3428)
	Narrow	1.039 ± 0.275 (0.500, 1.578)
Filipino	Open	−0.147 ± 1.273 (−2.643, 2.348)
	Narrow	1.068 ± 0.318 (0.443, 1.692)
Hispanic	Open	−0.006 ± 0.556 (−1.097, 1.084)
	Narrow	1.172 ± 0.464 (0.262, 2.0824)
African	Open	−0.444 ± 0.389 (−1.208, 0.319)
	Narrow	0.057 ± 1.756 (−0.467, 0.582)

[*] Data expressed as mean value ± standard deviation (95% confidence interval)

Table 4

Shaffer Gonioscopic Angle Grade by Ethnicity and Angle Status

Ethnicity	Angle	Shaffer Angle Grade: Superior Quadrant	Shaffer Angle Grade: Nasal Quadrant	Shaffer Angle Grade: Inferior Quadrant	Shaffer Angle Grade: Temporal Quadrant	Average Shaffer Angle Grade in All Four Quadrants
Chinese	Open	3.09 ± 0.05 (2.98, 3.20)	3.13 ± 0.04 (3.03, 3.22)	3.13 ± 0.05 (3.03, 3.24)	3.13 ± 0.04 (3.03, 3.22)	3.12 ± 0.04 (3.02, 3.21)
	Narrow	1.74 ± 0.09 (1.54, 1.93)	2.01 ± 0.11 (1.79, 2.23)	1.82 ± 0.12 (1.57, 2.06)	2.44 ± 0.32 (1.81, 3.07)	2.00 ± 0.11 (1.77, 2.23)
Caucasian	Open	3.16 ± 0.04 (3.06, 3.26)	3.22 ± 0.04 (3.13, 3.32)	3.24 ± 0.04 (3.15, 3.33)	3.22 ± 0.04 (3.13, 3.31)	3.21 ± 0.04 (3.12, 3.30)
	Narrow	1.44 ± 0.09 (1.27, 1.62)	1.74 ± 0.09 (1.55, 1.94)	1.59 ± 0.08 (1.41, 1.76)	1.64 ± 0.08 (1.46, 1.82)	1.60 ± 0.08 (1.43, 1.76)
Filipino	Open	3.18 ± 0.09 (3.00, 3.36)	3.29 ± 0.06 (3.16, 3.42)	3.28 ± 0.08 (3.12, 3.44)	3.29 ± 0.06 (3.16, 3.42)	3.26 ± 0.08 (3.10, 3.42)
	Narrow	1.34 ± 0.13 (1.08, 1.59)	1.69 ± 0.14 (1.42, 1.97)	1.58 ± 0.14 (1.30, 1.86)	1.57 ± 0.13 (1.30, 1.84)	1.44 ± 0.14 (1.16, 1.72)
Hispanic	Open	2.94 ± 0.07 (2.79, 3.09)	2.98 ± 0.04 (2.89, 3.06)	3.07 ± 0.03 (2.99, 3.15)	3.05 ± 0.06 (2.93, 3.17)	3.01 ± 0.05 (2.91, 3.11)
	Narrow	1.63 ± 0.21 (1.22, 2.05)	1.67 ± 0.21 (1.25, 2.08)	1.68 ± 0.20 (1.27, 2.09)	1.71 ± 0.21 (1.29, 2.13)	1.67 ± 0.19 (1.28, 2.06)
African	Open	3.20 ± 0.08 (3.03, 3.37)	3.23 ± 0.07 (3.09, 3.37)	3.25 ± 0.07 (3.10, 3.40)	3.27 ± 0.07 (3.13, 3.41)	3.24 ± 0.07 (3.09, 3.38)
	Narrow	1.68 ± 0.14 (1.39, 1.97)	1.78 ± 0.13 (1.51, 2.05)	1.69 ± 0.14 (1.41, 1.97)	1.82 ± 0.12 (1.59, 2.06)	1.76 ± 0.11 (1.53, 1.99)

* Data expressed as mean value ± standard deviation (95% confidence interval)

* Evaluation of the anterior chamber angle was based on the Shaffer gonioscopic grading classification: angular opening between 35° and 45° was classified as grade 4, between 20° and 35° was classified as grade 3, between 10° to 20° was classified as grade 2, and less than 10° was classified as grade 1. Grade 0 was assigned if no angle structures were observed.

Table 5

Comparison of Iris Parameters Among Narrow-Angle Racial Groups

Measurement	Chinese	Caucasian	Filipino	Hispanic	African	P Value
Nasal IT750	0.46 ± 0.11	0.44 ± 0.10	0.44 ± 0.07	0.45 ± 0.10	0.48 ± 0.09	0.49
Nasal IT2000	0.49 ± 0.09	0.42 ± 0.11	0.48 ± 0.07	0.46 ± 0.05	0.47 ± 0.07	<0.0001$^{\varphi}$
Nasal ITCM	0.63 ± 0.11	0.59 ± 0.12	0.61 ± 0.10	0.61 ± 0.06	0.64 ± 0.10	0.18
Temporal IT750	0.45 ± 0.09	0.44 ± 0.08	0.49 ± 0.12	0.45 ± 0.08	0.50 ± 0.14	0.45
Temporal IT2000	0.45 ± 0.06	0.40 ± 0.07	0.45 ± 0.12	0.42 ± 0.06	0.46 ± 0.11	0.053
Temporal ITCM	0.59 ± 0.10	0.55 ± 0.06	0.60 ± 0.12	0.58 ± 0.06	0.64 ± 0.12	0.021$^{\psi}$

[*] Data expressed as mean value ± standard deviation

[*] P values are by linear mixed-effects regression, a likelihood ratio test function, testing for ethnicity coefficient

[*] Linear mixed-effects regression accounted for age, gender, pupil diameter, spherical equivalent, and the use of both eyes in patients.

[*] IT750 = iris thickness measured at 750 μm from the scleral spur; IT2000 = iris thickness measured at 2000 μm from the scleral spur; ITCM = the maximum iris thickness at middle one third of the iris

[*] The conservative Bonferroni correction was utilized to correct the problem of multiple comparisons, which yielded a new critical value threshold of 0.05/12 (approximately 0.0042).

$^{\varphi}$Nasal IT2000 remains statistically significant after the Bonferroni correction for multiple comparisons

$^{\psi}$Temporal ITCM does not survive the Bonferroni correction for multiple comparisons, however the p value without the multiple measures correction suggests that significant difference might exist.

Table 6

Comparison of Iris Parameters Among Open-Angle Racial Groups

Measurement	Chinese	Caucasian	Filipino	Hispanic	African	P Value
Nasal IT750	0.46 ± 0.09	0.40 ± 0.08	0.46 ± 0.11	0.44 ± 0.07	0.44 ± 0.08	0.01[ψ]
Nasal IT2000	0.51 ± 0.09	0.42 ± 0.08	0.47 ± 0.09	0.48 ± 0.08	0.46 ± 0.11	<0.0001[φ]
Nasal ITCM	0.61 ± 0.08	0.59 ± 0.09	0.59 ± 0.07	0.60 ± 0.09	0.60 ± 0.09	0.83
Temporal IT750	0.45 ± 0.07	0.43 ± 0.13	0.44 ± 0.09	0.42 ± 0.09	0.42 ± 0.09	0.71
Temporal IT2000	0.45 ± 0.09	0.41 ± 0.13	0.42 ± 0.09	0.42 ± 0.08	0.41 ± 0.09	0.11
Temporal ITCM	0.59 ± 0.09	0.57 ± 0.16	0.56 ± 0.07	0.57 ± 0.08	0.56 ± 0.08	0.94

[*] Data expressed as mean value ± standard deviation

[*] P values are by linear mixed-effects regression, a likelihood ratio test function, testing for ethnicity coefficient

[*] Linear mixed-effects regression accounted for age, gender, pupil diameter, spherical equivalent, and the use of both eyes in patients.

[*] IT750 = iris thickness measured at 750 μm from the scleral spur; IT2000 = iris thickness measured at 2000 μm from the scleral spur; ITCM = the maximum iris thickness at middle one third of the iris

[*] The conservative Bonferroni correction was utilized to correct the problem of multiple comparisons, which yielded a new critical value threshold of 0.05/12 (approximately 0.0042).

[φ] Nasal IT2000 remains statistically significant after the Bonferroni correction for multiple comparisons

[ψ] NasalIT750 does not survive the Bonferroni correction for multiple comparisons, however the p value without the multiple measures correction suggests that significant difference might exist.

Table 7

Association Between Iris Thickness Parameters and Spherical Equivalent

Parameter	**P value**
Nasal IT 750	0.254
Nasal IT 2000	0.465
Nasal ITCM	0.307
Temporal IT 750	0.441
Temporal IT 2000	0.771
Temporal ITCM	0.631

*P values are by linear mixed-effects regression, a likelihood ratio test function, testing for spherical equivalent

*Linear mixed-effects regression accounted for age, gender, ethnicity, and the use of both eyes in patients.

*IT750 = iris thickness measured at 750 μm from the scleral spur; IT2000 = iris thickness measured at 2000 μm from the scleral spur; ITCM = the maximum iris thickness at middle one third of the iris

Table 8

Reproducibility of Iris Thickness Measurements in a Random Subset of 27 Eyes

Parameter	**ICC(95%CI)**
Nasal IT750	0.968(0.931, 0.986)
Nasal IT2000	0.982(0.961, 0.992)
Nasal ITCM	0.989(0.976, 0.995)
Temporal IT750	0.995(0.989, 0.998)
Temporal IT2000	0.976(0.948, 0.989)
Temporal ITCM	0.987(0.972, 0.994)

* ICC = intraclass correlation coefficient; CI = confidence interval; IT750 = iris thickness measured at 750 μm from the scleral spur; IT2000 = iris thickness measured at 2000 μm from the scleral spur; ITCM = the maximum iris thickness at middle one third of the iris